Sticky Intra-household Resource Allocation in the Face of Technological Change: Evidence from a Framed Field Experiment in Mozambique

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Abstract

Although new agricultural technologies are widely expected to enhance the productivity of rural households, evidence on how households reallocate resources to capitalize on these innovations is limited. To explore how households respond to a profitable, but risky new technology, I conduct a framed field experiment played with maize growing couples that simulates the exchange of labor and income in Mozambican households. When presented with a familiar local maize variety that is relatively insensitive to the wife's labor input, households allocate labor to husbands' maize production fairly efficiently. But when faced with an improved maize variety whose higher returns would induce cooperative households to increase maize labor, couples forego 17% of expected cooperative income. Analysis of husbands' income sharing rules reveals that wives stood to gain just 7% in expected income had they increased their labor as predicted, and in exchange for a 68% increase in their probability of coming away from the game with no income. These results suggest that stickiness in intra-household income sharing may dampen the reallocation of productive resources in households that adopt profitable new technologies. Novel empirical evidence on real life intra-household income sharing from sample communities corroborates key findings from the game.

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1 Introduction

Development institutions and donors have invested billions of dollars in the last decades to develop new varietals of food staples and thus increase agricultural productivity in low income countries. While colossal research efforts have sought to maximize the yield potential and profitability of new varietals, relatively little work studies how households reallocate resources once they have adopted these technologies. Yet inefficiencies in this adjustment process may contribute to widely documented shortfalls in attained yields relative to the potential of new varietals (Paul (2021)).

Recent advances in understanding how households allocate resources when members have different preferences provides some insight as to how households may adjust to new technologies. Cooperative bargaining models predict that households that are able to bargain with full information over all allocation decisions and enforce these costlessly[1] will seamlessly reallocate resources in response to new technologies and, thus, attain a Pareto optimal outcome. However, a growing experimental and empirical literature challenges the implication of cooperative models that households pool income, finding evidence that household members prioritize individual payoffs (Ashraf (2009)) and demand agency over income at the cost of inefficiency (Baland et al. (2024); Buchmann et al. (2025); Udry (1996)).

These findings point to the relevance of non-cooperative bargaining models, which relax the assumptions of perfect information and costless enforcement, to reconcile observed departures from efficiency. Such models suggest that spouses can avoid high monitoring and enforcement costs by individually assuming responsibility for a distinct set of household activities based on socially sanctioned gender roles. The resulting equilibria require minimal coordination insofar as each spouse makes decisions in their own sphere, optimizing subject to the constraint of individual resources (Lundberg and Pollak (1993); Carter and Katz (1997)). Rather than bargain over each allocation decision made by the household, spouses may instead bargain over the terms at which goods and services are exchanged between spheres. In this setting, intra-household resource allocation depends on the complex interplay of the individual and mutual interests of spouses, as well as individual members' expectations and activities (Carter and Katz (1997), pg. 95).

In this paper, I examine how a separate-spheres, non-cooperative bargaining framework shapes couples' ability to take advantage of a new technology that alters the structure of rewards and risk. To do this, I conducted a framed field experiment with 524 couples who grow maize in rural Mozambique. The game setup provided a stylized representation of the gender roles common in many settings in sub-Saharan Africa in which husbands control income from joint agricultural production, while wives, who have some autonomy in allocating labor to their husband's production, control income from their own individual

[1] Manser and Brown (1980); McElroy and Horney (1981); Lundberg and Pollak (1993)

activities and have socially constructed caring and expenditure responsibilities. To play the game, the first mover husband decided how he would share his state contingent maize income with his wife for each possible outcome. The wife then reacted to her husband's income sharing rule by choosing how much labor to allocate to his maize production versus her risk-free outside option. The wife's choice of maize labor determined the probabilities associated with each outcome; though to reflect the unobserved dimensions of wives' work, the wife's choice was hidden from her husband. To conclude, the husband drew from the relevant maize income distribution and payoffs were calculated by enforcing the sharing rule and deducting a fixed expenditure responsibility from the wife's income.

The game was played first with an Old technology and then with a New technology, which differed in their risk-return tradeoffs. The Old technology mimicked the local maize varieties commonly grown by sample households, while the New technology approximated the improved maize varietals that are increasingly available in sample communities, but have seen low levels of uptake.[2] The New technology had greater expected returns to the wife's labor, but given its comparatively high cost, there was a higher probability of earning zero maize income.[3] The characteristics of both technologies were common knowledge. For plausible ranges of risk aversion, cooperative households would have responded to the New technology by increasing the wife's labor to the husband's maize production.

I find that households did not fully exploit the more productive New technology and left significant money on the table. Under the Old technology, households allocated labor rather efficiently, foregoing just 5% of the income that most cooperative households would have obtained. With the New technology, in contrast, households' failure to increase wives' labor supply to maize production caused them to forego 17% of the income that cooperative households would have realized.

Analysis of husbands' income sharing decisions sheds light on households' sticky labor response. Under the New technology, wives who increased their maize labor supply as predicted would have gained just 7% in expected income, or 9% of their household's gain, and in exchange for a 68% increase in their probability of coming away from the game with no income.[4] In fact, husbands' income sharing rules exposed wives to a likelihood of earning zero game payoffs that was 2.5 times greater than that faced by husbands.

These findings are consistent with an interpretation that husbands' adjustments in income sharing in response to the New technology were too tepid to induce an advantageous increase in maize labor from wives. They suggest that stickiness in intra-household income sharing

[2]Upwards of 70% of agricultural households in my study area reports cultivating local or first-generation varieties of maize. One metric of increasing access to improved maize varieties is the 13% annual growth in the release of new maize varieties (Krishna et al. (2021)).

[3]Most sample households do not purchase complementary inputs such as fertilizers, thus seeds represent the primary on-farm investment. The transition from local to improved varieties would require at least a ten- to twenty-fold increase in non-labor input expenditures per hectare planted (from about 4 USD per hectare when local seeds are used to 64–84 USD when improved seeds are used).

[4]All participants received a participation fee.

may dampen the reallocation of productive resources in households that adopt a risky technology with greater returns to labor. Further, these results call into question whether adopting such technologies would be profitable for households in the first place. I calculate that the stickiness of intra-household resources I observe in the experiment would have constrained adoption for technologies with returns on investment as large as 68%.

While the experimental design permits straightforward inference, the stylized setup of the game admittedly comes at some cost as well. In particular, couples could not bargain over income sharing—that is, over the terms at which the wife exchanged her labor. Additionally, husbands could not rely on savings or other sources of income to insure their wives. If communication between spouses or household risk management strategies help husbands to share income in a way that is more advantageous to wives, the results may not generalize. To speak to the external validity of my findings, I provide evidence on the intra-household incentives provided by husband-to-wife income sharing outside the game setting.

Leveraging a novel panel dataset I collect, which is among the first to link real life income transfers to agricultural output, I find that income transfers increase in maize yields for the bottom tercile of the distribution of maize yields and level off for the top two terciles. The shape of the transfer function suggests that when production conditions are normal or good, husbands hand over a fixed amount of income so that wives can meet household consumption needs, but do not otherwise share upside risk. In contrast, when production falters, for example under drought, wives face downside risk as husbands are unable (or unwilling) to transfer income to meet consumption needs. Restricting my sample to households that have adopted improved maize varieties, I find that transfers are an even flatter function of maize yields. While adoption in these households is not exogenous and estimates must be interpreted with some caution, they are suggestive that the stickiness of low labor incentives I document in the experiment are robust.

As I formalize in Jones (2025), the transfer function structure would provide wives little incentive to shift their labor to technologies that improve average returns, but which increase wives' risk exposure. This may be especially true where wives' socially constructed caring and expenditure responsibilities implicate them as the providers of "last resort" in bad years and, thus, generate strong incentives to self-insure. Taken together, these experimental and empirical results suggest that sticky, low labor incentives may provide one explanation for yield gaps and low levels of technology adoption in settings where income sharing incentivizes intra-household cooperation in agricultural production.

My findings engage with three strands of literature. First, I contribute to the literature on intra-household resource allocations, connecting to the vast literature on bargaining within the household (Manser and Brown (1980), McElroy and Horney (1981) and Chiappori (1992)). This is one of a small number of experimental papers to explore how the distribution of consumption within the household affects productive efficiency and which find evidence

of productive inefficiency (Apedo-Amah et al. (2020); Baland et al. (2024); Buchmann et al. (2025)). To my knowledge, this is the first paper in which the risk-return tradeoff that wives face in allocating labor to joint production is made explicit through the elicitation of state-contingent intra-household distributions of income.

Second, I contribute to the literature on risk-sharing within the household (Duflo and Udry (2004), Robinson (2012)). I reject that husbands increase intra-household risk-sharing in response to a New technology that increases the riskiness of joint production, which suggests that stickiness in intra-household resource allocation may prevent households from obtaining Pareto optimality.

Third, I contribute to the literature on the role of intra-household dynamics in technology adoption (Zepeda and Castillo (1997); Gulati et al. (2024)), which has focused on the role of intra-household bargaining power in mediating demand for gender-biased technologies. In this paper, I consider how wives' labor supply decisions can affect the profitability of new technologies, and thus, the decision whether to adopt, even where wives do not explicitly participate in the decision. To my knowledge, this is the first paper to suggest that stickiness in state contingent income transfers can affect the benefits and sustained adoption of new technologies.

The remainder of the paper proceeds as follows. Section II presents the novel evidence on state contingent transfers that motivated the paper. Section III presents theoretical insights as to how the structure of the empirical transfer function may affect wives' labor supply and the profitability of a new technology. Section IV describes the framed resource allocation experiment that is designed specifically to estimate the responsiveness of the intra-household allocation of resources in the face of technological change. Section V presents the effect of adoption of the New technology on wives' labor allocation and the incentives provided by husbands. Section VI analyzes the role of the incentives provided by husbands versus husbands' preferences over their wives' labor allocation in driving wives' response to the New technology. Section VII discusses the relevance of the experimental framing for the technology adoption decision faced by sample households. Section VIII concludes.

2 Setting: Technology Adoption and Intra-household Dynamics

This section provides evidence of the key stylized facts that motivate this paper. First, I describe the organization of small-holder production in Mozambique and its reliance on household labor, and wives' labor in particular. Second, I document the ubiquity and economic importance of husband-to-wife income transfers.

Table 1: Panel survey descriptive statistics

	mean	p50	sd	min	max
Land holdings and maize yield					
Total area cultivated (ha)	5.07	3.0	5.64	0.5	36
Total maize area (ha)	3.29	2.0	3.64	0.0	45
Primary maize plot area (ha)	2.21	2.0	1.89	0.0	18
Maize yield (kg/ha) on primary maize plot	952.90	666.7	867.30	0.0	4000
Maize yield (kg/ha) on primary maize plot | improved maize	1070.28	750.0	947.51	0.0	4000
Maize yield (kg/ha) on primary maize plot | local maize	877.73	600.0	803.64	0.0	4000
Total maize output (kg)	2386.73	1400.0	2922.29	0.0	16200
Non-labor inputs on primary maize plot					
Used improved seed	0.39	0.0	0.49	0.0	1
Improved seed share	0.24	0.0	0.38	0.0	1
Expenditure on improved seed (USD) | used	41.91	11.5	72.60	0.0	310
Used npk/urea	0.04	0.0	0.19	0.0	1
Used irrigation	0.01	0.0	0.10	0.0	1
Labor inputs on primary maize plot					
Proportion of labor supplied by hh	0.72	0.8	0.24	0.0	1
Proportion of hh labor supplied by wife	0.33	0.3	0.23	0.0	1
Proportion of hh labor supplied by husband	0.38	0.3	0.26	0.0	1
Maize importance					
Proportion of income from own crops	0.60	0.6	0.27	0.0	1
Proportion of crop income from maize	0.33	0.3	0.26	0.0	1
Proportion of crop income from maize | > 0	0.41	0.4	0.23	0.0	1
Proportion of primary maize for sale	0.22	0.1	0.26	0.0	1
Proportion of primary maize for sale | > 0	0.39	0.4	0.23	0.0	1
Primary plot kgs for sale	603.34	100.0	1135.81	0.0	6000
Primary plot kgs for sale | > 0	1105.38	500.0	1345.20	4.0	6000
Decision making on primary maize plot					
What to plant generally decided by a man	0.78	1.0	0.42	0.0	1
Which inputs to buy generally decided by a man	0.78	1.0	0.42	0.0	1
Whether to sell generally decided by a man	0.78	1.0	0.41	0.0	1
Annual income and transfers (USD)					
Husband's solely and jointly produced income	641.06	256.0	1153.43	0.0	7693
Total transfers	441.42	304.0	467.75	0.0	2432
Routine household transfers	365.45	288.0	403.16	0.0	2032
Discretionary transfers for infrequent expenses	16.31	8.0	26.76	0.0	160
Total transfers as a share of husband's income	2.96	1.0	5.91	0.0	41
Observations	1025				

Notes: Land holdings, yields, maize output sold, husband's income and transfers are winsorized at the 99th percentile.

2.1 Organization of smallholder agriculture in Mozambique

The insights, presented in this paper, on the role of intra-household income sharing rules in household labor allocation and technology adoption draw on household characteristics and gender norms among rural households in the province of Manica in Mozambique. These data were enumerated by Malacarne et al. (2025) in an annual panel survey, administered from 2022–2024. The panel follows 1,096 maize growing households, which were randomly selected from 80 communities distributed across five districts in Manica.

Table 1 presents descriptive statistics from the 2023 survey, which recalled the 2022/2023 growing season. Average landholdings in the sample are 5 hectares. Maize represents 65%

of cultivated area and is one of the top two highest earning crops for 65% of households. 39% of sample households cultivated an improved variety of maize; however only 24% of the seed planted on the primary maize plot was improved, on average. The remaining 61% of households exclusively cultivated local, open-pollinated varieties of maize, which lack specific genetic modifications designed to increase yields. Notably, these rates of improved maize seed use represent a marked increase from that of the previous growing season, in which only 29% of households planted some improved maize.[5] This increase is attributable in part to the randomized roll-out of a voucher subsidy program in 40 sample villages, studied by Malacarne et al. (2025). Average maize yields are 953 kilograms per hectare, which represents less than 10% of the yields attained by regional seed producers on demonstration plots. The low agricultural productivity of these households is evidently a function of low rates of and partial adoption of improved varieties, minimal use of chemical or animal fertilizers, as well as a near total reliance on rain-fed irrigation.

Table 1 speaks both to the importance of household labor for agricultural production and women's significant contribution of labor to agricultural production. Households supply 72% of all labor employed on primary maize plots. Husbands supply 38% of household labor on the primary maize plot, wives supply 33%, and children and other family members provide the remaining 29%. Despite wives' labor contributions, the data show husbands' control of decisions around agricultural technology adoption and management, more generally. In 92% of households that comprise a husband-wife unit, husbands primarily decided what to plant, what inputs to buy, and whether to sell output for the household's most important maize plot. 53% of married women stated that cash crop farming decisions are taken only by men in their households, while just 5% stated that only women take related decisions in their households.

2.2 Economic importance of transfers

A novel survey module I developed, which elicits detailed information on monetary transfers from husbands-to-wives, was enumerated as part of the Malacarne et al. (2025) panel data collection in 2023 and 2024. The module asks wives to recall three types of monetary transfers they received from their husbands in the previous 12 months: 1) transfers for *despesas de casa*, or routine household expenditures, 2) discretionary transfers not for routine household expenditures, and 3) lump sums that were transferred from relevant sources of the husband's income or husband's and wife's joint production, which may have been used for routine household expenditures or not. The three-part methodology was designed to accommodate multiple models of household finance, including those where husbands frequently provide income for specific expenditures or at the wives' request, as well as models in which wives receive a share of their husband's income, which they manage to cover their expenditure

[5] See Appendix table A1 for descriptive statistics from the 2022 survey round.

responsibilities.

Table 1 reports that wives received transfers of 441 USD annually, on average. This represent 69% of husbands' 641 USD annual income from sole and joint (with wife) income generating activities.[6] A regression of total monthly transfers on month dummies (see Appendix Table A1) provides no statistically significant evidence of seasonality in transfers, though the coefficient on June, the month in which most households first harvest maize, is large and positive, and the coefficient on May, the last pre-harvest month in many households, is negative relative to the January base year.

3 Motivating Evidence and Conceptual framework: Transfers as Incentives

As motivated in the introduction, the broad goal of this paper is to explore how intra-household transfer functions allocate the risk that is inherent to agricultural income to specific members within the household, and how they affect the incentives and benefits associated with technology adoption. In this section, I provide empirical evidence as to how transfers transmit agricultural risk to wives. I link survey data on transfers to household agricultural production to create a novel dataset that enables estimation of the household transfer function. I then present theoretical intuition as to how the incentives embedded in the empirical transfer function affect the intra-household allocation of labor, and thus may contribute to the low adoption of productivity enhancing technologies. To conclude, I present descriptive evidence that suggests that transfer functions are generally indistinct among sample households by level of maize technology, though model predictions indicate that re-optimizing the empirical transfer function would increase productive efficiency.

3.1 Empirical evidence

I exploit cross-sectional variation in maize yields and transfers to estimate the sample-level transfer function. To construct a measure of transfers, I sum transfers that husbands provided for routine household expenditures, or *despesas de casa*, and discretionary transfers not for routine household expenditures. I then obtain the average of this quantity for post harvest months from May to September. As my objective is to link transfers to a particular agricultural season, I exclude the third category of transfers, lump sum transfers, which were elicited as single amounts for the previous 12-month period, and thus, could be attributed to either of two possible agricultural seasons. As I show in Appendix figure A2, however,

[6] Husbands' solely and jointly produced annual income is the sum of annual income from crop sales, livestock sales, running a small business/self-employment, and wage/salary employment. Annual income from each stream was elicited as a single value. These data are very noisy, and as revealed by the fact that the average transfer share is greater than one, appear to under report husbands' income.

the two components of transfers that I do include comprise the majority of transfers in sample households. Finally, I take household-level averages over a five month period only to ensure that the measure averages over the same months each year, even though I do not observe transfers for the same set of months each year. Because transfer data were collected in September 2023 and November 2024, 12-month recall data are missing for October and November 2023.[7]

In focusing on transfers as a function of shocks to maize production, I capture the transfer response to one of the primary sources of income risk for sample households. Maize is the primary crop cultivated by sample households, is the largest source of crop income, and is jointly produced by husbands and wives in 88% of households. Maize yield is not only the primary measure for agricultural productivity, which is the ultimate focus of the intra-household mechanisms I study in this paper, but also a natural proxy for the stochastic component of maize production. Compared to alternative measures such as total maize output or maize income, yields are not mediated by producer decisions regarding the quantity of acreage to be planted in maize, or by price volatility. I attempt to control for other determinants of yields that may be endogenous to transferring behavior, such as input intensity and soil quality.

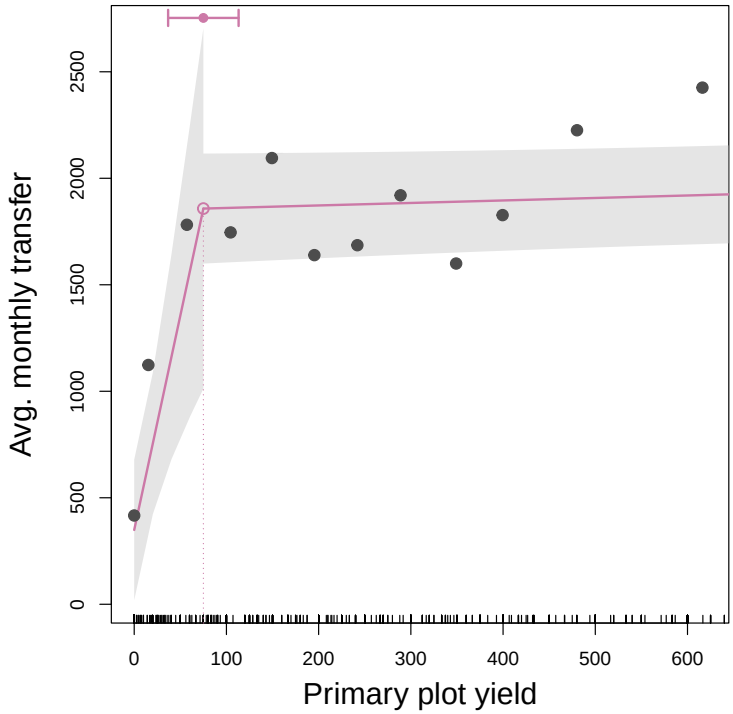
I first model the relationship between transfers and maize yields using a semi-parametric approach, in which transfers are a smooth function of maize yields and linear in other covariates, given uncertainty as to the appropriate functional form. While the existence of private information in the household provides a theoretical prediction as to why we might expect transfers to wives to increase in husband-controlled output—that is, to provide incentives for wives' labor—alternative models of intra-household income sharing may be relevant for Mozambican households. For example, if production is sufficient to meet household food requirements in good years, transfers and yields may be inversely related. Appendix figure A3, which plots predicted values from a quadratically penalized generalized linear model exhibits distinct concavity beginning at approximately the 25th percentile of yields (where log primary plot yield $\approxeq 5$).

To test statistically for a difference in the slope of transfers as yields increase, as well as to identify the breakpoint at which the effect of yield changes, I proceed by fitting a segmented, or broken-line, model in which the relationship between the response and explanatory variable is piecewise linear. The relevant model is

$$\begin{aligned} \text{avg monthly transfer}_{it} = \beta_0 + \beta_1 &\text{primary plot yield}_{it} \\ &+ \beta_2(\text{primary plot yield}_{it} - \psi)_+ + \boldsymbol{\beta_3'}\mathbf{X}_{it} + \epsilon_{it} \end{aligned} \tag{1}$$

[7]Transfer function estimates using average transfers from December through April are not markedly different. See Appendix.

Figure 1: Transfers as a function of primary plot maize yields



Notes: The estimated segmented relationship and 90% confidence interval are plotted. The confidence interval of $\hat{\psi}$ is graphed at the top of the figure. Figure plots bin means of primary plot yield and average monthly transfer, which are top-coded at the 98th percentile, having controlled for non-labor agricultural expenditures per hectare, the number of household adults and children and total land holdings. Sample excludes households in which husbands do not transfer income to their wives, defined as as households in which wives report never having received transfers for routine household expenditures in the past 24 months, and neither discretionary transfers nor lump sums in the past 12 months, though the household reported having normal or very good harvests in the previous two growing seasons.

for household i in survey round t, where $(\text{primary plot yield}_{it} - \psi)_+ = (\text{primary plot yield}_{it} - \psi)\mathbb{I}(\text{primary plot yield}_{it} > \psi)$, and $\mathbb{I}(\cdot)$ is the indicator function equal to one when the statement is true. β_1 is the left slope, β_2 is the difference in slopes and ψ is the breakpoint, which is also estimated. The vector of production and household characteristics, $\mathbf{X}_{it}$, includes non-labor agricultural expenditures per hectare, the number of household adults and children, which determine the size of the household labor force as well as the consumption needs of the household for which transfers provide, and total land holdings, which I use as a proxy for plot quality.

I exclude from analysis the 9.5% of households in which husbands arguably do not transfer income to their wives. These are households in which wives report never having received transfers for routine household expenditures in the past 24 months, and neither discretionary transfers nor lump sums in the past 12 months, though the household reported having normal or very good harvests in the previous two growing seasons.[8]

[8]The remaining sample still retains households in which monthly average transfers were zero. These include

As reported in Appendix table A2, a one unit increase in the yield of the primary maize plot is associated with an increase in monthly transfers of 20 Meticals for primary plot yields less than 500 kg/ha, compared to a 0.12 Metical increase in monthly transfers for yields above $\hat{\psi}$, ceteris paribus. The standard error of the break point is 23.213. Following Muggeo et al. (2008), I implement Davies (1987) test for a change in the slope, which is relevant where the coefficient to be tested, here β_2, depends on a nuisance parameter, here ψ, only under the alternative hypothesis, here of no difference in slope. I find that the difference in slope is highly statistically significant, with a p-value of 0.0003. Figure 1 plots $\hat{\beta}_0 + \hat{\beta}_1 \text{primary plot yield}_{it} + \hat{\beta}_2(\text{primary plot yield}_{it} - \hat{\psi})_+$ in red, as well as the 90th percentile confidence interval of the segmented slopes and the break point.

These estimates suggest that husband-to-wife transfers fail to insure wives against negative shocks to maize output and that benefits to wives from positive shocks to output, in terms of wives expenditures and savings, slow precipitously at a low level of output.

3.2 Theoretical insights on the impact of empirical sharing rules on productive efficiency

I now consider the theoretical implications of the empirical sharing rule for the intra-household allocation of labor, given adoption of technologies that improve average returns, but which increase downside risk due to their capital intensity. I first stipulate a minimum set of assumptions that describe the relationship between agricultural production and risk, which allow me to develop intuition about two distinct effects that the structure of the empirical transfer function portends.

I assume that maize income, Y, is stochastic and given by

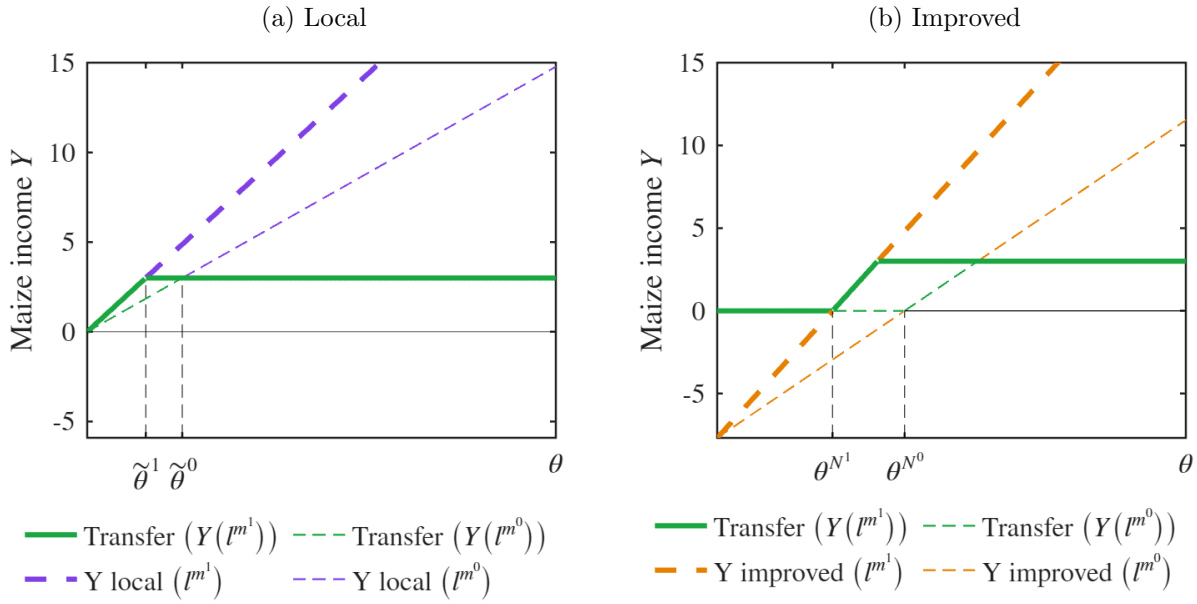
$$Y = A\theta f\left(l^m, T\right) - C. \tag{2}$$

Output is a function of the wife's maize labor, l^m, land, T, technology, A and a continuous, uniformly distributed random variable $\theta \in (0, 2)$. Labor and land are combined according to production technology $f(\cdot)$, which is characterized by non-increasing returns to all inputs. I assume that the household allocates its entire exogenously given land endowment, $\bar{T}$, to production and that adoption of technology A is a binary choice such that households convert all acreage, $\bar{T}$, to its production. C is the cost of the technology, that is, of local or improved maize seeds. I assume that wives are not paid wages for their labor and that there are no land rental markets. The price of output is one.

For local seeds, $A = 1$ and $C = 0$, assuming that local varieties are planted using seed retained from the prior harvest. The yield advantage conferred by improved seeds is

households in which wives reported receiving transfers in the last 13–24 months and in which monthly transfers were nill over the aggregation period. 63% of zero transfer observations are such households, wherein husbands routinely make transfers to their wives.

Figure 2: Stochastic agricultural income and transfers by technology



represented by $A > 1$. Improved seeds are purchased annually, thus $C > 0$.[9]

Figure 2 illustrates the effect of an increase in the cost of the maize varietal on maize income and downside risk. Here and throughout this article, mention of the production downside refers specifically to the subset of downside events in which maize income (or transfer income) are zero.[10] Dashed lines in both panels depict maize income as a function of the random variable, θ. Panel a depicts income from a local varietal for two different labor allocations, l^{m^0} and l^{m^1}. Given its negligible cost, income is non-negative for all θ. Income from the improved varietal, depicted in panel b, is a steeper function of θ due to $A > 1$, but it is shifted down by C. Thus, conditional on adopting improved maize, a better draw of θ is needed in order to recover the investment in seed, and the probability that a household earns zero income is positive for any $A > 1$.

I define a transfer function that is a stylized representation of the empirical transfer function, given by

$$T(Y) = \min\{\max\{0, Y(\theta, l^m)\}, P\}. \tag{3}$$

The wife receives the husband's obligatory transfer, P, except where maize income is less than P, in which case the wife receives the greater of Y, or zero transfers.

Figure 2 illustrates the effect of an increase in the cost of the technology on wives' transfer income, shown in green. In panel a, transfers, like income, are positive even for low levels of the production shock. With the improved variety, in contrast, transfers are positive only for

[9] I assume that seeds are planted in fixed proportion to the land according to a common rule of thumb; thus their cost is fixed conditional on $\bar{T}$.

[10] Downside risk refers more generally to the possibility of realizing a return below the expected return.

$\theta > \theta^N$.[11] Thus, the first key insight obtained from considering an increase in downside risk is that the wife faces an increased probability of receiving zero transfers. For $\theta \in (0, \theta^N)$, she receives less transfer income from the improved varietal than from the local varietal.

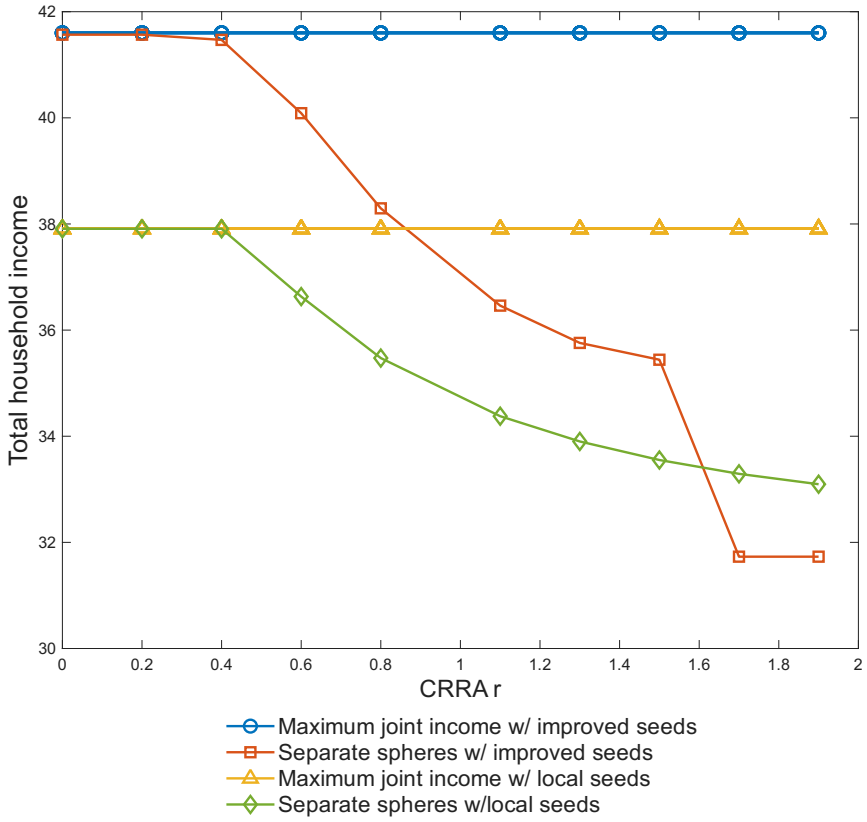
A second theoretical insight is gleaned by considering the interaction of the flat region of the transfer function and the increased probability of high income with the improved varietal. The constancy of transfers over the upside of production implies that the wife derives equal transfer benefits from any production shock that enables her husband to transfer P. Meanwhile, the transfer function provides the wife marginal incentives to increase her labor supply to maize for a narrow range of outcomes. Figure 2 shows that an increase in labor from l^{m^0} to l^{m^1} increases the probability that she receives P (compare $\tilde{\theta}^0$ to $\tilde{\theta}^1$ in panel a), and reduces the probability she receives zero transfers (compare θ^{N^0} to θ^{N^1} in panel b). In summary, for $\theta > \tilde{\theta}$, transfers provide the wife no marginal incentives to increase her labor supply to maize.

I now formalize this intuition for a separate spheres household in which the intra-household transfer of income follows the stylized versions of the empirical transfer function depicted in figure 2. As modeled by Carter and Katz (1997), the separate spheres household is the site of independent preferences and resource allocation decisions. In the Mozambican context, heterogeneous preferences, and especially, attitudes towards risk can be understood as the byproduct of wives' socially constructed responsibility for household reproduction and its related expenditures. The independent resource allocation decisions that distinguish the separate spheres household from the collective model of Chiappori (1992) flow from individual property rights over specific streams of income and individuals' autonomy in allocating their labor. Thus, the separate spheres household doe not pool income. Given the choice to allocate labor to her husband's risky agricultural production versus a safe, but low return activity, the wife's caring responsibilities provide strong incentives for her to self-insure. Though information asymmetries foreclose husbands from contracting the wife's labor directly, income transfers play a key role in inducing her to modify her labor allocation decision, in this case, towards the husband's risky agricultural production.

Theoretical simulation reveals how the stylized transfer function inhibits the household's exploitation of the improved varietal. Figure 3 shows that for constant relative risk aversion greater than 1.6, the wife's labor outlay on improved maize is sufficiently small that total household income is lower than what is obtained cultivating the local varietal. A separate spheres household in which wives have such risk preferences will not adopt the improved technology. Relative to a unitary household that pools income and is equally risk averse, a separate spheres household that shares resources according to the stylized intra-household

[11] The improved varietal is calibrated such that a better productive shock is needed for the husband to transfer his obligatory transfer P than was required under the local varietal. For greater values of A, this need not be the case. Nevertheless, the cost differential between the two technologies will still give rise to states in which wives receive less transfer income from the improved varietal than from the local varietal.

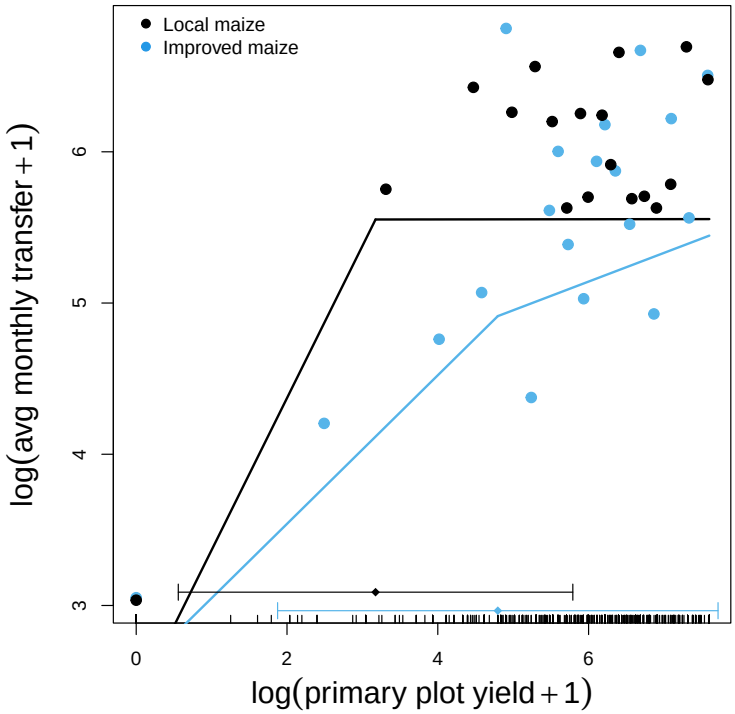
Figure 3: Foregone household income as a function of risk aversion



contract not only attains less income, but also, is relatively further from productive efficiency under the improved technology.

Taken together, these empirical and theoretical results suggest first, that increasing the incentives provided to wives is key to exploiting the productivity of the improved variety; and second, that the decision to adopt improved varietals will hinge on increasing wives' incentives in risk averse households. Given the potential consequences of stickiness in the intra-household contract—that is, of the failure to increase wives' labor incentives—will households adjust the contract upon adopting? I answer this question using a lab-in-the-field experiment that I design to study how intra-household transfer functions and labor adjust with adoption of a productivity and risk increasing technology. Before turning to describe the experiment that is the centerpiece of this paper, however, I briefly return to the Malacarne et al. (2025) survey data to investigate whether households that have adopted improved varieties have also adjusted the incentives provided to wives.

Figure 4: Transfers as a function of maize yields by maize varietal



Notes: The estimated segmented relationship is plotted by maize varietal. The confidence interval of $\hat{\psi}$ is graphed at the bottom of the figure. Figure plots bin means of log-transformed primary plot yield and average monthly transfer, which are top-coded at the 98th percentile, having controlled for non-labor agricultural expenditures per hectare, the number of household adults and children and total land holdings. Sample excludes households in which husbands do not transfer income to their wives, defined as as households in which wives report never having received transfers for routine household expenditures in the past 24 months, and neither discretionary transfers nor lump sums in the past 12 months, though the household reported having normal or very good harvests in the previous two growing seasons.

3.3 Empirical evidence of stickiness in transfer functions

Heterogeneity in the maize production technologies employed by households at baseline provides an opportunity for a preliminary investigation as to whether income sharing responds to a technology-induced increase in labor productivity.[12] 28% of sample households reported cultivating an improved variety of maize on their primary maize plot in 2023. Relative to households who cultivated only local varieties of maize, they obtained yields that were higher by 34% on average, as summarized in table A3 in the Appendix, and spent 31.7 USD per hectare, compared to the 4.9 USD per hectare spent by non-adopters.

Despite the presumed difference in labor productivity across these subsets of households, the relationship between husband-to-wife transfers and maize yield is largely similar. As figure 4 illustrates, transfers in households that cultivate improved maize are an even flatter

[12] Evenson and McKinsey Jr (1999) find that substantial improvement in agricultural productivity was associated with the Green Revolution starting in the late 1960 due to the importation of new, high–yielding seeds and public investment in seed development.

function of maize yields for positive shocks than in households that cultivate local maize. While the proportion of labor supplied by household members to the primary maize plot was 7 percentage points lower in households who cultivated improved maize—a statistically significant difference—the fact that households still provided 69% of all maize labor (see Appendix table A3) suggests that at the scale of production of sample households, the supply of labor to maize ought still to depend on the incentives provided to wives.

The endogeneity of households' choice of technology implies that these comparisons are descriptive, only. Differences in the unobserved characteristics of the two populations may explain the fact, for instance, that stickiness in the transfer function appears not to have constrained adoption for the subset of households that cultivates improved maize. Still, sticky transfer functions may prove binding for sustained adoption, or otherwise erode its benefits, if the tendency to invest less labor I observe among early adopters persists.[13] The experiment that is the centre piece of this paper obviates selection in households' choice of technology and thus enables investigation of whether a technology driven increase in labor productivity induces husbands to re-optimize their sharing rules.

4 Experimental design and procedures

To study the adjustment of the intra-household allocation of resources given adoption of a risky, but profitable technology, I conducted a framed field experiment with 524 maize producing couples in central Mozambique. The experiment featured a within-subjects design wherein all participants receive all treatment conditions. Here, participating couples were exposed to a low productivity technology frame, followed by a high productivity technology frame. By exposing all couples to both frames, the lab-in-the-field game eliminated selection in the adoption decision that may bias group-wise empirical transfer function estimates in section 3.

The experimental sample comprised 28 married couples from each of 20 communities spread across Sussundenga, Vanduzi and Gondola districts in the province of Manica. To construct the sample, I randomly selected 20 of the 40 villages that comprised the Malacarne et al. (2025) sample in those three districts.[14] In each of the 20 villages, the 14 households per village that participated in the panel survey were invited to participate in the experiment on the condition that they were headed by a married couple. Additional married couples were randomly selected from the village lists of maize producers that comprised the Malacarne

[13]It is feasible that improved maize seed is labor augmenting relative to local maize only when combined with fertilizer, whereby the returns to weeding increase. If so, low usage of fertilizer may explain why the labor outlay per hectare is similar across improved maize versus local maize cultivating households. So while credit constraints may be primary, labor constraints may prove binding once households are able to invest improved seeds and complimentary fertilizer.

[14]The full Malacarne et al. (2025) sample comprised 80 communities from five districts. These communities were chosen to maximize the sample's geographic dispersion within Manica province, and thus variation in weather shocks.

et al. (2025) sample frame to yield a total of 28 couples per village. If a couple confirmed that they would not be available to participate on the date of the session that had been scheduled in their community, they were replaced with another household that was randomly selected from the sample frame.

Table A4 in the Appendix provides summary statistics for participating couples. Couples have been married for 23 years and 25.5% are polygynous. They have 5.2 children on average and 74.7% have children under 10 years living in the household. Husbands are 48 years old on average and have 6.5 years of education, while wives are 39.7 years old on average and have 4.4 years of education. 56% of wives report having earned off-farm income in the last 12 months, and 34% report owning part of the household's land holdings solely. Wives report receiving an average of 311 USD annually for routine household expenses, compared to the 350 USD received on average by the 382 wives that comprise the Malacarne et al. (2025) panel and reside in the game districts. Though game participants are 6 percentage points less likely to grow improved maize, they obtained similar maize yields in 2024. Wives who participated in the game are relatively less likely to control agricultural production decisions.

4.1 Intra-household resource allocation game

The experiment was designed to closely mimic the reality of small-scale maize production in Manica, Mozambique. As previously mentioned, maize is the most common crop in the study area and an important source of income for small-scale farmers. Husbands and wives invest similar amounts of labor in maize production, though husbands primarily control maize sales and income. The maize production I simulated in the experimental frames thus provides a natural setting in which to explore intra-household labor contracts. Finally, sample households are generally aware of the existence of high productivity technologies in the context of maize production, namely improved maize seeds, many of which are commercially available in the study area. Study activities were framed using realistic production costs and returns. Participants were told that they had two hectares of land that they would cultivate using the couple's labor exclusively, and that husbands would dedicate their time endowment entirely to maize production.

The decisions taken by couples in the experiments provided a stylized representation of the intra-household contract. Husbands first declared how much of the maize income they would transfer to their wives under each income state, where transfers in each state could not exceed maize income. Wives observed their husband's transfer schedules, but not those of other couples. After observing the transfer schedule, wives then privately made their labor allocation decision. Specifically, wives chose how to allocate their labor endowment of five days per week between their husband's maize plot versus off-farm employment at a local maize mill from which they received a private, risk-free wage.[15] Husbands did not observe

[15] As wives could allocate time to different income generating activities, but not to leisure, income effects are not

Table 2: Old technology frame

Per week		Annual maize revenue (in thousands of Meticals) Weekly maize income									
Wife's Maize Days	Wife's Wage Income	0 0	10k 200	20k 400	40k 800	60k 1,200	80k 1,600	100k 2,000	Expected Maize Income	Unitary CRRA Range	Prop. in sample
2	120	5%	20%	20%	30%	20%	5%	0%	680	$(0.834, \infty)$	0.11
3	80	5%	15%	15%	30%	25%	10%	0%	790	–	
4	40	5%	10%	15%	25%	30%	15%	0%	880	$(-\infty, 0.835)$	0.89
5	0	5%	10%	15%	25%	30%	10%	5%	900	–	

Notes: All financial values given in Meticals per week. One Metical is 0.016 USD.

their wives' labor allocation decisions.

As couples keenly appreciated, good harvests were not guaranteed. Possible maize harvests ranged from zero to 100 or 180 bags of maize, depending on the experimental frame.[16] Maize output was a stochastic function of wives' labor. In particular, the wife's decision to devote 2, 3, 4, or 5 days per week to maize determined the conditional probability distribution of maize income. The greater the number of days a wife chose to allocate to maize production, the greater her husband's expected maize income. After husbands specified their state contingent transfer values and wives made their labor allocation decisions, husbands drew from the relevant maize income distribution. Individual payouts, which enforced the intra-household contract and were a function of each spouse's residual income, were then calculated.

In order to tether within-game transferring to the real life behavior, wives were assigned an expenditure responsibility of 100 meticals ($1.56) per week for household expenses. Wives could use their combined transfer and wage income to satisfy the responsibility. Thus, to calculate wives' payoffs, 100 meticals were subtracted from their total income. This framing was based on survey evidence that transfers for routine household expenditures account for most husband-to-wife transfers in sample households.

4.2 Experimental technological frames

Couples undertook the resource allocation game under two experimental frames. In the Old technology frame, couples cultivated low productivity maize, and in the New technology frame, they cultivated high productivity maize. In what follows, I describe the productivity and cost of both technologies, and highlight key differences between them.

The low productivity maize variety in the first scenario closely approximated open-pollinated, local maize varieties familiar to sample producers. A distinguishing feature of these varieties is that the grain can be recycled as seed, and thus replanted from year to year with no adverse impacts on productivity. The cost of replanting local maize seed is trivial

relevant to the interpretation of my experimental results.

[16] A bag is 50 kilograms of maize.

Table 3: New technology frame

Per week		Annual maize revenue (in thousands of Meticals) Weekly maize income													
Wife's Maize Days	Wife's Wage Income	0 0	10k 0	20k 0	40k 400	60k 800	80k 1,200	100k 1,600	120k 2,000	140k 2,400	160k 2,800	180k 3,200	Expected Maize Income	Unitary CRRA Range	Prop. in Sample
2	120	5%	0%	10%	15%	20%	20%	15%	10%	5%	0%	0%	1,020	$(0.9, \infty)$	0.11
3	80	5%	0%	10%	10%	15%	15%	20%	15%	10%	0%	0%	1,200	–	
4	40	5%	0%	5%	10%	10%	15%	15%	20%	15%	5%	0%	1,440	–	
5	0	5%	0%	5%	5%	10%	10%	15%	15%	20%	10%	5%	1,680	$(-\infty, 0.895)$	0.89

Notes: All financial values given in Meticals per week. One Metical is 0.016 USD.

in real life, and for simplicity, was approximated as zero in the experiment.

The Old technology presented couples the risk-return tradeoff shown in Table 2. The table reports how wives' wage income, along with the probabilities of different maize income states and thus expected maize income, varied as a function of the number of days wives allocated to maize production per week. Maize output could vary from zero to 100 bags of maize (5 tons). As it was assumed that participants would sell all maize at a fixed price of 1,000 MT per bag, the maximum harvest revenue (and income, given zero costs) was 100,000 MT ($1,565). Annual maize income was divided by 50 weeks to yield the weekly gross income states in the table. As seen in the last row of the table, a weekly income of 2,000 MT could be obtained only if wives allocated their full time endowment to maize production.

The improved maize variety, whose introduction in the second scenario constituted an exogenous positive shock to household production, mimicked a bundle of a high-yielding hybrid maize variety and chemical fertilizer. The cost of planting two hectares with 50 kilograms of improved maize seed was 20,000 meticals ($320). Couples were told they would purchase the improved seed on credit from an agro-input dealer who had first claim on output. As such, net maize income in all states was non-negative and voluntary default was not possible. The maximum harvest income was 160,000 MT ($2,560). Under the New technology frame, couples faced the risk return trade-off presented in Table 3. The headers of the New technology outcomes list weekly maize revenue first, and maize income second, equal to

$$(\text{Total maize sale} - 20,000 \text{ in seed costs})/50 \text{ weeks}.$$

The greater number of columns in Table 3 reflects the larger support of maize income under the New technology, and in particular, its greater upside risk.

The technologies differed principally in the following ways. First, the expected returns to an additional day of the wife's labor on maize were greater in the New technology frame for all labor allocations. Thus, the efficiency loss associated with diverting labor from maize production was greater under the New technology. For example, increasing the wife's maize labor allocation from three to four days increased expected maize income by 90 MT (1.44 USD) under the Old technology, and by 240 MT (3.84 USD) under the New technology.

Nonetheless, under the New technology, a better draw of output was needed to earn positive maize income net of the cost of the high productivity maize seed, the second key difference. Specifically, the probability of drawing zero maize income was two to three times greater in the New frame than in the Old, depending on the wife's choice of maize labor (5% versus 15% conditional on allocating two days and 5% versus 10% conditional on allocating five days).

The 40 meticals ($0.64) daily wage paid by the wife's outside option was constant across experimental frames and low relative to the expected marginal revenue product of the wife's labor in maize production, even under the Old technology frame. This parameterization, which reflects the limited outside options available to women in the study area, was intended to make the cost of deviating labor from maize production highly salient under the New technology in particular. Finally, in light of husbands' tendency in the pilot to share just 30% of maize income with their wives on average, the low wage helped to ensure that maize production was still relatively attractive, the purpose of which was to generate sufficient variation in wives' predicted labor choices.

From the tables above, we see that a risk neutral, unitary household that seeks to maximize joint income, and thus allocates labor where its expected marginal return is greatest, would allocate four days of the wife's labor to maize production under the Old technology and five days under the New technology. Under the Old technology, the expected returns to the second, third and fourth days of maize labor exceed wives' outside option; however the household gains less in expectation from allocating the wife's fifth day to maize than the outside option would pay. Under the New technology, in contrast, the expected marginal return from allocating the fifth day of wives' labor to maize production exceeds her wage; thus joint income maximization prescribes allocating the wife's entire time endowment to maize production. Note that in unitary households, the sharing rule declared by the husband has no bearing on the wife's labor allocation decision.

4.3 Predicted maize labor supply given risk aversion

Here, I consider the optimal responses of wives in unitary and separate sphere households who differ in their risk aversion. Convexity in the utility function of risk averse households induces labor allocations that enable income smoothing, at the expense of foregone expected income. Notably, under Old and New technologies alike, the single labor allocation that guaranteed the wife a positive payout, irrespective of her husband's draw, was two days.

Assuming that the unitary household has utility $U(x) = \frac{1}{1-r}x^{(1-r)}$, where r is the parameter of constant relative risk aversion (CRRA), wives in unitary households with $r \in (-\infty, 0.835)$—that is, risk seeking households as well as households that exhibit considerable risk aversion—were predicted to choose the joint income maximizing allocation of labor to maize production, thus increasing labor on maize from four to five days as

technology changed. Wives in unitary households with $r \in (0.835, 0.9)$ were predicted to increase labor on maize from two to five days as technology changed. Finally, wives in unitary households with $r \in (0.895, \infty)$ were predicted to allocate two days to maize under both technologies. The CRRA ranges that correspond to each labor choice are summarized in tables 2 and 3, along with the proportion of participating wives with an elicited CRRA parameter in these ranges.

Were they to belong to unitary households, 89% of sample wives would be predicted to supply a joint income maximizing allocation of labor to maize production, that is four days under the Old technology and five days under the New. The remaining 11% of the sample would keep labor constant at two days across technologies. Thus, the average unitary response to the New technology would be to increase labor to maize by 0.89 days, given the sample distribution of risk.

For wives in separate spheres households, in contrast, intra-household contracts provide key incentives for wives to allocate labor to maize production. To provide a sense of how separate spheres wives who are selfish and differ in their risk aversion would respond to different contracts, I report maize labor allocations for equity contracts that share income at a constant rate. The reference fixed-rate contracts I consider here differ markedly from the debt-like empirical sharing rules I estimate in section 3 insofar as the latter circumscribe wives' benefit from high yield realizations. Nevertheless, the reference contracts below are more parsimonious and thus clearly demonstrate how the transfer incentives embedded in contracts must counterbalance wives' risk exposure.

Under the Old technology frame, wives with $r \in (-\infty, 0.2)$ require a 40% share of maize income in order to increase their allocation to maize from the minimum two days to three days. Wives with $r \in (-\infty, 0.4)$ require a 50% share to allocate four days, while wives with $r \in (0.4, 0.6)$ require a 60% share to allocate four days. Finally, wives with $r \in (0.6, 0.8)$ require a 90% share to allocate four days. For greater risk aversion, maize labor does not increase in the share of maize income that husbands transfer.

That husbands would need to allocate more than half of maize income to wives to obtain a joint income maximizing labor allocation under the Old technology speaks to its low productivity: returns are too meager to compensate husbands well while offering a counterbalance to wives' risk aversion. Rather than offer the contracts that risk averse wives would require, husbands would do better were they to keep all maize income for themselves, and were wives to allocate minimal labor to maize production.

Under the New technology, wives with $r \in (0.0, 0.4)$ require a 20% share of maize income to allocate the joint income maximizing maize labor allocation of five days. Wives with $r \in (0.4, 0.6)$ require a 30% share to allocate five days, and wives with $r \in (0.6, 0.8)$ require a 60% share to allocate five days. Finally, though maize income nearly doubled under the New technology, the substantial increase in downside risk implies that even full control of

maize income would not induce a wife with $r > 0.8$ to allocate more than the minimum two days to maize production.

4.4 Experimental procedures

The field experiment was implemented in November 2024. Sample couples were invited to join one of two game sessions conducted per day, each lasting 3.5 hours. Before introducing the maize production experimental frame, all participants undertook an individual risk preference elicitation exercise that consisted in choosing between two lotteries for five different rounds, where the five pairs were a subset of the Holt-Laury lotteries.[17] Husbands were then asked how much they typically transferred their wives per week in past years with very bad, poor, normal and good maize harvests. Wives responded to analogous questions that elicited amounts they typically received from their husbands per week given the very bad, poor, normal and good maize harvests that their husbands had quantified. Like the 100 MT expenditure responsibility that was specific to wives, the elicitation of average weekly transfers in past years served to encourage husbands to think of within-game transfers as they would transfers outside the game.

The Game Leader then sensitized participants regarding the characteristics of the Old technology, the decisions to be taken by husbands and wives, respectively, and the rules of game play. All instructions were presented in local languages with the aid of a poster board (see Appendix figures A4 and A5) that displayed the possible maize income states, which were color coded, and their associated probabilities for each choice of maize labor. During the instruction for each scenario, participants practiced drawing tokens from four bags, each of which corresponded to a different choice of the wife's labor. Each bag contained 20 colored tokens and each color represented a different maize income. The proportion of tokens in a given color corresponded to the probability distribution of maize income states listed in tables 2 and 3. Couples first played the intra-household resource allocation game under the Old technology frame. Before the game was repeated under the New technology frame, participants received additional information about the characteristics of the New technology.[18] Couples played non-incentivized practice rounds before playing for potential payoffs in each frame.

Following the experiments, participants completed a short survey that elicited information on household demographics, experience cultivating improved maize, recent experience with negative shocks and individual understanding of the game.

[17] See Brañas-Garza et al. (2021) for an assessment of the comparability of risk preferences elicited using five lotteries instead of Holt and Laurie's ten lotteries

[18] I did not randomize the order of the low and high productivity technologies, which implies that couples' behavior in the second scenario may reflect learning in the first scenario. The experimental design is an analogue for households who adopt improved maize seed for the first time, having previously produced local varieties. Indeed, less than one third of study participants cultivate improved maize.

To ensure the anonymity of wives' labor diversion choices, husbands and wives were physically separated for the duration of game play. Enumerators circled between husband and wife to elicit and record each spouse's decision, outcomes and potential payoffs on individual specific game sheets.

To ensure that income effects stemming from winning money early in the game did not affect participant behavior across rounds, participants were informed that their payouts would be based on just one of the two experimental frames, selected at random. Each spouse's net income from the randomly selected frame was divided by 4 to compute cash payouts. Total payouts, including a participation fee of 50 MT per spouse, ranged from 50 MT ($0.78) to 850 MT ($13.30). The average payouts were 260 MT ($4.07) for husbands and 126 MT for wives ($1.97).

The experimental protocol was first tested with graduate students in Davis, California and then in 21 pilot sessions in non-sample villages in Manica, Mozambique.

5 Results

In this section, I present the reduced form effects of adopting the New technology on the wife's labor supply decision and the husband's sharing rule. Together, these estimates isolate the impact of adopting a risky, but profitable agricultural technology on intra-household resource allocation for households who previously cultivated less productive, less risky crop varieties.

5.1 Empirical strategy

To estimate the effects of adopting the New technology on intra-household resource allocation, I estimate the equation

$$\text{outcome}_{isg} = \beta \, \text{New tech}_g + \alpha_{is} + \epsilon_{isg} \tag{4}$$

where the outcome_{isg} of household i from session s in game g is a measure either of the wife's maize labor supply or of the incentives embedded in the contract the husband offers. I define the outcomes in sections 5.2 and 5.3, respectively. New tech_g, the New technology indicator, equals one in the second game. α_{is} is a couple fixed effect.

The research design eliminated selection into the choice of technology by exposing all participants to both Old and New technology conditions. Thus $\hat{\beta}_1$ is an estimate of the effect of adopting the New technology in a household that was first exposed to the Old technology. In low-income settings where many households grow unimproved varieties of key staples and increasing adoption of improved varieties is a key policy objective, this parameter is highly policy relevant insofar as it encompasses the learning households bring from their prior experience.

Table 4: Effect of New technology on intensity of technology adoption and household payoffs

	Days	Unitary payoff	Foregone unitary payoff	Foregone certainty equivalent
	(1)	(2)	(3)	(4)
New tech	0.05	8.54***	3.73***	3.21***
	(0.05)	(0.16)	(0.16)	(0.17)
Old tech mean	3.57	12.55	0.62	0.49
Couple FEs	yes	yes	yes	yes
Observations	1046	1046	1046	1030

Notes: All columns estimated using Ordinary Least Squares with couple fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

5.2 Effect of adopting the New technology on intensity of technology adoption and household payoffs

A natural starting point for my inquiry is to analyze the effect of adopting the New technology on wives' allocation of labor to maize production. The reasoning is that if wives adjust their labor supply in response to the New technology as risk aversion in the unitary model would predict, this would reveal that intra-household sharing rules do not impede households from exploiting the New technology.

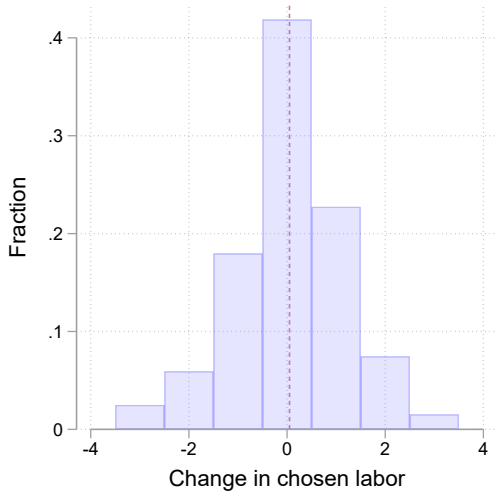
My outcome of interest is the number of days per week, l, that wives allocated to their husband's maize production, where $l \in (2, 3, 4, 5)$. It was assumed that wives would invest l for the duration of the growing season.[19] Table 4 reports that adopting the New technology had essentially no effect on the number of days the wife allocated to maize production. The 0.05 day increase under the New technology is insignificant. In addition, the Mann-Whitney two-sample test fails to reject that the distributions of maize labor are equal across technologies.

While column 2 reports that the average unitary payoff increased significantly by 8.54 USD under the New technology, wives' diversion of 1.4 days from maize production on average was particularly costly under the New technology, given the increase in labor productivity that its adoption connoted. Column 3 quantifies how adoption of the New technology increased inefficiency. Here, $foregone\ unitary\ payoff_{isg}$ is the difference between the expected unitary payoff households would have earned, had they supplied the joint income maximizing allocation of labor in game g, and the expected unitary payoff of household i, given the wife's realized choice in game g. Under the New technology, households forewent 4.35 USD per week in expected unitary payoffs, relative to the 0.62 USD they gave up under

[19] As a robustness check, I also estimate 4 using two-limit Tobit maximum likelihood estimation in Appendix table A5, given that the outcome is censored at the corner solutions corresponding to 2 and 5 days (Wooldridge (2010)).

Figure 5: Wives' chosen labor across technologies

(a)



(b)

			New		
Old	2	3	4	5	Total
2	**26**	24	17	8	75
	34.67	32.00	22.67	10.67	100.00
3	25	**61**	70	22	178
	14.04	34.27	39.33	12.36	100.00
4	20	43	**80**	25	168
	11.90	25.60	47.62	14.88	100.00
5	13	11	26	**52**	102
	12.75	10.78	25.49	50.98	100.00
Total	84	139	193	107	523
	16.06	26.58	36.90	20.46	100.00

Notes: Panel b rows are frequencies and row percents, respectively.

the Old technology. The results of columns 2 and 3 combined imply that households earned 17% less in expected unitary payoffs under the New technology than was possible, compared to the 5% in expected unitary payoffs foregone under the Old technology.

The results in column 3 nevertheless overstate the loss in productive efficiency that is attributable to intra-household incentives insofar as households with CRRA $r_i > 0.835$ were not predicted to choose a joint income maximizing labor allocation. To account for risk aversion, I calculate the certainty equivalent that unitary household i would have associated with the joint income maximizing allocation of labor to maize in game g, using the wife's elicited CRRA r_i; and the certainty equivalent associated with the wife's choice of maize labor in game g. I define the variable $foregone\ certainty\ equivalent_{isg}$, to be the difference between these values. Column 3 reports that on average, households forewent 3.69 USD per week in expected joint income, relative to the 0.49 USD they gave up under the Old technology. This finding suggests that risk aversion alone does not explain wives' failure to exploit the New technology.

The average null effect of adopting the New technology on the wife's labor and the static distribution of labor across technologies mask considerable heterogeneity in wives' labor response, however. The left panel of table 5 shows that while 42% of wives kept their maize labor supply constant across technologies and, thus, behaved consistently with the average treatment effect, 32% of wives increased their maize labor supply, and 26% decreased it. The right panel, which shows wives' New technology labor allocations by their Old technology choices, reveals that the wife's probability of increasing her allocation to maize varied conditional on her choice under the Old technology. The conditional probability

that the wife increased her labor supply to maize was 65% for wives who initially allocated two days, 52% for wives who initially allocated three days, and 15% for wives who initially allocated four days to maize. In short, wives who had greater scope to increase their labor supply to maize were more likely to do so, relative to those who initially allocated more of their time endowment to maize production.

The choices shown in panel b reveal the limited predictive power of the unitary model, as variation in risk aversion in the model would explain just 22% of wives' choices, namely sets (2,2), (2,5) and (4,5). In comparison, no single risk parameter in the unitary model can reconcile the choices made by the remainder of sample wives. The choices of the 26% of wives who decreased their labor supply to maize under the New technology—allocations in the lower left triangle of panel b—are of particular note, given that the New technology was not predicted to engender a decrease in maize labor for any unitary households with CRRA $-\infty < r < \infty$. As summarized in section 4.3, the 89% of sample wives with CRRA $r_i < 0.895$ would have increased their maize labor in response to the New technology, had they belonged to unitary households that pool income, while the remaining 11% of wives would have kept labor constant at two days.

What explains the fact that some wives allocated five days to maize production under the New technology, the joint income maximizing allocation, while others chose allocations that left as much as 8.86 USD in expected income on the table? As husband-to-wife income transfers provide key incentives for wives to supply labor to husbands' agricultural production in a non-cooperative, separate spheres household, I now turn to analyze how adoption of the New technology affected husbands' transferring behavior.

5.3 Effect of adopting the New technology on the husband's provision of contractual incentives

In this section, I analyze how husbands' chosen contracts changed with adoption of the New technology. I focus my analysis on two measures of the incentives that are embedded within the intra-household contract. The first is a measure of the expected transfer incentive husbands provided their wives; the second is a measure of wives' downside risk exposure.

The wife's transfer incentive measures the additional expected transfer compensation that she will receive under the sharing rule her husband selected by increasing maize labor from its minimum value to the joint income maximizing allocation. I define the transfer incentive provided to wife i in game g to be

$$\Delta \mathrm{E}[T(Y)]_{ig} \equiv \sum_{y \in \mathcal{Y}} t_{ig}(y) f_{Y|l_g^m}\left(y \mid l_g^{m^*}\right) - \sum_{y \in \mathcal{Y}} t_{ig}(y) f_{Y|l_g^m}\left(y \mid 2\right)$$

$t_{ig}(\cdot)$ is the transfer of husband i in game g, which is a function of maize income, y. Y is a discrete random variable with conditional probability mass function $f_{Y|l_g^m}$, given the wife's

maize labor supply, l^m. $f_{Y|l_g^m}$ is specific to game g and $\mathcal{Y}$ is the support of Y. As noted in Section 4.2, the joint income maximizing allocation of labor, $l_g^{m^*}$, depends on the maize technology in game g. $l_g^{m^*}$ is four days under the Old technology and five days under the New.

The advantage of the proposed measure is that it indicates how a wife's expected income differs as a function of her possible choices of maize labor, though is independent of her actual choice. In comparison, were I to estimate the effect of the New technology on the wife's expected transfer, $\sum_{y \in \mathcal{Y}} t_{ig}(y) f_{Y|l_g^m}\left(y \mid l_{ig}^m\right)$, I might spuriously conclude from a positive relationship that husbands had strengthened incentives across technologies, though an increase in wives' maize labor would have engendered the same correlation, all else equal.

To make it explicit how increasing maize labor from its minimum value to the joint income maximizing allocation affects the wife's game payout, I define the expected payout incentive provided to wife i in game g to be

$$\begin{aligned}\Delta \mathrm{E}[Z(Y)]_{ig} \equiv & \sum_{y \in \mathcal{Y}} \max\left\{0, w \cdot (L - l_g^{m^*}) + t_{ig}(y) - 100\right\} f_{Y|l_g^m}\left(y \mid l_g^{m^*}\right) \\ & - \sum_{y \in \mathcal{Y}} \max\left\{0, w \cdot (L-2) + t_{ig}(y) - 100\right\} f_{Y|l_g^m}\left(y \mid 2\right)\end{aligned}$$

The wife's payoff, Z, is a random variable that is a composite function of the husband's random maize income, Y. $z(\cdot)$ is equal to the wife's off-farm income, plus her state-contingent transfer $t_{ig}(y)$, less her 100 MT expenditure responsibility; except where this quantity is less then zero, in which case the wife's payoff is zero. w is the wife's off-farm wage and $L - l^m$ is the number of days the wife allocates to off-farm labor. The first term is the wife's expected payoff conditional on allocating $l_g^{m^*}$; the second term is the wife's expected payoff conditional on allocating two days to maize production.

In constructing a measure of the wife's downside risk exposure, I focus on the probability of the event in which she earns zero payoff, arguably the most salient of downside events. Recall that for the wife to earn a positive payoff, her combined transfer and wage income had to be greater than her 100 MT expenditure responsibility. I consider how the probability of this event, A, changes as the wife increases her maize labor supply from two days to the joint income maximizing allocation, $l_g^{m^*}$. I define the downside risk exposure of wife i in game g to be

$$\Delta P(A)_{ig} \equiv P(t_{ig}(y) + w \cdot (L - l_g^{m^*}) - 100 \leq 0 \mid l_g^{m^*}) - \ P(t_{ig}(y) + w \cdot (L-2) - 100 \leq 0 \mid 2).$$

Under Old and New technologies alike, allocating two days to maize production implied that the wife would earn a positive payoff with probability equal to one, given that $w \cdot (L-2) = 120 > 100$. It follows that the second term in the definition is equal to 0 for all

Table 5: Effect of New technology on the transfer incentive, income incentive, and downside risk exposure associated with increasing labor from 2 days to joint income maximizing l^{m^*}

	ΔE$[T(Y)]$ USD (1)	ΔE$[\Pi^w(Y)]$ USD (2)	$\Delta P(A)$ (3)
New tech	1.68***	1.17***	0.10***
	(0.07)	(0.07)	(0.01)
Old tech mean	0.83	-0.38	0.14
Couple FEs	yes	yes	yes
Observations	1048	1048	1048
R^2	0.72	0.68	0.73

Notes: All columns estimated using OLS with couple fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

wives.[20] As the wife increased her maize labor outlay and her wage income decreased, she required more transfer income to earn a positive payoff in expectation. Still, because each technology exposed households to some uninsurable risk, with $P(Y = 0) = 0.05$ under the Old technology and $P(Y = 0 \mid l) \geq 0.10$ under the New, this implied that $P(t_g(y) = 0) \geq 0.05$ under the Old technology and $P(t_g(y) = 0 \mid l) \geq 0.10$ under the New technology.

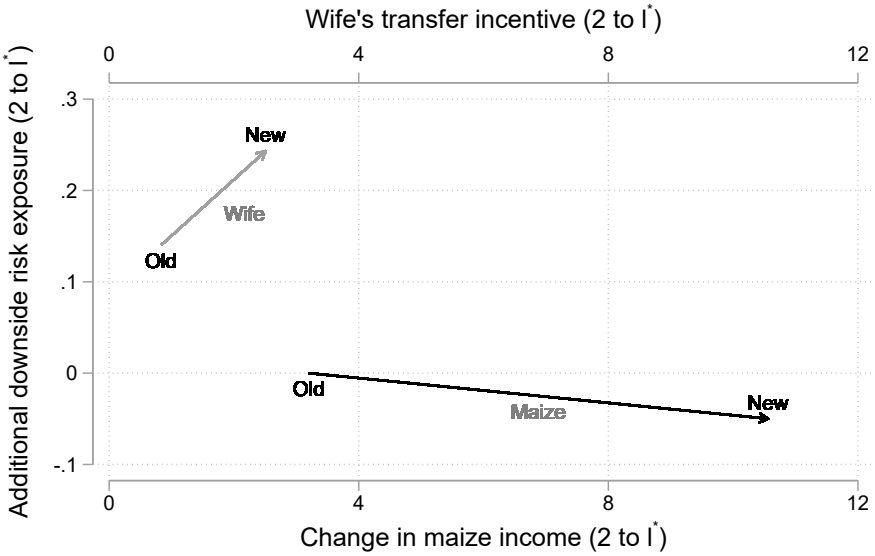
In table 5, I present estimates of the effect of adopting the New technology on the expected transfer incentive, expected income incentive and downside risk exposure that wives would have faced had they shifted their maize labor allocation from two days to the joint income maximizing allocation. Column 1 reports that wives' expected transfer incentive increased significantly by 1.68 USD with the New technology, an increase of 102% relative to the 0.83 USD average transfer incentive that husbands provided under the Old technology. Having accounted for the off-farm income wives forewent in shifting maize labor to l^{m^*}, wives stood to gain 0.79 USD from such a shift under the New technology.[21] In exchange for this modest increase in expected payoffs, supplying the joint income maximizing allocation of labor would have exposed wives to a 10 percentage point increase in wives' downside risk, as reported in column 3. While under the Old technology, increasing maize labor from two to four days exposed wives to a 14% probability of earning zero payoff, wives who increased their maize labor outlay from two to five days under the New technology were exposed to a 24% probability of earning zero payoff. Thus, New technology contracts increased the downside risk associated with choosing the joint income maximizing labor allocation by 71%.

To provide a sense of how far husbands went to incentivize their wives relative to the

[20] I retain the second term in the definition of wives' risk exposure to emphasize that it's construction is analogous to wives' transfer incentive. These measures communicate how the wife's risk-return tradeoff would change were she to allocate l^{m^*} days, rather than the minimum two days to maize production.

[21] Notice that under the Old technology, wives' expected payout would have decreased by 0.38 USD with a joint income maximizing shift of labor.

Figure 6: Comparison of wives' mean risk-return tradeoff versus the technology



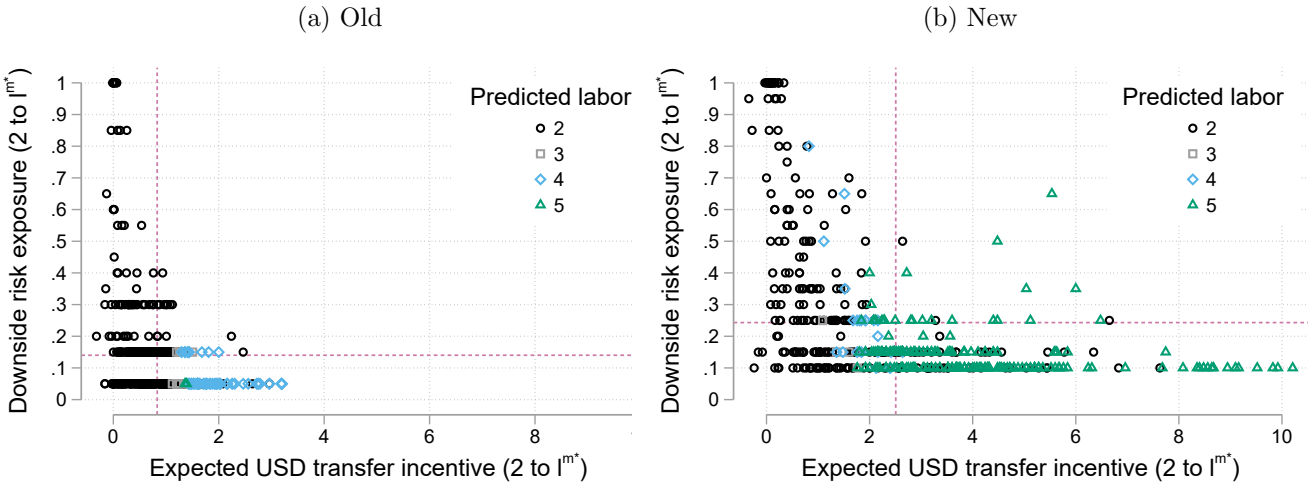
levers available to them, figure 6 relates these effects to the increased incentives that the New technology offered husbands. The return to shifting labor from two days to the joint income maximizing allocation increased for husbands by 7.04 USD with the New technology. Thus, in increasing wives' incentives by 1.68 USD on average, husbands transferred their wives 24% of the productivity gains that would have accrued to them in expectation.

In terms of risk-sharing, husbands chose contracts that exposed wives to more risk when shifting labor to the joint income maximizing allocation than what they personally bore. Under the Old technology, husbands faced a 5% chance of earning zero maize income, no matter their wife's choice of labor. So for wives to have faced the observed 14% average probability of receiving zero payoff had they allocated four days of labor to maize, husbands would have had to share 60 MT (0.96 USD) or less with 9% probability in states where they would have earned at least 200 MT (3.2 USD).[22] Similarly, under the New technology, wives faced a 24% probability of receiving zero payoff when allocating five days of labor to maize, though husbands had just a 10% chance of earning no maize income. That New technology contracts exposed wives to 2.4 times the downside risk that husbands faced suggests that husbands had limited understanding of the potential for relatively large transfers in bad states to substitute proportionate transfers in good states as a strategy for incentivizing wives' labor supply.

Summarizing these results, though husbands increased wives' incentives significantly under the New technology, they shared less than a quarter of wives' marginal product with

[22]See Appendix figures A6 and A7 for the distribution of wives' payoffs for each possible realization of maize income by technology.

Figure 7: Wives' risk-return tradeoff by technology and predicted maize labor supply



Notes: Predicted labor choices are the expected utility maximizing allocation for wife i, given the contract her husband offered and the wife's elicited CRRA parameter, r_i. Dashed lines denote the mean values of the x and y axes.

them. Meanwhile, the contracts husbands provided would have been ineffective at insulating wives from risk, were they to supply the join income maximizing allocation of labor. In fact, uninsurable risk—that is the downside risk inherent to the technology—accounted for less than half of the total downside risk wives bore under either technology. These findings are consistent with an interpretation that husbands' contractual response to the New technology was too tepid to induce a joint income maximizing increase in maize labor from wives.

While tepid on average, husbands' responses to the New technology varied considerably and thus offer an obvious potential explanation for wives' heterogeneous responses to the New technology. Panels a and b of figure 7 depict how contracts varied along two dimensions: the expected transfer incentives they provided, $\Delta \mathrm{E}[T(Y)]_{ig}$, plotted on the x axes, and the downside risk to which wives were exposed, $\Delta P(A)_{ig}$, plotted on the y axes. Variation in the risk-return tradeoffs that husbands offered wives increased markedly under the New technology. The figure shows a shift in mass from contracts that offered an average of 0.83 USD in transfer incentives under the Old technology to 2.5 USD under the New technology; and from contracts that were associated with 14% downside risk exposure under the Old technology to 24% downside risk exposure under the New technology.

Later in section 6, I will investigate whether variation in husbands' response to the New technology seems to be the mechanism driving wives' heterogeneous responses.

5.4 Effect of New technology on the wife's predicted maize labor supply

In this section, I conduct a thought experiment in which I identify the optimal maize labor allocations that wives would have chosen had they allocated labor in accordance with the separate spheres model of the household. This exercise translates the information

Table 6: Effect of New technology on wife's predicted maize labor supply

	Predicted choice | sharing rule$_i$, r_i (1)	Predicted choice | sharing rule$_i$, $r = 0$ (2)	Predicted choice | sharing rule$_i$, $r = 0.8$ (3)
New tech	1.11***	1.44***	0.49***
	(0.07)	(0.07)	(0.05)
Old tech mean	2.28	2.43	2.03
Couple FEs	yes	yes	yes
Observations	1048	1048	1048
R^2	0.67	0.70	0.57

Notes: Columns 1–3 estimated using OLS with couple fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

embedded in chosen intra-household contracts into the maize labor allocations that they were predicted to have incentivized. By comparing the predictions that result from different parameterizations of wives' utility functions, it is possible to discern for whom contracts were predicted to have been effective. In addition, this analysis will facilitate a one-to-one comparison of predicted and observed labor allocations, which is essential to determine whether stickiness in husbands' behavior mirrored the sticky labor response I estimate for wives.

To generate wives' predicted labor allocations, I identify the labor choice that would have maximized the expected CRRA utility of wife i, given the transfer function her husband declared in game g. I assume that wives are selfish and, therefore, consider only their individual income and payouts. I generate predicted allocations for three different parameterizations of wives' utility functions: 1) assuming wives are homogeneous risk neutral with $r = 0$; 2) assuming wives are homogeneously risk averse with $r = 0.8$; and 3) assuming wives have heterogeneous CRRA parameter r_i, whose elicitation I describe in section 4.4. To back out the CRRA parameter, I identify the first set of lotteries in which the wife preferred the riskier of the two lotteries. I construct the interval of r for which the wife would prefer the riskier lottery, but not prefer the riskier lotteries of earlier sets. I then use the middle point of the CRRA range associated with each choice, assuming that $r_i \in (0, 3.5)$. Wives have an average CRRA of 0.44, and husbands have an average CRRA of 0.41.

I present the effect of the New technology on wives' predicted maize labor allocations given these three parameterizations of wives' risk aversion in table 6. As the effects in table 5 foreshadowed, New technology contracts were predicted to have been particularly attractive for risk neutral wives. Column 2 reports that such wives were predicted to increase their

maize labor from 2.43 days under the Old technology to 3.87 days under the New technology, a 59% increase. Accounting for wives' elicited risk aversion in column 1 dampens the average predicted response to the New technology: wives were predicted to increase maize labor by just 1.11 days relative to their predicted Old technology maize labor supply of 2.28 days. Importantly, average contracts were not predicted to induce a joint income maximizing labor allocation from wives under either technology, for any CRRA parameterization I consider. That this holds even for risk neutral wives speaks to the limited benefits conveyed by observed contracts, as the stark inequality of risk exposure that characterized the average contract would not have disincentivized them.

Returning now to the central question of this paper, the evidence presented so far suggests that sharing rules do matter for households' exploitation of the profitable, but risky New technology. On average, wives allocated one day less to maize production under the New technology than the mean unitary model prediction of 4.7 days, and at a cost of 13.5% of expected household payouts.[23] Wives' diversion of labor from maize would appear to have its cause in the finding, presented here, that husbands failed to provide incentives that were predicted to induce more than 3.4 days of maize labor among separate spheres wives. Husbands' propensity to share just 24% of the gains that would have accrued to them had wives supplied a joint income maximizing allocation of labor reveals stickiness in husbands' response to the New technology, as this fraction was essentially unchanged across technologies. In a word, husbands did not adjust their residual claim to maize income in line with intra-household parity, or in proportion to wives' contribution to maize production. Finally, husbands failed to minimize the insurable risk embedded in contracts even as uninsurable risk increased with the New technology.

5.5 Implications of the wife's labor supply and the husband's provision of contractual incentives for adoption

In this section, I use the experimental results regarding the wife's maize labor supply and the contractual incentives provided by the husband to understand whether the household would have adopted the New technology, given the choice. Second, I calibrate the adoption cost that households would need to face in order for the observed stickiness in incentives and maize labor supply to explain non adoption.

In column 1 of table 7, I report how the husband's average expected payoff, $E[\Pi^h]$, changed as a result of having adopted the New technology. The payoff of husband i in game g depended on his wife's choice of maize labor, and the husband's transfer function $t_{ig}(Y)$. The reported increase in the husband's average expected payoff under the New technology

[23] The cost of wives' diversion of labor from maize would have been 27% of expected household payouts, had it been guaranteed that households would be paid out from the second game, which, as it were, had a 50% chance of determining payouts.

Table 7: Effect of New technology on husband's expected payoff and certainty equivalent

	$E[\Pi^h]$ USD	Certainty Equivalent^h USD
	(1)	(2)
New tech	6.78***	6.18***
	(0.20)	(0.19)
Old tech mean	9.29	8.39
Couple FEs	yes	yes
Observations	1046	1044

Notes: All columns estimated using OLS with couple fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

implies that a risk neutral husband would have adopted, given the choice.

To account for risk aversion, I calculate the certainty equivalent that husband i would have associated with game g, given the wife's choice of labor and the husband's elicited CRRA r_i. The positive coefficient reported in column 2 suggests that the husband's expected utility increased on average with adoption and that he would have adopted, given the choice. Given that the return on investment in the New technology was 335% when factoring in the household-specific intensity of adoption, it is not surprising that the average husband is expected to have adopted.

To understand how costly the New technology would have needed to be for observed contracts and labor decisions to constrain adoption, I calibrate the cost of improved maize seeds such that husband i would be indifferent between the Old and New technologies. Given that I do not observe the wife's maize labor supply for different adoption costs, I assume that her observed New technology allocation is invariant to an increase in the adoption cost. This assumption is akin to stating that the wife's decision is unaffected by an increase in the probability of receiving zero transfers and a decrease in her expected transfer. Insofar as a worsening of the wife's contract through an increase in the cost of the technology is expected to result in a reduction in her maize labor supply, the resulting calibrations represent an upper-bound of what the adoption cost would need to be for husbands to be indifferent between adopting and not adopting the New technology.

I find that the cost of adoption would have needed to be 911 USD, or 185% greater than the 320 USD adoption cost used in the game. Even with this large increase in cost, indifferent households would have obtained a large return on investment, equal to 68%. This implies that for technologies with more modest returns, such as those obtained by sample households who cultivate improved varietals, the mechanism I study experimentally is predicted to constrain adoption.

6 Mechanisms

In this section of the paper, I investigate the extent to which husbands' choices seem to drive wives', and thereby seek to relate the rather sticky effect of the New technology on the contractual incentives husbands provided to its sticky effect on wives' maize labor supply. Whereas the individual responses of both spouses are experimentally identified, wives' responses to the contracts their husbands provided are presumably endogenous. Nevertheless, because my within-subjects design allows me to observe households under two treatment conditions, I am able to control for the time invariant household unobservables that might bias my analysis.

I start by analyzing the relationship between the contractual incentives husbands provided and wives' maize labor allocations. I then analyze the relationship between husbands' preferred labor allocations and wives' chosen allocations.

6.1 The effect of contractual incentives on wives' maize labor supply

So far we have seen that in response to the New technology, wives increased their labor on maize less than the 0.89 days predicted under the unitary model, when accounting for the sample distribution of risk aversion. How did the predictions of the separate spheres model perform in comparison, given wives' observed contracts? Notably, wives' 3.65–day average New technology allocation nearly coincided with the 3.38–day average New technology prediction. That wives' average labor allocation did not change across technologies, even as the predicted allocation increased by 1.114 days for wives with heterogeneous CRRA parameter r_i, implies that wives generally "over" allocated labor to maize under the Old technology. In fact, panel a of table 8 shows that 77% of wives allocated more labor to maize than predicted under the Old technology. This large discrepancy is driven by the 66% of wives who allocated three or four days to maize, though 85% of wives were predicted to have chosen two days.

While the apparent misalignment of wives' chosen and predicted maize allocations would seem to suggest that husbands' decisions do not drive wives', this interpretation is premature for the following reason. Though the separate spheres model predicts that wives will increase their labor as husbands strengthen contractual incentives, this need not imply that households in which incentives are strongest are those in which wives allocate the most labor to husband-controlled crops. For example, husbands may provide weaker incentives if their wives are altruistic towards them, or if they can leverage non-monetary incentives in household bargaining, such as coercion. Such unobserved household characteristics may explain the lack of correlation between chosen and predicted values across households.

I address this source of bias by relying on within-household variation to estimate the effect of the contractual incentives husbands provided on wives' maize labor allocations. I estimate

Table 8: Predicted versus observed labor choices

(a) Old

Predicted labor	Wife's choice 2	3	4	5	Total
2	58	148	148	89	443
3	2	5	4	3	14
4	14	25	15	10	64
5	1	0	1	0	2
Total	75	178	168	102	523

(b) New

Predicted labor	Wife's choice 2	3	4	5	Total
2	43	71	105	51	270
3	0	1	3	0	4
4	3	3	10	7	23
5	38	64	75	50	227
Total	84	139	193	108	524

Notes: Predicted labor choices are the expected utility maximizing allocation for wife i, given the contract her husband offered and the wife's elicited CRRA parameter, r_i.

the effect using both couple-level fixed effects and correlated random effects 2-limit Tobit maximum likelihood estimation in table 9. While the Tobit model imposes the assumption of random effects in a panel setting, the CRE model admits correlation in errors. I account for household-level unobservables by including household-level averages of reported independent variables in all specifications.

Columns 1 and 2 report that the relationship between wives' labor allocation and both the transfer incentives and downside risk exposure that are embedded in their contracts is not statistically significant.[24] While the weakly positive effect of an increase in wives' transfer incentives is consistent with the separate spheres model, the large positive coefficient on downside risk exposure, if insignificant, is perplexing. It suggests that the average partial effect of increasing the probability of zero payout from zero to 100% is 0.3 (Tobit coefficient $0.30 \times .994$ scale factor). In robustness checks, I show that alternate measures of the contractual incentives that describe the structure of the transfer function, but do not account for the conditional probability density of each outcome, are similarly poor predictors of wives' maize labor allocations (see Appendix table A6).[25]

The fact that within-household variation in contractual incentives only weakly predicts wives' maize labor supply contradicts the key prediction of the separate spheres model. It is possible that observed changes in contractual incentives, however heterogeneous, were simply too inconsequential to induce changes in wives' behavior. Nevertheless, wives' seemingly discrepant behavior across technologies—deviating from predicted allocations under the Old technology, but not, on average, under the New—suggests a second explanation: that wives' decisions were constrained in the first game, but not in the second. In fact, comparison of columns 3 and 4 in table 9 shows that wives' transfer incentives were positively related to their maize labor allocation under the New technology, but not the Old. This suggests that

[24] See Appendix figure A8 for graphical support for this result.

[25] These measures differed from $\Delta \mathrm{E}[t_{ig}(Y)]$ and $\Delta P(A)_{ig}$ in that they could be readily observed by wives when consulting their husband's transfer schedule.

Table 9: Effect of contractual incentives on wife's maize labor supply

	Linear Fixed Effects (1)	Correlated Random Effects 2-Limit Tobit (2)	Old (3)	New (4)
ΔE$[T(Y)]$	0.02	0.04	-0.06	0.08
	(0.02)	(0.03)	(0.12)	(0.05)
$\Delta P(A)$	0.29	0.30	-0.57	0.06
	(0.21)	(0.31)	(0.57)	(0.36)
Controls	no	no	yes	yes
Session FEs	no	no	yes	yes
Couple FEs	yes	yes	no	no
Observations	1046	1047	508	508
Log likelihood		-1608	-705	-692
Scale factor		0.994	0.996	0.995

Notes: Column 1 is estimated using Ordinary Least Squares with couple fixed effects. Column 2 is estimated using Correlated Random Effects 2-limit Tobit MLE. Household-level means of independent variables are included but not reported. Columns 3–4 are estimated using 2-Limit Tobit MLE with session level fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

wives were better able to respond to the incentives their husbands provided under the New technology.

6.2 The effect of husbands' preferences on wives' maize labor supply

In this section, I investigate whether husbands' preferences over their wives' labor allocations to maize help to explain wives' chosen allocations and the contractual incentives husbands provided. Husbands' preferred allocation was elicited in private in response to the question "If you could decide how many days your wife works in maize production, how many days would you choose?" The question was posed to husbands after each practice round and before they declared their final contracts. Thus it nudged husbands to think carefully about the contracts they offered. The question was repeated in Old and New frames. Husbands responses were not disclosed to their wives or other participants.

Husbands' average preferred allocation nearly coincided with wives' average chosen allocation under both technologies. As reported in Appendix table A7, wives chose 3.6 days under the Old technology, compared to the 3.5 days husbands preferred; and 3.65 days under the New technology, compared to the 3.74 days husbands preferred. What's more, table 10 reports that within-household variation in husbands' preferred allocations is a significant predictor of wives' labor choices. The average partial effect of a one day increase in the husband's preferred maize labor allocation is a 0.2 day increase in the wife's chosen allocation (or a 0.312 day increase using two-limit Tobit maximum likelihood estimation).

Table 10: Effect of husband's preferred allocation on wife's maize labor supply

	Linear Fixed Effects	Correlated Random Effects 2-Limit Tobit
	(1)	(2)
Husband's preferred labor	0.20**	0.31**
	(0.07)	(0.11)
Couple FEs	yes	yes
Observations	924	940
Log likelihood		-1409
Scale factor		0.995

Notes: Column 1 is estimated using Ordinary Least Squares with couple fixed effects. Column 2 is estimated using Correlated Random Effects 2-limit Tobit MLE. Household-level means of independent variables are included but not reported. Standard errors in parentheses are clustered at the session level. Husband's preferred labor is missing for 107 observations for whom the quantity was elicited as per the experimental protocol. * p < 0.10, ** p < 0.05, *** p < 0.01.

Thus, barring the possibility of rampant collusion within couples, it appears that husbands' and wives' understanding of how best to allocate labor followed a similar arc as technology changed, at least in households in which the husband's preferences changed across rounds.

Given that within-household variation in husbands' preferences strongly predicts wives' chosen maize allocations, but variation in transfer incentives does not, it would seem that transfers have limited scope to improve intra-household coordination. However, just as wives' maize labor outlay was increasingly correlated with transfer incentives under the New technology, so too were husbands' preferences increasingly correlated with the transfer incentives they provided under the New technology. Table 11 reports that the partial effect of the husband's preferred labor allocation on the transfer incentive he provided is one order of magnitude larger under the New technology (0.15) than under the Old (0.032), though still insignificant.

What motivated those husbands who preferred greater outlays of maize labor to offer their wives more in the way of transfer incentives under the New technology? And was this effort not superfluous, given wives' propensity to supply labor in accordance with husbands' preferences? I approach the first question by regressing husbands' transfer incentives on their preferred allocation, with and without household fixed effects. As the couple fixed effect estimator is estimated only for those husbands whose preferred allocations varied across technologies, comparing the fixed effects estimate to the OLS estimate helps to identify which subset of husbands drove the increasing alignment under the New technology that I describe above. Column 4 reports that within-household variation in husbands' preferences strongly predicted variation in the contracts they provided. As it appears that it was husbands who changed their preferred allocation across technologies who drove the increased alignment of

Table 11: Effect of husband's preferences on expected transfer incentive by technology

	Old	New	Across	Within
	(1)	(2)	(3)	(4)
Husband's preferred labor	0.03	0.15	0.18**	0.32**
	(0.04)	(0.11)	(0.07)	(0.11)
Mean outcome	0.83	2.50	1.66	1.67
Controls	yes	yes	yes	no
Session FEs	yes	yes	yes	no
Couple FEs	no	no	no	yes
Observations	457	451	911	926
R^2	0.25	0.23	0.12	0.48

Notes: All columns estimated using OLS with session fixed effects. Standard errors in parentheses are clustered at the session level. Control variables including wife's game comprehension, frequency of transfers for domestic expenses, wife's off-farm income sources and land ownership, importance of maize as a portion of household income, cultivation area, maize yield, use of improved maize seed, days of hired labor, gender of primary decision-maker with regard to maize sales, whether the 2024 harvest was reported to be bad, as well as demographic controls are included in all regressions, but not reported. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 12: Effect of transfer incentives and husbands' preferences on wives' maize labor supply

	Days
	(1)
ΔE[$T(Y)$]	-0.16
	(0.11)
Husband's preferred labor	0.11
	(0.08)
ΔE[$T(Y)$]$\times$ Husband's preferred labor	0.05
	(0.03)
Mean outcome	3.61
Controls	no
Session FEs	no
Couple FEs	yes
Observations	924
R^2	0.68

Notes: Regression estimated using OLS with couple fixed effects. Standard errors in parentheses are clustered at the session level. * p < 0.10, ** p < 0.05, *** p < 0.01.

preferences we see in the full sample, this seems to suggest that the 60% of husbands who updated their preferred allocations across games recognized the instrumental role of wives' contractual incentives in obtaining their desired allocations.

As regards the second question—were husbands' efforts to better align their preferences and contracts in vain?—I find weak evidence, presented in table 12 that in the subset of households where husbands' preferred allocations changed across technologies, transfer incentives and husbands' preferred allocations had a complementary positive effect on wives' labor allocations. That is to say that the partial effect of incentives on wives' labor allocation, $\partial l/\partial income\ incentive = -0.16 + 0.05\ husband's\ preference$ is positive so long as husbands' preferred maize labor allocations is greater than 3.2 days.

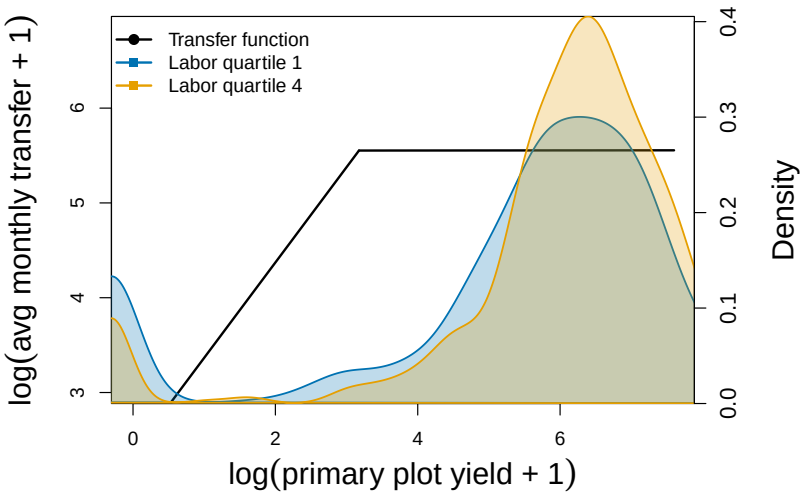
Summarizing, improvements in the contractual incentives provided by husbands were not significant predictors of changes in their wives' labor supply to maize production. In marked contrast, increases in husbands' preferred maize labor allocations significantly predicted increases in their wives' labor allocations. As husbands' preferences themselves had little relation to the incentives they provided, wives' compliance with husbands' preferences ostensibly precluded them from responding to contractual incentives as the separate spheres model predicted.

Nevertheless, for the 60% of husbands whose preferred allocations changed with the maize technology, larger increases in their preferred allocations were significantly associated with larger increases in the incentives they provide. This suggests that this subset of husbands appreciated the role of incentives in eliciting their preferred allocations of maize labor. But insofar as the wives of these husbands were less responsive to incentives than other wives, a mismatch may exist between husbands' comprehension and wives, or husbands' responsiveness and wives'.

7 Relevance of Experimental Framing

While the experimental approach adopted in this paper provides a clean test of intra-household efficiency within the experiment, a drawback is that the game setting is somewhat stylized. In particular, the key differences in the Old and New maize technologies—namely, the greater possibility of earning zero maize income under the New technology and its greater returns to labor—may not accurately characterize the difference in local and improved varieties of maize available to sample households. If not, then the decisions of game participants in terms of incentivizing wives' labor to exploit the New variety may be of limited real life consequence for households who adopt improved varieties of maize. In this section, I attempt to demonstrate that the stylized differences in the game technologies reasonably approximate the differences in local and improved maize varieties cultivated by sample households.

Figure 8: Conditional distribution of wife's labor incentives by quartile of maize labor outlay



Notes: The transfer function plots fitted values from the segmented regression $\log(\text{avg monthly transfer}_{it}+1) = \beta_0 + \beta_1 \log(\text{primary plot yield}_{it}+1) + \beta_2(\log(\text{primary plot yield}_{it}+1) - \psi)_+ + \boldsymbol{\beta_3'}\mathbf{X}_{it} + \epsilon_{it}$. Primary plot yield and average monthly transfer are top-coded at the 98th percentile. Sample is constrained to households that cultivate improved maize and excludes households in which husbands do not transfer income to their wives.

Appendix figure A9 plots the distribution of primary plot maize income by technology and quartile of total labor hours invested in the primary maize plot. The improved maize distributions have greater mass associated with negative incomes relative to the local maize distributions, which suggests that households that cultivate improved maize are exposed to greater downside risk insofar as they face a greater probability of earning non-positive income. In addition, the distribution of maize income for households with fourth quartile labor allocations[26] have greater mass associated with large incomes than do the distributions associated with first quartile labor allocations. As the returns to labor are greater for improved varieties, the figure shows that maize income is highest in households that have adopted improved varieties and have larger labor outlays.

Finally, I assess how the rightward shift in the distribution of improved maize yields affects the labor incentives provided by the empirical transfer function. Figure 8 shows that in households that cultivate improved maize, the probability mass coincides, by and large, with the flat region of the transfer function, which provides wives negligible marginal incentives to supply labor to maize. This speaks to the potentially high cost of the stickiness in intra-household contracts that the lab-in-the-field experiment reveals.

[26]Quartiles are defined using the distribution of total labor hours for households that cultivate local maize only.

8 Conclusion

Despite the large boost to expected income that shifting labor to maize production promised under the New technology, its adoption had no effect on wives' maize labor supply on average. Wives' diversion of labor from its joint income maximizing allocation cost households 217 USD on average under the New technology, or 17% of possible expected income. And while wives' responses were highly heterogeneous, risk aversion in the unitary model explains just 22% of observed labor allocations.

Meanwhile, husbands provided wives little incentive to supply a joint income maximizing allocation of labor to maize production. Though, the high cost of the New maize seed implied that households were two to three times more likely to earn zero maize income than under the Old technology, husbands did not recalibrate contracts so as to minimize wives' risk exposure. Were they to supply the joint income maximizing allocation of maize labor, wives would have borne nearly 2.5 times the downside risk that husbands did and stood to gain just 24% of the productivity gains that husbands did.

These results provide evidence in support of key components of the hypothesis that motivates this work. First, wives' sticky labor response left the full benefits of a profitable, but risky technology untapped. Second, the contracts husbands offered provided meager incentives for wives to shift labor to its most productive use. Given my within-subjects experimental design that allows me to observe the same couples across treatment conditions, I am able to push this evidence further by investigating whether within-household variation in incentives is correlated with wives' labor allocations. Surprisingly, I find that observed adjustments in contractual incentives do not predict adjustments in wives' labor allocations. Future research that investigates wives' response to exogenous transfer rules will be critical to validate the role of incentives in driving intra-household labor allocations.

Finally, the strong relationship between husbands' preferences and wives chosen allocations absent opportunities for them to collaborate suggests that both spouses may have imported priors regarding wives' role as the household's insurer into the game. That just 20% of husbands would have preferred a joint income maximizing allocation of labor seems consistent with the idea that husbands foremost expect wives to act as the household's risk bearers.

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APPENDIX

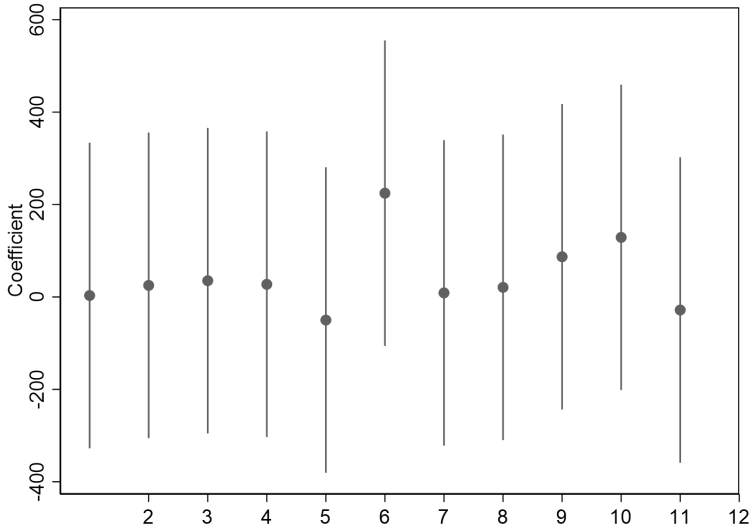
Setting: Technology Adoption and Intra-household Dynamics

Table A1: Panel survey descriptive statistics — 2021-2022 growing season

	mean	p50	sd	min	max
Land holdings and maize yield					
Total area cultivated (ha)	5.53	3.5	6.04	0.2	36
Total maize area (ha)	3.00	2.0	2.99	0.2	40
Primary maize plot area (ha)	2.19	2.0	1.84	0.2	20
Maize yield (kg/ha) on primary maize plot	639.89	500.0	571.52	0.0	4000
Maize yield (kg/ha) on primary maize plot | improved maize	790.33	600.0	684.10	0.0	4000
Maize yield (kg/ha) on primary maize plot | local maize	582.13	466.7	510.86	0.0	4000
Total maize output (kg)	1871.13	1000.0	2564.00	0.0	16200
Non-labor inputs on primary maize plot					
Used improved seed	0.28	0.0	0.45	0.0	1
Improved seed share	0.16	0.0	0.34	0.0	1
Expenditure on improved seed (USD) | used	46.20	16.0	70.18	0.0	310
Used npk/urea	0.03	0.0	0.18	0.0	1
Used irrigation	0.01	0.0	0.11	0.0	1
Labor inputs on primary maize plot					
Proportion of labor supplied by hh	.	.	.	.	.
Proportion of hh labor supplied by wife	.	.	.	.	.
Proportion of hh labor supplied by husband	.	.	.	.	.
Maize importance					
Proportion of income from own crops	0.63	0.7	0.29	0.0	1
Proportion of crop income from maize	0.30	0.2	0.27	0.0	1
Proportion of crop income from maize | > 0	0.39	0.3	0.24	0.0	1
Proportion of primary maize for sale	.	.	.	.	.
Proportion of primary maize for sale | > 0	.	.	.	.	.
Primary plot kgs for sale	.	.	.	.	.
Primary plot kgs for sale | > 0	.	.	.	.	.
Decision making on primary maize plot					
What to plant generally decided by a man	0.77	1.0	0.42	0.0	1
Which inputs to buy generally decided by a man	0.78	1.0	0.42	0.0	1
Whether to sell generally decided by a man	0.78	1.0	0.42	0.0	1
Annual income and transfers (USD)					
Husband's solely and jointly produced income	.	.	.	.	.
Total transfers	.	.	.	.	.
Routine household transfers	.	.	.	.	.
Discretionary transfers for infrequent expenses	.	.	.	.	.
Total transfers as a share of husband's income	.	.	.	.	.
Observations	1096				

Notes: Land holdings, yields, maize output sold, husband's income and transfers are winsorized at the 99th percentile.

Figure A1: Seasonality of transfers



Notes: Coefficients are from the regression $monthly\ transfers_{it} = month_t + \mu_{it}$. Monthly transfers are the sum of routine household transfers and discretionary transfers. $month_t$ is a categorical variable equal to the month in which the transfers were made.

Motivating Evidence and Conceptual framework: Transfers as Incentives

Figure A2: Routine household transfers as a component of total transfers

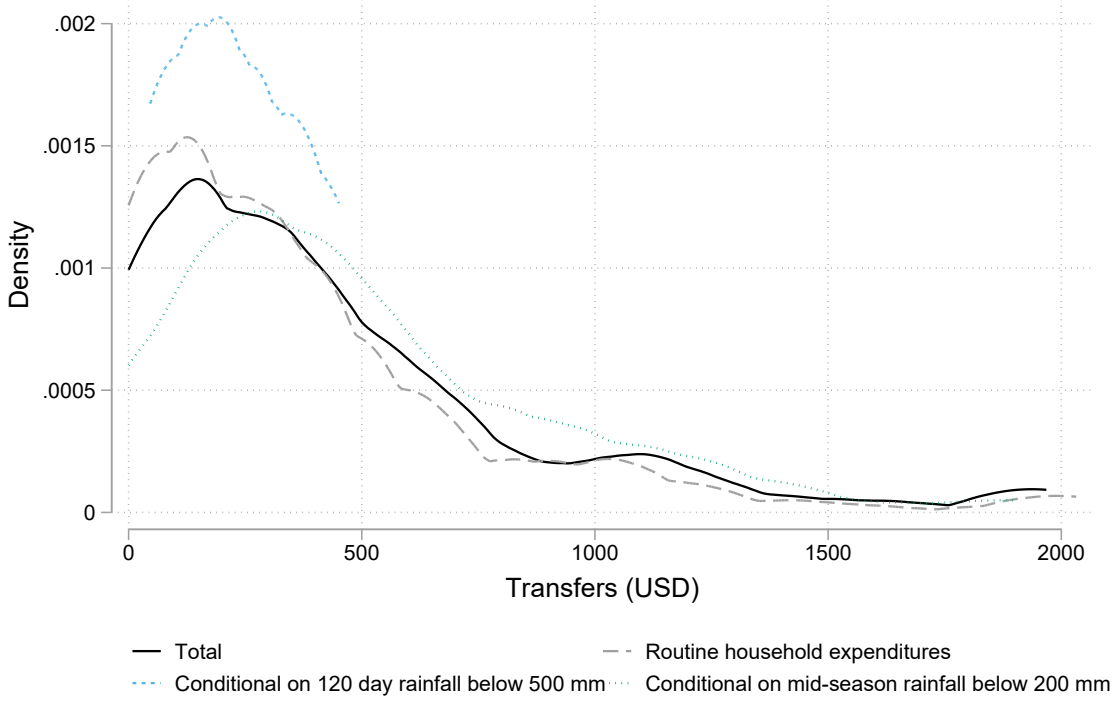
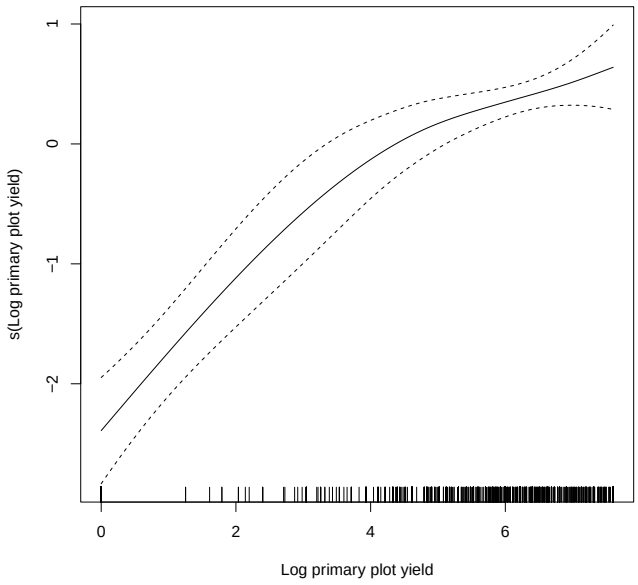


Figure A3: Transfers as a smooth function of maize yields



Notes: Figure plots predictions from a quadratically penalized generalized linear model that estimates the degree of smoothness of model terms as a part of fitting, as well as confidence intervals at two standard errors below the estimate of the smooth, plus uncertainty about the overall mean. Primary plot yield and average monthly transfers are top-coded at the 98th percentile.

Table A2: Estimation of segmented regression breakpoint and slopes

(Intercept)	yd_pri_bpc	total_area_bp	exp_hectare_mean_bp	hhadults_updtd	minors_count	U1.yd_pri_bpc	psi1.yd_pri_bpc
348.853	20.120	-0.143	0.055	24.968	-20.417	-20.003	74.997

Notes: Regression estimated using R package segmented (Muggeo et al. (2008)), which estimates model 4 by fitting iteratively the linear model with linear predictor $\beta_1 \text{primary plot yield}_i + \beta_2 \text{primary plot yield} - \tilde{\psi}_+ + \gamma \mathbb{I}(\text{primary plot yield} - \tilde{\psi})^-$ where $\mathbb{I}(\cdot)^- = -\mathbb{I}(\cdot)$ and γ is the parameter which may be understood as a re-parameterization of ψ and therefore accounts for the breakpoint estimation. At each iteration, a standard linear model is fitted, and the breakpoint value is updated via $\hat{\psi} = \tilde{\psi} + \frac{\hat{\gamma}}{\hat{\beta}_2}$; note that $\hat{\gamma}$ measures the gap, at the current estimate of ψ, between the two fitted straight lines coming from the equation above. When the algorithm converges, the 'gap' should be small, i.e. $\hat{\gamma} \approx 0$, and the standard error of $\hat{\psi}$ can be obtained via the Delta method for the ratio $\frac{\hat{\gamma}}{\hat{\beta}_2}$ which reduces to SE($\frac{\hat{\gamma}}{\hat{\beta}_2}$)if $\hat{\gamma} = 0$.

Theoretical model of labor allocation in the separate spheres household

Suppose the household is endowed with land, $\bar{T}$, and individuals are endowed with time, $\bar{L}$. Husband and wife have individual property rights over their wages from off-farm labor and wealth endowments.[27]

Suppose that the household engages both in on-farm maize production, as defined in the text, and off-farm labor.

[27] I assume the husband is endowed with wealth, e_m, and that the wife has no wealth. This assumption allows the model to abstract from savings behavior and credit markets once I introduce production technologies with fixed costs.

Income from off-farm labor, y^S is deterministic and characterized by non-decreasing returns to labor:

$$y^S = w_i l_i^S. \tag{A.1}$$

l_i^S is individual i's allocation of labor to the off-farm activity, which is remunerated wage w_i. I assume that the expected marginal value product of the husband's cash-crop labor is greater than his off farm wage, w_m, even when both spouses allocate their time endowments entirely to cash-crop production:

$$w_m < \mathbb{E}\left[\frac{\partial f(2\bar{L};\bar{T})}{\partial l_m^C}\right]. \tag{A.2}$$

Implicit in this comparison of marginal productivities is an assumption about the household land endowment, which must be sufficiently large for inequality A.2 to hold. Together with the husband's risk neutrality, which I describe below, inequality A.2 implies that the husband allocates his time endowment entirely to cash-crop production.

Spouses make individual consumption and labor allocation decisions, which take the transfer function, $T(\,\cdot\,;P)$, and the obligatory transfer, P, as given. Each spouse simultaneously maximizes expected utility subject to their budget constraints. The wife's income is equal to subsistence income, $w_f l_f^S$, plus the income transfer from her husband, $T(Y;P)$.[28] The husband's income is equal to subsistence income, $w_m l_m^S$, plus his gross returns from maize production, Y, plus his exogenous endowment, e_m, less the transfer, $T(Y;P)$.

$$\begin{aligned}
&\max_{x_f, l_f^S, l_f^C} \mathbb{E}[U_f(x_f)\,|P] && \max_{x_m, l_m^S, l_m^C} \mathbb{E}[U_m(x_m)\,|A] = \mathbb{E}[x_m|P] \\
&\text{s.t. } px_f \le w_f l_f^S + T(Y;P) && \text{s.t. } px_m \le w_m l_m^S + Y + e_m - T(Y;P) \\
&\qquad Y = \theta f(\hat{l_m^C}, l_f^C) && \qquad Y = \theta f(l_m^C, \hat{l_f^C}) \\
&\qquad l_f^S + l_f^C = L_f && \qquad l_m^S + l_m^C = L_m
\end{aligned} \tag{A.3}$$

Given equation A.2, which states that the expected marginal value product of the husband's cash-crop labor exceeds his off-farm wage for all choices of labor, he allocates his time endowment entirely to cash-crop production. His conditional labor supply function is given by

$$l_m^C(P) = \bar{L}. \tag{A.4}$$

Here, conditional emphasizes that the husband's labor supply is conditional on the given

[28] The model is instantaneous and therefore abstracts from the fact that inputs are committed before agricultural income is realized. This abstraction is equivalent to assuming that the husband is able to mobilize his wife's labor without committing upfront capital. Implicit is the assumption that the wife has complete information about the distribution of cash-crop income and the value of income for a given realization of θ.

conjugal contract. Note that $l_m^C(P)$ is independent of the wife's labor allocation. Thus, the wife solves constrained optimization problem A.3, assuming that her husband will allocate his full time endowment to cash-crop production.[29]

Empirical evidence of stickiness in transfer functions

Table A3: Productivity, expenditures and input use on primary maize plot by maize varietal

	(1)	(2)	(3)
Variable	No improved maize	Improved maize	Difference
Maize yield (kg/ha)	832.65	973.83	141.18***
	(600.54)	(627.62)	(46.39)
Primary plot non-labor investment/ha	4.41	51.22	46.81***
	(17.47)	(215.63)	(13.89)
Improved seed share	0.00	0.64	0.64***
	(0.00)	(0.37)	(0.02)
Expenditure on improved seed (USD)	0.00	163.08	163.08*
	(0.00)	(1445.53)	(88.74)
Used npk/urea	0.01	0.08	0.07***
	(0.12)	(0.27)	(0.02)
Used oxen	0.27	0.39	0.13**
	(0.44)	(0.49)	(0.05)
Total labor (hours) from workers hired permanently or for full season	32.46	50.56	18.10
	(368.82)	(250.22)	(21.68)
Total labor (hours) from day laborers	183.27	229.46	46.19**
	(164.16)	(187.07)	(21.55)
Wife's hours/ha	162.54	121.49	-41.05***
	(212.86)	(184.42)	(15.16)
Husband's hours/ha	166.40	124.28	-42.11**
	(181.25)	(134.01)	(16.28)
Total hours wife worked on primary maize plot	325.60	257.08	-68.53**
	(410.32)	(337.13)	(33.91)
Total hours husband worked on primary maize plot	328.65	262.51	-66.15*
	(385.95)	(198.15)	(34.15)
Proportion of hh labor supplied by wife	0.34	0.32	-0.02
	(0.23)	(0.22)	(0.02)
Proportion of hh labor supplied by husband	0.38	0.39	0.01
	(0.27)	(0.25)	(0.02)
Proportion of labor supplied by hh	0.76	0.69	-0.07***
	(0.22)	(0.25)	(0.02)
Observations	443	331	810

Notes: Data are from the 2023 survey round, which is the first year of the panel in which transfer and labor modules were enumerated. The sample has been restricted to the estimation sample of equation 1, which excludes wives who report never having received transfers for routine household expenditures in the past 24 months, and neither discretionary transfers nor lump sums in the past 12 months, though the household reported having normal or very good harvests in the previous two growing seasons. Primary plot maize yield is top-coded at the 95th percentile.

[29] Absent the assumption given in equation A.2, the couples' simultaneous solution of the choice variables could be modeled as a strictly competitive game of complete information. Each individual's labor supply function would be their best response function that depends on their expectations or conjectures, $\hat{l_j^C}$, about their partner k's behavior:

$$l_i^C(A) = l_i^C(\hat{l_j^C}|A). \tag{A.5}$$

If each partner myopically treats their partner's behavior as fixed, a Nash non-cooperative equilibrium obtains at the intersection of the best response function.

Experimental design and procedures

Table A4: Experimental sample descriptive statistics

Variable	(1) Game Sample	(2) Panel Sample	(3) Panel Sample in Game Districts
Husband's age	48.04		
	(15.25)	()	()
Wife's age	39.72		
	(13.55)	()	()
Husband's endline comprehension %	0.86		
	(0.16)	()	()
Wife's endline comprehension %	0.85		
	(0.17)	()	()
Husband literate	0.83		
	(0.37)	()	()
Wife literate	0.46		
	(0.50)	()	()
Years married	22.52		
	(13.72)	()	()
Number of wives	1.37		
	(0.77)	()	()
Children under 10 yrs live in hh	0.74		
	(0.44)	()	()
Wife receives transfers at least on a monthly basis	0.74	0.57	0.70
	(0.44)	(0.49)	(0.46)
Routine household transfers	311.22	298.66	349.76
	(712.00)	(473.86)	(518.16)
Wife earned off-farm income in last 12 months	0.56	0.38	0.31
	(0.50)	(0.49)	(0.46)
Wife owns some of household's land solely	0.21		
	(0.40)	()	()
Proportion of total income from maize	0.07	16.72	15.96
	(0.15)	(22.32)	(21.60)
Total area cultivated (ha)	4.35	6.23	5.55
	(3.83)	(8.29)	(7.24)
Maize yield (kg/ha)	368.28	323.62	389.19
	(328.68)	(381.10)	(350.48)
Used improved seed	0.39	0.48	0.45
	(0.49)	(0.50)	(0.50)
Improved seed share	0.20	0.31	0.26
	(0.34)	(0.41)	(0.39)
Hired permanent or full season agricultural labor	0.06	0.07	0.05
	(0.23)	(0.26)	(0.23)
Whether to sell from primary maize plot decided by wife	0.05	0.11	0.12
	(0.21)	(0.32)	(0.33)
Total harvest of food staples was bad in 2024	0.49	0.74	0.71
	(0.50)	(0.44)	(0.45)
Observations	524	764	382

Notes: Column 1 presents sample averages and standard deviations for all control variables included in experimental treatment effects regressions. Column 2 reports the same statistics for couples in the 2024 survey conducted by Malacarne et al. (2025) where there was overlap in survey variables. In Column 3, I restrict the panel survey sample to the three districts in which the games were conducted, thus dropping couples in Guro and Barue districts

Figure A4: Old technology conditional probability distributions

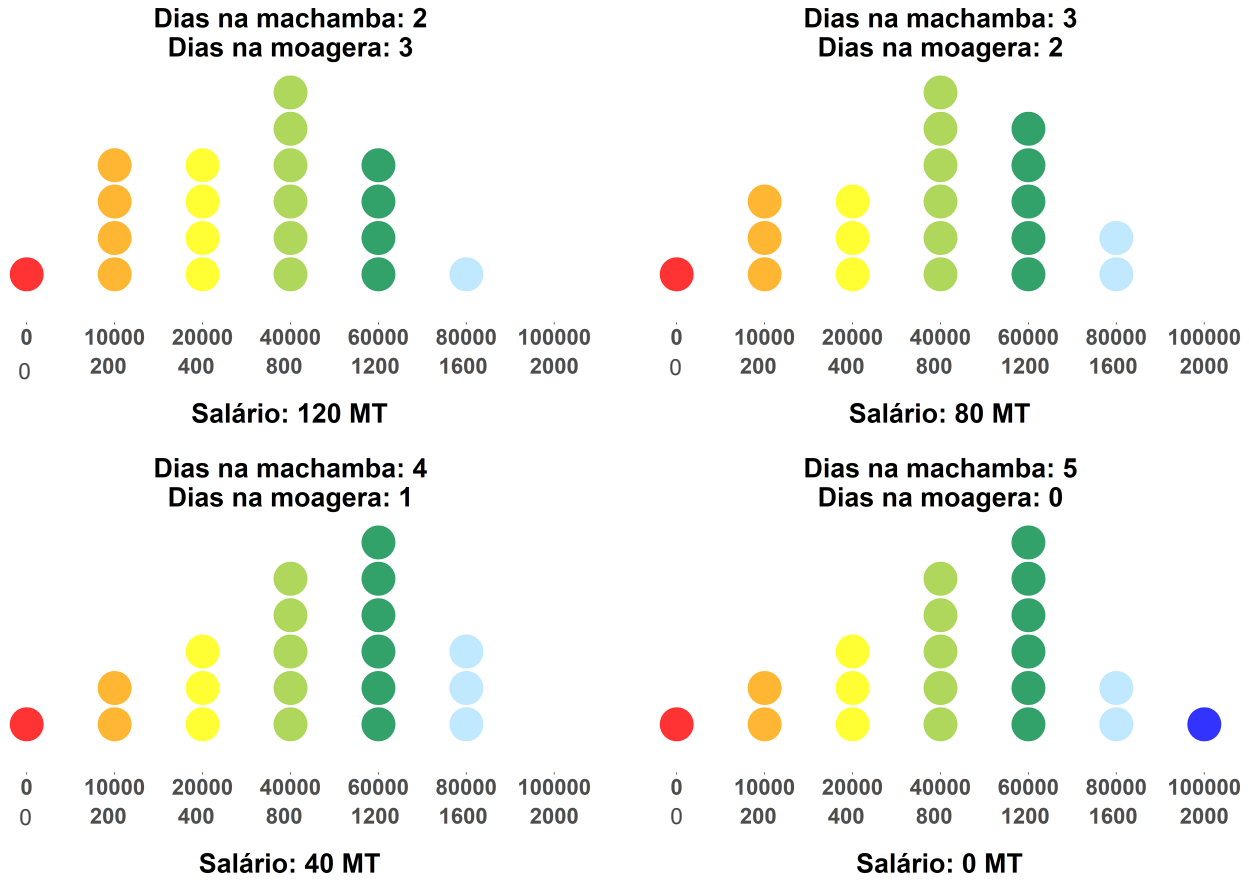


Figure A5: New technology conditional probability distributions

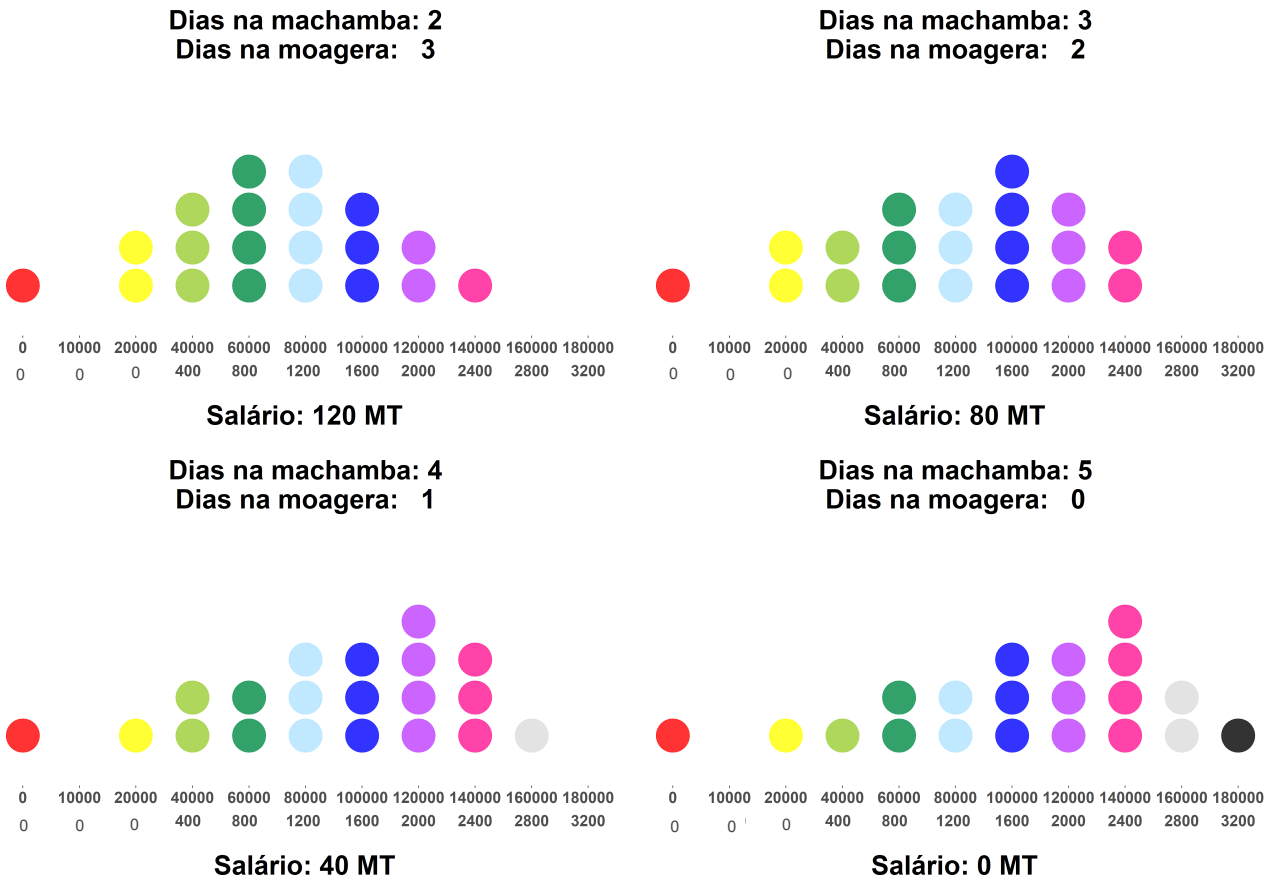
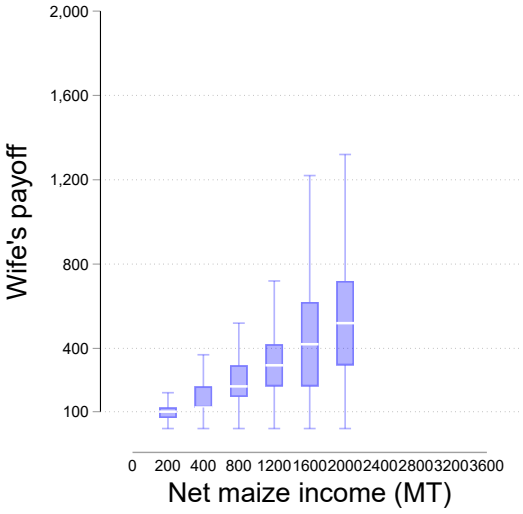
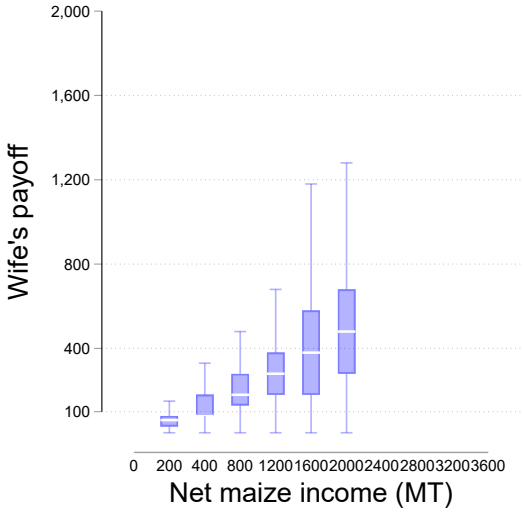


Figure A6: Wives' state-contingent payoffs by maize labor supply under Old technology

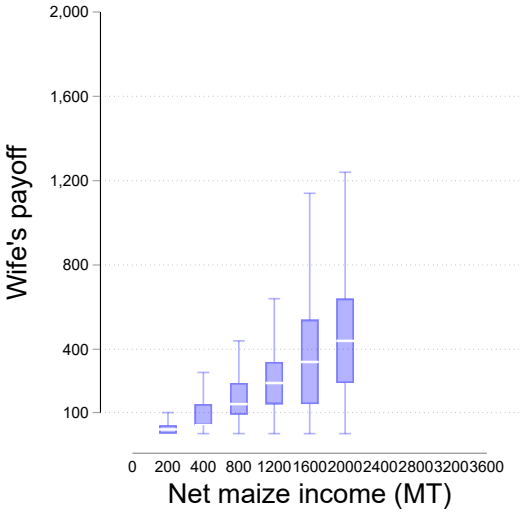
(a) 2 Days



(b) 3 Days



(c) 4 Days



(d) 5 Days

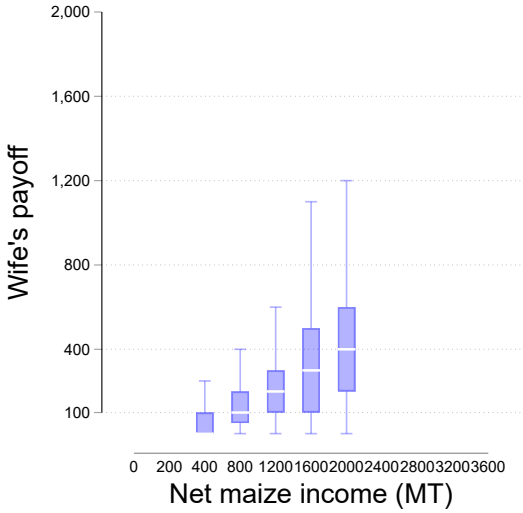
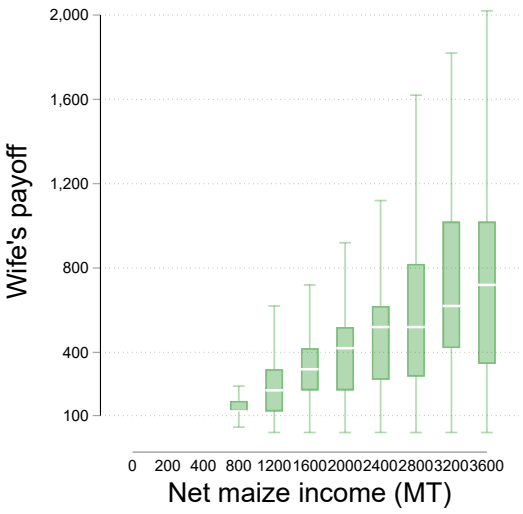
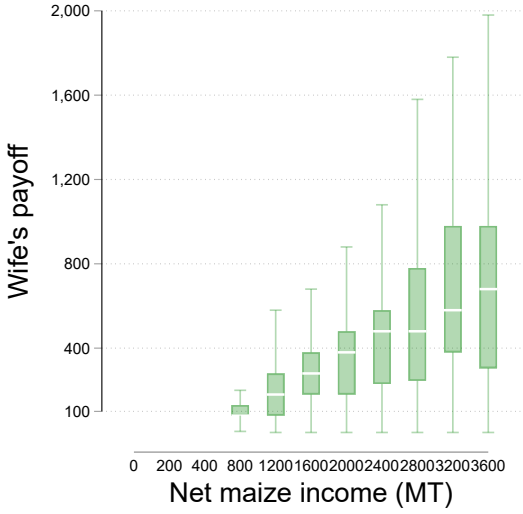


Figure A7: Wives' state-contingent payoffs by maize labor supply under New technology

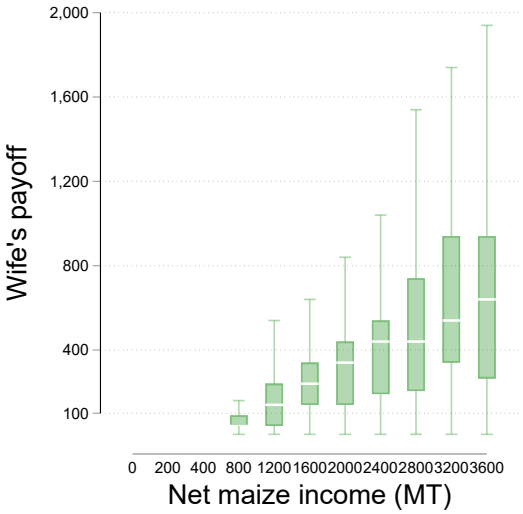
(a) 2 Days



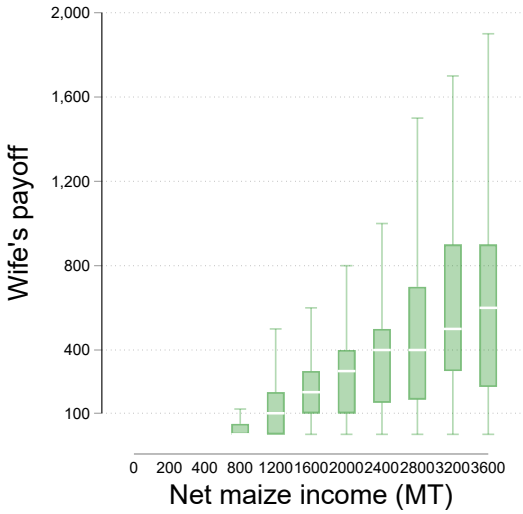
(b) 3 Days



(c) 4 Days



(d) 5 Days



Mechanisms

Figure A8: Effect of contractual incentives on wife's maize labor supply

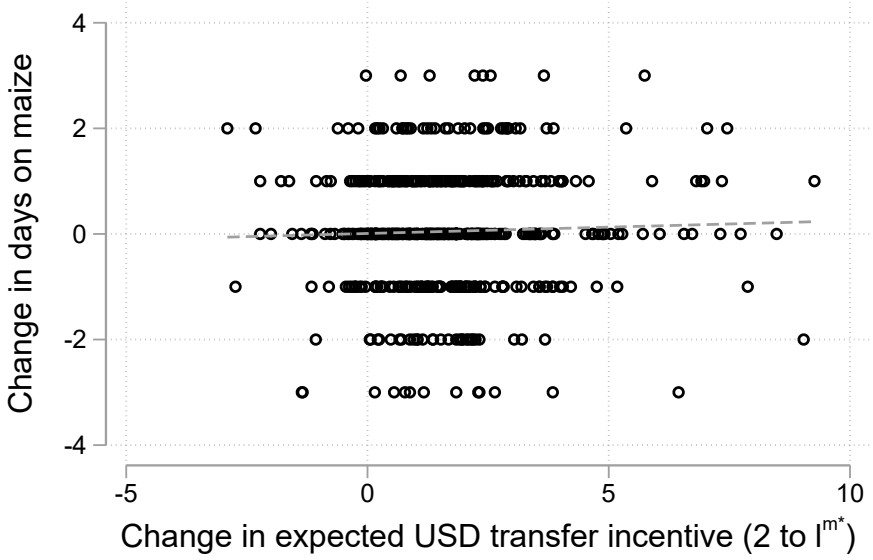


Table A5: Effect of New technology on intensity of technology adoption

	Days Chosen
	(1)
New tech	0.0658
	(0.08)
Old tech mean	3.587
Controls	yes
Session FEs	yes
Observations	1016
Log likelihood	-1451.4
Scale factor	0.994

Notes: Column 1 estimated using 2-limit Tobit MLE with session fixed effects. Standard errors in parentheses are clustered at the session level. Control variables including wife's game comprehension, frequency of transfers for domestic expenses, wife's off-farm income sources and land ownership, importance of maize as a portion of household income, cultivation area, maize yield, use of improved maize seed, days of hired labor, gender of primary decision-maker with regard to maize sales, whether the 2024 harvest was reported to be bad, as well as demographic controls are included in all regressions, but not reported. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A6: Effect of alternative measures of contractual incentives on wife's maize labor supply

	Days	
	(1)	(2)
Days		
Wife's average share	-0.0134	
	(0.71)	
# states: transfer < subsistence req.	0.0198	0.0525
	(0.04)	(0.05)
Unweighted mean transfer (USD)		0.0339
		(0.03)
Controls	no	no
Session FEs	no	no
Observations	1047	1047
Log likelihood	-1608.3	-1608.2
Scale factor	0.994	0.994

Notes: All columns are estimated using Correlated Random Effects 2-limit Tobit MLE. Columns 1 and 2 regress l on alternate measures of the wife's transfer incentive: 1) her share of maize income, averaged across the number of maize income states; and 2) her average transfer across income states. As an alternate measure of the wife's downside risk exposure, they also include the count of states in which transfers were less than her expenditure responsibility. Standard errors in parentheses are clustered at the session level. Household-level means of independent variables are included but not reported. * p < 0.10, ** p < 0.05, *** p < 0.01.

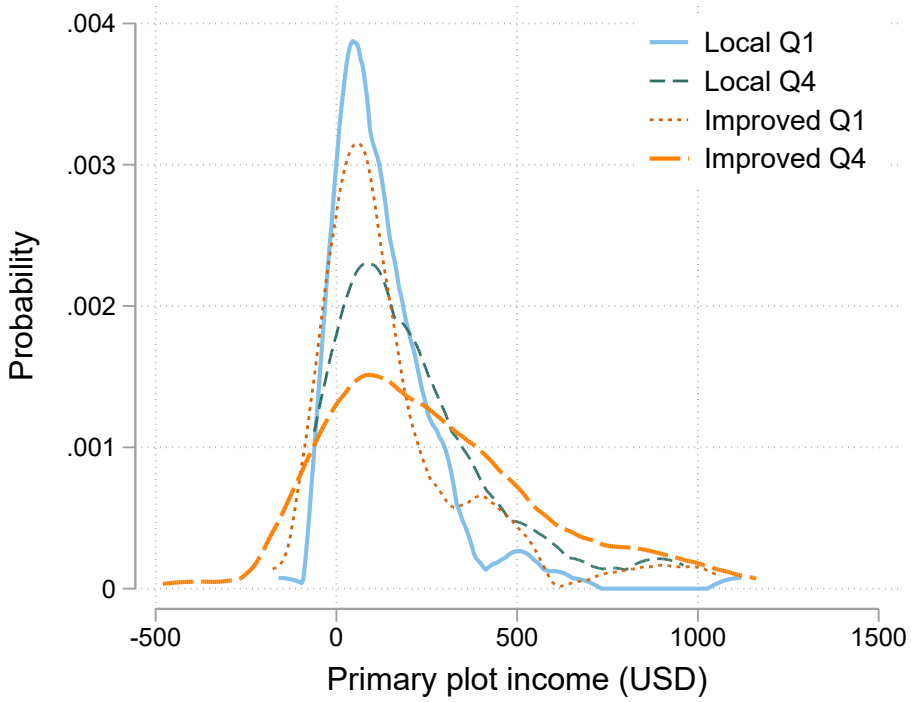
Table A7: Effect of New technology on wife's maize labor supply and husband's preferred allocation

	Days Chosen	Days Preferred
	(1)	(2)
New tech	0.0658	0.241**
	(0.08)	(0.07)
Old tech mean	3.587	3.508
Controls	yes	yes
Session FEs	yes	yes
Observations	1016	911
Log likelihood	-1451.4	-1291.7
Scale factor	0.994	0.996

Notes: All columns estimated using 2-limit Tobit MLE with session fixed effects. Standard errors in parentheses are clustered at the session level. Control variables including wife's game comprehension, frequency of transfers for domestic expenses, wife's off-farm income sources and land ownership, importance of maize as a portion of household income, cultivation area, maize yield, use of improved maize seed, days of hired labor, gender of primary decision-maker with regard to maize sales, whether the 2024 harvest was reported to be bad, as well as demographic controls are included in all regressions, but not reported. * p < 0.10, ** p < 0.05, *** p < 0.01.

Relevance of Experimental Framing

Figure A9: Conditional distributions of maize income by technology and labor quartile



Notes: Labor quartiles are defined for producers of local maize and applied to improved maize producers.