Modeling Gender Inequity in Household Decision-making*

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Abstract. The Food and Agriculture Organization (FAO) estimates that if female farmers in developing countries had access to the same resources as men, the number of undernourished people would decrease by 12%-17% [9]. Clearly, gender equity is a vital part of increasing agricultural production to feed the world's projected 9.7 billion people by 2050. However, programs designed to empower women in agricultural systems are expensive, and no quantitative model exists to define and explore the problem space in intended cultural contexts. We introduce a formal model of household decisions embedded in an agent-based model of community gender dynamics and show how the explicit definition of gender inequity can help inform decision-making about programs intended to empower women.

1 Introduction

As the global population increases, the world's demand on agricultural production is predicted to rise by 70% to 100% [10]. With almost ten billion people expected by mid century, those concerned with agricultural productivity must also be concerned with gender inequity. The FAO estimates that providing female farmers access to resources could increase agricultural productivity in developing countries by 2.5% to 4%, which translates to a 12% to 17% reduction in the number of undernourished people [9]. Also, women tend to allocate more resources in favor of their children, which can lead to more productive households in the future [12, 9]. Thus, any efforts to increase the world's food security should include programs to empower the women who make up nearly half of the world's farmers [7].

Programs designed to empower women in agricultural systems can focus on improving women's personal assets, farming inputs, land rights, education, or access to health care. However, interventions to reduce gender inequity do not always account for power imbalances within households. For example, as women's activities become more profitable, their husbands often usurp them [8]. In other

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cases, men become more violent as women's personal assets increase [15]. Accounting for the cultural context of interventions is vital to their success, as culture heavily influences decision-making within households.

Despite the high cost of programs designed to empower women, there are few methods to guide decision-making outside of qualitative work. Modeling the gender dynamics and cultural context of households can help bridge the gap between theory and practice. Defining the variables and relationships involved in the maintenance of inequitable cultural norms can offer a useful perspective outside the expertise of the qualitative researcher, and illuminate both worthy avenues of effort and unforeseen conflicts in the design phase of a program. Our model is the first to quantify gender inequity across multiple households and to consider the impact of community on intra-household bargaining. Given the expense of program pilot studies, the goal of our model is to make program design cheaper and faster for non-governmental organizations (NGOs), government agencies, and other entities invested in gender equity.

The remainder of this paper is organized as follows: In Section 2, we introduce a formal model of intra-household bargaining. In Section 3, we describe how households interact and how their members learn new bargaining policies. In Section 3.1, we show how the model can be used to explore and evaluate strategies for improving women's outcomes. We conclude with a discussion of future work.

2 Intra-household Bargaining

Early models of agricultural households assumed that household decisions are "unitary" [6], despite the reality that husbands and wives often disagree. Recent attempts to quantify household decision-making emphasize bargaining power and intra-household resource allocation. The "collective" framework accommodates scenarios in which household members have different preferences about how to allocate time, land and capital, where choices are made through Pareto-efficient cooperative bargaining [5, 3, 4]. However, theories of intra-household allocation are often applied in field studies to show that heterogeneity of preference can lead to inefficient choices [14]. Smith and Chavas (1999) model household decision-making as a two-stage game where household members optimize their utility functions and make final choices based on whether they would be better off with a divorce; the model is used to show that Pareto-efficiency does not hold [16]. Basu (2006) maximizes household members' utility as well, but allows members' bargaining power to be affected by choices made in the previous timestep [2]. In her summary of intra-household bargaining frameworks, Agarwal (1997) notes that household bargains do not occur in a vacuum, and that models must account for social norms and gender differences [1]. With this in mind, we base our model of intra-household decision-making on two dynamics derived from the literature: Men generally have more power than women, and women generally allocate more money to the household and their children [11, 12].

2.1 Portfolios and Payoffs

Here we present a bargain between Alice and Bob (A and B), members of a household (H). Alice and Bob must choose one of two portfolios, π_1 and π_2, which represent the allocation of land, labor and capital to activities. Let V_i^A, V_i^B, and V_i^H be the payoffs of $\pi_{i=1,2}$ to Alice, Bob and the household, respectively. To simplify, in this example we assume that V_i is known by Alice and Bob and that they only care about payoffs, not about the activities themselves. In general, Alice and Bob must estimate the return of π_i based on their preferences and past experience.

We assume $V_2 = \delta V_1$ for $0 < \delta < 1$; that is, π_1 has a greater total payoff than π_2. We also assume that $V_2^B > V_1^B$; that is, π_2, though smaller in total, gives more payoff to Bob. Thus, Bob prefers π_2 and Alice prefers π_1. Let p_1^B and p_2^B be Bob's proportion of V_1 and V_2, respectively:

$$V_1^B = V_1 p_1^B \tag{1}$$

$$V_2^B = \delta V_1 p_2^B \tag{2}$$

The proportions of V_1 and V_2 that remain for Alice and the Household are therefore:

$$V_1^{A,H} = V_1(1 - p_1^B) \tag{3}$$

$$V_2^{A,H} = \delta V_1(1 - p_2^B) \tag{4}$$

Alice prefers π_1 because it returns more to her and the household. Alice and Bob can negotiate the choice between π_1 and π_2 in three ways:

1. A wants π_1 and B agrees to select π_1.
2. A wants π_1 and B agrees, subject to A paying B a *penalty* from V_1^A;
3. A wants π_1 but agrees to select π_2, with no penalty.

Choice 1 is best for Bob iff $p_1^B V_1 \geq p_2^B \delta V_1$, or $p_1^B \geq \delta p_2^B$. Choices 2 and 3 can yield the same return to Bob if Alice pays a *penalty* by increasing Bob's proportion of V_1. To make Bob indifferent between Choices 2 and 3, Alice must offer a p_1^{B*} that makes $p_1^{B*} V_1 = p_2^B \delta V_1$:

$$p_1^{B*} = \frac{(p_2^B \delta V_1)}{V_1} = p_2^B \delta. \tag{5}$$

If Choice 2 yields $p_1^{B*}V_1$ to Bob, then Alice and the Household get

$$p_1^{A,H} = (1 - p_1^{B*})V_1 \tag{6}$$
$$= (1 - p_2^B\delta)V_1 \tag{7}$$

In contrast, Choice 3 yields:

$$p_2^{A,H} = (1 - p_2^B)V_2 \tag{8}$$
$$= (1 - p_2^B)\delta V_1 \tag{9}$$
$$= (\delta - p_2^B\delta)V_1 \tag{10}$$

For $0 < \delta < 1.0$, Alice prefers Choice 2 to Choice 3. In this example, the penalty Alice pays is in units of the portfolio's payoff. Depending on where Alice and Bob live, the penalty might be in terms of money, crops, labor, or things of less certain value like quality of housework.

3 External Interactions

Until now, we have assumed that Bob is indifferent between portfolios that return the same to him, but this is not the case in the real world. Agarwal (1997) states that social norms can affect household bargaining in several ways, including moving the point of compromise to fit what is "acceptable" [1]. Even if Alice offers a penalty to make Bob's $p_1^{B*}V_1 = p_2^BV_2$, Bob may be unsatisfied with the deal if it does not conform to the social norms of his culture. With the following example, we extend our formal model of the household bargain to include a p_{min} for Bob that represents the minimum proportion of payoff he accepts based on what he perceives to be the norm.

Suppose Bob lives in a town where men always get more than half of portfolio payoffs. Based on this norm, Bob has $p_{min} = 0.51$, where he rejects any deal that does not give him more than half of any portfolio's returns. He and Alice must choose between π_1 with $V_1 = 100$ and $p_1^B = 0.4$ and π_2 with $V_2 = 80$ and $p_2^B = 0.6$. Following the logic of the previous section, Alice offers Bob $p_1^{B*} = 0.48$ of π_1, suggesting a penalty of 8 portfolio units to get her way. Unfortunately, $p_1^{B*} \leq p_{min}$, so Bob is not happy with her offer. However, Alice can "sweeten the deal" by allowing him a greater fraction of V_1 ; she has between $(1 - p_2^B\delta)V_1$ (Equation 7) and $(\delta - p_2^B\delta)V_1$ (Equation 10) to offer him and increases her penalty by 3 units to make him happy. She still does better than if she and Bob had agreed on π_2, but Bob's attention to social norms has decreased her payoff.

Social norms must change if women are to achieve equity in agricultural systems, so we extend our model to incorporate social change. We allow Bob to adjust his

p_{min} through an evolutionary learning structure based on the theory of social influence learning [17]. In our model, there are N households, each with one male (Bob) and female (Alice) agent. Male agents have a "neighborhood" of M randomly assigned male neighbors. At each time step, after each Bob has bargained with his Alice, he talks to his M neighbors, as well as m random male agents with probability ρ. Bob assesses the mean household wealth of those agents he talks to, and he adjusts his p_{min} based on the $p_{min}s$ of the agents who are richer than average (R):

$$p^{Bob}_{min,t+1} = \alpha \cdot (p^{R}_{min,t} - p^{Bob}_{min,t}) \tag{11}$$

where α is Bob's learning rate. Currently Bob's estimates of his neighbors' wealth and $p_{min}s$ are accurate; in future we will explore the effects of biased estimates.

3.1 An Example

Here we show the behavior of our model with the following parameters: $N = 20; M = 4; m = 1; \rho = 0.5; \alpha = 0.2$.

We ran a simulation of $N = 20$ households over 30 time steps. During each time step, each household's male and female agent choose between portfolios π_1 and π_2. Agents do not care about the activities in the portfolio, only the portfolio's returns. π_1 returns 10 units of payoff with $p^B_1 = 0.4$; π_2 favors male agents with a p^B_2 of 0.6 and a total return of 8. Thus, female agents have between 3.2 and 5.2 of π_1 to bribe their husbands to select that portfolio, and male agents must have $p_{min} \leq 0.52$ for the bargain to work. 10 of the male agents begin with an initial p_{min} of 0.6, and the other 10 begin with a p_{min} of 0.4. In this example, portfolios are communal, so when a male agent updates his p_{min}, he judges his neighbors based on their household's total wealth.

Figure 1 shows the p_{min} of the 20 male agents over 30 time periods. Each line represents the p_{min} of one male agent at time t. The color of the line indicates how much the household's female agent offered to get her preferred portfolio, rounded to the hundredth place; "No Deal" indicates the male agent's p_{min} was too high to make her preferred portfolio worth it, so the male agent's preferred portfolio is selected. As expected, higher $p_{min}s$ in male agents reduce the payoffs for their female partners, who must "sweeten the deal" further. Also as expected, male agents' $p_{min}s$ converge to slightly below the initial average, with an average $p_{min} = 0.47$ at $t = 30$. Agents' $p_{min}s$ converge to slightly below both the average of the initial $p_{min}s$ (0.5) and the threshold for choosing π_1 (0.48) because the male agents with initial $p_{min}s$ of 0.4 have slightly more influence. Male agents with $p_{min}s$ that start at 0.4 and increase (we'll call these agents M_{low}) consistently agree to choose π_1, which has a higher payoff. As a result, the households of M_{low} add to their coffers faster than the households of the

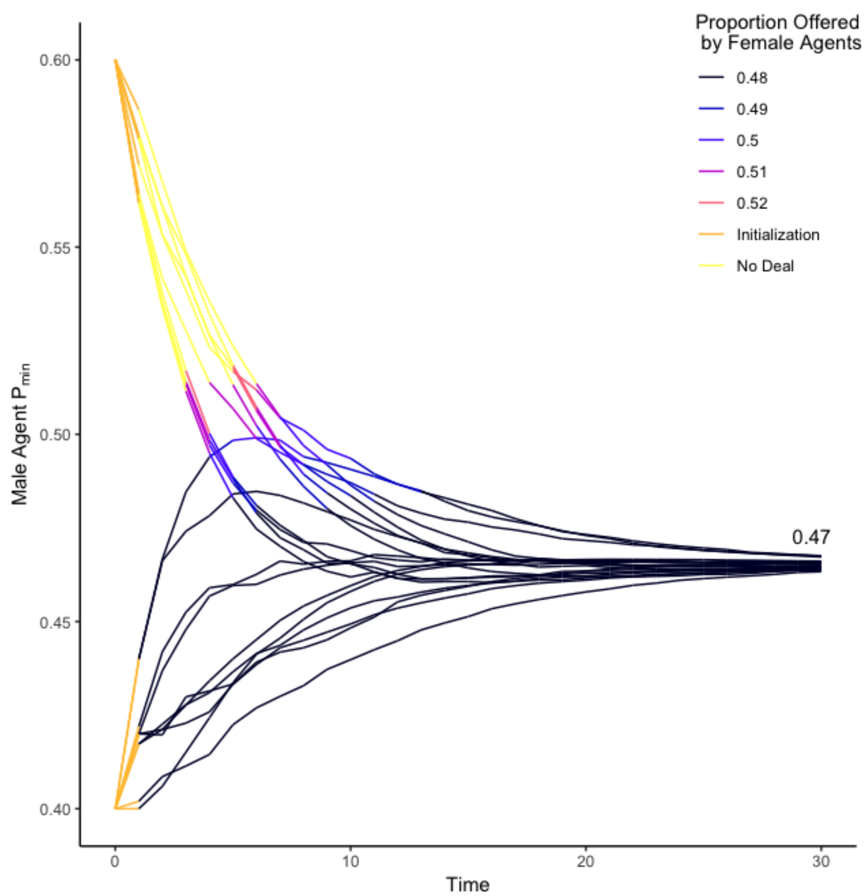

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Fig. 1. Basic behavior of the model. Each line represents one male agent's p_{min} over time. The color of the line shows how much the female agent offered the male agent to choose her preferred portfolio at that time step. Black,"No Deal", means that male agents' $p_{min}s$ are higher than the female agents can offer and the male agent's preference is chosen.

agents that start with the higher p_{min} (M_{high}). Agents with richer households tend to be part of the "richer than average" (R) group in Equation 11; thus, male agents adjusting their $p_{min}s$ are more often influenced by M_{low} to reduce their $p_{min}s$. As all agents increase or decrease their $p_{min}s$ towards the threshold for choosing π_1, the difference between any given pair's $p_{min}s$ gets smaller and the rate of adjustment decreases.

Although our results are preliminary, it is clear how they might be used to plan or improve a program intended to empower women. If new social norms can be formed in a community simply by increasing the wealth of those who choose the preferred behavior, then an NGO might successfully increase women's share of household payoffs by giving cash to households that allocate funds fairly. However, suppose male agents *insist* on their preference 10% of the time. In our simple model, insistence means that Bob unexpectedly increases his p_{min} to 1.0; that is, he demands the entire payoff of his preferred portfolio, regardless of what he usually does. At the next time step, Bob's p_{min} returns to what it was before he became insistent. Figure 2 shows that even when the probability of insistence in a bargain is just 10%, the initial conditions of the first experiment lead to a different outcome. Lines for each agent are reduced to points to preserve clarity. Each point represents the p_{min} of one male agent at time t; the color of the point indicates which portfolio the household chose at that time step. The presence of insistence in the model results in an upward trend where male agents increase their $p_{min}s$ to an average of 0.7 at $t = 30$. When the model is run out further, the average p_{min} converges to 1.0. As expected, without any counteracting efforts, even small upward perturbations in the model eventually lead to the maximization of p_{min}.

These results can be compared to situations in which husbands unexpectedly enforce their authority when they feel it is being challenged. For example, in a community where men are traditionally wealthier than women, a woman's husband may feel threatened if she receives a microcredit loan to build her own business. He may resort to violence, theft or isolation to keep her from increasing her power in the household, which might in turn leave a community's gender inequity worse off than it was before the intervention. Modeling gender inequity within a community can help identify potential conflicts before a program has launched. The responsibility to know whether these factors matter or not in a culture lies with the area expert; but defining the problem space can provide valuable insights. In this simple example, an NGO made aware of the possibility of male retaliation might budget resources to reduce it, perhaps by educating men in the community or using their program to reduce women's isolation [13].

4 Future Work

Future implementations will make the model more realistic by increasing the range of actions available to households, and revising some simplifying assump-

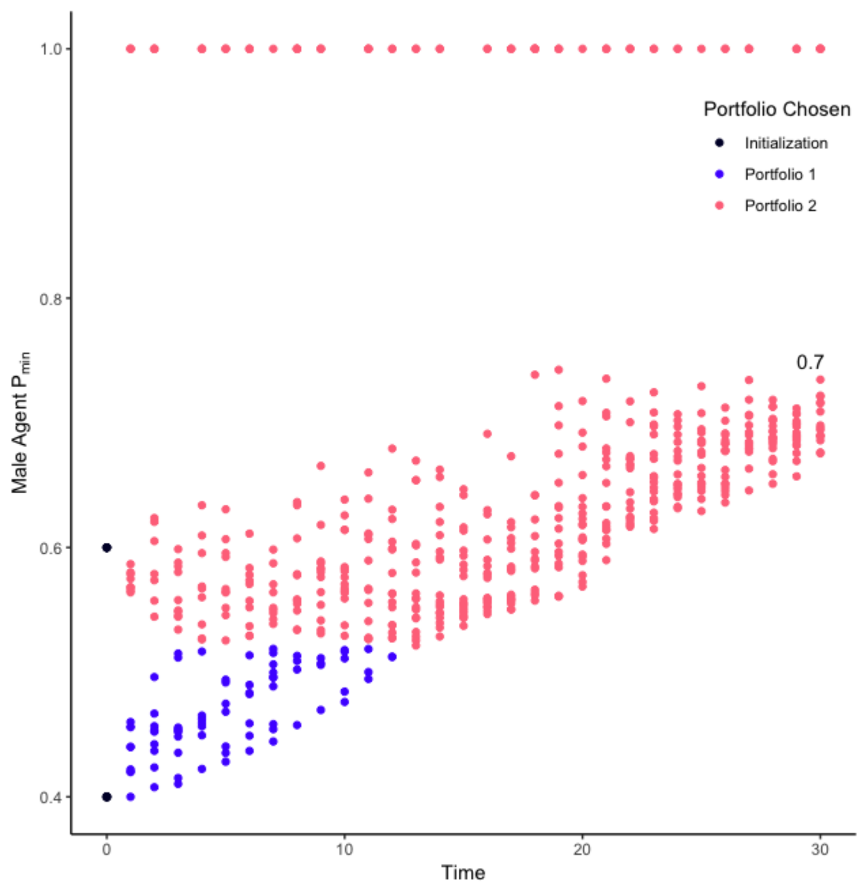

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Fig. 2. The model with insistence. Each point is a male agent's p_{min} at time t; its color indicates which portfolio that agent's household chose.

tions. Most importantly, Alice has no bargaining power outside of the penalty she offers Bob, whereas in reality, Alice's options may include threatening divorce or publicly shaming Bob. How the bargain changes when Alice's bargaining power increases is a complicated problem. Many factors can either increase Alice's bargaining power or lead to violence, from her personal wealth to how connected she is to other women in the community. Second, the model assumes that all portfolios are communal; that is, Bob and Alice do not discriminate between their individual inputs, and payoffs from all activities are summed and divided up. In many places, intra-household allocation depends on spheres of influences: Personal activities, such as vegetable gardens, and communal activities, such as cereal crops, have separate inputs and outputs. With this addition, we will be able to better model time poverty (the idea that if Bob requires Alice to labor in the fields, she has less time to tend her children and her own plots) and intervention strategies that increase Alice's personal assets. Third, Bob and Alice do not learn to better estimate the payoffs of portfolios. The next iteration of our model will allow agents to adjust their preferences for activities based on the perceived results of their neighbors' chosen portfolios. Finally, we will "close the loop" by making the available portfolios depend on earlier decisions; for example, if Bob and Alice amass enough capital, they will be able to invest in higher-quality seeds or education for their children.

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