Share and Share Alike: The Impact of Rainfall on Gendered Income Allocation in Malawi*

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Abstract

Studies of intra-household resource allocation have typically omitted income earned jointly, by two or more individuals. In this study, I empirically test the assumption that all household income is pooled, when joint income, as well as income earned individually by men and women, is accounted for in the analysis. I develop an intra-household collective model which explicitly includes joint and individual relationships to explain income allocation. I then use rainfall variation to examine changes in income and expenditure. This method is applied to 683 households in 2010 and 2013, in Malawi. Ultimately, I reject the hypothesis of complete income pooling and full insurance within the household. However, I find evidence that households members pool income and insure one another for expenditures on essential goods. Conversely, they do not pool income and do not insure one another for luxury goods. I conclude that there is strategic income pooling behavior with respect to particular types of expenditure, resulting in partial insurance for the household. These results are contrary to previous studies, which fail to find even partial insurance within households for essential goods. The conclusions of this study provide a different perspective on intra-household dynamics which highlight the essential nature of joint relationships in household analyses.

JEL Classification: O12, D13, J16
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1 Introduction

Despite the ubiquity of collective household models, empirical evidence suggests that in most households choices concerning income and spending are determined by individual decision makers.[1] Much of the existing literature addresses this issue by accounting for interactions between male and female household members.[2] But for many households, income earned jointly, by two or more household members, constitutes a large proportion of earned income. As an example, recent studies from Southern Africa show that between 12 percent and 50 percent of household plots are jointly managed, leading to a substantial amount of shared income (Kilic et al., 2015; Slavchevska, 2015). The failure to consider these joint income-earning relationships has likely to inaccuracies in studies of intra-household income and resource allocation.

In this paper, I empirically test the assumption that all household income is pooled, when joint income, as well as income earned individually by men and women, is accounted for in the analysis. Expanding on a model developed by Duflo and Udry (2004), I explore the disparities in expenditure by different income earners resulting from exogenous variation in rainfall. My analysis focuses on three categories of income earned by households in rural Malawi: that earned exclusively by men, that earned exclusively by women, and that earned jointly. I use these groups to test the restriction that income from the three sources is always pooled. The central observation underlying my methodological approach and empirical estimation is that if households completely pool income, then household members fully insure one another against short term fluctuations in income. Thus, non-persistent income variations will not result in changes to the allocation of resources within the household.

I reject the hypothesis of complete income pooling and full insurance within the house-

[1] This evidence comes from Chiappori (1992); Browning et al. (1994); Browning and Chiappori (1998); Chiappori et al. (2002), among others.

[2] Udry (1996); Duflo and Udry (2004); Basu (2006); Bobonis (2009); Doss (2013) are examples from this literature.

hold. However, I find evidence that household members partially insure one another for expenditure on essential goods, including food, clothing, education, and healthcare. Conversely, households do not insure one another for luxury goods, including cigarettes and alcohol, recreation, and housing and utilities. I conclude that observed income pooling is strategic, with respect to particular types of expenditure. This behavior results in partial insurance for the household. These results are contrary to previous studies, which fail to find even partial insurance within households for essential goods.[3]

My results are driven by the inclusion of joint income in the analysis. When I omit joint income and consider only income earned individually by men or women, I am able to replicate the findings of previous studies that households do not pool their income. This result indicates that earlier research has failed to account for a potentially important dynamic in household analysis, by omitting joint relationships. A key driver of the observed strategic behavior appears to be the societal composition of rural Malawi. When I examine differences between income pooling behavior in matrilineal and non-matrilineal societies, I find that households in matrilineal societies completely pool income and fully insure one another against income variation. Households in non-matrilineal societies do not. I similarly test household headship, to examine if the societal difference is driven by the gender of the household head. However, those results show that female-headed households are not different from male-headed households. I conclude that societal structures play an important role in intra-household income allocation.

My identification strategy relies on observing the impact of exogenous variation in rainfall on income and expenditure. I examine short term variations in rainfall, which are covariate at the household level. All members of a household experience the same rainfall, but the pattern of rainfall may have different impacts on individual household members, due to discrepancies

[3]Some work on income pooling and other intra-household cooperative behavior includes Duflo (2003); Quisumbing and Maluccio (2003); Duflo and Udry (2004); Bobonis (2009); Antman (2015), among others.

in inputs, crops cultivated, and plot quality. As previous literature has shown, women and men not only cultivate a different set of crops, but do so on plots of different qualities (e.g. Doss and Morris (2001); Karamba and Winters (2015)) and with different quantities and quality of inputs (e.g. Udry et al. (1995); Udry (1996); Kilic et al. (2015); Oseni et al. (2015); Slavchevska (2015)). Thus, rainfall may have disparate impacts on the income of different household members. However, in a household with complete insurance from pooled resources, the different impacts of rainfall on income by earner, conditional on total expenditure, should not translate into differences in the allocation of a particular expenditure to different purposes within the household. To test this, I consider broad expenditure aggregates, including total expenditure, as well as more detailed expenditures.

My study contributes to the body of literature that examines resource allocation within households in the developing world, by including jointly earned income in the analysis. I am the first, to my knowledge, to explicitly incorporate jointly earned income with individual income into the analysis of household income pooling.[4] While other areas of gender studies have included aspects of joint management (Kilic et al., 2015; Oseni et al., 2015; Slavchevska, 2015; McCarthy and Kilic, 2014), this consideration has been omitted from studies of gender-specific household resource allocation. The evidence presented in this study supports the validity and empirical relevance of including income earned jointly in intra-household analyses.

There is ample literature on the relationship between short term income fluctuations and changes in expenditure. But previous work specifically addressing the relationship between household weather variation and expenditure is more limited. This research has shown

[4]Bobonis (2009) includes joint income in the analysis of household efficiency in Mexico. His analysis and motivation are different from mine, however, driven by quasi-experimental observations. Additionally, there is a growing body of literature, centered in West Africa, which explores the concept of shared plots, which are generally managed by men. Although this literature highlights income which, in principle, may be classified as joint, it is not identified in this way, as the motivation is through anthropological mechanisms (Doss, 2002; Duflo and Udry, 2004; Kazianga and Wahhaj, 2013)

incomplete income pooling and lack of insurance within the household. In the presence of weather variability, Duflo and Udry (2004) fail to find support for complete income pooling in Côte D'Ivoire. Similarly, Akobeng (2016) finds that female-headed households significantly reduce per capita expenditure in cases when agricultural income is reduced due to rainfall variation in Ghana.

By explicitly including joint relationships, this paper adds an additional extension to previous findings. In some settings, joint relationships in intra-household behavior may have important consequences for households in the developing world and, correspondingly, important implications for development policy. In particular, the conclusions of this study lend support to cash transfer programs. Such policies are often fraught with concerns about the use of the funds, though these results suggest that the transfers will be efficiently allocated for essential goods. This may reduce some anxiety around cash transfer programs, particularly queries of how money will be used by different household members. In the future, analysis of the role of gender in the household will need to examine joint relationships in order to make accurate policy recommendations, based on actual household behavior in the developing world.

2 Country Context and Data

2.1 Country Context

Development strategies in Malawi have emphasized the critical nature of the agricultural sector in combating poverty (Chirwa and Muhome-Matita, 2013). As reported by Kilic et al. (2015), agricultural productivity has been erratic over the past two decades. Potential factors contributing to this inconsistency include weather variability, declining soil fertility, low adoption and use of agricultural technologies, as well as poor infrastructure and market failures. Correspondingly, poverty is widespread. In 1998, estimates showed that approximately

54 percent of Malawi's population was living below the poverty line, with rural poverty at about 58 percent. More recent estimates show slight declines in these figures, to 56 percent and around 43 percent, in 2004 and in 2009, respectively (Chirwa and Muhome-Matita, 2013). Despite these decreases in overall poverty, the World Bank finds that inequality, as measured by the Gini coefficient, remains around 0.39 (WB, 2008).

Poverty rates differ between female- and male-headed households. While poverty rates for male-headed households declined to 49 percent by 2011, rates for female-headed households stood at 57 percent (Kilic et al., 2015). Kilic et al. (2015) find that, on average, female-managed plots are 25 percent less productive than male-managed plots. This discrepancy in productivity may drive some of the gendered household poverty gap.

2.2 Data

Data for this study comes from the first two rounds of the Malawi Integrated Household Panel Survey (IHPS) which was implemented by the National Statistical Office under the Living Standard Measurement Survey - Integrated Household Surveys on Agriculture (LSMS-ISA) program with the World Bank. In 2013, the IHPS has succeeded in tracking 3,246 households across 204 enumeration areas, which were surveyed in the previous round in 2010. The original sample was designed to be representative at the national-, urban/rural, and regional levels. Efforts were made to track resettled and split off households and as a result attrition is low, 3.8 percent for households and 7.4 percent for individuals (McCarthy and Kilic, 2014). The data set contains rich information on demographics, expenditure, and agriculture, as well as household-level rainfall measurements.

I use a balanced panel of households collected in 2010 and 2013. Due to my interest in income earned by rural households, I omit from my analysis households which did not report income from crop sales. Each household included in my sample has at least one household member who earned some income from the sale of crops. In 2010, 1,771 individuals (35 percent of all individuals in the first round) reported selling some crops. In 2013, 2,146 individuals (35 percent of all individuals in the second round) reported selling some crops. In total, 693 households appear in both years, yielding a total of 1,386 observations. This provides the balanced panel for my analysis. As I am focusing on a subset of the population, it can no longer be considered nationally representative of the entire population, but rather only of households who participate in crop markets.

In addition to recording the amounts and values of crops sold, the survey indicates the household member who is responsible for decisions about the income earned from the sale of each crop. Respondents are asked to report the primary income manager, and as appropriate, a secondary income manager. I first consider only male and female income: I consider only the primary manager and designate male and female income based on the gender of the individual reported. Subsequent to this, I consider joint income. I designate income as joint if a secondary income manager is identified. My analysis is indifferent about whether joint funds are controlled by multiple women, multiple men, or both a man and a woman.[5] If no secondary manager is identified, income is classified as either male or female, following the gender of the primary manager. The primary difference when joint income is omitted is an over-attribution of earned income to men. Women's income remains approximately the same, regardless of whether joint income is included. The percent difference between specifications is approximately 25 percent (on average, 4,628 MK without joint, compared with 3,455 with joint). In contrast, men's income is vastly different when joint income is included, with a percent difference of around 70 percent (on average, 48,731 without joint, compared with 14,249 with joint). Table 1 presents summary statistics on earned income, by gender, both when joint income is included and when joint income omitted.

[5]Of jointly managed plots, in 2010, 1 percent are managed by individuals of the same gender, 1 percent have a primary female manager and a secondary male manager, and the remaining 98 percent have a primary male manager and a secondary female manager. In 2013, 2 percent are managed by individuals of the same gender, 2 percent have a primary female manager and a secondary male manager, and the remaining 96 percent have a primary male manager and a secondary female manager.

My analysis also relies on expenditure data. An aggregate measure includes all household expenditure, but I also include measures of disaggregated expenditure for seven types of goods.[6] I include measures of both essential and luxury goods to obtain a broad perspective on overall household spending. Food comprises the largest biggest share of household budget share, followed by housing and utilities.[7] Education and recreation comprise the smallest budget shares. Table 2 reports the specific percentage values for each year, as well as the results of a t-test, for differences over time in each type of expenditure.

Finally, Table 3 reports summary statistics for the rainfall measures used in my analysis. Figure 1 maps the averages for some of the statistics in Table 3. Rainfall measures are taken at the household level. The data record rainfall variation across households within a village, although fluctuations within a village for a time period are relatively small. I include three measures of rainfall: total rainfall, total rainfall in the wettest quarter, and average start of the wettest quarter.[8] Using three measurements gives a broad view of the varied impacts of rainfall. Therefore, the analysis focuses not only on total rainfall experienced, but also on the rainfall of the wettest quarter, due to the reliance of most Malawian households on rain-fed fields for agricultural production. The onset of the rains is additionally important as late onset of rains is associated with crop failures and low yields (Mugalavai et al., 2008). I also consider three time periods: the current year, the previous year, and an average across the period of interest. These variables capture the various pathways through which rainfall may influence agricultural productivity, and thus earned crop income.

[6] Households which have no expenditure for a particular good are designated with a zero.

[7] This measure generally does not include rent. Of the 693 households included in my analysis, only 19 do not own their properties, and therefore pay rent on the building in which they live.

[8] Average start of the wettest quarter is measured in dekads (1-36), where the first week of July is equal to one.

3 Theoretical Model

3.1 Theory

Collective household models are widely used in the development literature, but Udry (1996) was one of the first to question the fundamental assumption that households in developing countries must be Pareto efficient. Though Udry argues for the rationality of Pareto efficiency, in particular due to the long-term stable nature of intra-household relationships and the existence of relatively good information about one another's actions, he states that it is not mandatory, and demonstrates empirically that for farming households in Burkina Faso, Pareto efficient allocation of resources is not achieved across production activities. Subsequent literature upholds Udry's findings, determining that most households do not pool income and are Pareto inefficient. This is because the allocation of resources depends on individual income earners.[9] Similar behavior is also observed in the literature on gender relations and bargaining.[10]

In order to examine these issues more closely, I expand upon a model developed by Duflo and Udry (2004) to include jointly earned income. I use a one-period model of intra-household resource allocation in a risky environment.[11] To simplify notation, I consider a household consisting of two individuals, each of whom produces one crop on one plot and who together produce a joint crop on a shared plot ($i \in \{m, f, j\}$). This generalizes in a straightforward way to a situation in which multiple types of crops are produced on multiple plots.

Farms are cultivated using labor (L_i) which, for men (m) and women (f), can be traded in a competitive market at wage w. The agricultural production function for individual i is

[9] This is demonstrated in Duflo (2003); Duflo and Udry (2004); Antman (2015), among others.

[10] Evidence from Udry et al. (1995); Agarwal (1997); Basu (2006); Doss (2013); Fiala and He (2016); McCarthy and Kilic (2014), as well as others.

[11] Duflo and Udry (2004) demonstrate that the model is generalizable to a dynamic multi-period model.

$f_i(L_i, r)$ where $r \equiv (r_1, r_2)'$ is a vector of two measures of rainfall which impact cultivation on the plot each individual i.[12]

After rainfall is realized, each individual $i \in \{m, f\}$ consumes a vector of private goods c_i. Individual i's preferences are summarized by the expected utility function $\mathrm{E}u_i(c_i)$, where expectations are taken over potential realizations of rainfall. Rainfall influences the efficient allocation of resources only through its impact on cultivation.[13]

Any *ex ante* efficient allocation of resources can be characterized as a solution to:

$$\begin{aligned} \max_{c_i, L_i} \quad & \mathrm{E}u_f(c_f) + \lambda \mathrm{E}u_m(c_m) \\ \text{s.t.} \quad & p \cdot (c_m + c_f) \leq f_f(L_f, r) + f_m(L_m, r) + f_j(L_j, r) - w(L_f + L_m). \end{aligned} \tag{1}$$

where λ represents some Pareto weight, which depends on the observable and unobservable attributes of household members. This Pareto weight does not depend on r, as with an efficient allocation of resources, risk is pooled.[14]

Denoting expenditure as: $x \equiv p \cdot (c_m + c_f)$:

$$c_i = c_i(\lambda, p, x) \qquad \forall \;\; i \in \{m, f\} \tag{2}$$

Consumption of any particular good is independent of the rainfall realization r, conditional on expenditures, prices, preferences, and the Pareto weight parameter. Consumption considers only private goods and thus, jointly managed plots contribute to expenditure, though joint consumption is not a component of equation (2).

Equation (2) implies that the impact of rainfall realizations on expenditure for any particular commodity depends only on the expenditure elasticity of demand for that commodity

[12] As an example, r_1 might represent onset of rainfall and r_2 may represent total rainfall.

[13] This is a strong assumption, following Duflo and Udry (2004). I explore this assumption and some related limitations later.

[14] If risk is pooled, households insure one another against rainfall variation and over the period of interest; thus, there is not a change in bargaining power.

and on the effect of rainfall on overall expenditure. For simplicity, I assume that the relative prices of consumption are not related to rainfall realizations ($\frac{\partial p}{\partial r_i} = 0$).[15]

For any individual i and period $t \in \{1, 2\}$ and any good k:

$$\frac{dc_i^k}{dr_t} = \frac{dc_i^k}{dx} \cdot \frac{dx}{dr_t}. \tag{3}$$

Thus, the effect of rainfall in period t on consumption of good k by individual i and its impact on total expenditure should be equal across all rainfall realizations. That is,

$$\frac{\frac{dc_i^k}{dr_1}}{\frac{dx}{dr_1}} = \frac{\frac{dc_i^k}{dr_2}}{\frac{dx}{dr_2}}. \tag{4}$$

The crucial aspect of equation (4) is that dr_i impacts collective household decision making through its influence on the household's budget constraint.[16]

Equation (4) serves as an overidentifying restriction, which I test in my empirical analysis. The restriction specifies that realized rainfall influences demand for a particular good to the degree with which it impacts expenditure.

3.2 Empirical Implementation

There are several necessary assumptions required to implement the overidentifying restriction test in equation (4). The first assumes a particular form of commodity demand for a certain commodity c by household i in period t. Let:

$$\log(c_{it}) = \alpha \cdot \log(x_{it}) + f(\lambda_i) + Z_{it}\beta + v_i + \nu_{it} \tag{5}$$

where x_{it} again denotes expenditure, while Z_{it} represents region indicators (and year, as

[15]This follows assumptions made in the original model (Duflo and Udry, 2004).

[16]Only data on rainfall and expenditures is required in order to estimate equations (2) and (4). $f_f(L_f, r) + f_m(L_m, r) + f_j(L_j, r) - w(L_f + L_m)$ is not observed and, therefore, such data is not required for empirical analysis.

appropriate), v_i represents a household fixed effect, and ν_{it} represents an error term. In this, I assume that markets are regionally integrated, where rainfall varies across region. Any impact of rainfall on prices is captured in the region indicators. The shortcoming of this assumption is that it does not allow for prices to vary by household.[17]

Using this form, I can test the assumption of income pooling and complete insurance. That is, I test the hypothesis that, conditional on total expenditure and a household fixed effect, demand for a good does not depend on rainfall.[18]

Combining equations (4) and (5), I specify a relationship between rainfall and total household expenditure:

$$\log(x_{it}) = R_{it}\alpha + Z_{it}\beta + \epsilon_{it} \tag{6}$$

where I assume that rainfall (R_{it}) impacts individual and joint income and thus influences households' expenditures. Z_{it} denotes region indicators and ϵ_{it} represents an error term.

Next, I specify the following relationship between demand for a particular good and rainfall:

$$\log(c_{it}) = R_{it}\pi + f(\lambda_i) + Z_{it}\beta + v_i + \nu_{it} \tag{7}$$

where R_{it} denotes rainfall and λ represents a Pareto weight, while Z_{it} represents region indicators, v_i represents a household fixed effect, and ν_{it} represents an error term.

Next, equation (6) and (7) are differenced, giving reduced form equations for estimation:

[17] Duflo and Udry (2004) highlight two additional assumptions implied by equation (5). These are that commodity demands are multiplicatively separable between the Pareto weight and household expenditure as well as that commodity demands are log-linear in form.

[18] This test is subject to several potential issues. First, there may be measurement error in the expenditure variables, such that the relationship between total expenditure and specific expenditure of a single good may be over- or under-stated. Second, variations which result in changes to expenditure may be caused by events which would also influence preferences overall, such as the death of a family member. While these problems do not impact implementation, it is necessary to be aware of these shortcomings in the analysis.

$$\Delta \log(x_{it}) = \Delta R_{it}\alpha + \Delta Z_{it}\beta + \Delta\epsilon_{it} \tag{8}$$

$$\Delta \log(c_{it}) = \Delta R_{it}\pi + \Delta Z_{it}\beta + \Delta\nu_{it} \tag{9}$$

where all terms are as previously defined.

Differencing allows me to analyze changes over time, as well as to control for unobserved household heterogeneity, which may bias the coefficient estimates.[19]

In order to actually test the restriction proposed in equation (4), I employ an overidentification test:

$$f_f(L_f, r) + f_m(L_m, r) + f_j(L_j, r) - w(L_f + L_m) = \chi\alpha \tag{10}$$

for some scalar χ. To test this empirically, I use a proportional non-linear Wald test. However, this test is limited as it does not explicitly link variation in income with its respective gendered or joint origin.

To address this limitation, I create linear differences in rainfall for each of the income earners within a household. I estimate each first differenced regression, for household i, individual s, at time t:

$$\Delta log(y_{ist}) = \Delta R_{it}\psi_{ys} + \Delta Z_{it}\delta_{ys} + \Delta\gamma_{st}, \tag{11}$$

and from each calculate the predicted values: $\Delta R_{it}\hat{\psi}_{ys}$. All terms are as previously defined. Then I estimate:

[19]As my empirical analysis includes only two years of data, this difference is equivalent to the fixed effect estimator. Thus, the year indicators and household fixed effects from equation (5) are omitted in implementation.

$$\Delta \log(x_{it}) = \sum_{s=1}^{S} \Delta R_{it} \hat{\psi}_{ys} + \Delta Z_{it}\beta + \Delta\epsilon_{it}, \tag{12}$$

$$\Delta \log(c_{it}) = \sum_{s=1}^{S} \Delta R_{it} \hat{\psi}_{ys} + \Delta Z_{it}\beta + \Delta\nu_{it}. \tag{13}$$

where terms are as previously defined. Equations (12) and (13) allow me to test the impact of rainfall on expenditure, distinguished by different income sources. Instead of broadly considering rainfall's impact on expenditure, I am able to test its impact while simultaneously testing the assumption of a collective household, wherein all income is pooled.

In implementing this analysis, I control for heteroskedasticity and correlation within households using a clustered bootstrap procedure at the household level, running 1,000 repetitions.

4 Results and Discussion

I begin this section by considering the results when only male and female income is considered, as in much of the previous literature (section 4.1). I follow this with the results of interest, which consider male, female, and joint income, and how these different categories influence expenditure (section 4.2). I conclude the section with several robustness checks (section 4.3).

4.1 Rainfall and Expenditure: Male and Female Only

Panel 1 in Table 4 reports the first stage results from equation (11), considering only male and female income. These results indicate no difference across income source and, in fact, no significant relationship between rainfall and income. Joint significance F-test confirms this.[20]

I use the predicted values to estimate my restricted test, identifying the relationship between predicted income changes and expenditure. These results are reported in Panel 1 of Table 5. As I am interested in whether household income is pooled, I focus my discussion on the overidentification Wald test. This tests the hypothesis that the coefficients in each regression are proportional to their coefficient in column (1). The different impacts on income by earner, measured conditional on total expenditure, will determine any differences in the allocation of a particular expenditure to disparate purposes within the household.

I fail to reject equality for the case of cigarettes and alcohol, clothing, recreation, education, and healthcare. Failure to reject equality means that income is pooled for these expenditures and that household members insure one another for expenditure on these goods. However I reject equality in the case of food expenditure and expenditure on housing and utilities. Rejection of equality means that income is not pooled for these expenditures and that household members do not insure one another for expenditure on these goods.

These results are largely in line with other literature examining intra-household resource allocation. As in Duflo and Udry (2004), changes in income from rainfall variation result in changes in expenditure on food, while expenditure on other goods, including alcohol and tobacco do not change, as these expenditures are insured by other household members. Similarly, Akobeng (2016) also finds evidence of no insurance for food expenditure due to fluctuations in rainfall. Broadly, these results are supported by literature which suggests a lack of income pooling in households (Duflo, 2003; Quisumbing and Maluccio, 2003; Bobonis, 2009). Further, these results indicate that if joint income is omitted from analysis, rural Malawian households exhibit much of the same income pooling behavior as has been reported throughout the previous literature.

[20]This lack of significance suggests a potentially problematic specification. As this is not our result of interest, I continue my estimation, however.

4.2 Rainfall and Expenditure: Male, Female, and Joint

Panel 2 in Table 4 reports the first stage estimation results from equation (11), considering male, female, and joint income. These results show differences across income source. Joint significance F-tests are also significant. Further, there are significant relationships between each income source and rainfall. Average start of the wettest quarter increases joint income, while average start of the wettest quarter decreases female and male income. As average start of the wettest quarter is measured in dekads, a greater value is associated with a later onset of rainfall. Thus, these results suggest that plots cultivated jointly benefit from a later start of the rains, while plots individually cultivated by men and women do not. This may be a difference in plot quality or in investment on plot, but may also be due to differences in crops cultivated. If men and women individually grow staples for home consumption, these crops may suffer more from a late onset of rain. Similarly, if shared plots primarily cultivate cash crops, such as tobacco or various tree crops, there may be some benefit (or less relative cost) to a late onset of rain.

There are several additional significant relationships between rainfall and female income, which include past year's rainfall in the wettest quarter, past year's start of the wettest quarter, current year's total rainfall, and current year's rainfall in the wettest quarter. These results suggest that women's plots and crops may be more sensitive to changes in rainfall patterns than plots cultivated jointly or plots cultivated by men. Again, this may be due to quality of plots, availability and quality of input and labor resources, as well as crop choice. Addressing crop choice, specifically, there is some evidence that women cultivate more staple crops than their male counterparts (Doss, 2002; Doss and SOFA, 2011) and as these crops are more responsive to irregular and erratic rainfall, this may drives some of the observed sensitivity.

Next, using the predicted values from the first stage, I estimate my restricted test, identifying the relationship between predicted income changes and expenditure. These results are reported in Panel 2 of Table 5. Again, as I am interested in whether household income is pooled, I focus my discussion on the overidentification Wald test. This tests the hypothesis that the coefficients in each regression are proportional to their coefficient in column (1). I perform this test as the impacts on income by earner, measured conditional on total expenditure, will determine potential discrepancies in the allocation of a particular expenditure to different purposes within the household.

I fail to reject equality for the cases of food, clothing, education, and health expenditure. Failure to reject equality means that income is pooled for these expenditures and household members insure one another for expenditure on these goods. However, I reject equality for expenditure on cigarettes and alcohol, recreation, and housing and utilities. Rejection of equality means that income is not pooled for these expenditures and household members do not insure one another for expenditure on these goods.

These results are salient as they suggest households pool income for the most important expenditures: food, clothing, education, and healthcare. The expenditures for which I reject equality are for non-essential, and to some extent luxury, goods. Cigarettes and alcohol as well as recreation are clearly luxury goods. Further, though some maintenance on a residential property is an essential good, other housing and utilities are less essential. Utilities are still a luxury for many rural households in Malawi, and more generally across Southern Africa. As a result, this essential expenditure also includes a component of luxury. Thus, although I cannot conclude that households fully pool income and completely insure one another against variation, there is strategic income pooling behavior with respect to particular types of expenditure. This suggests a type of partial insurance for households that experience short term rainfall variations.

These results are important as they empirically demonstrate the need to include joint relationships in analyses of household behavior. They further call into question the results of previous studies, which fail to include joint relationships. The implications of this study are disparate from those of previous work, which do not find evidence of strategic resource pooling. As a result, different policy recommendations are driven from each set of conclusions. Future analysis of gender in the household will need to examine joint relationships in order to make better informed policy recommendations.

4.3 Robustness Checks

4.3.1 Aggregation by Types of Goods

The results reported above suggest differences in income pooling behavior by types of goods. In order to verify that this is not an artifact of individual expenditure measurement, I categorize consumption goods as either: essential goods or luxury goods. I perform the same test as in section 4.2, but solely consider consumption goods as either luxury or essential. I define essential goods as food, clothing, education, and healthcare expenditures, while luxury goods are defined as cigarettes and alcohol and recreation. As mentioned above, although housing and utilities have aspects of essential goods, the measure also has traits of luxury goods. Thus, I consider two additional specifications, wherein 1) housing and utilities is included as a component of essential goods and 2) as a component of luxury goods. These results are reported in Table 6.[21]

These results indicate that my conclusions from section 4.2 are robust to this alternative specification. Regardless of whether essential goods include housing and utilities, I fail to reject equality for the case of essential goods. Conversely, regardless of whether luxury goods include housing and utilities, I reject equality for the case of luxury goods. This confirms my assertion that there is strategic income pooling behavior broadly across types of expenditures.

[21]First stage rainfall resutls are not reported as they are the same as in Panel 2 in Table 4.

4.3.2 Matriarchies and Female-Headed Households

Next I examine the possibility that there are behavioral differences driven by societal charactersitics. As suggested by Walther (2016), there may be disparities in non-cooperative decision making behavior in Malawi, depending on women's status in the household. Specifically, those residing in matrilineal societies may exhibit different behavior, due to women's relatively strong bargaining power in these communities. In order to explore this, I reanalyze the data considering whether the community reports being matrilineal. The data include a question: "Do individuals in this community trace their descent through their father, their mother, or are both kinds of decent traced?" Communities which respond "their mother" are deemed to be matrilineal.[22]

I focus my discussion on the restricted results, presented in Table 7.[23] The first panel in the table reports non-matrilineal societies. In this case, I fail to reject equality for food, clothing, recreation, and healthcare expenditure. I reject equality for the case of cigarettes and alcohol, education, and housing and utilities. These results are broadly similar to the pooled results shown in Panel 2 of Table 5. The second panel presents results for matrilineal communities. In this case, I fail to reject equality for all types of goods. Thus, households in matrilineal societies pool income and completely insure on another against income variations.

It may be the case, however, that the difference in matrilineal societies is unrelated to social structure, but is instead simply due to differences in household headship: in matrilineal societies there are more female-headed households. Thus, I also report results for male- and female-headed households. Restricted results are reported in Table 8.[24] The first panel shows male-headed households and the second panel shows female-headed households. In both cases, I fail to reject equality in most cases, except for education and housing and util-

[22]Less than 10 percent of respondents indicated "both" and so these communities were grouped with those communities which trace lineage from their father. This entire group is simply classified as "non-matrilineal".

[23]I report first stage results in Table 10, found in the Appendix.

[24]First stage results are reported in Table 11, found in the Appendix.

ities for male-headed households and for housing and utilities for female-headed households. As female-headed households are ultimately not different than male-headed households, I conclude that it is not simply female household headship, but a societal difference, which results in my observation of complete income pooling for households in matrilineal communities.

These results have important implications. First, the non-matrilineal results parallel the results which include joint income, with the entire sample. This suggests that the dominant cultural behaviors in rural Malawi are in line with patriarchal societies, which result in incomplete income pooling and thus, at best, partial insurance for households. Second, the results show that matrilineal societies pool income and completely insure one another. This suggests that some elements of women's negotiation and bargaining power in the household is crucial in order to ensure complete income pooling.

5 Conclusions and Policy Implications

In this study I revisit the role of income earned by men and women in intra-household resource allocation. Using data from Malawi, I replicate previous results which show that members fail to insure household expenditures after exogenous rainfall variation causes short term changes in income. However, when I account for jointly earned income, which constitutes a significant portion of total income in Southern Africa, I find evidence of strategic income pooling and partial insurance. Households members partially insure one another for expenditure on essential goods, including food, clothing, education, and healthcare, though they do not insure one another for luxury goods, including cigarettes and alcohol, recreation, and housing and utilities. The differences between specifications with and without jointly earned income clearly indicate that failure to account for joint income biases results. My results suggest that previous studies which omitted jointly earned income have failed to account for an important dynamic in household analyses.

The conclusions of this study have crucial implications for a variety of policies relevant across Sub-Saharan Africa. In particular, they are germane to cash transfer programs, which have gained recognition in recent years. The literature regarding the efficacy of cash transfer programs is mixed. Case and Deaton (1998) suggest that transfers are used much the same as other income and Barrientos and DeJong (2006) observe success in reducing child poverty. However, Duflo (2003) finds that gender of the transfer recipient is essential for success and Ellis (2012) identifies a variety of costs associated with cash transfer programs. Given these concerns, many policy institutes still have a great deal of trepidation about implementing similar programs. My results suggest that cash transfers will be efficiently allocated for essential goods. This may reduce some anxiety around cash transfer programs, particularly questions of how money will be used by different household members.

Further, the conclusions of this study support the growing body of literature on women's bargaining power and ability to negotiate in the developing world. Households in matrilineal communities fully pool income and insure one another against short term, exogenous rainfall variations. Women in these communities typically have greater negotiations and bargaining power in their households, which likely drives this difference in behavior. Although I can draw no definitive conclusions, it may be the case that as women's bargaining power increases in households over time, income pooling and complete insurance may be observed in more households.

The results presented here are important for future consideration in the study of gender in developing countries. It is imperative to include jointly earned income to obtain a complete and realistic picture of the circumstances faced by rural households in the developing world. Inclusion of joint income in studies of intra-household behavior may have broad consequences for the study of household behavior and development policy. In the future, analysis of the role of gender in the household should include joint relationships, in order to make better policy recommendations, based on actual household behavior in the developing world. Overall, the conclusions of this study support the idea that households respond to changes in the environment in ways that do not correspond to the predictions of simple household collective models. To understand the impact of these changes, it is necessary to consider the entire household, by accounting for individual and joint decision makers.

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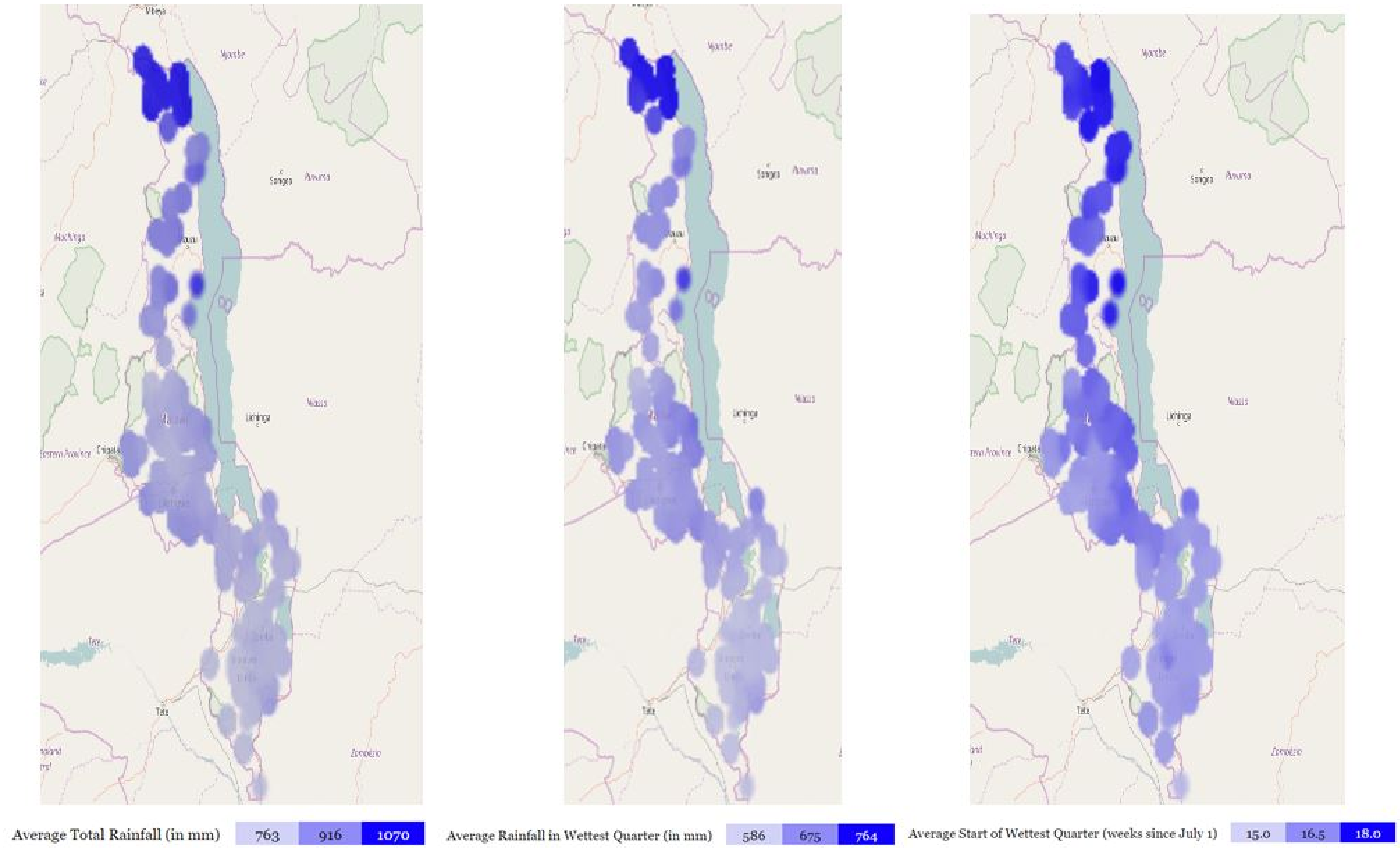

Values are averages of total rainfall over the entire year, rainfall in the wettest quarter, and start of wettest quarter. Relevant numerical values are provided in Table 3.

Figure 1: Rainfall Maps

Table 1: Summary Statistics: Income

	2010		2013		Total	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Female Income (MK)	2,762.626	11,777.82	4,148.737	18,461.06	3,455.682	15,494.24
Male Income (MK)	16,267.81	61,533.92	12,431.83	60,394.9	14,349.82	60,975.25
Joint Income (MK)	22,761.41	79,699.34	46,002.82	133,823.5	34,382.12	110,710.1
Female Income (MK)	3,603.03	14,630.77	5,654.80	24,355.25	4,628.91	20,109.22
Male Income (MK)	39,029.22	97,101.53	58,434.65	143,220.40	48,731.94	122,693.90

Note: Means and standard deviations of income for men, women, and joint sources, calculated from author's data.

Table 2: Percent Expenditure on Particular Good of Total Expenditure

	2010	2013	T-Test
Food	62.92	61.96	0.144
Cigarettes and Alcohol	2.51	3.13	0.045**
Clothing	3.31	3.37	0.755
Recreation	0.37	0.27	0.003***
Education	1.33	1.30	0.800
Health	1.74	1.03	0.000***
Housing and Utilities	13.58	15.74	0.000***
Other	14.24	13.20	0.014**

Note: Values are calculated as a percent of each good, with respect to aggregate expenditure, calculated from author's data. Significant t-test values designated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Summary Statistics: Rainfall Variables

	2010			2013			Total		
	Mean	St. Dev	Median	Mean	St. Dev	Median	Mean	St. Dev	Median
Average Total Rainfall	857.834	95.988	831.000	852.303	92.274	828.000	855.069	91.156	829.000
Average Rainfall of Wettest Quarter	649.963	53.038	645.000	644.450	48.728	639.000	647.206	50.985	640.000
Average Start of Wettest Quarter	16.466	0.635	16.300	16.636	0.643	17.000	16.551	0.645	16.400
Past Year's Total Rainfall	915.976	185.574	859.000	825.033	77.959	821.000	870.505	149.372	828.000
Past Year's Rainfall of Wettest Quarter	663.711	141.764	625.000	577.895	62.567	578.000	620.803	117.642	597.000
Past Year's Start of Wettest Quarter	16.609	1.815	17.000	18.124	1.233	19.000	17.366	1.726	18.000
Current Year's Total Rainfall	784.202	127.122	754.000	825.362	135.132	819.000	804.782	132.747	785.000
Current Year's Rainfall of Wettest Quarter	594.438	103.207	584.000	662.892	71.013	663.000	628.665	94.942	634.000
Current Year's Start of Wettest Quarter	16.974	0.696	17.000	16.434	0.579	16.000	16.704	0.695	17.000

Note: Means, standard deviations, and median values of rainfall variables, calculated from author's data.

Table 4: First Stage: Rainfall Estimates

	Joint Income	Female Income	Male Income
Panel 1: Male and Female Only			
		Female Income	Male Income
Average total rainfall		0.012	0.010
		(0.021)	(0.018)
Average rainfall of wettest quarter		−0.040	0.029
		(0.040)	(0.035)
Average start of wettest quarter		−0.737	0.081
		(0.457)	(0.434)
Past year's total rainfall		0.005	−0.003
		(0.003)	(0.003)
Past year's rainfall of wettest quarter		−0.007	0.002
		(0.005)	(0.004)
Past year's start of wettest quarter		0.133	−0.090
		(0.084)	(0.083)
Current year total rainfall		−0.003	−0.003
		(0.003)	(0.003)
Current year rainfall of wettest quarter		0.005	0.002
		(0.003)	(0.003)
Current year start of wettest quarter		−0.187	0.235
		(0.228)	(0.212)
Joint Significance - F-Test		1.17	0.81
		0.291	0.663
R^2		0.031	0.039
Panel 2: Male, Female, and Joint			
	Joint Income	Female Income	Male Income
Average total rainfall	−0.046	0.007	0.037
	(0.043)	(0.022)	(0.034)
Average rainfall of wettest quarter	0.106*	−0.041	−0.066
	(0.060)	(0.041)	(0.055)
Average start of wettest quarter	1.231*	−0.888*	−1.220*
	(0.734)	(0.480)	(0.662)
Past year's total rainfall	0.008	0.005	−0.009
	(0.007)	(0.004)	(0.006)
Past year's rainfall of wettest quarter	−0.010	−0.009*	0.011
	(0.008)	(0.005)	(0.008)
Past year's start of wettest quarter	0.058	0.219***	−0.171
	(0.152)	(0.085)	(0.139)
Current year total rainfall	−0.006	−0.008**	0.005
	(0.006)	(0.003)	(0.005)
Current year rainfall of wettest quarter	−0.000	0.010***	−0.001
	(0.006)	(0.003)	(0.006)
Current year start of wettest quarter	−0.277	0.024	0.452
	(0.396)	(0.232)	(0.358)
Joint Significance - F-Test	1.78**	1.61*	1.69**
	0.034	0.065	0.048
R^2	0.025	0.047	0.023

Note: Fully robust standard errors clustered at the household are in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$). Regressions also include agro-ecological zone indicators.

Table 5: Restricted Overidentification Tests: Log of Consumption

	(1) Aggregate	(2) Food	(3) Cigarettes and Alcohol	(4) Clothing	(5) Recreation	(6) Education	(7) Health	(8) Housing and Utilities
Panel 1: Male and Female Only								
Predicted change in male income	0.126*	0.081	−0.488	0.193	0.480	0.667	−0.395	0.044
	(0.074)	(0.085)	(0.784)	(0.704)	(0.440)	(0.410)	(0.670)	(0.095)
Predicted change in female income	0.168***	0.215***	0.190	0.301	−0.231	0.811**	−0.307	−0.122
	(0.063)	(0.073)	(0.672)	(0.604)	(0.377)	(0.351)	(0.574)	(0.081)
Overidentification Wald-Test		5.57*	1.04	0.05	3.93	3.59	0.86	13.77***
		(0.062)	(0.594)	(0.974)	(0.140)	(0.166)	(0.650)	(0.001)
R^2	0.031	0.033	0.008	0.005	0.017	0.024	0.039	0.013
Panel 2: Male, Female, and Joint								
Predicted change in male income	−0.022	−0.032	−1.060	0.115	−0.090	0.567	−0.108	0.039
	(0.073)	(0.084)	(0.769)	(0.694)	(0.432)	(0.403)	(0.659)	(0.093)
Predicted change in female income	0.096**	0.115***	0.422	0.044	−0.056	0.543**	−0.255	−0.028
	(0.039)	(0.045)	(0.409)	(0.369)	(0.230)	(0.215)	(0.351)	(0.050)
Predicted change in joint income	0.012	−0.024	−0.497	−0.111	0.342	0.545	0.204	0.106
	(0.068)	(0.079)	(0.724)	(0.653)	(0.407)	(0.380)	(0.621)	(0.088)
Overidentification Wald-Test		3.21	6.90*	1.16	7.61*	5.83	2.79	10.87**
		(0.360)	(0.075)	(0.762)	(0.055)	(0.120)	(0.425)	(0.012)
R^2	0.037	0.022	0.011	0.007	0.026	0.018	0.046	0.029

Note: The table presents coefficients of the difference in log consumption of each item on the difference in predicted log income, as obtained from Table 10. Standard errors are given in parentheses. Regressions include agro-ecological zone indicators. Fully robust standard errors clustered at the household are in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 6: Restricted Overidentification Tests: Log of Pooled Consumption Aggregates - Male, Female, and Joint

	(1) Aggregate	(2) Necessary Goods	(3) Luxury Goods	(4) Necessary, with Maintenance	(5) Luxury, with Maintenance
Predicted change in male income	−0.022	−0.254	−0.522	−0.115	−0.235
	(0.073)	(0.348)	(0.592)	(0.297)	(0.386)
Predicted change in female income	0.096**	0.391**	0.591*	0.252	−0.183
	(0.039)	(0.185)	(0.315)	(0.158)	(0.205)
Predicted change in joint income	0.012	−0.139	−0.001	−0.035	0.135
	(0.068)	(0.328)	(0.558)	(0.279)	(0.363)
Overidentification Wald-Test		5.53	10.18**	2.29	7.57*
		(0.137)	(0.017)	(0.515)	(0.059)
R^2	0.037	0.015	0.027	0.010	0.027

Note: The table presents coefficients of the difference in log consumption of each item on the difference in predicted log income, as obtained from Table **??**. Standard errors are given in parentheses. Regressions include agro-ecological zone indicators. Fully robust standard errors clustered at the household are in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 7: Restricted Overidentification Tests: Log of Consumption - Matrilineal

	(1) Aggregate	(2) Food	(3) Cigarettes and Alcohol	(4) Clothing	(5) Recreation	(6) Education	(7) Health	(8) Housing and Utilities
Panel 1: Non-Matrilineal								
Predicted change in male income	−0.028	0.063	−1.032	0.143	−0.629	1.224***	−0.363	−0.228**
	(0.083)	(0.094)	(0.795)	(0.792)	(0.510)	(0.408)	(0.735)	(0.103)
Predicted change in female income	0.185***	0.191**	1.369**	−0.215	0.150	0.523	−0.584	−0.092
	(0.065)	(0.074)	(0.627)	(0.625)	(0.402)	(0.322)	(0.580)	(0.081)
Predicted change in joint income	−0.028	0.033	−0.551	0.176	−0.351	0.981***	−0.075	−0.076
	(0.067)	(0.076)	(0.643)	(0.640)	(0.412)	(0.330)	(0.594)	(0.083)
Overidentification Wald-Test		4.32	13.01***	0.59	1.78	10.91**	2.12	11.31***
		(0.229)	(0.005)	(0.900)	(0.620)	(0.012)	(0.547)	(0.010)
R^2	0.034	0.032	0.015	0.011	0.014	0.025	0.041	0.016
Panel 2: Matrilineal								
Predicted change in male income	−0.087	−0.134*	−0.613	−0.692	0.182	0.396	0.085	−0.069
	(0.059)	(0.068)	(0.655)	(0.559)	(0.340)	(0.345)	(0.547)	(0.076)
Predicted change in female income	−0.003	−0.003	−0.179	−0.295	0.240	0.388	0.084	−0.079
	(0.046)	(0.054)	(0.513)	(0.438)	(0.266)	(0.270)	(0.429)	(0.060)
Predicted change in joint income	−0.078	−0.128*	−0.466	−0.977	0.421	0.509	0.066	−0.082
	(0.063)	(0.074)	(0.706)	(0.603)	(0.366)	(0.372)	(0.590)	(0.082)
Overidentification Wald-Test		3.71	1.02	3.58	3.83	3.07	0.13	3.16
		(0.295)	(0.795)	(0.311)	(0.281)	(0.380)	(0.987)	(0.368)
R^2	0.058	0.077	0.020	0.052	0.092	0.101	0.076	0.076

Note: The table presents coefficients of the difference in log consumption of each item on the difference in predicted log income, as obtained from Table 10. Standard errors are given in parentheses. Regressions include agro-ecological zone indicators. Fully robust standard errors clustered at the household are in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 8: Restricted Overidentification Tests: Log of Consumption - Female-Headed

	(1) Aggregate	(2) Food	(3) Cigarettes and Alcohol	(4) Clothing	(5) Recreation	(6) Education	(7) Health	(8) Housing and Utilities
Panel 1: Male-Headed								
Predicted change in male income	0.044	0.059	−0.927	−0.021	0.124	0.560	−0.316	−0.008
	(0.075)	(0.087)	(0.793)	(0.698)	(0.441)	(0.417)	(0.669)	(0.093)
Predicted change in female income	0.116***	0.139***	0.235	0.134	−0.022	0.723***	−0.325	−0.034
	(0.043)	(0.050)	(0.457)	(0.402)	(0.254)	(0.240)	(0.385)	(0.054)
Predicted change in joint income	0.062	0.055	−0.491	−0.303	0.393	0.514	0.016	0.058
	(0.072)	(0.083)	(0.756)	(0.665)	(0.421)	(0.398)	(0.638)	(0.089)
Overidentification Wald-Test		2.10	4.31	2.41	3.59	7.20*	2.81	8.67**
		(0.552)	(0.230)	(0.544)	(0.309)	(0.066)	(0.422)	(0.034)
R^2	0.034	0.032	0.015	0.011	0.014	0.025	0.041	0.016
Panel 2: Female-Headed								
Predicted change in male income	−0.060	−0.171*	0.783	0.280	0.630	0.183	1.160	0.270**
	(0.088)	(0.102)	(1.011)	(0.994)	(0.588)	(0.498)	(0.915)	(0.135)
Predicted change in female income	−0.016	−0.055	−0.039	0.790	0.160	−0.121	−0.352	0.029
	(0.059)	(0.068)	(0.677)	(0.666)	(0.394)	(0.333)	(0.613)	(0.090)
Predicted change in joint income	−0.024	−0.130	0.916	0.313	0.644	−0.025	1.140	0.217
	(0.095)	(0.111)	(1.096)	(1.078)	(0.638)	(0.540)	(0.993)	(0.146)
Overidentification Wald-Test		4.23	1.40	1.91	1.99	1.91	3.81	7.16*
		(0.238)	(0.705)	(0.592)	(0.574)	(0.591)	(0.283)	(0.067)
R^2	0.058	0.077	0.020	0.052	0.092	0.101	0.076	0.076

Note: The table presents coefficients of the difference in log consumption of each item on the difference in predicted log income, as obtained from Table 11. Standard errors are given in parentheses. Regressions include agro-ecological zone indicators. Fully robust standard errors clustered at the household are in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Appendix

Unrestricted Overidentification Tests

Table 9 presents the unconstrained estimates of the relationship between expenditure and rainfall. For each regression, nine rainfall variables, are included, as well as location indicators. These results are not disaggregated by gender and hence cannot address the potentially gendered nature of income earning and expenditure.

Table 9: Unrestricted Overidentification Tests: Log of Consumption

	(1) Aggregate	(2) Food	(3) Cigarettes and Alcohol	(4) Clothing	(5) Recreation	(6) Education	(7) Health	(8) Housing and Utilities
Average total rainfall	−0.001	−0.002	−0.044	−0.002	−0.000	−0.004	−0.054*	−0.003
	(0.003)	(0.004)	(0.033)	(0.024)	(0.020)	(0.018)	(0.033)	(0.004)
Average rainfall of wettest quarter	0.006	0.005	0.036	−0.002	0.058*	0.012	0.085	0.011*
	(0.005)	(0.006)	(0.053)	(0.047)	(0.033)	(0.029)	(0.053)	(0.006)
Average start of wettest quarter	−0.036	−0.182**	1.349*	−0.334	0.841*	−0.604	0.264	0.163*
	(0.069)	(0.081)	(0.713)	(0.677)	(0.453)	(0.402)	(0.592)	(0.091)
Past year's total rainfall	0.000	0.000	0.011*	−0.002	−0.001	0.005	0.008	−0.000
	(0.001)	(0.001)	(0.006)	(0.005)	(0.004)	(0.003)	(0.005)	(0.001)
Past year's rainfall of wettest quarter	−0.001*	−0.001*	−0.014*	−0.000	−0.002	−0.008*	−0.010	0.001
	(0.001)	(0.001)	(0.008)	(0.007)	(0.005)	(0.004)	(0.007)	(0.001)
Past year's start of wettest quarter	0.024*	0.043***	0.116	−0.008	0.056	0.070	−0.080	−0.026
	(0.014)	(0.016)	(0.137)	(0.140)	(0.090)	(0.076)	(0.129)	(0.019)
Current year total rainfall	−0.002***	−0.001**	−0.007	−0.000	−0.006*	−0.004	0.000	−0.001
	(0.001)	(0.001)	(0.006)	(0.005)	(0.003)	(0.003)	(0.005)	(0.001)
Current year rainfall of wettest quarter	0.002***	0.002***	0.010*	0.002	0.006*	0.003	−0.003	0.001
	(0.001)	(0.001)	(0.006)	(0.005)	(0.003)	(0.003)	(0.005)	(0.001)
Current year start of wettest quarter	−0.091**	−0.092**	−0.114	−0.096	−0.154	0.093	−0.683**	−0.041
	(0.037)	(0.042)	(0.388)	(0.362)	(0.237)	(0.187)	(0.335)	(0.048)
Joint Significance - F-Test	3.58***	2.51***	1.97**	0.22	2.08**	1.03	2.456	2.74***
	(0.000)	(0.008)	(0.040)	(0.991)	(0.029)	(0.385)	(0.417)	(0.004)
R^2	0.065	0.051	0.029	0.008	0.038	0.029	0.052	0.040

Note: Fully robust standard errors clustered at the household are in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$). Regressions also include agro-ecological zone indicators.

First Stage Results: Robustness Checks

First stage results for the robustness checks are reported in the following pages.

Table 10: First Stage: Rainfall Estimates - Matrilineal

	Joint Income	Female Income	Male Income
Non-Matrilineal			
Average total rainfall	−0.081	−0.012	0.062
	(0.060)	(0.032)	(0.047)
Average rainfall of wettest quarter	0.146*	0.002	−0.113
	(0.082)	(0.066)	(0.075)
Average start of wettest quarter	−0.330	−0.046	−0.985
	(1.032)	(0.715)	(0.968)
Past year's total rainfall	0.002	−0.000	−0.005
	(0.009)	(0.005)	(0.008)
Past year's rainfall of wettest quarter	−0.006	−0.003	0.009
	(0.012)	(0.008)	(0.011)
Past year's start of wettest quarter	0.115	0.234**	−0.092
	(0.208)	(0.111)	(0.187)
Current year total rainfall	−0.002	−0.005	0.005
	(0.011)	(0.005)	(0.009)
Current year rainfall of wettest quarter	0.001	0.009	−0.002
	(0.010)	(0.006)	(0.008)
Current year start of wettest quarter	0.597	0.093	−0.506
	(0.671)	(0.323)	(0.602)
R^2	0.075	0.056	0.072
Matrilineal			
Average total rainfall	0.011	0.027	−0.016
	(0.063)	(0.035)	(0.058)
Average rainfall of wettest quarter	0.027	−0.098*	0.055
	(0.102)	(0.054)	(0.094)
Average start of wettest quarter	2.891**	−1.605**	−1.884*
	(1.130)	(0.690)	(1.042)
Past year's total rainfall	0.012	0.010*	−0.017
	(0.011)	(0.006)	(0.010)
Past year's rainfall of wettest quarter	−0.004	−0.013*	0.010
	(0.013)	(0.007)	(0.012)
Past year's start of wettest quarter	0.011	0.194	−0.288
	(0.245)	(0.135)	(0.228)
Current year total rainfall	−0.000	−0.011**	−0.000
	(0.008)	(0.005)	(0.008)
Current year rainfall of wettest quarter	−0.008	0.013***	0.004
	(0.009)	(0.005)	(0.009)
Current year start of wettest quarter	−0.843	−0.173	1.110**
	(0.596)	(0.352)	(0.531)
R^2	0.050	0.066	0.050

Note: Fully robust standard errors clustered at the household are in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$). Regressions also include agro-ecological zone indicators. Blank spaces indicate omissions due to collinearity.

Table 11: First Stage: Rainfall Estimates - Female-Headed

	Joint Income	Female Income	Male Income
Male-Headed			
Average total rainfall	−0.078*	0.008	0.070**
	(0.043)	(0.025)	(0.035)
Average rainfall of wettest quarter	0.130**	−0.040	−0.098*
	(0.062)	(0.045)	(0.056)
Average start of wettest quarter	1.128	−0.649	−1.337*
	(0.791)	(0.524)	(0.728)
Past year's total rainfall	0.010	0.006	−0.013**
	(0.007)	(0.004)	(0.006)
Past year's rainfall of wettest quarter	−0.010	−0.010*	0.014
	(0.009)	(0.005)	(0.009)
Past year's start of wettest quarter	0.026	0.209**	−0.117
	(0.168)	(0.092)	(0.155)
Current year total rainfall	−0.005	−0.009**	0.004
	(0.006)	(0.004)	(0.006)
Current year rainfall of wettest quarter	−0.001	0.010***	0.000
	(0.007)	(0.004)	(0.006)
Current year start of wettest quarter	−0.370	−0.002	0.557
	(0.430)	(0.244)	(0.394)
	(0.671)	(0.323)	(0.602)
R^2	0.028	0.046	0.033
Female-Headed			
Average total rainfall	0.146	0.014	−0.173*
	(0.103)	(0.044)	(0.097)
Average rainfall of wettest quarter	−0.196	0.016	0.280*
	(0.183)	(0.093)	(0.165)
Average start of wettest quarter	2.056	−3.181**	−0.704
	(1.969)	(1.343)	(1.493)
Past year's total rainfall	0.004	−0.003	0.004
	(0.017)	(0.009)	(0.016)
Past year's rainfall of wettest quarter	−0.009	−0.001	−0.003
	(0.022)	(0.011)	(0.019)
Past year's start of wettest quarter	0.189	0.291	−0.404
	(0.375)	(0.211)	(0.326)
Current year total rainfall	−0.014	−0.005	0.014
	(0.018)	(0.005)	(0.015)
Current year rainfall of wettest quarter	0.012	0.005	−0.016
	(0.020)	(0.005)	(0.017)
Current year start of wettest quarter	0.526	0.203	−0.253
	(1.083)	(0.748)	(0.913)
R^2	0.125	0.148	0.129

Note: Fully robust standard errors clustered at the household are in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$). Regressions also include agro-ecological zone indicators. Blank spaces indicate omissions due to collinearity.