Altruism, Cooperation, and Efficiency: Agricultural Production in Polygynous Households

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Abstract

Altruism among family members can, in some cases, inhibit cooperation by increasing the utility that players expect to receive in a non-cooperative equilibrium. To test this, we examine agricultural productivity in polygynous households in West Africa. We find that cooperation is greater – production is more efficient – among co-wives than among husbands and wives because co-wives are less altruistic towards each other. The results are not driven by selection into polygyny, greater propensity for cooperation among women, or household heads enforcing others' cooperative agreements.

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1. Introduction

Altruism towards others is thought to aid cooperation, as the inter-dependence of utility functions helps to align incentives and reduce transaction costs. Thus, we should be more likely to observe an efficient allocation of resources among family members because they are altruistic towards each other (Foster and Rosenzweig, 2001). Pareto efficiency has been confirmed in many studies (Browning and Chiappori, 1998; Chiappori, Fortin, and Lacroix, 2002; Bobonis, 2009), but a growing body of empirical evidence suggests that households fail to achieve efficiency in certain circumstances, particularly in the presence of transaction costs (Duflo and Udry, 2004; Rangel and Thomas, 2005; Goldstein and Udry, 2008; Dubois and Ligon, 2010). However, what is less clear from these studies are the factors that may be inhibiting cooperation.

In this paper, we argue that altruism may, in fact, be the culprit. We consider a game involving three players with differing degrees of altruism towards each other. We show that stronger altruism can actually inhibit cooperation by increasing the utility that is obtained in the non-cooperative equilibrium and, therefore, reducing both the gains to cooperation and the threat of punishment. The implications of the model are tested using data on agricultural production in monogamous and polygynous households in Burkina Faso. We control for plot characteristics and household-crop-year fixed effects and examine the variation in yields due to the inefficient allocation of inputs across plots controlled by individuals in the same household, planting the same crop in the same year. We find greater cooperation and more efficient production among co-wives in polygynous households than among husbands and wives. The results are not driven by stronger preferences (lower costs) for cooperative behavior among women, nor are they the result of the household head serving as an enforcement mechanism for others' cooperative agreements. Rather, we argue that, in this case, greater altruism among spouses inhibits cooperation. We also provide suggestive evidence to rule out endogenous selection into polygyny, although it is, admittedly, difficult to do so conclusively.

The remainder of the paper is organized as follows. Section 2 discusses the socio-cultural context and household arrangements in Burkina Faso. Section 3 presents a game-theoretic model of interactions within polygynous households. Section 4 describes the data and empirical strategy and presents the main results, along with several robustness checks. Section 5 concludes.

2. Burkinabé Households

Intrahousehold dynamics in rural Burkina Faso are complex. Households cultivate several rain-fed, primarily subsistence crops on multiple plots, with each plot controlled by different household members. Married Burkinabé women often have access to private plots under their own control (Kevane and Gray, 1999).[1] Control over plots includes decision-making over crop choice, quantity and timing of inputs, and ownership of output (Guyer, 1986; Udry, 1996). This access does not relieve women of their responsibility to contribute labor to household fields for joint production (Dey, 1997), which typically takes precedence over females' work on their own fields (van Koppen, 1990). While household heads are usually assumed to provide staple foods and cover expenditures on medical care and school fees, in practice, females often have to supply their own crops or cover expenses. A single household may include multiple mother-child pairs (Thorson, 2002), but each husband/wife pair is viewed as a separate entity (Boye *et al.*, 1991).[2] Mother-child pairs typically live in their own nuclear units, and wives are responsible for

[1] Wives' plot locations and sizes are determined by the husband, and they may change each year. Conversely, private fields of other household males are usually more stable and allow the male to accumulate wealth to eventually break off to form his own household (Diallo and Nagy, 1986).

[2] Compounds are the major social unit of organization, overseen by the male lineage head. Inside compounds are one or more households headed by males who have single and married male dependents and numerous hearth-holds comprised of widows, wives, wives of non-resident migrants, daughters-in-law, and single children (Thorson, 2002).

primary caretaking activities for their own children.[3] Co-wives occupy various positions of power in the household, with the first wife typically holding the most power of the wives.

Much of the anthropological literature suggests that co-wife relationships are characterized by conflict. Jankowiak *et. al.* (2005) find this to be true in almost all of the 69 polygynous cultures they review. Despite this near-universal trait, they note the tendency for co-wives to cooperate to achieve pragmatic goals, particularly if females are not as reliant on their husbands for material or emotional support. This was suggested earlier by Becker (1981), who applied his Rotten Kid Theorem in polygamous households to suggest that cooperation could occur in productive activities, while conflict might still occur over distribution. Given that women in Burkina Faso have been found to work significantly more hours per day than male household members (Saito, 1994), cooperation by co-wives could be an important method of managing demands on time and energy. Indeed, in rural areas of the Sahel, polygyny can serve to reduce a co-wife's daily responsibilities by allowing women to engage in labor-sharing activities (Boye *et al.*, 1991). Members of the same household often exchange goods or services through involved agreements that are driven by local norms and customs (Saito, 1994).

Several papers test for productive efficiency within African households, although none focus on the distinction between monogamous and polygynous households. Peterman *et al.* (2010) find lower productivity on female-controlled plots in Uganda and Nigeria, even after controlling for crop choice, agricultural inputs, socioeconomic background, and household fixed effects. Pareto inefficient outcomes have also been observed in fallow times in Ghana, a result attributed to the role of ambiguous property rights and individual political power (Goldstein and

[3] Other female duties include retrieving water and wood, doing domestic chores, and income generating activities such as selling millet beer or food products (Diallo and Nagy, 1986). In general, each wife prepares daily meals for her own children, with a rotation system among wives for preparing for the husband.

Udry 2008). As households in the region are often organized along separate production spheres (Lundberg and Pollak 1993), observation of non-cooperative outcomes is not entirely surprising.

Using International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) data, Udry (1996) finds that, among plots planted with the same crop in the same year within a given household, female-controlled plots achieve significantly lower yields than male-controlled plots, even after controlling for plot characteristics, suggesting a lack of cooperation between husband and wife in the allocation of resources. His analysis reveals that households use inputs inefficiently; female-controlled plots use less male labor and manure. Households could increase output simply by reallocating inputs across plots. Rangel and Thomas (2005) show that differences in cropping patterns and fallow explain the male-female yield differences found by Udry. However, fallow and cropping patterns are still endogenous production decisions. Akresh (2008) shows that inefficiencies within Burkinabé households are muted in the face of adverse shocks, perhaps because the gains to cooperation are larger when household production is closer to subsistence level. Kazianga and Wahhaj (2012) use household-crop-year fixed effects and reject Pareto efficiency in household production in Burkina Faso in 1993 and 1994. They distinguish between the household head, junior males, and females but do not consider differences across monogamous and polygynous households.

Efficiency outside of agricultural production has been examined for monogamous and polygynous African households. Kazianga and Klonner (2009) examine child survival in Mali and cannot reject efficiency in monogamous households. However, they find evidence of differential child survival for junior wives and suggest that co-wife competition and the junior wives' weaker bargaining position drive this inefficient result. Mammen (2004) also finds education-related outcomes are worse for children of junior wives, although she cannot reject a collective bargaining model if credit constraints are allowed.

3. Modeling Cooperation in Polygynous Households

The notion that altruism can reduce efficiency was first formally suggested by Bernheim and Stark (1988). They describe two channels through which altruistic preferences may inhibit cooperation and the efficient allocation of resources. First, an altruist may take action to preempt exploitative behavior, in effect committing him/herself to an inefficient allocation so as to provide other household members with better incentives. Second, when altruism improves the static non-cooperative outcome, it also weakens the severity of punishments, making cooperative behavior more difficult to sustain. Our model goes in a slightly different direction, allowing for three players within the same family to have differing degrees of altruism towards each other. The advantage of this formulation is that, when we turn to empirical tests of the model, we can control for other features of the household that may facilitate cooperation, such as capacity for monitoring or expectations about future interactions. We show that, when altruism between two players improves the static non-cooperative outcome, it also reduces the gains to cooperation, encouraging cooperation with a non-altruistic player over an altruistic one when transaction costs are fixed. We also consider how altruism may affect the feasibility and renegotiation-proofness of cooperative equilibria when commitment is imperfect.

3.1 Theoretical Framework

Consider a polygynous household with a husband (h) and two wives (w_1 and w_2). Each individual has preferences over own consumption of two goods (x and z). Additionally, husbands and wives derive utility from each other's consumption of good z, but co-wives exhibit no altruism towards each other.

$$U_h = U_h(x_h, z_h, z_1, z_2) \text{ and } U_{w_i} = U_{w_i}(x_i, z_i, z_h)\ \forall i \in \{1,2\}$$

Note that our characterization of altruism follows that of Fehr and Schmidt (2006), in which the utility of an individual is increasing in the consumption of another person (other people). Preferences are not functionally interdependent, as each player cares only about the final allocation of resources and not how that allocation was reached or the utility of the other players.

The feature of the *z* good that drives the main implications of the model is that the altruist cannot purchase it directly or, more generally, the altruist and the subject face different implicit prices for the same good.[4] Thus, even with interdependent preferences ($U_{j\neq i}$ enters the utility function of i), the main implications of the model will still hold, provided the altruist does not fully internalize the effect of his actions on other(s) (*i.e.*, at the point where utility is maximized, $\partial U_i/\partial U_{j\neq i} < \min[\partial U_i/\partial x_i\,, \partial U_i/\partial z_i]$). This is very similar to the separate spheres assumption in Lundberg and Pollak (1993) and is consistent with many common forms of altruism (*e.g.*, preferences for the utility of one's spouse, parents' preferences for children's future earnings, preferences for the well-being of individuals in another group). If we think of *z* as child "quality", this assumption is also consistent with anthropological descriptions of Burkinabé households, with wives having ultimate control over the care of their own children. More generally, we could think of *z* as a vector, with some elements being private goods that provide derived utility (*e.g.*, aesthetic appearance of spouse) and other elements being public goods for the conjugal unit (child quality). Moreover, a subset of the *z*-vector (*e.g.*, meals, childcare) may overlap across family members, including co-wives, with the important distinction that, even where elements of *z* overlap, each individual possesses the ability to purchase that good directly.

[4] Alternatively, we could allow both the husband and wife to purchase all *z* goods directly, but at different prices. Note that, if both players can purchase the public good at the same price and both make strictly positive contributions, an efficient allocation of resources can be achieved even without explicit cooperation among players (Warr, 1983 and Bergstrom et al., 1986).

On the production side, each individual operates one plot of agricultural land. Farm production utilizes both male labor (N_M) and female labor (N_F), which are imperfect substitutes. Although all individuals have access to the same production technology, they are endowed with plots with different characteristics (*e.g.*, size, soil type, toposequence), denoted *A,* that affect the optimal input mix. Denote each individual's production function as follows:

$$Y_h = Y(N_M, N_F; A_h), Y_{w_1} = Y(N_M, N_F; A_{w_1}), Y_{w_2} = Y(N_M, N_F; A_{w_2})$$

Farm production is the only source of income, with the price of output normalized to one, and each individual supplies one unit of labor inelastically. Each pair of players may negotiate a cooperative agreement for labor-sharing.[5] This agreement stipulates plot-specific labor allocations for each player as well as a (net) payment from j to i, R_i^j, (with $R_i^j = -R_j^i$). For now, we assume that cooperative agreements are fully binding; however we impose a fixed cost of $c \geq 0$, per player, for negotiating each cooperative agreement. Each player may also choose to forgo explicit arrangements for cooperation, in which case he/she will not incur any costs.

3.2 Stage Game with Transaction Costs

Clearly, multiple equilibria are possible in this very general model. What we wish to establish here is that there exists a Nash equilibrium in which co-wives cooperate with each other in each period, but never cooperate with the husband. To see this, note that co-wives will be willing to cooperate with each other as long as the gains to cooperation exceed the cost

$$\left(\hat{Y}_{w_1} + \hat{Y}_{w_2}\right) - (Y'_{w_1} + Y'_{w_2}) \geq 2c \qquad [1]$$

where ^ denotes the allocations that prevail when only the co-wives cooperate and $'$ denotes the allocations that prevail when no cooperative agreements have been reached. However, they will

[5] The key implications of the model are unaffected by the existence of markets for labor, provided those markets are imperfect.

not additionally cooperate with the husband if the marginal benefit, conditional on cooperating with the co-wife, does not exceed the cost

$$2c > \left(Y_{w_i}^* + Y_h^*\right) - \left(\hat{Y}_{w_i} + \hat{Y}_h\right) \; \forall i \in \{1,2\} \qquad [2]$$

where * denotes the allocations that prevail when a wife is cooperating with both her husband and her co-wife. Provided the optimal allocation of female labor on each wife's plot is not equal to the labor endowment, there exist gains from trade, and condition [1] will hold for some arbitrarily small value of *c*. Conversely, the second condition must hold for some arbitrarily large value of *c*. Given that male and female labor are imperfect substitutes in farm production, there exist gains from trade between husbands and wives, even if co-wives are already cooperating, which suggests $c > 0$.

Thus, for some intermediate value of $c > 0$, there exists an equilibrium in which co-wives cooperate with each other but not with their husbands, as long as each wife finds cooperating with only her co-wife to be more beneficial than cooperating with only her husband. Because each wife derives utility from her husband's consumption of *z*, this condition must be expressed in terms of utility rather than income: $\widehat{U}_{w_i} - U'_{w_i} > \widetilde{U}_{w_i} - U'_{w_i}$. Taking a linear approximation,

$$\frac{\partial U_{w_i}}{\partial \hat{x}_i}\frac{dx_i}{d\hat{V}_{w_i}} + \frac{\partial U_{w_i}}{\partial \hat{z}_i}\frac{dz_i}{d\hat{V}_{w_i}} > \frac{\partial U_{w_i}}{\partial \tilde{x}_i}\frac{dx_i}{d\tilde{V}_{w_i}} + \frac{\partial U_{w_i}}{\partial \tilde{z}_i}\frac{dz_i}{d\tilde{V}_{w_i}} + \frac{\partial U_{w_i}}{\partial \tilde{z}_h}\frac{dz_h}{d\tilde{V}_h} \forall i \in \{1,2\} \qquad [3]$$

where $V = Y + R$ are total earnings (recall that R is the net transfer between cooperating players). Then $d\hat{V} = (\hat{V} - V')$ is the net income gain for wife *i* when co-wives cooperate only with each other, and $d\tilde{V} = (\tilde{V} - V')$ is the net income gain when wife *i* cooperates only with the husband. To simplify this expression further, note that, at the constrained optimum,

$$\frac{\partial U_{w_i}}{\partial z_i} = \frac{\partial U_{w_i}}{\partial x_i} p_i \, .$$

And, taking into account the budget constraint, we can rewrite condition [3] as follows:

$$\frac{\partial U_{w_i}}{\partial \hat{x}_i} d\hat{V}_{w_i} > \frac{\partial U_{w_i}}{\partial \tilde{x}_i}\left(d\tilde{V}_{w_i} + d\tilde{V}_h\right) - \left(\frac{\partial U_{w_i}}{\partial \tilde{x}_i} - \frac{\partial U_{w_i}}{\partial \tilde{z}_h}\frac{1}{p_h}\right) d\tilde{V}_h - \frac{\partial U_{w_i}}{\partial \tilde{z}_h}\frac{1}{p_h} d\tilde{x}_h$$

$d\tilde{V}_{w_i} + d\tilde{V}_h$ is exactly the total surplus generated by the cooperative agreement between the husband and wife i. Provided the marginal utility of own consumption exceeds that for consumption of others and the utility function is well-behaved,

$$\frac{\partial U_{w_i}}{\partial x_i} > \frac{\partial U_{w_i}}{\partial z_h} \text{ and } \frac{\partial^3 U_{w_i}}{\partial x_i^3} > 0 ,$$

a sufficient condition for [3] is to verify that the surplus generated by co-wives cooperating exceeds the surplus generated by each wife cooperating with the husband independently.

$$\left(\hat{Y}_{w_1} + \hat{Y}_{w_2}\right) - \left(Y'_{w_1} + Y'_{w_2}\right) > \left(\tilde{Y}_{w_i} + \tilde{Y}_h\right) - \left(Y'_{w_i} + Y'_h\right) \forall i \in \{1,2\} \qquad [4]$$

This condition also ensures that the husband cannot entice either wife to cooperate with him by offering her a much larger share of the surplus, because the co-wife can always offer her a slightly larger payment. And, she would be willing to do so because this would allow her to still retain a smaller amount of the cooperative surplus, rather than being excluded entirely.[6]

Condition [4] does not necessarily imply that the total cooperative output generated by the co-wives exceeds the output that could be generated by the husband and wife together. Given that male and female labor are imperfect substitutes, it is more likely that the opposite is true. However, the surplus that is generated, above and beyond the non-cooperative equilibrium, may be greater when co-wives cooperate if, as is suggested in the anthropological literature (Dey 1997), husbands and wives pool some resources even in the absence of an explicit cooperative

[6] We can ensure that this equilibrium is coalition-proof (Bernheim, Peleg and Whinston, 1987) by assuming that the husband cannot simultaneously offer both wives agreements that dominate the agreement between co-wives

$$\left(\hat{Y}_{w_1} + \hat{Y}_{w_2}\right) - \left(Y'_{w_1} + Y'_{w_2}\right) > \left[\left(\dot{Y}_{w_1} + \dot{Y}_h\right) - \left(Y'_{w_1} + Y'_h\right)\right] + \left[\left(\dot{Y}_{w_2} + \dot{Y}_h\right) - \left(Y'_{w_2} + Y'_h\right)\right]$$

where $\dot{}$ denotes the allocations that prevail when both wives cooperate with the husband but not each other. This is a somewhat extreme case. In a repeated game, as we describe below, we can maintain condition [4] and ensure the equilibrium is coalition-proof by assuming that coalitions, once formed, cannot be re-formed for some minimum number of periods such that the gain to deviating is not Pareto-improving for any coalition.

agreement, whereas co-wives do not. Altruistic preferences make it more probable that husbands and wives engage in some minimal exchange behavior even when no cooperative agreement is reached.[7] Put another way, in the absence of cooperative agreements, each husband-wife pair is closer to the Pareto frontier for agricultural production than is the wife-wife pair.

More formally, assume that each wife chooses *x* and *z* to maximize her utility, subject to her husband's choice of *z* and the income generated on her plot. The husband chooses *x* and *z* to maximize his own utility, subject to his wives' choices of *z* and his own agricultural production. Additionally, the husband chooses how to allocate his labor between his own and his wives' plots, recognizing that an increase in the wives' income will increase their purchases of *z* as well.

$$\max_{N_M^1, N_M^2, z_h} U_h(x_h, z_h, z_1, z_2) \text{ subject to } x_h = Y_h(1 - N_M^1 - N_M^2, N_1^M + N_2^M; A_h) - p_h z_h$$

$$\text{and } z_i = z_i^*(N_M^i, N_1^i + N_2^i, \mu_i, A_i) \text{ for } i = 1,2$$

where μ represents parameters of the wives' utility functions, N_M^i represents male labor allocated to wife *i*'s plot and N_i^M represents wife *i*'s labor allocated to the husband's plot. From the first order condition,

$$\frac{\partial U_h}{\partial z_i}\frac{\partial z_i^*}{\partial N_M^i} = \frac{\partial U_h}{\partial x_h}\frac{\partial Y_h}{\partial N_M^i} \text{ for } i = 1,2$$

we see that the optimal allocation of labor to wife *i*'s plot is strictly greater than zero, as long as the husband's marginal utility of z_i exceeds his marginal utility of *x* and the wife's choice of *z* is increasing in the labor he allocates to her plot.

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[7] Note that mutual altruism is not necessary and, in fact, makes the proposed equilibrium more difficult to sustain, as it increases the gains to husband-wife cooperation. As long as the husband is altruistic toward the wife, he will share resources with her, and the gains to cooperation for the wife will always be less when dealing with her husband than when dealing with her co-wife.

Moreover, the husband's allocation of labor in the absence of a cooperative agreement will not be efficient because production and consumption decisions are not separable. To see this more clearly, rewrite the above condition as

$$\frac{\partial U_h}{\partial z_i}\frac{\partial z_i^*}{\partial Y_{w_i}}\left(\frac{\partial Y_{w_i}}{\partial N_M^i}+\frac{\partial Y_{w_i}}{\partial N_i^i}\frac{dN_i^i}{dN_M^i}+\frac{\partial Y_{w_i}}{\partial N_j^i}\frac{dN_j^i}{dN_M^i}\right)=\frac{\partial U_h}{\partial x_h}\frac{\partial Y_h}{\partial N_M^i} \qquad [5]$$

where N_F^i represents wife *i*'s labor on her own plot. In order for the marginal product of the husband's labor to be equalized across plots, the marginal rate of transformation between *x* and *z*, in utility terms, must be equal to one, and both wives' labor allocations to wife *i*'s plot must be independent of the husband's labor allocation. Each wife solves

$$\max_{N_i^M, N_i^j, z_i} U_{w_i}(x_i, z_i, z_h) \text{ subject to } x_i = Y_i\left(N_M^i, (1-N_i^M-N_i^j)+N_j^i; A_i\right)-p_i z_i$$

$$N_M^i = N_M^{i\,*}(N_i^i, N_j^i, \mu_h, A_i) \text{ and } z_h = z_h^*(1-N_M^i-N_M^j, N_i^M+N_j^M, \mu_h, A_i)$$

which gives us the following first order condition for N_i^M for an interior solution.

$$\frac{\partial U_{w_i}}{\partial x_i}\left(\frac{\partial Y_i}{\partial N_i^M}+\frac{\partial Y_i}{\partial N_M^i}\frac{\partial N_M^{i\,*}}{\partial N_i^M}\right)+\frac{\partial U_{w_i}}{\partial z_h}\frac{\partial z_h^*}{\partial N_i^M}=0 \qquad [6]$$

The wife is willing to provide labor on her husband's plot as long as he is willing to provide enough labor to offset the decline in her production, net of the utility gain she receives via the husband's increased consumption of *z*. Both spouses should benefit from this arrangement if, in the absence of labor-sharing, the marginal product of own labor is lower on own plots than on spouses' plots. Note that, when simply maximizing own utility, co-wives will not provide labor on each other's plots because they do not expect reciprocity. However, as long as the husband and wife are at an interior solution, her labor allocation will be responsive to his choices. Thus, although the husband and wife supply labor on each other's plots even in the absence of an explicit cooperative agreement, they do not reach an efficient outcome. This result is, of course, sensitive to the separate spheres assumption and is a result of the husband and wife not being able to purchase each other's *z*-goods directly.

3.3 Repeated Game with Limited Commitment and Zero Transaction Costs

If transaction costs are reduced or eliminated then, all else equal, a Pareto efficient outcome is feasible, with all three players cooperating and pooling labor. However, we must also consider the possibility that players may renege on established cooperative agreements. Because each player retains control over the output produced on his/her own plot (as is consistent with the anthropological literature from West Africa), it is possible to renege on both the labor allocated to other players' plots and the payment R. Clearly, with limited enforcement, cooperation cannot be sustained in a one-shot (or finitely repeated) game. However, if the stage game is repeated infinitely and players are sufficiently forward-looking, then Nash reversion (Friedman, 1971) may be used to sustain cooperative agreements. First, consider the punishment phase in which the players revert to their non-cooperative Nash strategies for a predetermined number of periods. In this equilibrium, altruism between the husband and wife leads to some strictly positive labor-sharing, even though wife i does not share labor with her co-wife. Thus, as long as condition [3] above still holds, the gains to cooperating with the co-wife exceed the gains to cooperating with the husband which, in turn, implies that, under Nash reversion, wife j can hold wife i to a more severe punishment than can her husband.

Next, consider a deviation by player i from the equilibrium in which all players behave cooperatively. When deviating from a cooperative agreement with player j, player i withholds both labor as well as any positive payments owed to player j ($R_j^{i^*} < 0$), while the other players continue to provide the agreed-upon payments and/or labor on player i's plot. Total income for player i, conditional on reneging on his/her agreement with player j, is then

$$\bar{V}_{w_i} = \bar{Y}_{w_i} + \left|R_j^{i^*}\right| + R_i^{k^*}$$

where $\bar{Y}_{w_i}$ is the output player *i* produces by sharing labor with player *k* but not player *j*. This payoff is positively correlated with the surplus that would have been generated by cooperation, because the sum of $\bar{Y}_{w_i}$ and $R_j^{i^*}$ is (weakly) increasing in the quantity of labor to be shared. Condition [4] then implies that the gain to deviating from an agreement with the co-wife should be greater. However, when wife *i* deviates from a cooperative agreement with the husband, she allocates strictly less labor to his plot than she would in the Nash equilibrium. Therefore, the gain in output is greater when deviating against the husband than the co-wife. Moreover, the more labor-sharing there is in the one-shot Nash equilibrium, the greater are the gains in output.

But, when wife *i* deviates from a cooperative agreement with her husband, towards whom she is altruistic, she is penalized via a reduction in her husband's consumption of *z*. Though the optimal deviation involves less labor-sharing than the Nash strategy, it will not be to supply zero labor on her husband's plot (recall that labor-sharing with the co-wife is exactly zero under the Nash strategy). Under the optimal deviation, the value of the marginal unit of own labor on wife *i*'s plot just offsets the loss from her husband's reduced consumption of *z* (see condition [6]).

$$\frac{\partial U_{w_i}}{\partial x_i}\frac{\partial Y_i}{\partial N_i^M} = -\frac{\partial U_{w_i}}{\partial z_h}\frac{\partial {z_h}^*}{\partial N_i^M}$$

Thus, whether wife *i* deviates against her husband or co-wife, in both cases she is able to fully capture the value of the other's labor to her plot as well as the labor she should have allocated to his/her plot, although she converts the income gains into utility with different bundles of goods. Deviating against the husband will, therefore, yield both greater income and greater utility than deviating against the co-wife, while the threat of punishment from the husband is weaker.[8] Altruism between the husband and wife makes cooperation more difficult to sustain.

Alternatively, we can consider a min-max punishment strategy, in which the husband punishes a deviation by wife *i* by allocating zero labor to her plot until she again plays cooperatively. This would be a more severe punishment than Nash reversion and could be sufficient to sustain cooperation, but it is not weakly renegotiation-proof (Abreu *et al*. 1993). Once in the punishment phase, both the husband and wife *i* would be better off playing the Nash equilibrium. Because of the altruistic linkage between the two, the husband's utility is increasing in the wife's payoff and, therefore, there does not exist a tit-for-tat punishment that rewards the husband while min-maxing wife *i*. We could consider a tit-for-tat punishment in which the husband receives at least his Nash payoff as well as a side payment from the wife – consisting of his private good, the public good or a combination of the two – at the expense of her own private consumption. However, the wife will be tempted to renege in the punishment phase and, if she were to do so, the strongest punishment the husband could invoke would be the min-max strategy. Thus, this equilibrium too would unravel with renegotiation.

In summary, we have shown the existence of an equilibrium in which co-wives cooperate with each other but not with their husband. Altruism between the husband and each wife makes such an equilibrium more likely, for three reasons. First, in the presence of transaction costs, each player may choose to invest only in the single most beneficial cooperative agreement. Because altruism facilitates exchange behavior even in the absence of an explicit agreement, it reduces the gains to cooperation, making cooperative agreements between husbands and wives

[8] Of course, if the husband and wife *j* can jointly punish wife *i* for deviating from either agreement, then cooperation among all three players could be sustained. However, joint punishment is not subgame-perfect, as condition [4] implies that wife *i* can always offer wife *j* a higher pay-off by deviating from the joint punishment to co-wife cooperation.

less likely. Second, altruism can both increase the gains to deviating from a cooperative agreement and reduce the severity of the punishment that may be imposed. Then, in the presence of limited commitment, a non-altruistic party (a co-wife) is better able to prevent deviations from the cooperative agreement and, therefore, better able to sustain cooperation. Finally, even when the altruistic party is willing to impose very severe punishments, these will not be renegotiation-proof because altruism makes it impossible to punish the deviating player while rewarding the cooperating player. Thus, payoffs in the punishment phase will be Pareto-dominated by the Nash equilibrium.

These results are sensitive to our separate spheres-type assumption which, based on the anthropological evidence, seems to be an accurate representation of Burkinabé households. Moreover, the notion of a good over which one has preferences but no direct control is consistent with many formulations of altruism. The basic framework and implications can, therefore, be applied to a variety of contexts, even though they have been derived from a very specific case.

4. Empirical Application

4.1 Testable Implications

To generate testable implications from our theoretical model, recall that cooperation maximizes joint farm production and equalizes the marginal productivity of inputs across plots controlled by the cooperating individuals. This implies that, controlling for land characteristics, crop choice and shocks to the production process, yields should be equalized across plots. We estimate plot yield as a function of plot characteristics (area, soil type, toposequence, location) and cultivator characteristics (gender, relation to household head – head, wife, or other), conditional on a household-crop-year fixed effect. That is, we examine the deviation of plot yield from mean yield as a function of the deviation of plot characteristics from mean plot characteristics within a group of plots planted with the same crop by members of the same household in a given year (Udry, 1996). Yield Q for plot i, planted with crop c, in year t, in household h is expressed as:

$$Q_{htci} = \boldsymbol{X}_{htci}\beta + \gamma_G G_{htci} + \gamma_{OM} OM_{htci} + \gamma_{OF} OF_{htci} + \lambda_{htc} + \varepsilon_{htci}$$

where $\boldsymbol{X}$ is a vector of plot characteristics, G is gender of the plot cultivator (1=female), OM and OF are indicators equal to one if the plot cultivator is an "other male" (not the household head) or an "other female" (not a wife of the head), respectively, λ is a household-crop-year fixed effect, and ε is an error-term. Cultivator characteristics (gender and relationship to household head)[9] are allowed to differ for polygynous households via an interaction with an indicator for polygyny (*Poly*), with $\gamma_k = \gamma_k^0 + (Poly_{ht} * \gamma_k^P)$ for k = G, OM, OF.[10] Note that our empirical tests focus on *efficiency* within the household, the equalization of marginal product, rather than productivity, the level of output. Clearly, monogamous and polygynous households, as well as individual cultivators within those households, may differ in their *levels* of productivity, but the degree of cooperation will be evidenced by the efficiency with which inputs are allocated, given household-specific constraints on technology, access to inputs, obligations to family/clan, etc.

The interaction of polygyny and cultivator characteristics indicates how the variation in yields between cultivators differs across monogamous and polygynous households. We can attribute this difference to the causal effect of additional wives as long as the household-crop-year fixed effects account for unobserved characteristics that are correlated with both conjugal status and the *difference* in yields between cultivator types, conditional on planting the same crop, in the same year, in the same household. In Sections 4.3-4.5, we present several tests of the robustness of this strategy. Given a negative coefficient on gender, then a positive coefficient on

[9] Unfortunately, the data do not link agricultural plots to individual identifiers, so we are unable to identify the specific relationship of the cultivator to the head or to other household members. We are also unable to differentiate senior and junior wives in polygynous households.
[10] Akresh, Chen, and Moore (2012) use a similar specification but do not differentiate "other" cultivators by gender.

the interaction of polygyny and gender indicates that the husband-wife yield differential is smaller when the husband has multiple wives. This may be indicative of cooperation among co-wives or (greater) cooperation between husbands and wives. To differentiate these, we need to examine how polygyny affects the yield differential between husbands and other cultivators. A decline in other cultivators' yields, relative to the household head, suggests that the head himself is also able to achieve a more efficient allocation of agricultural inputs in the presence of multiple wives, whereas an increase in other cultivators' yields, relative to the head, suggests that wives cooperate more with each other (and perhaps with other cultivators) than with the head.

By including indicators for the relationship of the cultivator to the household head, we can examine other opportunities and incentives for cooperation among household members. In Section 3, we argue that a positive coefficient on the interaction between polygyny and gender is the result of greater altruism between husbands and wives than between co-wives. However, we would observe the same result if the cost of cooperation is simply lower among women, not necessarily just co-wives. In this case, the presence of additional women, due to polygyny, should facilitate greater cooperation among all women and reduce any difference in yields between wives and other female cultivators. Alternatively, the household head may be able to serve as an enforcement mechanism for cooperative arrangements among other household members. That is, with multiple wives, the head may be able to enforce an optimal allocation of agricultural inputs among their plots, even when he is unable to enforce cooperative arrangements between himself and his wives, because he can act as a third-party monitor/ arbitrator. In this case, the head should be able to enforce cooperation between other cultivators within the household as well, resulting in smaller yield differences among other cultivators who are not the household head or wife (wives).

These dynamics, summarized in the table below, allow us to distinguish between alternative explanations for smaller male-female yield differentials in polygynous households. Our altruism story is consistent only with the first row. However, if women prefer to cooperate with each other over men, we will observe a smaller yield differential between wives and other females in polygynous households as well as smaller yield differentials between men and women in polygynous households. Alternatively, if the head enforces cooperative arrangements, we will observe smaller yield differentials among other cultivator pairs, in addition to co-wives. And, if co-wives find the head to be less credible as a neutral third-party than do other cultivator pairs, then we should only observe cooperation between co-wives *in conjunction* with cooperation between other cultivator pairs. Given the importance of order and rank in the treatment of co-wives (Boye *et al.*, 1991; Mammen, 2004 and Kazianga and Klonner, 2009), this seems plausible. In this case, the three hypotheses have distinct empirical implications.

Hypothesis	Testable Implication
Greater cooperation among co-wives than among husbands and wives	Smaller yield differential between husbands and wives in the presence of multiple wives, and smaller or unchanged yield differential between husbands and other male cultivators $\gamma_G^P > 0$ and $\gamma_{OM}^P \geq 0$
Greater cooperation among women than among men	Smaller yield differential between wives and other female cultivators in the presence of multiple wives (more women) $\gamma_G^P > 0$ and $\gamma_{OF}^P > 0$
Household head enforces others' cooperative arrangements	Smaller yield differential between other male cultivators and other female cultivators than between husbands and wives $\gamma_G^P > 0$ and $\gamma_{OM} - \gamma_{OF} < 0$

4.2 Empirical Results

In this paper, we use the 1984-85 ICRISAT Burkina Faso household survey, which covers 150 households in 6 villages across 3 provinces: Djibo, Yako, and Boromo (see Matlon, 1988 and Udry, 1996 for detailed descriptions of the data). 50.7 percent of the households are polygynous, defined as the household head having two or more wives. Of these households, 56 percent have two wives, 33 percent have three wives, and 11 percent have four or five wives.[11] For household heads and other female non-wife cultivators, average yields are considerably lower in polygynous households, although average plot size is quite similar (Table 1). For wives and other males, yields are slightly higher and plots are somewhat larger in polygynous households. The percentage of plots planted with a given crop is quite different, with wives in polygynous households devoting a larger fraction of plots to millet and sorghum (staple crops) and a smaller percentage to okra and earthpeas/fonio (cash crops). Other cultivators also have a different distribution of crops across household types, although it does not differ as clearly between staple and cash crops. This suggests that polygynous households may utilize a different cropping strategy, although some of the differences may be driven by agro-climatic differences that coincide with differences in polygyny rates within the ICRISAT sample.[12]

Column I of Table 2 replicates the household-crop-year fixed effects specification in Udry (1996), using only data for 1984-85.[13] We find a negative and significant effect of cultivator gender on plot yield, but the magnitude is larger than in Udry. In part, the difference is due to the ICRISAT survey design. In 1981-83 (the data used in Udry's analysis), detailed information was collected for a selected sample of plots (all cereal, cotton, and root crops, but only one plot under each of the household head's and senior wife's control for legumes/garden

[11] We classify households as polygynous using the number of wives listed in the household roster, because household heads did not report directly the number of wives. Thus, if there are wives of the head living outside the household at the time of the survey, we could mistakenly classify the household. However, migration of wives is quite rare. In our data, only 6 percent of migrants reported being a wife and, of these, the majority are listed in the household roster. In addition, we construct both definitions of polygyny (reported versus observed number of wives) using the 1993 Demographic and Health Survey and find a difference of only 2 percentage points in the implied polygyny rate.

[12] The Djibo region is well-suited to millet and fonio but not white sorghum, and respondents in this region are predominantly Rimaibe with a low incidence of polygyny. The Yako region is well-suited to white sorghum, millet and cotton, and respondents in this region are predominantly Mossi with a high incidence of polygyny. The Boromo region is better suited to sorghum and maize than millet, and respondents are predominantly Dagari and Bwa, both with high incidences of polygyny (see Matlon, 1988).

[13] In addition to including household-crop-year fixed effects, all regressions control for plot size (by decile), soil type, toposequence, and location.

crops), whereas summary information was collected for all plots in 1984-85 (Matlon 1988). Because we are interested in the yields of other cultivators, particularly senior and junior co-wives, and wives devote a greater share of plots to legumes and garden crops, data from 1981-83 suffer from significant sample selection and are, therefore, excluded from our analysis. In column II, we add indicators for other male and other female cultivators within the household. The coefficient on gender is still statistically significant and similar in magnitude. Other male cultivators have significantly lower yields, relative to the household head, consistent with Udry's (1996) findings, suggesting that inefficiencies in intrahousehold allocation arise along dimensions other than gender. In column III of Table 2, we add interactions of cultivator characteristics with an indicator for polygyny. We also add interactions of all plot characteristics with polygyny, to allow for differences in technology across household types.[14] Relative to the head, wives in polygynous households have significantly higher yields than wives in monogamous households, and the same is true for other males. This is consistent with greater cooperation among co-wives than among husbands and wives. The point estimate for γ_{OF}^{P} is consistent with stronger preferences for cooperation among women but is not statistically significant, and there is no significant difference between wives and other females to begin with. We do not find evidence of the household head acting as an enforcement mechanism; although the point estimates are consistent with that story, we cannot reject the hypothesis that the coefficients on other male and other female are equal (*p-value* = 0.196). Thus, while we do not find evidence in favor of these alternative explanations, we cannot yet confidently rule them out.[15]

Limiting the estimation to cultivator pairs provides additional evidence to distinguish these hypotheses. Identification in Table 3 relies on variation in yields across plots planted with

[14] We reject the hypothesis that the interactions of polygyny with plot characteristics are not jointly significant, (*p-value* = 0.000), so we include them in all specifications that distinguish monogamous and polygynous households.
[15] We discuss the Table 2 column IV results after Table 3.

the same crop, in the same year, in the same household, between only two types of cultivators, rather than all four types. In column I, we see that polygyny reduces the male-female differential even when the sample is limited to plots cultivated by the head and his wife (wives). Focusing on plots cultivated by other males and other females (column II) shows that yield differences are nearly identical to those between husbands and wives, providing more conclusive evidence that heads are not enforcing cooperation among other cultivators, in either monogamous or polygynous households. When the estimation is limited to only male cultivators (column III), we again find that the difference in yields between the head and other males is significantly smaller in polygynous households. Polygyny allows other male cultivators to narrow the gap, relative to the head, which suggests that husbands' yields do not benefit from polygyny.[16]

Limiting the estimation to female-cultivated plots still does not rule out a greater propensity for cooperation among women generally. Yields for other female cultivators are not significantly different from those for wives of the head, in either type of household (column IV). To test this more directly, we look at how the presence of another female cultivator, not a wife of the head, affects efficiency in the household. In effect, we compare the male-female yield differential across households that do and do not have an "other female" cultivator. We limit this estimation to household heads and wives to ensure that the coefficients on the gender variable and its interactions are not driven by the behavior of the other female cultivators themselves. In column V, we see that the presence of an additional female cultivator significantly increases the difference in yields between husbands and wives, and polygyny again eliminates this gap, although the point estimates are imprecise. There may be multiple explanations for this, but the results are not consistent with stronger preferences for cooperation among all women; rather, the

[16] Note that this does not necessarily imply that polygynous household heads are less productive than other male cultivators in the same household, only that they receive fewer inputs relative to other male cultivators, compared to monogamous households.

identity of the “additional” woman – wife of the head or other female – determines whether her presence will worsen or improve allocative efficiency within the household.

Our model shows that cooperation between altruistic parties can actually be more difficult to sustain than that between purely self-interested parties. We test this by comparing the male-female yield gap across monogamous and polygynous households, where polygyny represents the addition of a potential collaborator with altruistic preferences towards the husband but not the co-wife. However, this contrast between husband-wife and co-wife interaction provides a second testable implication: the likelihood of cooperation should be declining in the degree of altruism between players. If altruism is, at least in part, based on children as a shared public good, then we should see greater cooperation (smaller yield differences) among couples who have fewer children and, therefore, fewer shared goods. Consistent with this, the interaction of gender and the number of children of the head currently living in the household is negative and significant (column IV, Table 2), and the direct effect for female cultivators is now not statistically significant. This suggests that there is no statistical difference in yields between husbands and wives when there are no children in the home – *i.e.*, when they do not share public goods, particularly those that tend to fall into separate production spheres.

In polygynous households, the direct effect of gender is also small and not significant. But the interaction term is positive and statistically significant and offsets the effect of children on women’s yields in monogamous households. The opposite sign for polygynous households suggests the specification is not just picking up some effect of childcare on time allocation and productivity. Women in polygynous households are better able to specialize and optimally distribute childcare and farm duties amongst each other, presumably via cooperative arrangements, but women in monogamous households cannot do the same with their husbands.

We do not rely too heavily on these results, as fertility may be correlated with efficiency or cooperation in the household and social norms may constrain the amount of childcare that men perform. However, this specification provides additional suggestive evidence supporting our altruism story over other explanations.

4.3 Input Use and Unobserved Plot Quality

To further support our story, we would like to find differences in input usage that could explain the observed yield differences among cultivators in the same household. Unfortunately, data on agricultural inputs is limited for the years in which we have information on all plots cultivated by the household. We cannot compare male and female labor inputs across the plots of different cultivators, making it difficult to corroborate directly our labor-sharing hypotheses. Moreover, input data from 1984-85 are subject to significant measurement error, as they are based on recall at the end of each year. Using panel Tobit estimation (Honoré, 1992) and controlling for household-crop-year fixed effects, we find suggestive evidence in columns I-III of Table 4 that women use inputs less intensively. Coefficients on gender are negative for labor hours in land improvement (clearing, burning, and bund construction), value of paid labor, and manure, although the point estimates are imprecise. There are no significant differences for polygynous households, although the estimated coefficients are of the opposite sign (except for manure).

Despite the data limitations, the estimates, although not conclusive, are consistent with women in polygynous households being better able to offset less intensive use of paid labor with a more efficient allocation of labor throughout the cropping season, providing indirect evidence for our labor-sharing hypothesis. However, women also use shorter cropping cycles (columns IV and V), keeping plots fallow for less time and allowing fewer years between fallows. This is consistent with Goldstein and Udry (2008) and may indicate differences in property rights by gender. Point estimates are of the opposite sign for women in polygynous households but not statistically significant. More frequent fallowing by women is not sufficient to offset yield differences, which implies the intra-household allocation of some other inputs must be sub-optimal as well.[17] Alternatively, differences in fallow may point to differences in unobserved plot quality, which would pose a significant threat to our identification strategy. It may be the case that wives in polygynous households are endowed with plots of better unobserved quality. We cannot test for this directly because plot borders change from year to year, making it impossible to include time-invariant plot fixed effects. Omitting all plot characteristics (size, toposequence, soil type, location) from our preferred specification decreases the magnitude of the coefficients on both the indicator for female and the interaction with polygyny, leaving the total effect for women in polygynous households essentially unchanged (column I, Table 5). If we assume observed and unobserved plot characteristics are positively correlated, our results are consistent with higher unobserved plot quality for women, but this does not differ across household types. Moreover, polygyny is found to increase yields equally for wives and other female cultivators, and it is not clear why other female cultivators in polygynous households would also have higher quality plots even though other male cultivators do not.

4.4. Endogenous Crop Choice

As seen in the descriptive statistics (Table 1), cropping patterns differ across monogamous and polygynous households and, since household-crop-year fixed effects cannot account for this, it is possible that the results could be driven by endogenous planting decisions. To check for this, we first split the data by cereal and non-cereal crops, and it is evident that non-cereal crops are driving the main results (columns II and III, Table 5). For cereal crops, the coefficients on gender

[17] These results may also reflect differences in plot history or crop rotation (recall that the fixed effects control only for the current crop) if, for example, women tend to farm crops that are less deleterious to soil quality.

and gender interacted with polygyny are smaller in magnitude and neither is statistically significant, while the opposite is true for non-cereal crops. This may reflect stronger social norms governing the pooling of resources in the production of staple foods. However, wives in polygynous households devote a greater share of plots to cereal crops (38 versus 24 percent), so differences in crop choice would tend to attenuate observed differences in cooperative behavior across monogamous and polygynous households.

We also use an alternative specification (household-year, rather than household-crop-year, fixed effects) to identify gender yield differences from variation across all plots cultivated by the household, rather than only those planted with the same crop. But, because factors such as weather variability may differentially affect certain crops, we also include village-crop-year fixed effects to account for aggregate crop-specific shocks. With this specification, we obtain the same qualitative results in terms of sign and significance, although the point estimates are smaller in magnitude (column IV, Table 5). This suggests that the main results cannot be entirely explained by differences in crop choice across monogamous and polygynous households.

4.5 Selection into Polygyny

Clearly, polygyny may be correlated with household characteristics such as wealth, capital and family size (Jacoby, 1995; Tertilt, 2005). Household-crop-year fixed effects control for any such factors that are constant across people in the same household planting the same crop in the same year. Yet, they do not control for factors that differentially affect husbands and wives, such as propensities for cooperation or varying relative demand for male/female labor. As a general test for this, we take advantage of the ICRISAT survey design. In 1981-83, data on the plots of junior wives were collected only for cotton, cereal, and root crops, which are representative of less than 40 percent of wives' plots. Thus, with the inclusion of household-crop-year fixed effects, the

1981-83 data allow us to examine yield variation on plots planted with the same crop in the same year by the head and his senior wife for all crops, but restrict the analysis for junior wives to cotton, cereal and root crops. In contrast, the 1984-85 data allow us to examine yield variation across plots planted with the same crop by the head and senior and junior wives for all crops.[18] Thus, the beneficial effect of polygyny on women's yields should be more muted in 1981-83, unless it is driven by unobserved heterogeneity across household types. Conversely, if the smaller gender yield differential in polygynous households is the result of greater cooperation between husbands and wives, instead of greater cooperation between co-wives, then the same effect should be evident when we look predominantly at plots controlled by the head and the senior wife, omitting most of those controlled by the junior wives. Results in column V of Table 5 are not consistent with either of these alternate explanations. The coefficient on the interaction between female and polygynous is small in magnitude and not statistically significant.

More specifically, we test for the possibility that households that achieve more efficient allocations are more likely to take on additional wives by comparing polygynous households with different numbers of wives. That is, if more efficient households also take on more wives, the positive effects of polygyny should be more pronounced for households with greater numbers of wives. We find no evidence of this; the point estimates for cultivator characteristics interacted with polygyny are not significantly different when we restrict the definition of polygyny to exactly two wives or more than two wives, respectively (columns I and II of Table 6). Of course, we cannot rule out the possibility of a non-monotonic relationship between number of wives and efficiency or preferences for cooperation (*e.g.*, a threshold effect around exactly two wives).

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[18] For example, in 1981-83, we essentially would not observe variation in yields across plots planted with okra, a predominantly female crop planted on over 20 percent of wives' plots and less than 1 percent of heads' plots.

Although we have shown that the effect of polygyny is not simply a scale effect – that is, the addition of an "other" female cultivator is not equivalent to the addition of a wife – polygyny may still affect production decisions in another manner unrelated to cooperation. For example, multiple wives may be able to meet labor requirements on communal plots more quickly or efficiently, leaving more time for own cultivation. Alternatively, polygyny may increase demands on the husband's time via spousal, familial, or social norms/obligations and reduce the time available for his own cultivation. To check for these possibilities, we split the sample into two different types of households, with access to different mechanisms for contract enforcement. In vertically-extended households (head with adult children), the head is also the patriarch, and social norms may allow him to exert more influence over other household members and enforce greater cooperation. Power dynamics are more complex in horizontally-extended households (head with adult siblings), and the influence of the head may be undermined by coalitions among other household members. If polygyny causes changes in productive arrangements that are not the result of cooperative agreements, then we should observe the same effects for both vertical and horizontal households. However, in our model, polygyny provides greater benefits for households with more limited scope for cooperation.

We define horizontally-extended households as those that include a brother of the household head and vertically-extended households as those that do not. When we split the sample along these lines (columns III and IV of Table 6), we observe significant effects of polygyny only in horizontally-extended households. Because the same effects are not evident in vertically-extended households, where there is already greater scope for cooperation, our main results do not seem to be explained by a reorganization of productive activities outside of cooperative arrangements among cultivators. Interestingly, among vertically-extended households, we observe no significant yield differences across conjugal status or cultivator type, and the point estimates are small in magnitude, consistent with (but not proof of) efficiency in production. This suggests that, where the head is able to enforce cooperation among other cultivators, he does so among all cultivators, without preference for certain types or pairs. Of course, to the extent production in vertically-extended households is already efficient, our falsification test may lack power in that there are no gains to be realized from polygyny. However, this begs the question of why productive efficiency is related to the composition of the household and the relationships among members.

Finally, we consider the possibility that husband-wife yield differentials are driven by endogenous productivity differences between monogamous and polygynous households. To do so, we use a household fixed effects specification, controlling also for village-crop-year fixed effects, to estimate the effect of polygyny on the level of productivity. Identification of the direct effect of polygyny is, however, based on a small sample: only four households, farming 155 plots over two years, switch from monogamous to polygynous during the survey period. In Panel A of Table 7, we see that polygyny has a negative, although not statistically significant, effect, suggesting that the transition to polygyny actually reduces yields. We then look at the distribution of the implied household fixed effects. Because cultivator characteristics are included as control variables, these fixed effects can be interpreted as a measure of the latent productivity of the household head, net of plot characteristics and aggregate village-crop-year farming conditions. In Panel B, we regress the implied household fixed effects on characteristics of the household. Without any controls, the household fixed effect is not significantly different for monogamous and polygynous households or for households that become polygynous. Adding village and time fixed effects increases the magnitude of the polygyny coefficient, and it is now statistically significant, with heads in polygynous households having *lower* latent productivity than those in monogamous households. Differences in latent productivity are still negative but relatively minor and not statistically significant at the time households become polygynous, suggesting the differences arise over time, rather than being intrinsic.[19] Comparing columns I and II suggests that polygynous households are not randomly distributed across regions, consistent with anthropological evidence that polygyny is driven primarily by ethno-cultural traditions, rather than agricultural practices. Adding controls for household composition and total cultivated area increases the magnitude of the coefficient on polygynous, but including capital intensity has no effect (columns III and IV).

4.6 Dynamic Inefficiency

The degree of cooperation in a household affects efficiency, but it can also affect growth via investment choice. Investments with large fixed costs will have higher returns if they can be used across plots controlled by multiple cultivators. Conversely, where there is little opportunity for cooperation, individuals may invest in smaller capital goods or higher quality variable inputs that have both lower fixed costs and lower returns. We examine household expenditure on large capital investments (plows, scarifiers, weeders, ridgers, line tracers, seeders, sprayers, carts, tractors and draft animals). Because larger and wealthier households are more likely to undertake such investments, we look at expenditures as a percent of the household's total expenditure on agricultural inputs. We control for household demographics and land holdings, treating land holdings and polygyny as endogenous. And, because both capital investments and polygyny are now at the household level, we can no longer include household fixed effects and must instead rely on the use of instrumental variables. As instruments, we use (1) the quantity of land that was acquired via inheritance and (2) the ethnic group of the household.

[19] Quantile regressions (results not shown) at the 10th, 25th, 50th, 75th, and 90th percentiles yield similar results.

Although land tenure and property rights in Burkina Faso tend to follow a more informal "customary" system, inherited land is granted to the household for permanent cultivation (Stamm, 1994). The instrument should, therefore, isolate the variation in land area (wealth) that arises from the household's relative position within the lineage, excluding differences due to heterogeneity in skill that are unobserved by the researcher but known to the lineage head. With regard to the second instrument, anthropologists note that polygyny has strong foundations in ethno-cultural traditions (Omariba and Boyle, 2007), while farming practices tended to be quite similar across ethnic groups, at least until very recently (Kevane and Grey, 1999). Since ethnic groups tend to be geographically concentrated and, therefore, in differing agro-climatic zones, we also include village- and year- or village-year fixed effects, to account for regional and temporal differences. Our key identifying assumption is that expenditures on large capital investments, as a percentage of total farm inputs, are not directly affected by the long-term land allocation decisions of the lineage or the ethnic group of the household, conditional on household composition and village and year (or village-year) fixed effects.

Without using instrumental variables, we find that household landholdings have a significant positive effect on the percentage of agricultural expenditures devoted to large capital goods, while polygyny has no effect (column I, Table 8). When estimating the IV regression (column II and III), the coefficient on land holdings is small and not statistically significant. This suggests that asset accumulation, in both land and large capital investments, is driven by unobserved factors, such as ability or endowments. Conversely, the coefficient on polygyny increases in magnitude and becomes statistically significant when instrumental variables are used, suggesting that households who select into polygyny are, in fact, less likely to utilize a capital-intensive production process. This is consistent with Tertilt (2005), who suggests that wives may be an alternate form of capital accumulation. Our estimates indicate that polygynous households spend more on large capital goods, as a percentage of their total expenditure on agricultural inputs, which are also goods for which the economic returns are increasing in the scope for cooperative behavior. Tests of over-identification lend support to the validity of our instruments, and the difference between the IV and OLS estimates are as expected. However, we cannot rule out the possibility of a weak instruments problem and, therefore, do not wish to rely too heavily on these results. Nonetheless, this exercise provides additional suggestive evidence to support our altruism hypothesis as, all else equal, we would have expected more intensive use of indivisible goods to be associated with greater inefficiency in the allocation of farm inputs.

5. Conclusion

Polygyny creates opportunities for both cooperation and competition. We find that co-wives are more likely to cooperate with one another than with their husband, and our model suggests that this is the result of selfish behavior rather than altruism. Because of the altruism between husbands and wives, the non-cooperative equilibrium does not differ much from the cooperative equilibrium, making the gains to cooperation greater for co-wives than for husband-wife pairs. Other female cultivators also seem to benefit from polygyny, but cooperation among women is influenced by identity/relationship as well as gender. We do not find evidence of the household head acting as a third-party enforcement mechanism for others' cooperative agreements, except in the context of vertically-extended households, where the head may have greater influence.

Our results do not appear to be driven by differences in crop choice or the propensity for cooperation between monogamous and polygynous households. We cannot definitively rule out the possibility of unobserved plot characteristics being correlated with women's yields in polygynous households. However, we do not observe differences in women's fallow decisions across the two household types, and the positive effect of polygyny on other female cultivators rules out a simple story about better plot quality for subsequent wives. Moreover, when junior wives' plots are excluded from the estimation, we do not observe the same pattern, suggesting that the results are driven by interaction among co-wives, rather than fixed characteristics of polygynous households. Analysis of latent productivity measures further reveal that polygynous men tend to have lower productivity, and this difference is not intrinsic but arises over time. Finally, we show that the positive effects of polygyny on efficiency are evident only in a subset of households (horizontally-extended), which suggests that our results cannot be explained by other impediments to cooperation, such as social norms or administrative obligations.

Altruism can facilitate cooperation by reducing transaction costs, improving information flows and ensuring repeat interaction. However, we show that altruism can also inhibit cooperation by increasing payoffs in the non-cooperative equilibrium and/or limiting the scope for (credible) punishment. Although we use the unique case of polygynous households to test this hypothesis, there are many situations in which our findings may be relevant. For example, trade agreements between countries that have contentious relationships may be more generous than those between friendly countries because shared political interests (a type of altruism) ensure amicable negotiations, even in the absence of an explicit agreement. The adage about never mixing business with family also seems to be rooted in the problems created specifically by altruistic linkages. Our findings imply that there may be some optimal social distance – perhaps policy makers could achieve better outcomes by targeting groups of individuals who belong to the same social network but are not directly connected (*e.g.*, joint liability groups for microcredit, early adopters of new technologies, peer groups in school and the workplace).

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Table 1. Yield, Area and Primary Crop, by Plot, Household Type and Cultivator

	Monogamous				Polygynous			
	Household Head	Wife of Head	Other Male	Other Female	Household Head	Wife of Head	Other Male	Other Female
Yield (1000 FCFA)	126.29	49.15	142.93	124.82	85.47	59.50	145.51	71.57
	(651.6)	(267.0)	(498.2)	(434.7)	(341.3)	(208.4)	(358.6)	(250.6)
Average Plot Size	0.748	0.075	0.318	0.069	0.756	0.099	0.385	0.074
(hectare)	(1.24)	(0.13)	(0.54)	(0.12)	(1.14)	(0.14)	(0.48)	(0.10)
Observations	743	425	172	319	1156	1305	407	699
Percentage of Plots Planted with a Given Primary Crop								
Millet	27.05	9.18	25.00	7.52	18.94	11.42	13.51	6.58
White Sorghum	20.46	8.71	19.77	10.66	22.92	21.30	29.73	12.45
Red Sorghum	8.48	4.00	4.65	6.58	10.73	3.60	5.65	4.15
Maize	17.50	2.35	8.72	0.94	15.57	2.15	8.60	3.72
Groundnuts	4.44	18.35	8.72	-	6.14	18.62	10.32	-
Okra	0.81	21.65	1.74	18.18	0.35	15.33	-	17.02
Cotton	7.67	1.65	17.44	1.57	9.95	1.00	22.60	1.86
Earthpeas/Fonio	1.62	28.23	2.32	36.05	1.04	19.08	1.72	45.21
Others	11.97	5.89	11.62	18.48	14.38	7.51	7.88	9.01

Note: Standard deviations in parentheses. Data source: 1984-85 ICRISAT Burkina Faso survey. During 1984-85, the average exchange rate was approximately US $1 = 441 FCFA.

Table 2. Fixed Effects Estimates of the
Effect of Cultivator Characteristics on Plot Yield[a]

	(I)	(II)	(III)[b]	(IV)[b]
Gender (1=female)	-74.51 ***	-87.69 ***	-202.21 ***	-45.46
	(15.39)	(18.14)	(34.14)	(50.68)
Other Male		-40.49 **	-97.18 **	
		(20.41)	(39.38)	
Other Female		-12.77	-31.96	
		(15.37)	(31.39)	
Gender*Number of Kids				-23.28 **
				(10.27)
Gender*Polygynous			168.94 ***	41.94
			(40.09)	(64.85)
Other Male*Polygynous			86.50 *	
			(45.82)	
Other Female*Polygynous			28.71	
			(35.81)	
Gender*Polygynous*Number of Kids				22.15 *
				(11.62)
Observations	5230	5230	5230	4701

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include household-crop-year fixed effects and controls for plot size (by decile), soil type, toposequence and location. Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Calculated as value of plot output per hectare.

[b]Includes interactions of all plot characteristics with the indicator for polygyny.

Table 3. Fixed Effects Estimates of the
Effect of Cultivator Characteristics on Plot Yield[a], Pairwise Groupings

	Head and Wives (I)	Other Cultivators (II)	Men Only (III)	Women Only (IV)	Head and Wives (V)
Gender (1=female)	-151.97 ***	-160.72 ***			-63.60
	(40.47)	(54.01)			(66.14)
Gender*Add'l Female[b]					-132.29 *
					(78.33)
Other Male			-74.78 **		
			(36.06)		
Other Female				18.16	
				(20.77)	
Gender*Polygynous	118.52 **	131.04 **			33.67
	(47.32)	(61.80)			(75.20)
Gender* Poly*Add'l Female					126.61
					(88.86)
Other Male*Polygynous			69.99 *		
			(42.05)		
Other Female*Polygynous				-18.87	
				(23.23)	
Observations	3629	1597	2478	2748	3629

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include household-crop-year fixed effects and controls for plot size (by decile), soil type, toposequence, location and interactions with polygyny.
Data source: 1984-85 ICRISAT Burkina Faso Survey.
[a]Calculated as value of plot output per hectare.
[b]Additional Female equal to one if there is an other female cultivator present in the household.

Table 4. Panel Tobit Fixed Effects Estimates of Input Choice

Dependent Variable	Hours in Land Improvement[a] (Per Hectare)	Paid Labor (1000 FCFA Per Hectare)	Manure (1000 Kg Per Hectare)	Length of Fallow[b]	Years Since Fallow
	(I)	(II)	(III)	(IV)	(V)
Gender (1=female)	-12.89	-2.27	-2.69	-3.82 ***	-6.73 ***
	(26.20)	(2.29)	(3.79)	(1.04)	(2.20)
Other Male	-10.82	-5.97	-5.57	-2.12 *	-9.48 **
	(27.43)	(5.01)	(5.32)	(1.20)	(3.99)
Other Female	14.78	-10.03	15.45	-0.25	2.73
	(33.66)	(6.11)	(25.12)	(1.08)	(2.14)
Gender*Polygynous	24.99	2.25	-4.04	1.79	1.31
	(28.17)	(3.15)	(5.46)	(1.15)	(2.32)
Other Male*Polygynous	-34.60	0.39	-3.03	1.50	2.34
	(33.34)	(5.49)	(6.17)	(1.35)	(4.03)
Other Female*Polygynous	-90.97 *	8.99	-21.45	0.26	-3.21
	(48.54)	(6.53)	(25.91)	(1.20)	(2.33)
Mean	6.94	0.85	1.17	10.24	11.15
Mean if >0	62.74	5.30	9.30		14.58
Observations	5172	5230	5172	3076	4356

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include household-crop-year fixed effects and controls for plot size (by decile), soil type, toposequence, location and interactions with polygyny.

Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Land improvement refers to clearing, burning and bund construction.

[b]Linear regression with fixed effects, as values are recorded conditional on fallowing.

Table 5. Fixed Effects Estimates of the Effect of Cultivator Characteristics on Plot Yield[a], Alternate Specifications

	No Plot Chars. (I)	Cereals (II)	Non-Cereals (III)	Hh-Year Fixed Effects[b] (IV)	1981-83 Only (V)
Gender (1=female)	-125.67 ***	-51.61	-482.87 ***	-108.12 ***	-35.13 ***
	(31.15)	(32.91)	(74.50)	(25.97)	(12.48)
Other Male	-8.52	-92.94 **	-83.43	-58.48 *	-30.30 **
	(36.98)	(37.39)	(82.15)	(31.45)	(12.58)
Other Female	-3.58	-70.15 *	-23.15	-13.57	2.74
	(31.80)	(36.17)	(51.06)	(26.85)	(15.60)
Gender*Polygynous	128.65 ***	10.01	452.14 ***	74.53 **	1.66
	(35.90)	(38.45)	(86.90)	(29.84)	(14.88)
Other Male*Polygynous	21.09	84.15 *	63.75	35.70	17.15
	(43.12)	(43.47)	(95.29)	(37.09)	(15.25)
Other Female*Polygynous	6.01	68.88	17.24	5.470	-23.77
	(36.33)	(42.36)	(57.24)	(31.37)	(18.53)
Observations	5230	2923	2307	5230	4198

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include household-crop-year fixed effects (unless otherwise noted) and controls for plot size (by decile), soil type, toposequence, location and interactions with polygyny. Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Calculated as value of plot output per hectare.

[b]Also includes village-crop-year fixed effects.

Table 6. Fixed Effects Estimates of the Effect of Cultivator Characteristcs on Plot Yield[a], by Household Structure

	Polygynous =2 Wives (I)		Polygynous >2 Wives (II)		Vertical[b] (III)	Horizontal[c] (IV)	
Gender (1=female)	-155.14	***	-155.14	***	-8.43	-516.33	***
	(40.11)		(39.01)		(21.02)	(111.29)	
Other Male	-56.35		-56.35		-18.55	-237.79	**
	(47.21)		(45.91)		(25.80)	(109.52)	
Other Female	-16.02		-16.02		-22.94	-5.00	
	(36.50)		(35.49)		(20.73)	(74.17)	
Gender*Polygynous	136.33	**	154.32	***	-9.68	518.79	***
	(53.59)		(53.01)		(26.50)	(117.88)	
Other Male*Polygynous	72.42		45.40		8.06	251.77	**
	(62.19)		(62.09)		(34.52)	(116.05)	
Other Female*Polygynous	14.76		13.91		20.62	2.30	
	(48.07)		(44.86)		(27.05)	(78.45)	
Observations	3112		3142		2878	1823	

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include household-crop-year fixed effects and controls for plot size (by decile), soil type, toposequence, location, and interactions with polygyny. Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Calculated as value of plot output per hectare.

[b]Excludes households that contain a brother of the household head.

[c]Includes only households that contain a brother of the household head.

Table 7. Household Fixed Effects Estimates

			A. Plot Yield[a]	
	Gender (1=female)		-99.54 ***	
			(26.25)	
	Other Male		-32.28	
			(31.46)	
	Other Female		7.914	
			(27.03)	
	Polygynous[b]		-82.87	
			(83.71)	
	Gender*Polygynous		65.37 **	
			(30.21)	
	Other Male*Polygynous		12.21	
			(37.27)	
	Other Female*Polygynous		-15.13	
			(31.65)	
	Observations		5230	
	B. Household Fixed Effect[c]			
Switch to Polygynous	-27.79	-15.99	-22.69	-30.98
	(57.21)	(55.22)	(47.73)	(49.66)
Always Polygynous	-18.51	-33.71 *	-67.79 ***	-67.78 ***
	(13.87)	(19.82)	(20.34)	(20.49)
Total Hh Plot Area			8.109 ***	7.790 ***
			(2.698)	(2.752)
Capital Intensity[d]				30.21
				(37.21)
Village/Time Fixed Effects	N	Y	Y	Y
Controls for Hh Composition[e]	N	N	Y	Y
Observations	136	136	122	120

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. Panel A includes household fixed effects, village-crop-year fixed effects and controls for plot size (by decile), soil type, toposequence, location and interactions with polygyny.

Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Calculated as value of plot output per hectare.

[b]Direct effect of polygyny, conditional on household fixed effect, identified from households that switch from monogamous to polygynous during the survey period.

[c]Estimated from specification presented in Panel A.

[d]Defined as share of total expenditure on agricultural inputs devoted to large capital goods (plows, scarifiers, weeders, ridgers, line tracers, seeders, sprayers, carts, tractors, draft animals).

[e]Number of individuals in nine age-sex categories, excluding females age 17-54.

Table 8. Share of Large Capital Investments in Total Agricultural Input Expenditures[a]

	Village, Year Fixed Effects (I)	IV with Village, Year Fixed Effects[b] (II)		IV with Village*Year Fixed Effects[b] (III)	
Polygynous	0.018	0.590**		0.592**	
	(0.044)	(0.209)		(0.209)	
Total Hh Plot Area	0.023 ***	0.008		0.008	
	(0.006)	(0.017)		(0.017)	
Observations	231	231		231	
First Stage		Polygynous	Total Area	Polygynous	Total Area
Dagari-Djula		0.707 ***	0.820	0.708 ***	0.841
		(0.188)	(1.175)	(0.190)	(1.172)
Bwa		0.201	4.138 ***	0.201	4.140 ***
		(0.146)	(0.912)	(0.147)	(0.909)
Other Ethnic Group		0.100	0.648	0.096	0.648
		(0.193)	(1.209)	(0.195)	(1.208)
Inherited Area		0.004	0.257 ***	0.004	0.260 ***
		(0.008)	(0.050)	(0.008)	(0.050)
Sargan Test of Overidentification		0.24		0.27	
(p-value)		(0.89)		(0.87)	
Cragg-Donald Statistic[c]		4.09		4.01	

Notes: Standard errors in parentheses. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively. All specifications include controls for household composition.
Data source: 1984-85 ICRISAT Burkina Faso Survey.

[a]Includes plows, scarifiers, weeders, ridgers, line tracers, seeders, sprayers, carts, tractors and draft animals.

[b]Polygynyous and total household plot area treated as endogenous. Instruments include ethnic group ("other" includes Rimaibe, Fulani/Peulh, Fulse/Kurumba, Mossi and Dafing/Marka; "Southern" Fulani/Peulh Mossi is the excluded category) and hectares of inherited land.

[c]Based on Stock and Yogo (2005).