Intrahousehold Risk Sharing: Evidence from Samburu County, Kenya*

January 2021

Abstract

Women often bear the brunt of negative shocks to household incomes. I show that non-cooperative models household models with voluntary contributions to public goods can explain this result, and conduct a lab-in-the-field experiment testing household public goods insurance as a potential solution to the problem. In a non-cooperative model, the poorer member of the household, who in many cases is a woman, reduces downside risk for her partner by stepping in to pay for public goods and reducing her own consumption in the event of negative shocks to his income. This structure puts women's consumption at risk when their partner's income or assets are faced with negative shocks. I test demand for household goods insurance relative to traditional asset insurance with a lab-in-the-field experiment in Samburu County, Kenya. The data support the hypothesis generated by the model: women buy more insurance when it is linked to household public goods rather than male-owned assets. The results suggest that in cases where men are primary breadwinners, household public goods insurance may have greater benefits for women than traditional asset insurance. More broadly, I argue that household structure can lead to gendered differences in decisions and outcomes even absent differences in individual preferences.

JEL Codes: D13, D81, O12

Keywords: Risk, Gender, Intrahousehold, Insurance

*Thanks to Michael Carter, Katrina Jessoe, Travis Lybbert, and seminar participants and the University of San Francisco and University of California Davis for their helpful comments. Thanks to Oscar Naibei, Watson Lepariyo, Philemon Chelanga, Kevin Kidimu, Wako Gobu, and Diba Galgallo, Andrew Mude and Nathan Jensen at the International Livestock Research Institute for supporting data collection on this project. Finally, thanks to Agnes Naretu Leparlero, Alfred Leisido Lpangesian, Amos Chinua Lemarkat, Anita Lekamario Caroline, Benjamin Julius Lekararo , Benjamin Lolmingani Ltarapua, Benjamin Sab Lekitasharan, Daniel Lekiriao, Daniel Leyola Lemarkat, David Ldalangwan Lelejuk, David Mwana Faustine, Edward Jeremiah Lenailoj, Edward Letuke Soopen, Elijah Lesimalele Tony, Faustine Lepadaasa, Godfrey Lolkinyati, Henry Ngoley Ltalian, Hezron Lemarkat, Jacob Lengeruan Lesorogol, Joseph Lempesie, Karas Loidingae Letura, Letorongos Risayo, Lekiluai Lparari, Lesepe Major Jeremy, Lentaano Naweli Nanyok, Loosenge Bakana, Ltuwoka Leiroya, Namelin Kopir, Nicholas Lkasulan, Pascalina Nambasio Lasangurikuri, Peter Learat, Samuel Lalarari, Samuel Lenaruti, and William Lmereni Lenguro for helping develop the SimPastoralist and collect the data for this project.

Women and girls often bear the brunt of economic shocks. Droughts adversely affected the body mass index (BMI) of women and daughters in a sample of rural Zimbabwean households, but not men and sons (Hoddinott and Kinsey, 2000). Crop failures in Rwanda adversely affected girls' health, but not boys' (Akresh et al., 2011). Indonesian women who grew up in areas with lower-than-average rainfall during their early years grew up to be shorter, completed less school, and lived in households with fewer assets later in life (Maccini and Yang, 2009). In post-Mao China, increases in womens' incomes led to higher survival rates for girls and increases educational attainment for all household members, while increases in mens' income actually reduced survival rate for girls and increases education attainment only for boys (Qian, 2008). Typhoons in the Philippines increased child mortality for female infants, but not males (Anttila-Hughes and Hsiang, 2013). Dercon and Krishnan (2000) document that women who got sick in a sample from rural Ethiopia received a smaller share of household nutrition, but the same was not true for men.

This paper shows that a non-cooperative household model with voluntary public goods contributions can explain the disproportionate effect of shocks on women. Negative shocks shift the burden of providing household public goods toward women, leading them to curtail their own consumption. On the other hand, men who are primary breadwinners are implicitly insured when their wives have positive wealth because they can count on their wives to support public goods provision in the event of negative shocks. This means they are incentivized to take greater risks than would otherwise be the case and are disincentivized from purchasing insurance. To diminish the negative impact of shocks to male assets and incomes on women, I propose linking insurance directly to household public goods: if the model is correct this should increase its benefit and appeal for women in households where men control the bulk of wealth.

To test whether linking insurance to household public goods increases demand among women as the model predicts, I conduct a framed field experiment in Samburu County, Kenya. Samburu County is a good place to test this theory, because traditional general roles mean that men are generally the primary income-earners and asset-owners, and frequent droughts mean their livestock assets and income are often subject to shocks. I find that framing insurance in a way that ties payouts to household public goods increases the amount of insurance purchased by women relative to insurance framed around livestock, which are the main household assets in the region and are usually controlled by men. I find weaker evidence that the opposite is true for men, who invest more when insurance is linked to livestock assets.

This paper builds on a large body of existing work on intrahousehold models, and is the first I am aware of to study what non-cooperative models mean for insurance decisions. Intrahousehold models in general can be divided into two groups: cooperative and non-cooperative models. Cooperative models can accommodate unequal weight in household decisions, but always yield outcomes that are Pareto optimal; see Chiappori and Mazzocco (2017) for an overview. Non-cooperative models on the other hand assume outcomes are determined by Nash equilibria of a non-cooperative game, and outcomes are not always efficient. Lundberg and Pollak (1993) and Carter and Katz (1997) add gendered responsibilities and transfer payments within the household to non-cooperative models. The theory developed in this paper focuses on the dynamic implications of the non-cooperative model studied in detail by Browning et al. (2010). Specifically I show in this paper that higher-income partners in non-cooperative households buy less insurance than they would if single. This is because the non-cooperative household structure leads risk on the higher income partner's income to be partly borne by the lower income partner.

A broader implication of both the theoretical and empirical results in this study is that when individuals are part of a non-cooperative household, their investment[1] and insurance decisions are affected by the household structure. More concretely, men who control more wealth than their partners may appear to be less risk averse than women simply because the structure of the household insulates them from downside risk. For the same reason, returns to womens' investments are implicitly taxed because higher incomes mean increased responsibility for household public goods provision, discouraging investment. Taken together, this sort of household structure means that when men are the primary holders of household wealth, women may behave as if there were more risk averse and men less risk averse than they would absent the non-cooperative household structure.

The theoretical implications of non-cooperative household models for investment and insurance decisions are laid out in the next section of this paper. The lab-in-the-field experiment described in the following section tests one implication of the theory, which suggests that insurance on household public goods will have greater benefit to women than insurance on partner income or assets. Next, I discuss results from the experiment, which support the theory's prediction: women buy more insurance when it is framed around household public goods than when it is framed around assets.

[1] In addition to its implications for insurance and risk-taking, the model in this paper provides an explanation for the common finding that male but not female-operated enterprises benefit from business grants (De Mel et al., 2008; Fafchamps et al., 2014; Fiala, 2018). Previous analyses interpreted this as evidence that women had lower returns to investment than men, but Bernhardt et al. (2019) show that returns at the household level do not appear to differ by gender of grant recipient. However, they also show that returns for women in multi-enterprise houses are lower than returns for both men in multi-enterprise households and women in sole-enterprise households. They argue that household may be efficiently reallocating capital to male-owned businesses because men within the household tend to operate the businesses with the highest returns. The model in this paper provides different interpretation: women who receive grants increase their contributions to household public goods and men correspondingly decrease their contribution and increase their own investment. This explanation is similar in that grants are shifted toward mens' businesses, but it does not require that mens' businesses have higher returns.

Theory

This section examines the dynamic implications of a standard Nash equilibrium based non-cooperative voluntary contributions model. The model is a special case of the model examined in detail in Browning et al. (2010), which builds on earlier work on the private provision of public goods by Bergstrom et al. (1986) and Warr (1983), among others. They also link their model to the separate spheres model proposed by Lundberg and Pollak (1993), which they argue can be viewed as a sub-case of the general Nash Equilibrium model.[2] Non-cooperative models can be contrasted with cooperative intrahousehold models, which assume cooperative bargaining and thus Pareto efficiency, and unitary models, which assume household preferences can be represented by a single utility function. For an overview of cooperative models, see Chiappori and Mazzocco (2017). Browning et al. (2010) focus on the distributional effects of non-cooperative models, and this paper builds on their work by examining how those distributional effects are likely to affect portfolio choice when two partners in a household each control their own wealth.

The key insight from the model I develop in this paper that the existence of multiple equilibria in non-cooperative models discourages investment for lower income partners and discourages insurance for higher income partners. This is because the model implies 'kinks' in both partners' indirect utility functions at the boundaries between equilibria, as shown in Figure 1. These kinks lead to corner solutions for investment and an indirect utility function that is not globally concave, which has several important implications. First, the lower wealth member of the household's optimal level of investment is lower than it would otherwise be because returns to investment beyond a certain level are 'taxed' by a growing need to contribute to

[2] Browning et al. (2010) note, however, that while their model can produce the same results as the separate spheres model proposed by Lundberg and Pollak (1993), the Nash equilibrium model relies on preferences to determine which partner finances which public good(s) while the separate spheres model relies on societal gender roles.

household public goods. Second, the higher wealth member of the household benefits from implicit insurance because a large enough drop in their income leads their partner to begin contributing to household public goods, dampening the effect of business losses on utility.

For simplicity, I focus on the case of Cobb-Douglas preferences and a single household public good representing expenditures that benefit both partners such as food, children's consumption and education, or housing. The results here likely hold in the more general case, but I focus on the simple case since the purpose of this theory is to motivate the framed field experiment to follow. Generalizing this model is a useful avenue for future research.

Let the two partners in the household be indexed by the letters i and j. Each individual in the household gains utility from private consumption c_i and total household public goods z, which is the sum of individual contributions z_i and z_j. Since the problem is symmetric, we can focus on one partner's side. Individual i has income y_i and solves the problem:

$$\max_{c_i, z_i} u_i(c_i, z_i + z_j) \text{ such that } c_i + z_i \leq y_i \tag{1}$$

Let agent i's utility function be given by $u_i(c_i, z) = c_i^{\alpha_i} z^{1-\alpha_i}$ where $\alpha_i \leq 1$. Solving for a Nash equilibrium yields the following optimal contributions to the public good.

$$z_i^*(y_i, y_j) = \begin{cases} (1-\alpha_i)y_i & \text{if } \frac{y_i}{y_j} > \frac{1-\alpha_j}{(1-\alpha_i)\alpha_j} \\ \frac{(1-\alpha_i)y_i - \alpha_i(1-\alpha_j)y_j}{1-\alpha_i\alpha_j} & \text{if } \frac{(1-\alpha_j)\alpha_i}{1-\alpha_i} \leq \frac{y_i}{y_j} \leq \frac{1-\alpha_j}{(1-\alpha_i)\alpha_j} \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

It follows that $c_i^*(y_i, y_j) = y_i - z_i^*(y_i, y_j)$. In the first case, agent i's income is large enough relative to their partner's that they are the sole contributor to public goods.

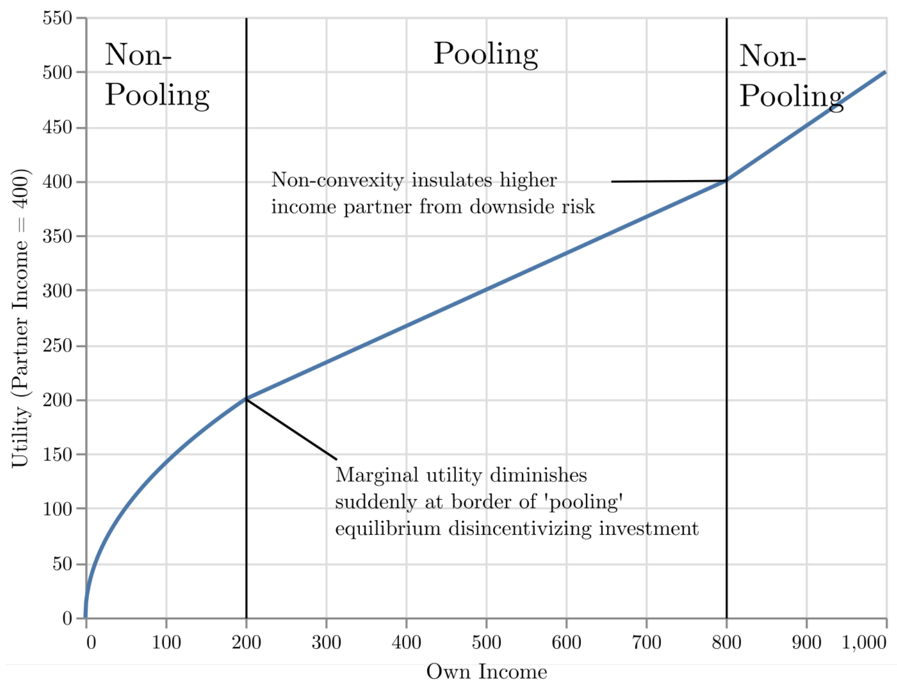
In the second, both agents contribute, and household income is ‘pooled’ in the sense that income received by either partner in the household will have the same effect on household expenditures. In the third case, only agent j contributes to public goods. Intuitively, the first case holds when agent i has enough income that their contribution to public goods is greater than agent j would prefer, leading agent j's optimal contribution to public goods to be zero. Instead, agent j spends their entire budget on consumption c_j. The third case is the inverse of this, and the second occurs when incomes are relatively equal so that both agents make a positive contribution to household public goods. It is worth noting that the boundaries between these equilibrium are determined by each partner's relative preference for private consumption. Intuitively, if one agent puts relatively more weight on household public goods than the other, they will begin contributing at a lower relative income and will also become the sole contributor at a lower relative income.

Individual Preferences in Noncooperative Households

Up until this point, the model I have described is standard in the literature. My contribution is to study how two agents who know that income will be allocated according to the non-cooperative model described above make investment and insurance decisions. Define the indirect utility function $v_i(y_i, y_j) = u_i(c_i^*(y_i, y_j), z_i^*(y_i, y_j))$. We can use this function to study preferences over both own and partner income. To summarize, because responsibility for public goods production depends on relative incomes, lower-income partners are less likely to invest and higher income partners are less likely to insure than they would be absent this structure.

The most salient feature of $v_i(y_i, y_j)$ is that it is not globally concave when both partners have a positive income. As shown in Figure 1, there are two ‘kinks’ in each partner's utility function holding the other's income constant. This figure was generated assuming identical Cobb-Douglas utility functions with $\alpha_i = \alpha_j = \frac{1}{2}$. The

Figure 1. Utility Function.



Holding partner income constant at 400, each partner faces an indirect utility function over their own income with two 'kinks.' For the lower-wealth partner this is likely to yield a corner solution when making investment decisions because of rapidly diminishing marginal utility for own incomes over 200. For the higher income partner, the second kink provides implicit insurance by flattening the utility function if own income falls below 800. The non-convexity at this point could induce locally risk-loving behavior.

shape of this indirect utility function has important implications for both insurance and investment, but in this paper I focus on the insurance implications. At the same time, it is worth noting that the shape of the utility function discourages investments that would lead to a 'pooling' outcome, meaning it is likely the lower income partner will find themselves in the 'non-pooling' region of the graph on the left and the higher income partner will find themselves in the 'non-pooling' region on the right.

The non-concavity of the indirect utility function depicted in Figure 1 means that relative incomes are important drivers of insurance decisions: the lower income partner will be indirectly affected by downside risk to her partner's income. This is because a large enough negative shock to the higher income partner's income will reduce his responsibility for household public goods provision and increase the lower income partner's responsibility for public goods provision. In many patriarchal settings, the woman is the lower income partner, which means she will bear more risk than her husband and thus may benefit more from insurance. Her husband, on the other hand, will be 'insured' by the fact that below a certain level of income his wife will step in and contribute to household public goods, reducing the impact of a negative shock.

Holding partner preferences constant, a stronger preference for private consumption (a higher α_i) shifts both 'kinks' in the utility function depicted in Figure 1 rightward. This means that if the agent with higher income has a stronger preference for private consumption relative to household public goods his insurance 'deductible' will be smaller, because his partner's stronger preference for public goods will lead them to begin contributing more readily. Intuitively, someone who values public goods more than their partner will public goods contributions at a lower relative income. This means that if, for example, women tend to be lower income and also have a stronger preference for public goods than their partners, the implicit insurance they provide is more effective.

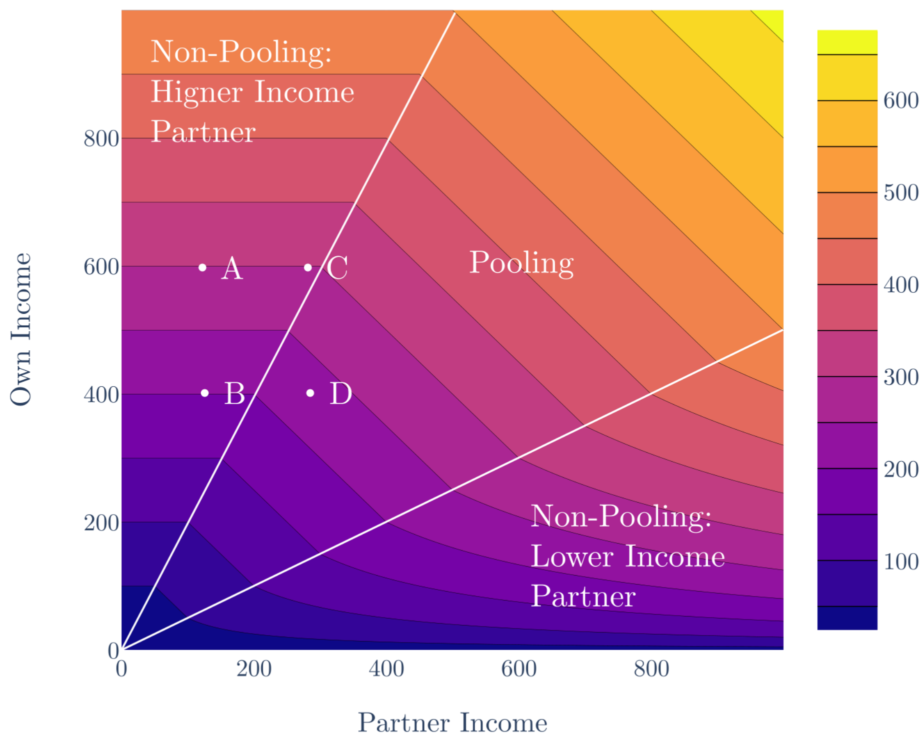
Figure 2 shows how own utility varies with both own and partner income under the same assumptions used to generate Figure 1. If we let the figure represent utility for agent i, a stronger preference for household goods (a decrease in α_i) would reduce the slope of both of the rays from the origin that divide the regions of the graph. In other words, partner i would begin contributing to public goods at a lower income relative to partner j, and partner j would stop contributing at a lower relative income. This is intuitive: the partner who cares more about public goods will tend to contribute more. More concretely, if women place greater weight on household public goods such as expenditures on food and education, the burden of paying those expenses shifts toward women.

By examining Figure 2 we can further clarify the intuition behind the 'insurance' provided to the household's higher income partner by the lower income partner. Consider an individual whose expected income is at point A on the graphic, but is driven by a negative shock to point B. Since his partner's income is still much lower, he remains in the non-pooling equilibrium and the implicit 'insurance' does not kick in, and his utility falls from 600 to 400. However, if his partner's income is slightly higher, the same shock to his own income will move him from point C to D, reducing his utility only to about 450. Further, recall that relative preferences determine the slopes of the separating lines: if his partner cares more about household public goods than he does, the vertical line dividing the 'pooling' and 'non-pooling' regions will be steeper, making his 'insurance' more effective in that his partner will begin chipping in after a smaller shock.

Insurance in Non-cooperative Households

The shape of the utility function described above means that agents who are poor enough relative to their partner have a disincentive to invest their own endowment and agents who are rich enough have a disincentive to insure their own endowment.

Figure 2. Indirect Utility Function



Contour lines represent equivalent utility values. In a non-pooling equilibrium, the higher income partner will be in the upper left region of the graphic while the lower income partner will be in the lower right. A shift along the y-axis represents a change in own income, while a shit along the left represents a change in partner income. The kinks along the borders between the pooling and non-pooling equilibria show how the lower-income partner is insulated from upside risk while the higher-income partner is insulated from downside risk.

Further, the 'poor enough' agent benefits more from insurance on the z good than their partner because in the event of a decline in their partner's income their responsibility to pay for z goods will increase. This is exactly the phenomenon that has been reported in the real world: disasters lead women to curtail their own consumption to cover household expenses.

It is useful to explore the intuition of the model a bit further. The wealthier partner is partially insured by the knowledge that if their income falls sufficiently relative to their partners, the partner will step in and cover a share of household expenses. A small increase in their partner's income is analogous to a reduction in their insurance deductible because it increases the minimum level of y_i at which they'll make a positive contribution to z. At the same time, higher income partners in a non-pooling equilibrium do are unaffected by risk to their partner's income unless a shock drives them into a pooling equilibrium.

The poorer partner in a non-pooling equilibrium is exposed to risk on both incomes. At the same time, they are disincentivized to invest their income because their responsibility for z goods will increase as their earnings increase. This effect is more pronounced if the poorer partner's preference for z goods is stronger than their partners. Concretely, in the many cases in which women are the poorer partners, their disincentive to may be *stronger* if they care about expenditures on household expenses more than their husbands.

In a pooling equilibrium, income is 'pooled' in the sense that changes in either partner's income have the same effect on household expenditures. Thus, both partners are affected by risk to each income. However, the kinks in the utility function make this equilibrium unlikely, as they tend to create corner solutions in which the lower wealth partner avoids investing enough for pooling to occur.

Due to the fact that this model leads to a non-convex indirect utility functions with respect to both own and partner income, the standard result that agents will fully insure when actuarially fair insurance is available does not apply. Further, the fact that the indirect utility function is not globally concave makes solving the problem analytically difficult; first order conditions are not sufficient for a solution. However, we can study easily study optimal insurance purchase decisions with numerical methods.

Suppose that agent i has wealth w_i to invest and that they know that their partner's future income. Further, suppose they know that household decisions will be made according to the non-cooperative model described above. Their wealth is held in a risky asset with expected return $R > 1$ (for example, livestock), but they have access to insurance against downside risk. They buy allocate a share q_i of their wealth to insurance so that without insurance their expected next period wealth is $y_i = w_i R$. Now define an insurance contract composed of a payoff function ψ and a premium p that pays out whenever $R < 1$, so that one unit of insurance pays

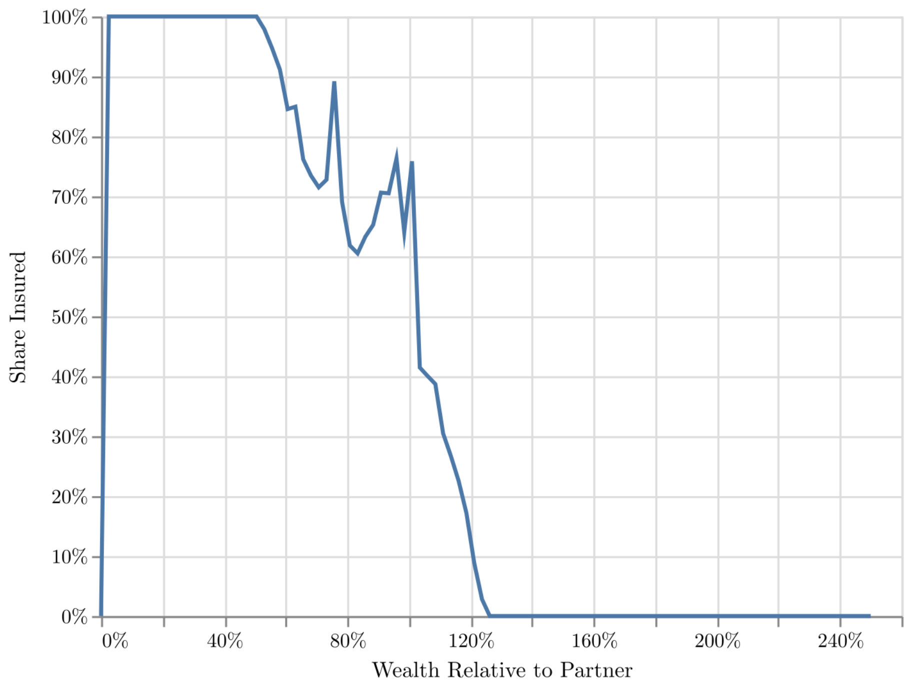
$$\psi(R) = \begin{cases} 1 - R & \text{if } R < 1 \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

That means partner i is solving the problem

$$\max_{q_i} E[v((1 - q_i)w_i R + q_i(\psi(R) - p), y_j)] \text{ such that } q_i \in [0, 1].$$

Figure 3 depicts the optimal level of actuarially fair ($p = E[\psi(R)]$) insurance purchased by individuals in a non-cooperative household setting. Most strikingly, the standard result that individuals with concave utility functions over wealth will fully insure in this setting does not hold. In particular, individuals with high incomes relative to their partners do not buy insurance precisely because they are implicitly insured. On the other hand, individuals with low levels of wealth relative to their

Figure 3. Optimal level of insurance.



Insurance is highly beneficial for the lower income partner (lower right) and less beneficial for the higher income partner (upper left) in the household. This graphic assumes a Cobb-Douglas utility function with $\alpha_i = 0.5$ and with $r\ N(0.1, 0.2)$.

partner fully insure just as they would outside of the non-cooperative setting.

This model provides an explanation for the common empirical observation that negative shocks disproportionately impact women. Since women are the lower wealth members of many households, in non-cooperative households their husbands may not be inclined to buy insurance even when it is available. This is precisely because their wives will partially absorb negative shocks. The next section explores household public goods insurance as a solution for this problem.

Public Goods Insurance

As shown in the previous section, men in non-cooperative households who have more wealth than their wives have a disincentive to insure, which exposes women to risk. The most obvious solution would be to offer insurance to women. However, in many households in rural agrarian economies women earn little income, and as a result the risk they are exposed to indirectly via their husband's income is much larger than the risk from their own income. Providing women with the opportunity to insure their own income may be valuable for those women who are entrepreneurs, but it still leaves them exposed to substantial indirect risk, and is less useful when womens' incomes are a small share of the household total. An alternative is to insure household public goods (z goods in the model).

For the purpose of the theoretical discussion to follow, I assume household public goods can be directly insured, but it is worth discussing how this might work in a real-world setting. Household public goods insurance could be implemented either by directly providing food, payment of school fees, and other expenses in the event of a negative shock or by simply reframing insurance to connect payouts to household public goods. The idea that labeling cash payments affect their final use is explored theoretically by Thaler (1990, 1999), and there is empirical evidence for this idea in a range of cases including the UK Winter Fuel Payment (Beatty et al., 2014), SNAP benefits Hastings and Shapiro (2018), and a lab setting Abeler and Marklein (2017). The experiment described in the sections that follow this one implements household public goods insurance using a labeling approach, and the fact that framing insurance around household goods increases insurance demand for women suggests that labeling matters in this context as well.

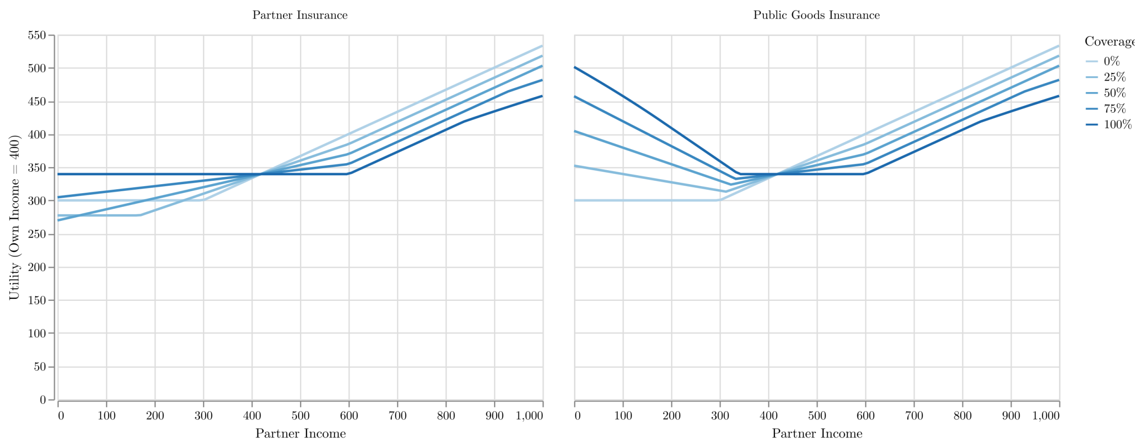
This section will compare insurance for household goods to insurance for partner income. Again, insuring own income may dominate both of these options when own income is the primary source of risk, but insuring public goods dominates insuring partner income from the individual perspective when most risk comes from partner income. In particular, this is the case for most households in the region where we conducted the lab-in-the-field experiment to follow: men are the primary owners of livestock herds, which are the main source of risk for their households.

In order to compare the two types of insurance, we can compare an identical insurance contract structured as described in Equation 3 across two scenarios. In the first scenario, the insurance payout will go to the partner's income. In the second, it goes directly to household public goods.

Figure 4 compares the partner income and household public goods insurance for a scenario in which the partner invests 600 and the contract is identical to the one described above (it pays $600 - y_j$ if $y_j < 600$ and zero otherwise). In both cases, I assume the partner whose perspective the graphs represent is the one buying the insurance. In other words, they take the perspective of a woman who is choosing between buying insurance on her partner's income or for public goods.

Figure 4 shows that public goods insurance is superior to insurance on partner income. Medium-sized shocks lead to a 'pooling' equilibrium in which case the two options are identical; the insurance payment simply increases pooled income. However, in the worst states of the world, outcomes are actually better than in intermediate states for the agent buying the insurance because public goods provision is dramati-

Figure 4. Public Goods Insurance Dominates Partner Income Insurance



cally increased.

Experimental Game

The theory above suggests that in settings where women generally have lower incomes than men, insuring household public goods may be more desirable and beneficial for women and children[3] than insuring male-owned assets.

This section describes a framed, incentivized field experiment designed to test the potential of linking insurance to household public goods rather than male-owned assets or income. This experiment was conducted in Samburu County, Kenya, where most household livelihoods are based on herding livestock (pastoralism). Traditionally, the household's livestock herd and income are controlled by men, with women making little to no income of their own. This makes it an ideal venue for testing this theory as the strongly patriarchal norms mean men consistently have larger expected incomes than women in these households. Further, the region faces frequent droughts which cause large shocks to livestock assets and hence incomes. Finally, the International Livestock Research Institute's Index-Based Livestock Insurance (IBLI)

[3] Assuming that expenditures on children are z goods in the language of the model.

program is currently being rolled out in the region. This program has traditionally linked insurance payouts to replacing lost livestock or preventing their deaths, which according to the model above may provide limited benefit to women relative to a program that insures household public goods.

The experiment is based on an tablet-based game that simulates pastoralist life (SimPastoralist), allowing players to make both investment and insurance decisions with probabilities and payoffs that approximate the real world. In half of the game sessions, insurance was framed around livestock to mirror the currently existing products offered by the IBLI Program. In the other half, insurance was framed to associate payouts with household public goods. The results show that in an experimental setting, framing insurance payouts around household public goods increases demand among women and has no effect on demand among men.

Framed field experiments have been used extensively in past studies on index insurance. A subset of this research focuses on games as a way of educating potential customers on index insurance. Patt et al. (2009) used games to educate individuals on index insurance with the goal of educating users and building trust in the product. Cai and Song (2017) find evidence that participating in insurance games can increase takeup by as much as 46%. Vasilaky et al. (2020) find evidence that insurance games can indeed increase demand in the real world, and Janzen et al. (2021) find evidence that games increased reported preferred insurance coverage levels among participants.

Experimental games have also been used to study individual preferences as they relate to insurance, with a particular focus on understanding why demand for insurance has been lower than expected in many cases. Brick and Visser (2015) use games to show that individuals with high levels of risk aversion are less likely to adopt risky agricultural technologies than others, and that index insurance does little to reduce that tendency. They suggest focusing on reducing basis risk, which is the risk that index insurance contracts fail to pay out when losses are realized, to increase demand among risk averse buyers. McIntosh et al. (2019) use insurance games to explicitly estimate individual utility functions, finding evidence that both probability weighting and loss aversion affect insurance choices. Norton et al. (2014) find evidence that individuals prefer contracts with higher frequency payouts (i.e. lower deductibles). Serfilippi et al. (2020) provide evidence that uncertainty aversion also curtails demand for index insurance. Both of these papers add to the chorus emphasizing the importance of basis risk for increasing insurance demand.

The experiment I conduct is similar to many of those done in the past in that it seeks to add to our understanding of what makes insurance appealing to individuals. However, it is the first I am aware of to test whether there are important gendered dimensions to the decision.

I designed the SimPastoralist game in close collaboration with a number of Samburu young people who also served as enumerators on the project. The game lasts 10 rounds. In each round, players allocate their budget between insurance, goats (investment), and education. In half of the experimental sessions, insurance was linked to livestock, while in the other half it was linked to household public goods. As the theory above predicts, women chose to purchase more insurance when it was linked to household public goods.

Experimental Game

The SimPastoralist game makes it possible to collect rich data on decisionmaking by individuals and couples in a setting that mirrored the decisions they make in their daily lives. The game was developed over the course of several months at UC Davis, and was then intensively revised for several weeks with feedback from local pastoralists in Samburu. The probabilities, prices, and the insurance markup were all designed to match reality as closely as possible while keeping the game relatively simple.

Figure 5. SimPastoralist

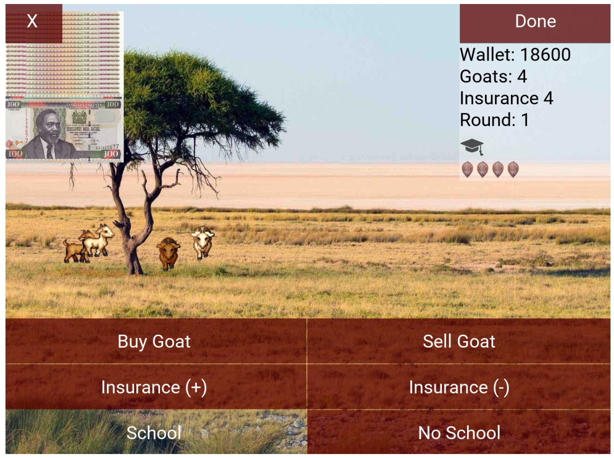


Figure 5 depicts the gameplay screen from SimPastoralist. The shield icons represent the amount of insurance the player holds, and the graduation hat icon represents years of school. The wallet balance is shown both numerically and by adjusting the size of visible stack of cash on the left hand side of the screen. The enumerators explain all of these symbols to the players, and update them on their balances of cash, goats, and insurance before they finalize each decision and at the beginning of each round.

Because data collection is integrated into the game, it is possible to move through the game quickly. This increases participant engagement and allows participants to practice the game many times before they participate in the incentivized round. As a result, participants remained engaged, and many asked to stay longer to play more after the incentivized sessions were over. Participants also reported without prompting that they felt the game was educational and reflective of their lives.

Players start with a relatively small budget: enough to buy 12-18 goats. This corresponds to a herd size of less than 4 Total Livestock Units (TLU). In a non-game setting, herds this small have been found to be below the Micawber Threshold, which is an asset level below which both theory and empirical evidence suggests households are more likely to fall into poverty.[4] One testament to the fact that SimPastoralist accurately approximated reality is that the results are consistent with the research on Micawber thresholds: participants who experienced good luck in the first few rounds so that their herds grew above the critical threshold tended to remain in play throughout the game, while others did not.

At the beginning of each round in SimPastoralist, the player must pay 5000 KSh for essential household consumption. If they do not have sufficient cash on hand, they can sell one or more goats to pay these costs. If they are unable to pay these costs, the game ends early - otherwise it ends after 10 rounds.

After paying consumption expenses, players can buy and sell goats and insurance. Goats are worth 2000 KSh and reproduce with probability 2/3 in a good year and die with probability 2/3 in a bad year. Goats who reproduce also produce milk which leads to income of 1500 KSh. Insurance is sold in discrete units. The premium is 350 KSh and it pays 1000 KSh in the event of a drought, so the net income from insurance is -350 in a good year and 650 in the event of a drought. This means that the insurance is slightly more expensive than actuarially fair - the markup was designed to be similar to the index insurance available in the region.

Every year each player also decides whether or not to send their children to school. School costs 2000 KSh, and six years of school are required for graduation. If the student graduated from school, the player earns a bonus of 10000 KSh at the end of the game. Nearly 100% of participants of both genders chose to send their children to school until they graduated, meaning there is no significant variation.

The game can end in one of two ways. If the player does not have sufficient funds to pay the mandatory 5000 KSh for household consumption at the beginning of the round, the game ends early with a score of zero. Otherwise, the games ends at the

[4]For discussion and evidence on Micawber thresholds in Northern Kenya see Janzen and Carter (2018) and Ikegami et al. (2017).

tenth round. The final score is the sum of the value of the goats in their herd and the cash in their wallet, plus a bonus of 10000 KSh if their child finished school. The incentive is calculated so that every 500 KSh in the game translate into 1 KSh of real-world payment.

In the 'couples' version of the game, the rules are the same as above, with several important modifications. First, the initial budget is split between the two members of the household. Second, household members are given the option to split the cost of education/ consumption or allow one member to pay it entirely. Third, household members can transfer money to each other at any time and for any reason. This version of the game is used to study household preferences as distinct from individual preferences.

Experimental Design

The experimental sessions were conducted by four groups of enumerators who worked with roughly 8 couples per session[5] for a total of 387 couples. The couples were randomly selected from a larger sample of women who are participating in a randomized controlled trial of the BOMA Rural Entrepreneur Access (REAP) program.[6] For that evaluation, women were selected randomly from a group screened by BOMA through a participatory process designed to identify the poorer households in each village. As a result, the households in this study are also among the poorer households in the study region.

In each session, the study team introduced the concepts in the game gradually. First, the enumerators performed a scripted skit situating the game. After seeing the skit, each player then played a version of the game without insurance twice. This was

[5]The same number of couples were invited to each session, but in some cases a few did not show up.

[6]The BOMA REAP Program is a poverty graduation program similar to the well-known BRAC Program documented in Banerjee et al. (2015) and elsewhere.

designed to introduce the part of the game that parallels life as they already experience it without the complication of insurance (insurance had not yet been introduced in the study region). The wife and husband alternated, with the person going first determined at random and selected by the tablet. The enumerators then performed another skit introducing the insurance version of the game, and each member of the couple played that game.

As mentioned above, in half of the game sessions, we described insurance using the traditional 'livestock' framing. The skits and verbal explanations were adapted to fit this framing.[7] Insurance is explained as a product designed to help the household replace or support livestock in the event of a drought. In the other half, we framed insurance as something the household could use to support livestock or to pay for household expenses such as food, medical expenses, and school fees. The hypothesis, based on the theory above, is that women will buy more insurance under the household framing because money allocated to household public goods is more beneficial than money allocated to replacing their husbands' herds during droughts.

After each player practiced the game without insurance twice and then with insurance twice, they were reminded that they were now playing the incentivized game. Incentives were paid out based on the total budget at the end of the game divided by 500, so that a player ending the game with 100,000 Kenyan Shillings would receive a payout of 200 Kenyan Shillings in addition to the 500 KSh offered to all participants in the study in compensation for their time. Only the data from the incentivized games are included in the analysis to follow.

[7]Detailed scripts for both framings can be found in Appendix

Results

The theory above generates the hypothesis that insurance linked to household public goods will be more appealing to women than insurance linked to livestock. This section focuses on testing the impact of the household framing compared to the livestock framing, which represents current practice.

I examine two specifications: one to estimate the average effect of the household framing on units of insurance purchased and another to compare insurance demand as a function of budget levels in each framing. In both specifications, I pool the data from the individual and couples versions of the game. Partitioning the data and running the analysis on couples and individuals separately yields results that are qualitatively similar. In both specifications, women buy more insurance under the household framing. Further, some specifications suggest men buy less insurance under the household framing.

Average Treatment Effect

From the model above, we can see that the factors affecting decisions are the total budget, the round within the game t, and the individual's preferences. I estimate the equation

$$D_{it} = \beta_1 Treat_i Woman_i + \beta_2 Treat_i + \beta_3 Woman_i + \beta_4 Budget_{it} + \beta_5 Budget_{it}^2 + \gamma_t + \epsilon_{it}$$

where D_{it} is the dependent variable (goats or insurance), $Treat_i$ is a variable equal to 1 in the household framing, $Woman_i$ is a dummy variable equal to 1 when the respondent is a woman, and γ_t is a round fixed effect.

The key challenge in identifying the above equations is that the budget is endogenous after the first round, since preferences affect prior investment decisions which have some effect on future budgets. Fortunately, the design of the game provides a set of ideal instruments: the history of drought shocks that the player has experienced at time t and the starting budget.

The first stage of our instrumental variables estimation can be written

$$Budget_{it} = \sum_{i=1}^{t} \delta_t I_t FracGood_{it} + \sum_{i=1}^{t} \kappa_t I_t StartBudget_i + \text{controls} + \mu_{it}$$

where I_t is a year dummy, and the controls are the exogenous variables, and

$$FracGood_{it} = \frac{\sum_{j=1}^{t} \omega_{ij}}{t}$$

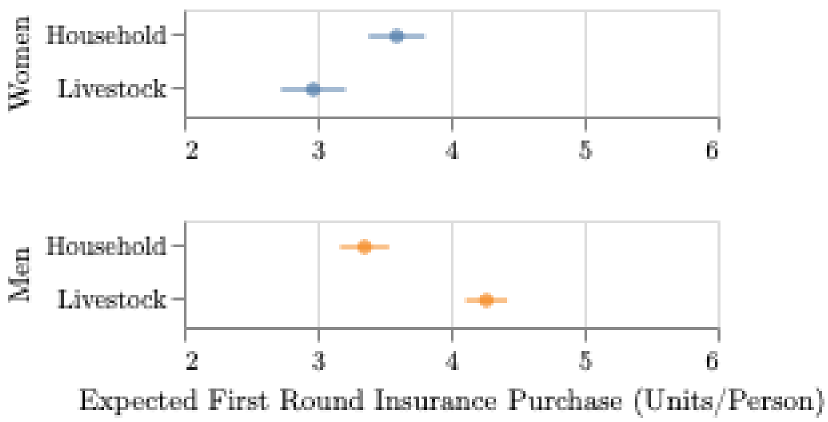
where ω_t is a dummy variable that is equal to 1 in the event of a good year and 0 in the event of a drought. In words, it represents the share of years that have been good for the pastoralist. The instrument is strong: the first stage F-statistic is 53.75.[8]

We can estimate all three of these equations simultaneously: two equations for goats and insurance and one equation estimating the budget as a function of the instruments. In a two stage least squares framework the budget equation would be the first stage, but all three are estimated simultaneously in this case. Because the instrument was randomly generated by the tablet, I know for certain it is strictly exogenous and can use System Generalized Least Squares (GLS) rather than the Generalized Method of Moments to estimate the system of equations, which improves efficiency. Here I focus on the effect on demand for insurance; other regression results can be found in Appendix 1.

Figure 6 summarizes the regression results by plotting a confidence interval for the predicted insurance purchase at the average starting budget of 30,000 KSh. The

[8] This substantially exceeds the rule of thumb proposed by Staiger and Stock (1997), who find that first stage F-statistics less than 10 are likely to lead to weak instrument problems.

Figure 6. The household framing increases average insurance demand for women and reduces it for men



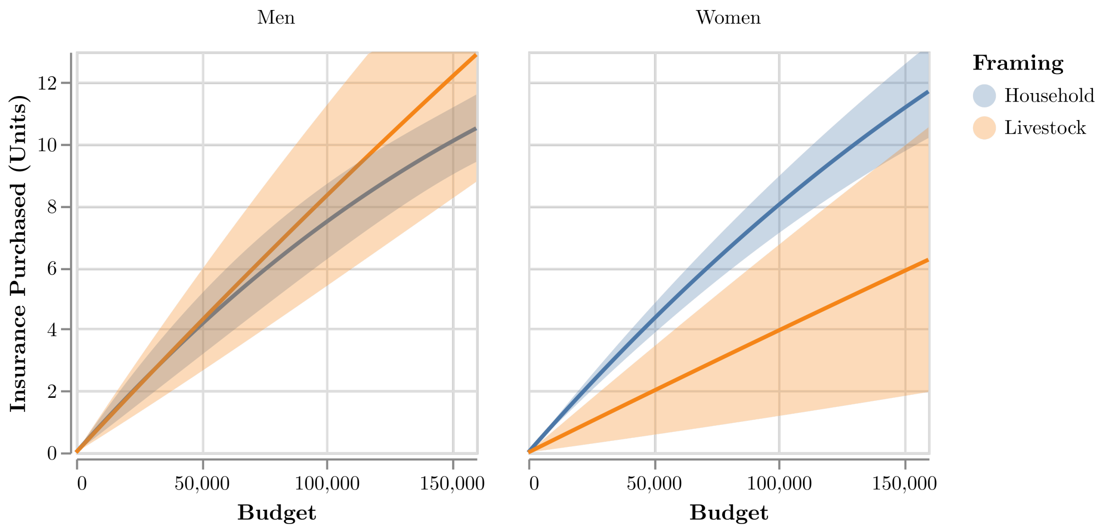
household framing leads women to increase insurance purchase from 3.2 to 3.5 units on average, a 12.5% increase. Interestingly, it appears to reduce demand for men by about the same amount, though as shown below this effect is no longer statistically significant when I estimate a more flexible specification that allows the treatment effect to depend on the budget. Detailed coefficient estimates are available in Appendix 1.

Variable Treatment Effect

In order to obtain more estimates that allow the treatment effect to vary with the budget, I estimate a regression similar to the above with an important modification: the 'Budget' variables are interacted with framing and gender variables so that the effect of the framing on demand can vary with the budget. This more flexible specification is a better fit for the theory, in which insurance demand is a function of budget. Due to the many interaction terms, the coefficient estimates are difficult to interpret and so I have relegated them to Appendix 1. Instead, I provide visualizations of predicted insurance purchase in each framing along with 95% confidence intervals.

As depicted in Figure 7, these results are consistent with the average results above

Figure 7. The household framing increases insurance demand for women and reduces it for men (robust standard errors)



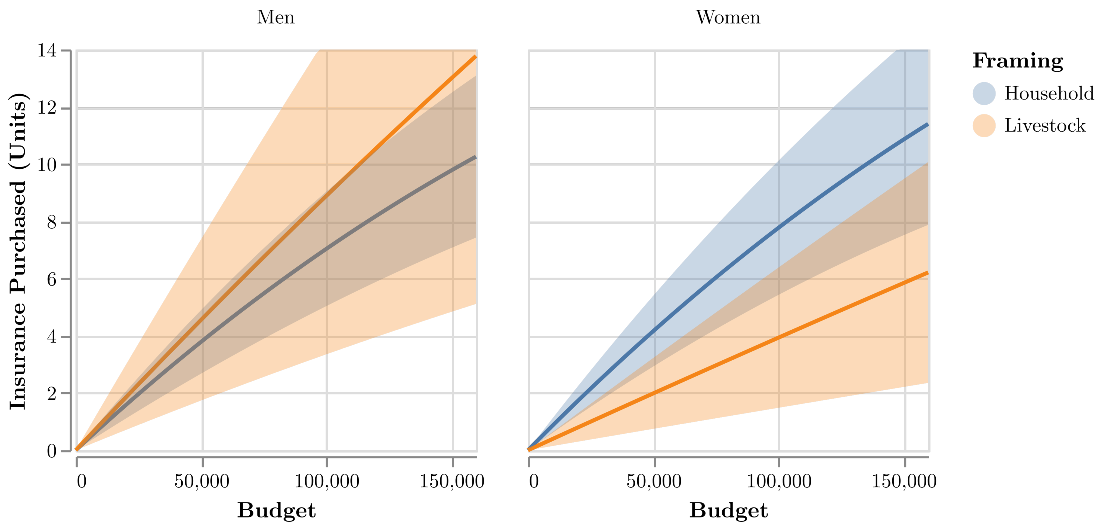
except that the effect of the household framing on men is no longer statistically significant. Further, the effect for women becomes statistically insignificant at high budgets. This makes sense given the theory: since household expenditures do not depend on the number of goats in the herd, they will play a smaller role in the quantity of insurance purchased as budgets grow.

Because treatment was randomized at the session level rather than the individual level, the results depicted in Figure 7 may underestimate standard errors.[9] As shown in Figure 8, clustering standard errors at the session level increases the size of the confidence intervals, which means that the effect of the treatment on demand is only statistically significant at the 95% level at low budgets. Player budgets start between 25,000 and 35,000 KSh, so the graphic represents the range in which most of the data are found.

In general, these results suggest that the finding that the household framing increases demand by women is more robust than the finding that it decreases demand by men. This is promising for household public goods insurance in general, because

[9]According to Abadie et al. (2017), it is appropriate to cluster standard errors in this setting at the session level since that was the level at which the treatment was randomized.

Figure 8. The household framing increases insurance demand for women and reduces it for men (standard errors clustered at session level))



it suggests this framing can increase the appeal for women more than it decreases it for men. Of course, in a real-world setting both traditional livestock insurance and household public goods insurance could be offered simultaneously, and a household could buy a combination of both.

Conclusion

It is well documented that unitary or cooperative models fail to explain observed household behavior in some settings and that the negative shocks tend to disproportionately affect women. This paper has shown that a simple non-cooperative model of household behavior predicts these disproportionate impacts for an intuitive reason: higher income members of households are implicitly insured by the knowledge that their partners will contribute to public goods when times are tough. If this model prediction is true, it also means that insuring assets belonging to men may have limited benefits to women, and that insuring household public goods and or womens' income may provide an effective workaround. I use experimental games test whether framing insurance around household public goods increases demand among a group of pastoralists in Samburu County, Kenya. As the theory predicts, demand increases for women, but not men.

The theory presented in this paper focuses on the simple case of Cobb-Douglas preferences and a single public good; future work will focus on generalizing the model. Also, Browning et al. (2010) note that many of the 'pooling' characteristic of their model extends to all bargaining models that use noncooperation as an outside option; testing whether the indirect utility function 'kinks' described in this paper also extend to that setting would be a useful future step.

On the empirical front, this paper makes it clear that there is a need to test insurance products that take into account intrahousehold dynamics in a real-world setting. This paper suggests that this may increase demand among women as well as reduce the disproportionate burden they face from shocks. Future work ought to test whether this holds true outside of insurance games.

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Appendix 1: Average Effect Regression Results

The following tables contain the full System GLS results from the joint estimation of equations for insurance, goats, and the 'first stage' equation that estimates budgets as a function of the instruments.

Insurance

The results below are the same as those included in the paper except I include coefficient estimates for the round fixed effects.

Table 1. Coefficient Estimates: Average Effects Regression

Variable	Coefficient	Std. Err.	T-stat	P-value	Lower CI	Upper CI
Round 0	2.1522	0.2202	9.7740	0.0000	1.7206	2.5837
Round 1	2.0404	0.2233	9.1385	0.0000	1.6028	2.4780
Round 2	2.0728	0.2412	8.5952	0.0000	1.6001	2.5454
Round 3	2.1078	0.2770	7.6104	0.0000	1.5649	2.6506
Round 4	2.2364	0.3393	6.5911	0.0000	1.5714	2.9015
Round 5	2.3612	0.3984	5.9262	0.0000	1.5803	3.1421
Round 6	2.1430	0.4757	4.5050	0.0000	1.2107	3.0753
Round 7	2.0909	0.5566	3.7569	0.0002	1.0001	3.1818
Round 8	2.1574	0.5126	4.2083	0.0000	1.1526	3.1622
Round 9	2.3446	0.7016	3.3417	0.0008	0.9695	3.7197
Household	-0.4374	0.2352	-1.8603	0.0628	-0.8983	0.0234
Female	-0.4593	0.2893	-1.5874	0.1124	-1.0264	0.1078
Household x Female	0.8030	0.3466	2.3167	0.0205	0.1237	1.4822
Budget	5.523e-05	8.01e-06	6.8950	0.0000	3.953e-05	7.093e-05
Budget^2	-1.69e-11	6.079e-12	-2.7808	0.0054	-2.882e-11	-4.99e-12

Budget

These results are equivalent to the 'first stage' in a two stage least squares regression. As shown below, the instruments individually are very significant: chance plays a major role in determining future budgets.

Table 2. Coefficient Estimates: First Stage

Variable	Coefficient	Std. Err.	T-stat	P-value
FracGood x Round 0 x StartBudget	0.5879	0.0006	999.44	0.0000
FracGood x Round 1 x StartBudget	0.8348	0.0005	1538.6	0.0000
FracGood x Round 2 x StartBudget	1.0362	0.0006	1659.9	0.0000
FracGood x Round 3 x StartBudget	1.2890	0.0008	1523.0	0.0000
FracGood x Round 4 x StartBudget	1.6090	0.0010	1538.3	0.0000

Variable	Coefficient	Std. Err.	T-stat	P-value
FracGood x Round 5 x StartBudget	2.0690	0.0011	1890.8	0.0000
FracGood x Round 6 x StartBudget	2.7623	0.0012	2215.9	0.0000
FracGood x Round 7 x StartBudget	3.7089	0.0014	2698.5	0.0000
FracGood x Round 8 x StartBudget	5.2575	0.0018	2874.8	0.0000
FracGood x Round 9 x StartBudget	7.2813	0.0006	1.233e+04	0.0000

Appendix 2: Variable Effect Regression Results

The following are the results from the OLS regression with robust standard errors used to create Figure 7.

Table 3. OLS Specification: Variable Effect Regression

Variable	Coefficient	Std. Err	z	p-value
Intercept	9.31e-10	2.69e-10	3.460	0.001
Round 1	-1.812e-08	9.12e-09	-1.986	0.047
Round 2	1.051e-08	4.79e-09	2.196	0.028
Round 3	2.573e-09	1.53e-09	1.684	0.092
Round 4	4.945e-09	3.31e-09	1.492	0.136
Round 5	1.062e-10	2.3e-11	4.625	0.000
Round 6	1.255e-10	2.08e-11	6.034	0.000
Round 7	1.362e-10	2.29e-11	5.950	0.000
Round 8	1.253e-10	2.34e-11	5.355	0.000
Round 9	1.168e-10	1.76e-11	6.657	0.000
Household	-2.076e-10	7.28e-10	-0.285	0.776
Female	4.472e-10	3.03e-10	1.478	0.139
Household x Female	8.374e-10	4.97e-10	1.685	0.092
Budget	8.717e-05	1.86e-05	4.679	0.000
Household x Budget	4.321e-06	2.38e-05	0.182	0.856
Female x Budget	-4.691e-05	2.38e-05	-1.967	0.049
Household x Female x Budget	4.808e-05	2.85e-05	1.685	0.092
Budget^2	-3.997e-11	4.98e-11	-0.802	0.423
Household x Budget^2	-1.389e-10	1.14e-10	-1.216	0.224
Female x Budget^2	3.265e-11	5.06e-11	0.645	0.519
Household x Female x Budget ^2	1.755e-11	1.17e-10	0.150	0.881
Budget^3	-3.828e-18	2.71e-17	-0.141	0.888
Household x Budget^3	1.158e-16	1.15e-16	1.003	0.316
Female x Budget^3	3.93e-18	2.74e-17	0.143	0.886

The following are the results with clustered standard errors, used to create Figure 8:

Table 4. Cluster Robust Specification: Variable Effect Regression

Variable	Coefficient	Std. Err	z	p-value
Intercept	9.31e-10	3.85e-10	2.418	0.016
Round 1	-1.812e-08	1.01e-08	-1.787	0.074
Round 2	1.051e-08	5.36e-09	1.961	0.050
Round 3	2.573e-09	1.78e-09	1.449	0.147
Round 4	4.945e-09	3.81e-09	1.299	0.194
Round 5	1.062e-10	3.33e-11	3.188	0.001
Round 6	1.255e-10	2.83e-11	4.429	0.000
Round 7	1.362e-10	2.89e-11	4.716	0.000
Round 8	1.253e-10	2.81e-11	4.454	0.000
Round 9	1.168e-10	2.52e-11	4.637	0.000
Household	-2.076e-10	9.26e-10	-0.224	0.823
Female	4.472e-10	3.42e-10	1.308	0.191
Household x Female	8.374e-10	5.36e-10	1.561	0.119
Budget	8.717e-05	2.57e-05	3.392	0.001
Household x Budget	4.321e-06	3.15e-05	0.137	0.891
Female x Budget	-4.691e-05	2.29e-05	-2.051	0.040
Household x Female x Budget	4.808e-05	3.08e-05	1.561	0.119
Budgetˆ2	-3.997e-11	8.7e-12	-4.592	0.000
Household x Budgetˆ2	-1.389e-10	1.11e-10	-1.251	0.211
Female x Budgetˆ2	3.265e-11	7.27e-12	4.491	0.000
Household x Female x Budget ˆ2	1.755e-11	8.29e-11	0.212	0.832
Budgetˆ3	-3.828e-18	2.7e-18	-1.416	0.157
Household x Budgetˆ3	1.158e-16	9.09e-17	1.274	0.203
Female x Budgetˆ3	3.93e-18	4.91e-18	0.801	0.423
Household x Female x Budgetˆ3	-7.2e-17	7.41e-17	-0.972	0.331

Appendix 3: Scripts

The following are the scripts that were read by pairs of enumerators at the beginning of each session. Within each of the four teams, the same two enumerators held the roles in each session to minimize variation.

Household Framing

Woman 1: It has been a tough season - no rain at all. How is the drought affecting your family?

Kotogolo ana ng'amata meti nchan pii , aji eikunita nkolong'/lamei nkang' ino?

Woman 2: We lost half our goats and cattle and have been cutting back on meals because the goats that survived aren't producing much milk. It's going to be hard to pay school fees this year, and if the children have any medical expenses we will probably have to sell even more livestock.

Kotuata yio nkineji o nkishu, nomokure eta nkera ndaa, amaa amu meata ntare natelekunye naara kule. Kogolu abaki laata e skool e nkera, teneibisieng'u abaki nkera suom natelekunye naake kimir .

Woman 1: Have you heard about the new insurance that helps families in this kind of situation? It sends money to your M-Pesa account when droughts strike to help cover household expenses. We also lost half our goats and cattle, but at least we'll be able to pay school fees and buy food.

You can also buy insurance to help offset lost animals in the event of drought. You have to pay 500 KSh per goat in August, before the rainy season begins. If the rains are poor, they send 1000 Ksh for each goat to help revive your herd.

Itining'o ana ripet ng'ejuk naret nkang'ite ta mbaa/ramat natiwenyi? Kereu ropiyiani te simu (M-pesa) nkata e nkolong' payie eyasie ramat e nkaji. Kotuata yio ntare o nkishu, keikash naa amu kindim taa atalak ropiyiani e nkera e skool, nikindim sii ainy'angu ndaa

Woman 2: That sounds very helpful. How do I get this benefit?

Panijo kotuwua keretisho kulo omon. Aji aiko payie atum ana reto?

Woman 1: Well, it's not free – you have to pay a X KSh per family member in August, before the rainy season begins. If the rains are poor, they send 1000 Ksh for each person to help pay household expenses.

If you're interested, I can introduce you to the agent who sold us our insurance.

Maara taa pesheu, keyiari nilak ropiyiani X te ltung'ani obo le nkaji Ta lapa le esiet, eng'or ltumuren .tanaa etuesha aitibiraki nikirewakini 1000 te Ltung'ani obo le nkaji payie iasishere te ramat e nkaji. Tanaa iyieu,kaidim atirikoki ltung'ani otimiraka yio Inia ripet

Woman 2: Sounds interesting - I will speak to the agent to learn more.

Keining'o ajo keisupati kulo omon pii-kalo aiparishere ltung'ani omir ripet

Livestock Framing

Woman 1: It has been a tough season - no rain at all. How is the drought affecting your family?

Kotogolo ana ng'amata meti nchan pii , aji eikunita nkolong'/lamei nkang' ino?

Woman 2: We lost half our goats and cattle. It's going to be hard to pay school fees this year, and if the children have any medical expenses we will probably have to sell even more livestock.

Kotuata yio nkiteeng'ata e nkishu o nkineji.kogoliki yio laata e skool tale ari, o si tinimaniki ebisiong'u nkera, kuna kuni suom naatelekunye naake kimir alakie sipitali

Woman 1: Have you heard about the new insurance program? It sends money to your M-Pesa account when droughts strike. We also lost half our goats and cattle, but we'll be able to replace them using the insurance money.

Itining'o ana ripet ng'ejuk? Kereu ropiyiani te simu (M-pesa) nkata e nkolong'. Kotuata yio ntare o nkishu, keikash naa amu kindim taa ainyang'u nkule te nenia *ropiyiani e ripet.*

Woman 2: That sounds very helpful. How do I get this benefit?

Panijo kotuwua keretisho kulo omon. Aji aiko payie atum ana reto?

Woman 1: Well, it's not free – you have to pay a X KSh per goat or X*5 KSh per cow in August, before the rainy season begins. If the rains are poor, they send 1000 Ksh for each goat or 5000 KSh for cow to help revive your herd.

If you're interested, I can introduce you to the agent who sold us our insurance.

Maara taa pesheu, keyiari nilak ropiyiani X te nkine nabo o ropiyiani X te nkiteng' nabo Ta lapa le esiet, eng'or ltumuren.tanaa etuesha aitibiraki nikirewakini 1000 te nkine nabo o si 5000 te nkiteng' nabo payie iramatie mboo ino. Tanaa iyieu,kaidim atirikoki ltung'ani otimiraka yio Inia ripet

Woman 2: Sounds interesting - I will speak to the agent to learn more.

Keining'o ajo keisupati kulo omon pii-kalo aiparishere ltung'ani omir ripet