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A strictly economic explanation of gender norms: The lasting legacy of the plough.*

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Abstract

We show that the descendants of primeval plough users have an interest in maintaining the gender division of labour which was originally justified on comparative-advantage grounds, even though in a modern economy individual productivity depends on education rather than physical characteristics. The result rests on the argument that the contract enforcement technology developed in response to the availability of the plough serves a purpose also in a modern economy because of a possible hold-up problem in the implementation of a Nash-bargaining equilibrium with domestic division of labour.

Key-words: Plough, comparative advantage, matching, hold-up problem, migration.

JEL Codes: C78, D02, J16, J61

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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 in income-raising activities, 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? Why was this legacy not lost when migration offered the descendants of ancient plough users the opportunity to marry members of different ethnic groups?

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. Yet another argument is grounded in the identity approach advocated by Akerlof and Kranton (2000). According to that approach, people derive utility from, and are thus willing to pay a price for, remaining true to what they regard as their identity. Suppose that being a true man means producing income, and being a true woman means looking after the home. Men and women will then be willing to pay a price in order to conform with their identities. But, where do those identities come from? Where ancient plough users and their descendants are concerned, the answer could be that they are the result of hundreds or thousands of years of gendered division of labour. A problem for us economists is that we are not equipped to explain how this

happens (Akerlof and Kranton rely on the findings of sociology and social psychology). Without such an explanation, we cannot explain why the importance of identity does not diminish and eventually vanish as men lose their comparative advantage in income production.

In the present paper we use a simple economic model of marriage and household decisions where men and women are matched by their potential income as singles, and then Nash-bargain the allocation of their joint endowments of time and money. Parents do not discriminate between sons and daughters. We show that, so long as utility depends only on the agent's consumption of the private good, and on a domestically produced public good reflecting the quality (of life) of the couple's children, then, in an efficient equilibrium, the higher-wage spouse specializes in income production, the lower-wage one in domestic activities, and the two consume the same amount of the private good. There is a potential hold-up problem however. If the spouses have different productivity (in an industrial economy because they have different amounts of education, in a plough-using agricultural economy simply because one is a man and the other a woman), the less productive of the two will not agree to specialize in domestic activities unless the equilibrium is enshrined in an enforceable pre-marital contract, or the more productive spouse compensates the less productive one 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 be done only by legal means. In an agricultural 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 society that is usually associated with such an economy, however, a simple contract, the same for all couples, saying that the husband is to spend all his time working in the fields, the wife is to spend all hers at home looking after the children, and the two must have the same level of consumption, can be costlessly enforced with the local community's help and approval by the threat of extra-legal sanctions ranging from ostracism to physical punishment for the spouse who does not comply. This enforcement technology is a collectively rational response to a potential market failure.

Given that education does not yield direct utility, children will not get one in an agricultural economy where productivity is independent of education. That will change with emigration to an industrial economy where education raises the probability of getting a high wage rate. Continuing to assume that parents do not have gender preferences, if they originate from a plough using agricultural economy, they will carry

with them their ancestral contract enforcement technology. In the destination country, they may then invest in their son's education, but not in their daughter's, because they expect that the latter will do no paid work, and will thus have no use for an education. Given that children of these immigrants have then an interest in marrying the children of other immigrants with the same origin ("homogamy") in order to preserve their valuable contract enforcement technology, they will then do that and practice the traditional division of labour supported by this technology as their parents expected. Will this equilibrium be replicated generation after generation? We show that the answer is yes under present assumptions, because nobody has then an interest in deviating from it. We also show, however, that the equilibrium may break down if we allow for the possibility that people derive direct utility not only from own consumption and quality of the children, but also from education, and from time spent with the children. Assuming that people feel uncomfortable if they do not conform with their perceived identity, and that the identity of plough users's descendants is shaped by the long practice of the gendered division of labour would not affect behaviour, because these people would conform anyway. It could affect behaviour, in the sense that the people in question would be less ready to depart from the gendered division of labour, only if utility depends also on education and time spent with children.

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 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,

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

¹See Becker (1981), Cigno (1991) and Folbre (1994).

²Allowing 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.

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 ,

$$g_K = \ln y_K + \gamma \ln a_K, \quad \gamma > 0.$$

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 certain amount of attention. At this stage, their children's stage-2 wage rates (or productivity) may be uncertain. At stage 2, when these wage rates are known with certainty, the children may either marry or stay single. 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 $\pi(\cdot)$ is increasing and concave, with $\pi(0) = 0$.

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 then

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

If i marries, the couple Nash-bargain the allocation of their joint time and money endowments, and the distribution of their joint income. A spouse's reservation utility is equal to her or his utility as a single. 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

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

and women. If several individuals of each sex 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

$$R_f = R_m = R, \quad (2)$$

it follows that

$$w_m - w_f = b_f - b_m. \quad (3)$$

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,

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

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,

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

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

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

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

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

the couple choose

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

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

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

the couple choose

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

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,

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

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 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, i 's parents choose b_i and z_i so as to make i 's expected utility as large as possible. Let $\bar{y}_i$ denote the amount of money they have decided to spend on i (by solving a problem analogous to the one, described in the last subsection, that i and i 's partner will jointly solve at stage 2 when it comes to choosing y), so that

$$\bar{y}_i - z_i \geq 2\gamma. \quad (8)$$

The couple then maximize

$$EU^*(R_i) = \pi(z_i) (b_i + w^H + C) + [1 - \pi(z_i)] (b_i + w^L + C),$$

where

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

subject to (8), and to the additional constraint that b_i must be large enough for i to be able to pay $T = 2\gamma$ at the start of stage 2 if $w_i = w^H$. That is the same as maximizing

$$ER_i = \pi(z_i) (\bar{y}_i - z_i + w^H) + [1 - \pi(z_i)] (\bar{y}_i - z_i + w^L)$$

subject to (8). The optimization has an interior solution at $z_i = z^* \geq 0$, where z^* solves

$$\pi'(z_i) = \frac{1}{w^H - w^L}, \quad (9)$$

and a corner solution at $z_i = \bar{y}_i - 2\gamma$. We assume that investing z^* is a fair bet,

$$z^* = \pi(z^*) w^H + [1 - \pi(z^*)] w^L. \quad (10)$$

Given that the couple in question have a daughter and a son, both children will receive the same amount of education z_i , and cash in hand $b_i = \bar{y}_i = z_i$.

4 From primitive to modern economies

A primitive agrarian economy differs from a modern industrial one in that a person's wage rate or physical productivity is independent of education. Parents may then give a child money, but never an education.⁵

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

therefore, $z_i = 0$ and $b_i = \bar{y}_i$. 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 used in country B, but not in country A.⁶ In the latter, the wage rate is equal to w^L for everybody, and the two types of work are shared equally between the spouses ($\delta = \frac{1}{2}$). There is thus no question of one spouse having to compensate the other, and no risk of a hold-up problem. In this economy, $U_i = U^*(R_i)$.

In country B, by contrast, a woman's wage rate is w^L , but a man's wage rate is w^H thanks to the plough technology. Therefore, in an efficient NB equilibrium, the wife spends all her time with the children ($\delta = 1$). What if (8) does not hold? Will there be a hold-up problem as in a modern economy? In the traditional societies that we associate with primitive economies, there is usually the possibility of a pre-marital contract not between the betrothed, but between their families of origin (this does not imply that marriages are arranged between the two families of origin, but that is typically the case). In these societies, contracts are costlessly enforced by the local community's implicit threat of extra-legal sanctions ranging from ostracism to physical punishment. This enforcement technology may be seen as the local community's collectively rational response to a situation where it is in everyone's interest that the husband should be allowed to follow his comparative advantage in agricultural production, but not to turn this comparative advantage into a bargaining advantage at his wife's expense. Therefore, in this economy too, $U_i = U^*(R_i)$.

Now suppose that a couple migrate 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, the couple will consider the merits of investing in their children's education. If the couple in question originate from country A, they have no reason to treat their daughter differently from their son. They will then behave like native couples (i.e., in the way described in Section 2). Not so if the couple originate from country B, because they then know that, if a child of theirs marries the child of another immigrant couple from the same country, their contract enforcement technology will relax (8),⁷ and thus guarantee

⁶Using 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.

⁷If country B immigrants are numerous enough to form a community, the threat of sanctions for the husband who does not honour his premarital contract will come from this community. Otherwise, it will come from the community of origin.

the implementation of an efficient equilibrium. This gives their children an interest in marrying those of other immigrants from the same country (practicing homogamy).

Let f be the daughter, and m the son of an immigrant couple from country B. The couple know that, at stage 2 of the game, f will specialize in raising children, and m in raising income. For any given $\bar{y}_f$ and $\bar{y}_m$, at stage 1, the couple will then set $z_f = 0$ so as to maximize

$$R_f = \bar{y}_f - z_f + w^L$$

subject to

$$\bar{y}_f - z_f \geq 0,$$

and z_m so as to maximize

$$ER_m = \bar{y}_m + \pi(z_m) w^H + [1 - \pi(z_m)] w^L$$

subject to

$$\bar{y}_m - z_m \geq 0. \tag{11}$$

The first optimization yields $z_f = \bar{y}_f$. The second has an interior solution at $z_m = z^*$, and a corner solution at $z_m = \bar{y}_m$. In view of (10), however, (11) is never binding, and the solution is always interior. Therefore, the couple in question will equalize R_f and ER_m by choosing $\bar{y}_f = \bar{y}_m = \bar{y}$ (as it they were natives, or immigrants from country A).

Having a costless enforcement technology which allows the husband to specialize in raising income at stage 2 of the game is thus better than having none. Would a technology which allowed the spouse with the higher wage rate to specialize in that activity irrespective of gender be just as good? So long as education does not give direct utility as we have assumed so far (but more about this later), the answer is no, because country B immigrants would then invest in their daughters' education as much as in their sons'. Given that educating a person who will not produce income is wasteful, the waste would in fact be double if everybody got an education, than if only half the population did. Therefore, a gender-blind enforcement technology would be inefficient.

5 Extensions and conclusion

In the last two sections, we used a bare-bones model where people derive direct utility only from consumption, and from their children's quality, to show that the descendants of ancient plough users have an interest in marrying among themselves (practicing homogamy) and maintaining the gendered division of labour which was justified on comparative advantage grounds in a primitive agricultural economy, even after they have

emigrated to a modern industrial economy where productivity depends on education irrespective of gender. The argument was that the contract enforcement technology originally developed in response to the plough implements an efficient equilibrium characterized by the gendered division of labour not only in a primitive agricultural economy but also in a modern industrial one.

Different story if own education and time spent with children yield direct utility. Realistically assuming that these are luxury goods, the demand for them will be negligible in a poor economy where most people live close to the subsistence line, but not in a prosperous one. In the latter, an efficient domestic equilibrium may well be characterized by little or no specialization. Such an equilibrium is not supported by the contract enforcement technology described in the last two sections, but that is not a big loss. If, in equilibrium, the spouses earn the same, there is in fact no need for enforcement. If they earn about the same, there is a good chance that the equilibrium will be implemented anyway, because the compensation due by the high to the low wage spouse will be smaller, and (8) consequently less stringent, than in the basic model without luxury goods. A share of the descendants of those ancient plough users would then have no interest in practicing homogamy and the gendered division of labour, and this share would rise with that of those among them who are rich enough to demand the luxury goods in question.

Would it make a difference if people derived utility also from conforming with their perceived identity as suggested by Akerlof and Kranton (2000), and if the descendants of ancient plough users had their identity shaped by their long practice of the gendered division of labour? So long as education and time spent with children do not figure in the utility function, the answer is no, because the descendants of those ancient farmers would specialize along gender lines anyway. The answer could be yes, however, if education and time spent with children gave direct utility, because the rise in the demand for those luxury goods would tend to compensate for the fall in the demand for contract enforcement. If that were the case, the flight from homogamy and the gendered division of labour would in fact be slower than it would otherwise be, or not happen at all.

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