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ISSN: 2365-9793

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ABSTRACT

A Strictly Economic Explanation of Gender Norms: The Lasting Legacy of the Plough*

We show that the descendants of ancient farmers may have an interest in marrying among themselves, and thus maintaining the gendered division of labour originally justified on comparative- advantage grounds by the advent of the plough even after they emigrate to a modern industrial economy where individual productivity depends on education rather than physical characteristics. The result rests on the argument that, if an efficient domestic equilibrium requires the more productive spouse to specialize in raising income, and the less productive one in raising children irrespective of gender, this equilibrium will be implemented by a costlessly enforceable contract stipulating that the husband should do the former and the wife the latter, even if individual productivity reflects education rather than gender. Such a contract may not be needed if education and time spent with children give direct utility, because an efficient equilibrium may then be characterized by little or no division of labour.

JEL Classification: C78, D02, J16, J61

Keywords: plough, comparative advantage, matching, hold-up problem, migration, social norm

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* Comments by Annalisa Luporini and Dilip Mookherjee are gratefully acknowledged.

1 Introduction

Alesina et al. (2013) bring empirical evidence in support of the hypothesis advanced by Boserup (1970) that the gendered division of labour, whereby men work outside the home raising income, while women specialize in domestic, prevalently child-raising activities, draws its origins from the introduction of the plough some four thousand years ago. Unlike shifting cultivation, which is very labour intensive but requires no special physical characteristics, plough cultivation is in fact less labour intensive but requires "upper body strength, grip strength, and bursts of power" which are more likely to be found in men than in women. That gives the former a comparative advantage over the latter in agricultural production. The first of the two articles cited reports that European and US residents descending from populations who used the plough in their countries of origin display still today, in their country of destination, less equal gender attitudes than the descendants of populations who did not have that experience. That is amazing. Why is the legacy of the plough still felt after countless other innovations have drastically reduced the importance of physical characteristics in the determination of individual productivity, and the share of the population employed in the agricultural sector? And why was this legacy not lost when migration offered the descendants of ancient plough users the opportunity to marry outside their ethnic group? The often heard argument that women are genetically programmed to enjoy raising children more than men do is irrelevant in the present context, because it should apply to everybody, not just to the descendants of ancient plough users. Another often heard argument is that men took advantage of the power achieved when physical strength mattered to indulge their taste for discriminating against women. The problem with this argument is that discrimination has an efficiency cost (Becker, 1957), and that the cost of discriminating against women rises as technological progress increases the importance of education vis-a-vis physical characteristics.

In the present paper we use a simple economic model of marriage and household decisions where men and women are matched by their potential incomes as singles, and then Nash-bargain the allocation of their joint time and money endowments. Parents have no gender preferences. We show that, so long as utility depends only on the agent's consumption of a private good, and on a domestically produced public good reflecting the quality (of life) of the couple's children, then, in equilibrium, the higher-wage spouse will specialize in income production, the lower-wage one will specialize in domestic activities, and the two will consume the same amount of the private good. There is a potential hold-up problem however. If the spouses command different wage rates (in an industrial

economy, because they have different amounts of education, in a plough-using agricultural one, because one is a man and the other a woman), the lower paid of the two will not agree to give up paid work unless the equilibrium is enshrined in an enforceable pre-marital contract or, failing that, the better paid spouse compensates her or him at front (before the children are born, and resources expended on them). The latter may not be possible because the more productive spouse's initial endowment of the private good may not be large enough. The former may be prohibitively expensive if the enforcement can only be done by legal means. In a primitive agrarian economy, a hold-up problem can arise only if the plough gives men a comparative advantage over women in the production of the private good. In the traditional societies that we usually associate with such economies, however, the equilibrium is costlessly implemented by the threat of extra-legal sanctions at the hands or with the approval of the entire community.

So long as education does not yield direct utility, children will not get one in a primitive economy where productivity is independent of education, but this may change with emigration to a modern industrial economy where education raises the probability of getting a high wage rate. We show that, in the destination country, the descendants of ancient farmers who never experienced the plough will give their daughters as much education as their sons. By contrast, under certain conditions, the descendants of ancient plough users will invest in their sons', but not in their daughters' education, in which case their children, their children's children and so on will have an interest in marrying among themselves (practicing homogamy). The story changes somewhat if people derive direct utility also from luxury goods like education, and time spent with children, because an NB equilibrium may then involve little or no specialization, and there may thus be no need for advance compensation. As more and more people become rich in the process of economic growth, fewer and fewer of them will then practice homogamy and specialize on gender lines.

2 Basic assumptions

As in much of the economics of the family literature,[1] we assume that the agent derives utility from her or his own consumption of a private good ("money") and, if married, from a number of domestically produced, couple-specific public goods representing the quality (of life) of the couple's children. Later in the paper we shall allow for additional sources of utility. For simplicity, we further assume that, if individual

[1] See, among others, Becker (1981), Cigno (1991) and Folbre (1994).

i marries, the couple have a daughter D and a son S.[2] Therefore, the decision to marry coincides with the decision to become a parent.

Let c_i denote i's consumption of the private good, and g_K the quality of K's life, where $K = D, S$. To fix ideas and facilitate calculations, we take the utility function to be linear,

$$U_i = c_i + g_D + g_S, \tag{1}$$

and g_K to be a log-linear function of the amount of money y_K, and time ("attention") a_K, that the couple jointly spend on K,

$$g_K = \ln y_K + \gamma \ln a_K, \ 0 < \gamma < 1.$$

Notice that not only maternal and paternal money contributions, but also maternal and paternal time contributions, are perfect substitutes in the domestic production of child quality. Notice also that parents do not harbour gender preferences. If daughter and son entered the picture symmetrically also in every other respect (as is very often the case in the economics of the family literature), there would then be no need to keep their identities separate. We keep them separate because, in Section 3 below, we will find that gender may matter even if daughter and son are interchangeable where their parents' utility is concerned.

Parents and their children play a two-stage game. At stage 1, the couple allocate their children a certain amount of money (optimally allocated between cash-in-hand and educational expenditure), and a certain amount of attention. At this stage, their children's stage-2 wage rates or productivities may be uncertain. At stage 2, when these wage rates or productivities are revealed, the children decide whether and whom to marry. The model is solved by backward induction.

3 Modern economies

We start by considering a modern industrial economy where the probability of earning a high wage rate increases with education. Specifically, we assume that individual i's wage rate is $w_i = w^H$ with probability $\pi(z_i)$, where z_i denotes i's education,[3] and $w_i = w^L < w^H$ with probability $1 - \pi(z_i)$. The function $\pi(.)$ is increasing and concave, with $\pi(0) = 0$.

[2] Allowing for the number of children to be a random variable with probability distribution conditional on certain parental actions, and assuming that a child will be born male or female with equal probability, would complicate the analysis without altering our results in any substantial way.

[3] If education is compulsory up to a certain level, z_i is measured from that minimum.

3.1 Stage 2

At this stage, i is endowed with one unit of time and b_i units of money, and commands a known wage rate w_i. If i stays single, her or his utility is measured by her or his consumption, equal to to her or his income,

$$R_i := c_i = b_i + w_i.$$

If i marries, the couple Nash-bargain the allocation of their joint time and money endowments, and the distribution of their joint income. Player i's reservation utility is equal to her or his utility as a single, R_i. We plausibly assume that men and women are matched by their reservation utilities, and that the distribution of these utilities is the same for men and women. If several individuals of each gender have the same reservation utility, they are sorted into couples in such a way, that i's utility is maximized given R_i.

Take the couple formed by a particular woman, f, and a particular man, m. Having assumed that

$$R_f = R_m = R, \tag{2}$$

it follows that

$$w_m - w_f = b_f - b_m. \tag{3}$$

The Nash-bargaining (NB) equilibrium maximizes

$$N = (U_f - R)(U_m - R),$$

subject to f's and m's budget constraints,

$$c_f = b_f + (1 - 2\delta a) w_f - y + T$$

and

$$c_m = b_m + [1 - 2(1 - \delta) a] w_m - y - T,$$

where $0 \leq \delta \leq 1$ denotes f's share of a, and T is defined as a transfer (positive, negative or zero) from m to f. Each parent is conventionally assigned the monetary cost of one child, y, but the amount effectively contributed will depend on the sign and size of T. In equilibrium,

$$U_K = U.$$

Given that D and S enter the optimization symmetrically, in equilibrium, D and S are treated the same,

$$y_K = y,\ a_k = a \text{ and } g_K = g.$$

Given also that a_f and a_m are perfect substitutes in the production of g, the choice of δ will be either at a corner (1 or 0), or indeterminate.[4] For any given δ, the first-order conditions on the choice of a, y and T are, respectively,

$$\left(-2\delta w_f + 2\frac{\gamma}{a}\right)(U_m - R) + \left[-2(1-\delta)w_m + 2\frac{\gamma}{a}\right](U_f - R) = 0, \quad (4)$$

$$\left(-1 + \frac{2}{y}\right)(U_m - R) + \left(-1 + \frac{2}{y}\right)(U_f - R) = 0 \quad (5)$$

and

$$(U_m - R) - (U_f - R) = 0. \quad (6)$$

In equilibrium,

$$U_f = U_m = U$$

and

$$y = 2. \quad (7)$$

The values of the other variables depend on the parents' relative wage rates.

For

$$w_f = w^L,\ w_m = w^H,$$

the couple choose

$$\delta = 1,\ a = \frac{2\gamma}{w^L},\ T = 2\gamma.$$

In this case, f allocates all her time to the production of child quality, and m to the production of income. Consequently, he compensates her for forgone earnings. Their common utility level is

$$U^*(R) := R - 2(1+\gamma) + 2\left(\ln 2 + \gamma \ln \frac{2\gamma}{w^L}\right).$$

In the opposite case, where

$$w_f = w^H,\ w_m = w^L,$$

the couple choose

$$\delta = 0,\ a = \frac{2\gamma}{w^L},\ y = 2,\ T = -2\gamma.$$

[4] If the mother's and the father's time contributions substituted at a diminishing marginal rate, the solution could be interior, and the specialization less than full, but this would make no difference of substance to the results.

The only difference between this and the previous case is in the sign of T. As m now does all the child related work, and f all the income related work, it is now her who compensates him for loss of earnings. But the common utility level is still $U^*(R)$.

For

$$w_f = w_m = w,$$

the couple are indifferent between splitting the two types of work equally between them, or spinning a coin. Assuming the former,

$$\delta = \frac{1}{2},\ a = \frac{2\gamma}{w},\ y = 2,\ T = 0$$

There is no compensation. If $w = w^L$, the couple's common utility level is again $U^*(R)$. But, if $w = w^H$, the common utility level is only

$$U^\circ(R) := R - 2(1+\gamma) + 2\left(\ln 2 + \gamma \ln \frac{2\gamma}{w^H}\right) < U^*(R)$$

because the children's opportunity-cost is in that case higher than in the other.

Therefore, a marriage between two high-wage persons is inefficient. In an efficient matching, a high-wage person is always married to a low-wage person, because the latter is indifferent between marrying a high-wage or a low-wage person with the same R, but the former is better-off marrying a low-wage person with the same R. Realistically assuming that children are born at (or close to) the start of stage 2, but wages are paid at the end (or at any rate in the course) of it, however, an NB equilibrium where the spouses have different wage rates may not be implementable. Given that once the children are born they cannot be sent back, and making the usual assumption that a complete, legally enforceable pre-marital contract is out of the question because the transactions cost is prohibitively high for ordinary folk, the low-wage spouse will in fact demand to be paid at front. But, this payment will not be forthcoming if the high-wage spouse's money endowment is lower than the compensation due, and credit is rationed. If that is the case, there is a hold-up problem. The efficient equilibrium cannot be implemented. For $w_i = w^L$, i will then marry a high-wage member of the opposite sex with money endowment greater than 2γ or, if there are not enough of these, another low-wage person. In either case, i will get the utility level $U^*(R_i)$. By contrast, if $w_i = w^H$, and b_i is less than 2γ, i will have no choice but to marry another high-wage person, and get the utility level $U^\circ(R_i)$, which is not as good as $U^*(R_i)$, but still better than remaining single and getting only R_i.

It may be argued that, in a developed society, there are legal instruments, other than a court-enforceable contract, which may obviate the emergence of a hold-up problem. Cigno (2012) shows that marriage may substitute for a fully contingent pre-marital contract if divorce is sufficiently inexpensive, and divorce courts can be relied upon to award compensation to the party who sacrificed her or his career prospects in order to specialize in domestic activities, because the party in question can then credibly threaten divorce if the other party does not deliver the compensation voluntarily. But this is unavoidably uncertain, because there are verifiability problems, and also because of court discretionality. Therefore, the availability of low-cost divorce, and the possibility that the compensation for the spouse who specialized in domestic work would be mandated by a divorce court, reduces but does not eliminate the probability of a hold-up problem.

3.2 Stage 1

At stage 1, the parental couple maximize the sum of their children's expected utilities,

$$EU^*\left(R_d\right) + EU^*\left(R_s\right),$$

where d denotes this couple's daughter, and s this couple's son, subject to appropriate constraints. Given that d and s enter the optimization symmetrically, however, the problem reduces to maximizing the expected utility of either child. Omitting the identifying subscript, the couple then choose (b, z) to maximize

$$EU^*\left(R\right) = \pi\left(z\right)\left(b + w^H + C\right) + \left[1 - \pi\left(z\right)\right]\left(b + w^L + C\right) \tag{8}$$

where

$$C = 2\left(\ln 2 + \gamma \ln \frac{2\gamma}{w^L}\right) - 2\left(1 + \gamma\right),$$

subject to two constraints. The first is

$$b + z = \overline{y}, \tag{9}$$

where $\overline{y}$ is the amount of money that the couple jointly spend on each child at this stage (determined in the same way as the amount y that each child will spend, jointly with her or his future husband or wife, at the next stage). The second constraint is that, if a child's wage rate turns out to be high, she or he must be able to pay her or his future spouse the equilibrium amount of compensation at the start of stage 2,

$$b \geq 2\gamma. \tag{10}$$

Maximizing (8) subject to (9) and (10) is the same as maximizing

$$ER = \pi(z)\left(\overline{y} - z + w^H\right) + [1 - \pi(z)]\left(\overline{y} - z + w^L\right)$$

subject to

$$z \leq 2(1-\gamma). \tag{11}$$

This problem has either an interior solution at $z_i = z^* \geq 0$, where z^* solves

$$\pi'(z) = \frac{1}{w^H - w^L}, \tag{12}$$

or a corner solution at $z_i = \overline{z} := 2(1-\gamma)$.

4 From primitive to modern economies

A primitive agrarian economy differs from a modern industrial one in that a person's wage rate is independent of education (we continue to talk of wage rate even though there may not be a labour market and, if that is the case, we should talk of physical productivity). Parents may then give a child money, but never an education.[5] All we said in the last section regarding the need to guarantee the actual delivery of T for an NB equilibrium with domestic division of labour to be implementable, still applies. Let there be two such economies, A and B. For geographical reasons, the plough is available in country B, but not in country A.[6] In the latter, the wage rate is equal to w^L for everybody, and consequently $\delta = \frac{1}{2}$ for all couples. There is then no question of a spouse having to compensate the other, and no risk of a hold-up problem. In country B, by contrast, the woman's wage rate is w^L, but the man's is w^H thanks to the plough technology. Therefore, $\delta = 1$. Is there then a potential hold-up problem as in a modern industrial economy?

In the traditional societies that we associate with primitive agrarian economies, a contract may be enforced not only by a law court, but also, if it is in everybody's interest that the contract should be honoured, by the threat of severe extra-legal sanctions (ranging from ostracism to physical punishment, or even murder) at the hands or with the approval of the entire community. In equilibrium, this form of enforcement costs nothing, because the threat does not need to be carried out. In country B, this applies to pre-marital contracts, because every couple has a

[5] That is obviously a simplification. In reality, a small minority of prospective priests, scribes and astrologers will receive an education of sorts.

[6] Using a wealth of archaeological and linguistic evidence, Diamond (2005) argues that the reason why agriculture and certain agricultural technologies developed in certain parts of the world rather than others, and spread in certain directions rather than others, is due to geographical factors.

daughter and a son. At stage 1 of the game, it is thus in every couple's interest that their son should be able to follow his comparative advantage in agricultural production, but their son-in-law should not be allowed to turn his comparative advantage into a bargaining advantage at their daughter's expense. Generation after generation, therefore, all country B couples comply with a simple contract, the same for all of them, specifying that the wife must spend all her time attending to the children, that the husband must spend all his producing income, and that the spouses will consume the same amount of the private good. No such contract is needed in country A, where the NB equilibrium does not involve specialization.

Now suppose that a number of couples emigrate from either A or B to a modern economy. Observing that, in their new country, educated workers command a higher wage rate than uneducated ones, these immigrants will consider the merits of investing in their children's education. If a couple originate from country A, they have no reason to treat their daughter differently from their son. What if the immigrant couple originate from country B? If (11) is satisfied for $z = z^*$, they will give both their children the same amount of education z^*. Otherwise they may not. Suppose that these parents can rely, in their new country, on the same extra-legal methods that are used in their country of origin to enforce a pre-marital contract with domestic specialization along gender lines (we will show in a moment that this is so under certain conditions). That introduces an asymmetry in the way their daughter d and son s enter the optimization, because the contract in question relaxes (11) only if, in their future married lives, d specializes in raising children, and s in raising income. The parental optimization cannot then be reduced to maximizing the expected utility of either child. If

$$U^*\left(\overline{y}_d + w^L\right) + EU^*\left(\overline{y}_s - z^* + w_d\right) > EU^*\left(\overline{y}_d - \overline{z} + w_d\right) + EU^*\left(\overline{y}_s - \overline{z} + w_s\right) \tag{13}$$

for any $(\overline{y}_d, \overline{y}_s)$, the parents' best strategy is to set $z_d = 0$ and $z_s = z^*$, and then to equalize the children's expected utilities (or rather, her utility and his expected utility) by choosing

$$\overline{y}_d - \overline{y}_s = \pi\left(z^*\right)\left(w^H - w^L\right) - z^*.$$

The hypothesis (13) implies

$$\left[\pi\left(z^*\right) - 2\pi\left(\overline{z}\right)\right]\left(w^H - w^L\right) > z^* - 2\overline{z},$$

and it is thus true for

$$\overline{z} < \frac{z^*}{2}. \tag{14}$$

In other words, if $\overline{z}$ is sufficiently smaller than z^*, and (11) is relaxed by a costlessly enforceable pre-marital contract involving specialization along gender lines, the parents' best bet is to invest only in their son's education, and to compensate their daughter by giving her more money than him. Given that the contract in question is enforceable only if d's future husband and s's future bride have parents who originate from country B, it is then in d's (s's) interest to marry the son (daughter) of another couple originating from that country. The same will apply also to d's and s's respective children, children's children, and so on. So long as (11) is violated by $z = z^*$, but (14) holds true, the descendants of ancient plough users will have an interest in practicing homogamy and the gendered division of labour.

Would an amended version of the contract in question, saying that the spouse with the higher wage rate must specialize in raising income, and the one with the lower wage rate in raising children, irrespective of gender (but the two should still get the same amount of consumption), do just as well in a modern industrial economy where individual productivity depends on education rather than gender? So long as education does not give direct utility as we have assumed so far (but more about this in the next section), the answer is no, because, as we have just seen, the amended contract could induce country B immigrants and their descendants to give their daughters the same amount of education as their sons. Given that, under present assumptions, educating a person who is not destined to produce income is wasteful, the waste will be double if both children get an education, than if only one of them (the daughter or, equivalently, the son) does. The amended contract would then be inefficient, and thus unenforceable.

5 Extensions and conclusion

In the last two sections, we used a bare-bones model where people derive direct utility only from their own consumption, and from their children's quality, to demonstrate that, under certain conditions, the descendants of ancient plough users have an interest in marrying among themselves, and practicing the gendered division of labour even if they live in a modern industrial economy where wage rates reflect education rather than gender. This result carries the strong implication that these people are more likely to practice homogamy, and to specialize along gender lines if they do, than the rest of the population. What happens if we allow for education and time spent with children to yield direct utility? Realistically assuming that these are luxury goods, the demand for them will be negligible among the poor, but not among the rich. For the latter, an NB equilibrium might in fact be characterized by little or no specialization.

Such an equilibrium will not be implemented by the contract described in the last section, but that is no great loss. If, in this equilibrium, the spouses earn exactly the same, there is in fact no need for an enforceable contract. And, there is a good chance that such a contract will not be needed even if the spouses earn almost the same, because the advance compensation due to the lower earning spouse will then be smaller than it would with complete specialization.[7] Thus extended, the model carries the further implication that, as more and more people become rich enough to express a demand for luxury goods thanks to economic growth, a larger and larger share of the descendants of those ancient plough users will lose interest in practicing homogamy and specializing on gender lines. These theoretical predictions are consistent with evidence reported in Alesina et al. (2013), that European and US residents descending from populations who used the plough in their countries of origin display still today, in their country of destination, less equal gender attitudes than the descendants of populations who did not have that experience, and that a similar difference emerges also from the comparison of those who descend from ancient plough users on both the father's and the mother's side, with those who descend from them on only one parent's side.

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[7] In the first case, (11) is irrelevant. In the second, there is less of a chance that (11) is not satisfied for $z = z^*$.

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