# 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. 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 in explaining resource allocation. I then use rainfall variation to examine changes in income and expenditure. Ultimately, I reject the hypothesis of complete income pooling and full insurance within the household. However, I find evidence that households members partially insure one another for expenditures on essential goods. Conversely, they do not insure one another for luxury goods. From this, 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 household bargaining and intra-household dynamics which highlights the essential nature of joint relationships in intra-household analyses.

*JEL Classification*: O12, D13, J16
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# 1 Introduction

Despite the abundance 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, composes a large portion of earned income. This is evinced in Southern Africa, where studies show that between 12 percent and 50 percent of household plots are jointly managed, earning shared income (Kilic et al., 2015; Slavchevska, 2015). The failure to consider these joint relationships is likely to lead to biased results in studies of intra-household income and resource allocation.

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. Expanding a model and empirical test first developed by Duflo and Udry (2004), I explore the disparities in expenditure by different income earners after the experience of a short term income shock. 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 a restriction of the collective household model: that income from the three income 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 shocks will not result in changes in allocation of the resources of 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 utilities and maintenance on the residence. I conclude that the income pooling that exists is strategic 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.[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, households do not strategically pool income resources and thus do not insure one another against shocks. This conclusion parallels much of the previous literature and thus indicates that earlier research has failed to account for an important dynamic in household analysis, by omitting joint relationships. A key contribution to the observed strategic behavior appears to be in 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 shocks. Households in non-matrilineal societies fail to do so. 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. Therefore, I conclude that societal structures play an important role in intra-household income allocation.

My identification strategy examines the effect of a short term shock on income and expenditure. I examine short term variations in rainfall, which represents a shock to income that is covariate at the household level. All members of a household experience the same

[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), among others.

rainfall, but the pattern of rainfall may have different impacts on individual members, due to differences in activities, crops cultivated, and plot quality.[4] As previous literature has shown, women and men not only cultivate a different set of crops, but do so on plots of different qualities (Doss and Morris, 2001; Karamba and Winters, 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, will not translate into any differences in the allocation of a particular expenditure to different purposes within the household. To examine this, I consider broad expenditure aggregates, including total expenditure, as well as more detailed expenditures.

Collective household models are common throughout the development literature, but Udry (1996) was 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 for households, 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 a necessity for a household. Udry demonstrates empirically that for farming households in Burkina Faso, Pareto efficient allocation of resources is not achieved across production activities. Subsequent literature agrees with Udry, finding that most households do not pool income and are Pareto inefficient. This is because the allocation of resources depends on individual income earners.[5] Similar behavior is also observed in the literature on gender relations and bargaining.[6]

My study contributes to the body of literature that examines resource allocation within

[4]As described in more detail in the section 2, rainfall measurements are taken at the household level, and thus do not vary within households, but vary within and across communities.

[5]This is demonstrated in Haddad and Hoddinott (1994); Duflo (2003); Duflo and Udry (2004); Antman (2015), among others.

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

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.[7] While other areas of gender studies have included aspects of joint management (Kilic et al., 2015; Oseni et al., 2015; Slavchevska, 2015), it 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 household analysis.

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

With the explicit inclusion of joint relationships, this study calls into question the results of previous work and begs the reexamination of these previous studies. The importance of joint relationships in intra-household behavior will have expansive consequences for the study of household behavior in the developing world and, correspondingly, important implications for development policy. In particular, the conclusions of this study lend support to cash transfer programs and provide a modicum of optimism for households facing possible food insecurity in the face of the changing climate. 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.

[7] 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.

# 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 in 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 the population was living below the poverty line, with rural poverty at about 58 percent. More recent estimates show slight declines, with rural poverty around to 56 percent in 2004 and around 43 percent in 2009 (Chirwa and Muhome-Matita, 2013). Despite these decreases in poverty however, 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 were still estimated 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, likely driving some of the gendered household poverty gap.

## 2.2 Data

Data for this study comes from the World Bank Living Standards Measurement Survey-Integrated Surveys on Agriculture Project (LSMS), collected by the Malawi National Statistical Office in collaboration with the World Bank. 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 allocation among rural households, I omit from my analysis households which did not report income from crop sales. Each included household has at least one household member who earned some income from the sales 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. This provides the sample for my analysis

In addition to identifying the amounts and values of crops sold, the survey identifies the household member who is responsible for decisions about the income earned from the sale of each crop sold. 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 restrict my consideration to only the primary manager, and designate male and female income based on the individual reported. Subsequent to this, I also consider joint income. I designate income as joint if a second 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.[8] If no second manager is identified, income is classified as either male or female, following the gender of the primary manager. As shown in Figure 1, the primary difference when joint income is omitted is an over-attribution of earned income to men. The figure shows that women's income remains approximately the same, regardless of if joint income is included, but men's income is vastly different when joint income is included. With more detail, Table 1 presents summary statistics on earned income, by gender, both when joint income is included and omitted.

My analysis also relies on expenditure data. An aggregate measure includes all household

[8]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.

expenditure, but I also include measures of expenditure on seven types of goods. Households which have no expenditure for a particular good are designated with a zero. I include measures of both essential and luxury goods to obtain a broad perspective on overall household spending. Figure 2 shows expenditures on each type of good, as a percent of total household expenditure. The figure shows that food comprises the largest percent of a household's expenditure, followed by utilities and maintenance for the residential area. Education and recreation comprise the smallest percent of a household's expenditure. The charts for each year appear to be quite similar, so Table 2 reports the percent values for each year, as well as the results of a t-test for each type of expenditure.

Finally, Table 3 reports summary statistics for the rainfall measures used in my analysis. Figure 3 maps 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.[9] With the three measurements, the analysis not only focuses on total rainfall, but also 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 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 of the two periods. These variables capture the various pathways through which rainfall may influence agricultural productivity and thus earned income.

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

# 3 Theoretical Model

## 3.1 Theory

My theoretical model expands upon a model developed by Duflo and Udry (2004) in order to include the earning of joint income. I use a one-period model of intra-household resource allocation in a risky environment.[10] To simplify notation, I consider a household of two individuals, each of whom produce one crop on one plot and 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 production function on farm for individual $i$ is $f_i(L_i, r)$ where $r \equiv (r_1, r_2)'$ is a vector of two measures of rainfall which impact cultivation on the plot each individual $i$.[11]

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.[12]

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 $\lambda$ 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

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

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

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

efficient allocation of resources, risk is pooled.

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 parameters. Consumption considers only private goods and thus, jointly managed plots contribute to expenditure, though joint consumption is not a component of the 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 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 ($\frac{\partial p}{\partial r_i} = 0$).[13]

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

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

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,

$$\frac{\frac{dc_i^k}{r_1}}{\frac{dx}{dr_1}} = \frac{\frac{dc_i^k}{r_2}}{\frac{dx}{dr_2}}. \tag{4}$$

The crucial aspect of equation (4) is that $dr_i$ impacts collective household decision making through its influence on the household's budget constraint.[14]

I define equation (4) as my overidentifying restriction, which I test in my empirical analysis. The restriction specifies that realized rainfall influences demand for a particular

[13] This follows Duflo and Udry (2004).

[14] 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 such data is not required for empirical analysis.

good to the degree with which it impacts expenditure.

## 3.2 Empirical Implementation

There are several necessary assumptions required to implement the 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 appropriate), $v_i$ represents a household fixed effect, and $\nu_{it}$ 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.[15]

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. However, 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, shocks 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.

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

[15] 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.

household expenditure:

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

where I assume that rainfall ($R_{it}$) impacts individual and joint income and thus influences households' expenditures.

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

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

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

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

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

Differencing allows me to analyze changes over time, as well as to control for unobserved household heterogeneity, which may bias the coefficient estimates.[16]

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 $\chi$. When testing this empirically, I use a proportional non-linear Wald test. This test is limited as it does not explicitly link variation in income with its respective

[16] 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.

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:

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

and from each calculate the predicted values: $\Delta R_{it}\hat{\psi}_{ys}$. Then I estimate:

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

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

This allows 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 my results of interest, which consider male, female, and joint income, and how changes to these categories influence expenditure (section 4.2). Following these results, I conclude the section with several robustness checks (section 4.3) and a discussion of the limitations of the analysis (section 4.4).

## 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. A joint significance F-test confirms this.

Despite the lack of significance in the first stage, 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. However I reject equality in the case of food expenditure and expenditure on utilities and maintenance. 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 in line with other literature examining intra-household resource allocation. As in Duflo and Udry (2004), changes in income 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 suggest 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.

### 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 is a significant relationship 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 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 a difference 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, there may be some benefit to a late onset of rain. The differences in the relationships between rainfall and income earner depend on the quality and resources on the plot as well as the crops cultivated by the manager.

There are several additional significant relationships between rainfall and female income, which include past year's rainfall in the wettest quarter, start of the wettest quarter, current year's total rainfall, and rainfall in the wettest quarter. This suggests that women's plots and crops may be more sensitive to changes in rainfall patterns than plots cultivated jointly or plots cultivated by men. 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 rainfall, this likely 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 expenditure, clothing expenditure, education expenditure, and health expenditure. However, I reject equality for expenditure on cigarettes and alcohol, recreation, and utilities and maintenance. 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, 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 utilities and maintenance are less essential.[17] 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.[18] 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

[17]Utilities in this case refer to electricity.

[18]It is not possible to disaggregate the two expenditures for separate testing.

experience short term shocks.

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 discussed above suggest a difference 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 utilities and maintenance have aspects of essential goods, the measure also has traits of luxury goods. Thus, I consider two additional specifications, wherein utilities and maintenance is included as a component of essential goods and as a component of luxury goods. These results are reported in Table 6.

These results indicate that my conclusions from section 4.2 are robust to this alternative specification. Regardless of whether essential goods include utilities and maintenance, I fail to reject equality for the case of essential goods. Conversely, regardless of whether luxury goods include utilities and maintenance, 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.

#### 4.3.2 Matriarchies and Female-Headed Households

Next I examine the possibility that there are behavioral differences by community. 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. That is, 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 World Bank LSMS data includes 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.[19]

I focus my discussion on the restricted results, presented in Table 7.[20] 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 utilities and maintenance. 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 their social structure, but is instead simply due to differences in household headship: in matrilineal societies there may be more female-headed households. Thus, I also report results for male- and female-headed households. Restricted results are reported in Table 8.[21] The first

[19]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".

[20]I report first stage results in Table 12, found in the Appendix.

[21]First stage results are reported in Table 13, found in the Appendix.

panel shows male-headed households and the second panel shows female-headed households. In both cases, I fail to reject equality in all cases, except for utilities and maintenance. 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 a patriarchal society, which results in incomplete income pooling and thus, at best, partial insurance for households. Second, the results indicate that matrilineal societies pool income and completely insure one another. This suggests that women's bargaining power in the household is crucial in order to ensure complete income pooling.

## 4.4 Limitations

It is a possibility that markets are not well integrated and price changes over time may bias my estimates. Although I control for location to address price effects, if markets are not well developed, the estimates may still be biased. I test this possibility using data available on prices in the LSMS. Unfortunately, despite a diverse set of goods and services available in the first round of the survey, the second round includes a more limited set of prices, which restricts my analysis.

Table 9 reports the relationship between predicted changes in income and prices, for five goods or services. These goods and services include maize, cloth, cigarettes, beer, and the cost of grinding 50 kilograms of maize. I find statistically significant relationships for the predicted change in male income for maize, cloth, and the cost of grinding maize. For the predicted change in female income, I find statistically significant relationships with all products. Finally, for the predicted change in joint income, I find a statistically significant relationship between maize price and the cost of grinding maize. These significant relationships suggest that, to some extent, the changes in expenditure and income are related to changes in prices. Therefore, my results should be considered as an upper-limit of the effects of rainfall on expenditure.

# 5 Policy Implications

The results of this study have crucial implications for two areas of policy. The first policy area considers cash transfer programs which have gained recognition in recent years in Sub-Saharan Africa (Case and Deaton, 1998; Duflo, 2003; Barrientos and DeJong, 2006; Ellis, 2012). The conclusions of this study may reduce some anxiety around cash transfer programs, which often question how money will be used by different household members. My results suggest that cash transfers will be efficiently allocated for essential goods and thus further lend support for the existence of these programs. The second policy area deals with household adaptations to the changing climate. Understanding how changes in income impact household expenditure and consumption are essential for crafting policy recommendations for households facing a changing climate. My results indicate that these income changes will be completely insured by household members for essential goods. This may provide support for optimism on the implications for food insecurity in the face of a changing climate. Of course, by no means does this indicate that optimism for climate change itself is desired, but simply that the consequences of the changing climate may not be as ominous for household welfare as has been previously suggested.

To further explore these results, I calculate the change in expenditure on each good, by each group, for both a positive and negative change of ten percent of average income.[22] These results are reported in Table 10. Average expenditures are reported in the top panel,

[22] Generally calculated as: $\hat{\beta}(\bar{x} \pm (0.1)\bar{x})$, where $\bar{x}$ is the mean income and $\hat{\beta}$ is the estimates from the analysis, reported in Panel 2 of Table 5.

as a reference.

As changes in essential goods are insured by the household, the predicted changes in expenditure on food, clothing, education, and healthcare are responses by the household, based on income pooling behavior. Thus, I limit my discussion to the non-insured, non-pooled expenditures: cigarettes and alcohol, recreation, and utilities and maintenance. Of these, utilities and maintenance sees the smallest changes: a decrease in female income results in a decrease in expenditure by 96.41 Malawian kwacha (about $0.40). The greatest changes is an increase from predicted expenditure of joint income of 529.48 Malawian kwacha (about $2.20). These changes are relatively minimal, and of approximately the same scale, regardless of income source. Cigarettes and alcohol and recreation are quite different, however. First, addressing cigarettes and alcohol, while the predicted expenditure change in female income results in an expenditure change of around 1,400 Malawian kwacha (about $5.80), predicted expenditure change for male income and joint income are much greater, approximately 13,500 Malawian kwacha (about $56.25) and 17,000 Malawian kwacha (about $70.80), respectively. Second, addressing recreation, while the predicted expenditure change in female income results in an expenditure change of around 40 Malawian kwacha (about $0.17), predicted expenditure, change for male income and joint income are much greater, approximately 1,300 Malawian kwacha (about $5.40) and 4,000 Malawian kwacha (about $16.70), respectively.

The magnitudes of these changes are almost shockingly large and potentially concerning when considering policy recommendations. However, closer examination reveals that, while large, the predicted changes in expenditure for male income for both cigarettes and alcohol and recreation, as well as the predicted changes in expenditure for joint income for cigarettes and alcohol, are negative. This means that these groups are actually reducing their expenditure on these goods, in response to income changes. This is an optimistic result and serves as evidence contrary to previous empirical and anecdotal studies, where men are often observed spending large portions of income on cigarettes and alcohol. Somewhat surprisingly, women are increasing their expenditure on these goods, however, the scale is much smaller and composes only a fraction of total household expenditure. Of some concern, however, is the increase in expenditure, based on joint income, for recreation. All income changes drive large and positive shifts in expenditure, suggesting that any fluctuation in joint income will result in increased expenditure on recreation. This result is necessary to consider when evaluating possible policy recommendations.

Taken together, these results of this study imply that cash transfer programs and income changes due to climate change or other shocks may result in improvements in household conditions. The most essential goods will be insured through income pooling behavior of the household, and other luxury goods will see a decrease in consumption when income changes. However policies should be wary of changes in recreation behavior associated with increased expenditure by joint earners. This result may lend itself to the recommendation in which transfers are allocated to a particular income earner, as suggested by Duflo (2003).

# 6 Conclusion

When I account for joint income in intra-household resource allocation, I find evidence of strategic income pooling and partial insurance. The conclusions of this study support the result that that 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 utilities and maintenance on the residence. My results are contrary to those of previous studies, which fail to find even partial insurance within households for essential goods.

My results are driven by the inclusion of jointly earned income in the analysis. The differences between specifications with and without jointly earned income clearly indicate that failure to account for joint income biases results. When including only male and female income, income pooling is not observed for essential goods; results parallel those of previous studies. This indicates that the inclusion of joint income is crucial in the analysis of intra-household resource allocation.

Further, my results support the growing body of literature on women's bargaining power in the developing world. Households in matrilineal communities fully pool income and insure one another against exogenous shocks. Women in these communities typically have greater 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 cases.

The results of this study are essential for future considerations in studies 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 will have broad consequences for the study of household behavior and development policy. In the future, analysis of the role of gender in the household must 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 household outcomes respond to changes in the environment in ways that do not correspond to the predictions of simple household collective models: for understanding the impact of these changes, it is necessary to consider the entire household, including accounting for individual and joint decision makers.

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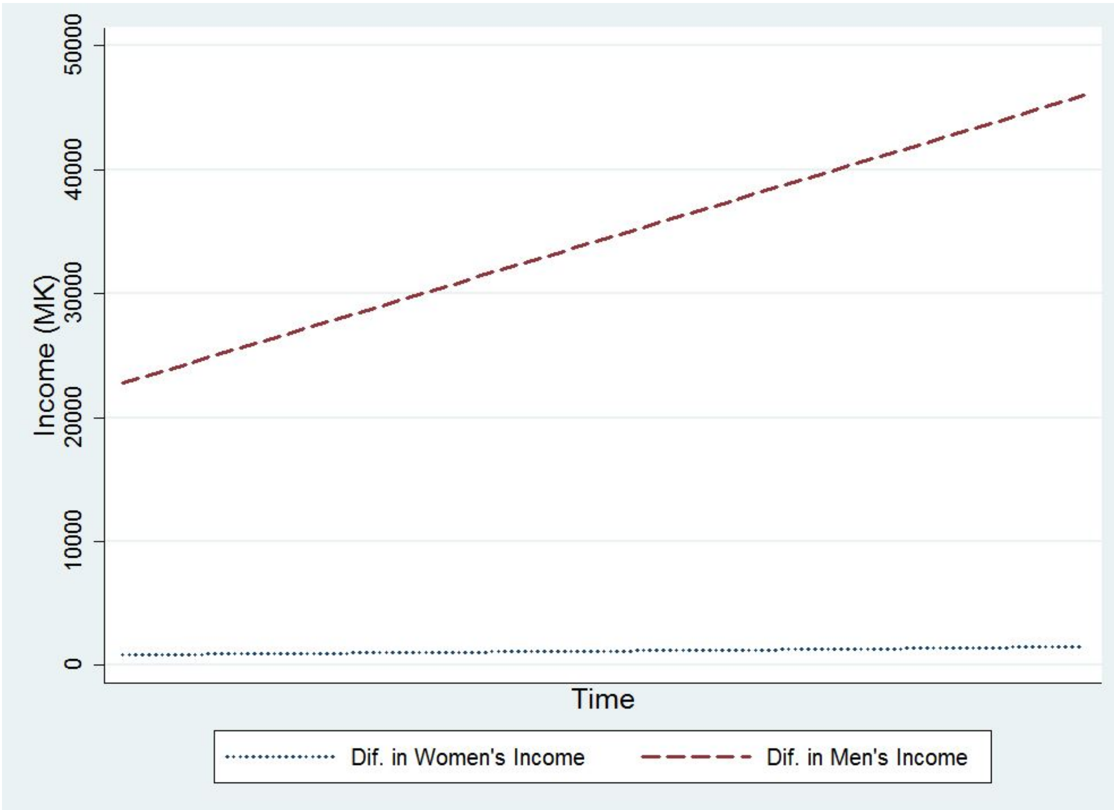
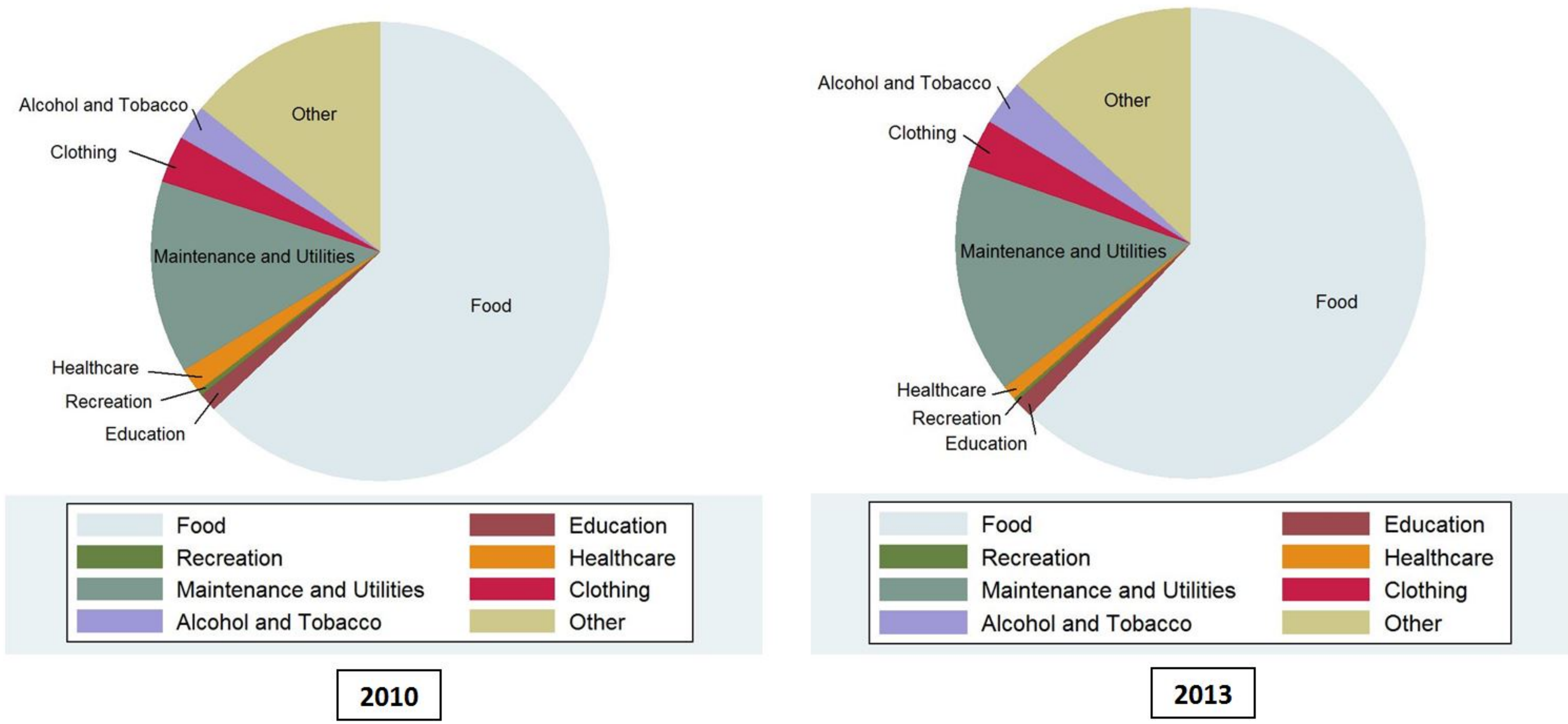


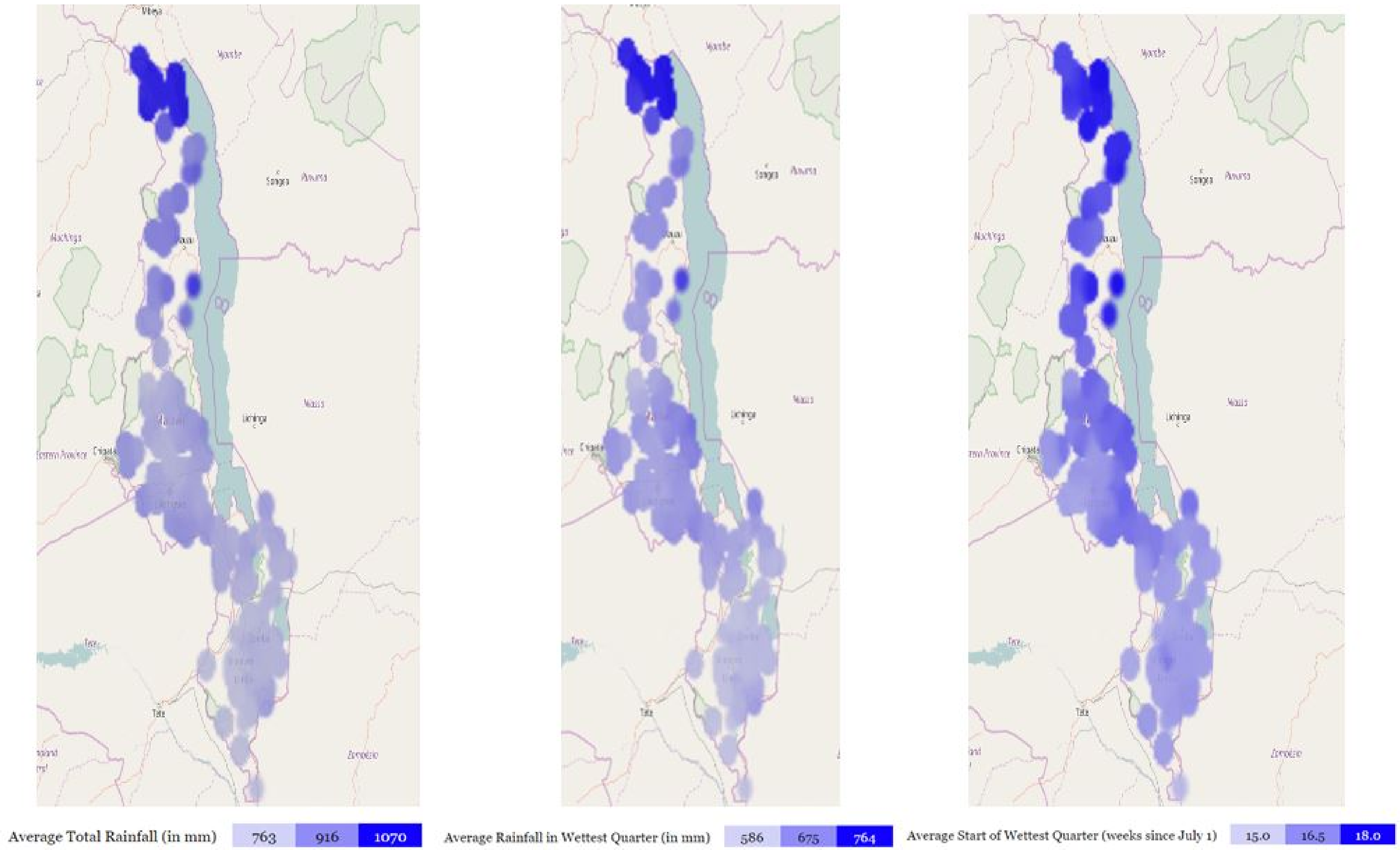

Calculated as the difference between men and women's income, with and without joint income. Generally: $x_{\text{without joint income}} - x_{\text{with joint income}}$, repeated for each both men and women.

Figure 1: Differences in Men and Women's Income
Without - With Joint Income Calculated




Values are calculated as a percent of each good, with respect to aggregate expenditure. Numerical values are provided in Table 2.

Figure 2: Household Expenditures, by Year




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 3: 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*** |
| Utilities and Maintenance | 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) Utilities and Maintenance |
|---|---|---|---|---|---|---|---|---|
| **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 12. 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) Utilities and Maintenance |
|---|---|---|---|---|---|---|---|---|
| **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 12. 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) Utilities and Maintenance |
|---|---|---|---|---|---|---|---|---|
| **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 13. 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 9: Relationship between predicted income shocks and local prices

| | (1) Maize | (2) Cloth | (3) Cigarettes | (4) Beer | (5) Grinding Maize |
|---|---|---|---|---|---|
| Predicted change in male income | $-0.715^{**}$ | $0.138^{**}$ | 0.078 | 0.050 | $-0.325^{***}$ |
| | (0.317) | (0.066) | (0.209) | (0.101) | (0.103) |
| Predicted change in female income | $-0.475^{***}$ | $-0.151^{***}$ | $0.442^{***}$ | $-0.122^{**}$ | $-0.517^{***}$ |
| | (0.126) | (0.048) | (0.105) | (0.057) | (0.059) |
| Predicted change in joint income | $-0.610^{**}$ | 0.072 | 0.059 | 0.027 | $-0.515^{***}$ |
| | (0.293) | (0.067) | (0.199) | (0.092) | (0.108) |
| Joint Significance F-Test | $5.28^{***}$ | $12.98^{***}$ | $7.15^{***}$ | 1.84 | $36.09^{***}$ |
| $R^2$ | (0.001) | (0.000) | (0.000) | (0.140) | (0.000) |

*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 10: Predicted Expenditures (in Malawian kwacha)

| | (1) Aggregate | (2) Food | (3) Cigarettes and Alcohol | (4) Clothing | (5) Recreation | (6) Education | (7) Health | (8) Utilities and Maintenance |
|---|---|---|---|---|---|---|---|---|
| **Average Expenditures** | | | | | | | | |
| Predicted expenditure for average male income | 373.10 | 760.54 | −13,847.58 | −2,597.32 | −1,391.93 | 8,122.00 | −57.40 | −358.75 |
| Predicted expenditure for average female income | 362.85 | 438.871 | 1,482.49 | 1,326.98 | 41.47 | 1,458.304 | −518.35 | −107.13 |
| Predicted expenditure for average joint income | 1,856.63 | 2,269.22 | −17,638.03 | −7,839.12 | 8,286.09 | 19,529.04 | 5,569.90 | 481.35 |
| **Changes in Expenditures** | | | | | | | | |
| **Increase of 10 Percent** | | | | | | | | |
| Predicted expenditure change from male income | 410.40 | 826.59 | −15,232.33 | −2,857.05 | −1,531.13 | 8,934.20 | −63.14 | −394.62 |
| Predicted expenditure change from female income | 399.13 | 482.76 | 1,630.74 | 1,459.68 | 45.62 | 1,604.13 | −570.19 | −117.84 |
| Predicted expenditure change from joint income | 2,042.30 | 2,496.14 | −19,401.83 | −8,623.04 | 9,114.70 | 21,481.95 | 6,126.89 | 529.48 |
| **Decrease of Ten Percent** | | | | | | | | |
| Predicted expenditure change from male income | 335.79 | 684.49 | −12,462.82 | −2,337.59 | −1,252.74 | 7,309.80 | −51.66 | −322.87 |
| Predicted expenditure change from female income | 326.56 | 394.98 | 1,334.24 | 1,194.28 | 37.32 | 1,312.47 | −466.52 | −96.41 |
| Predicted expenditure change from joint income | 1,670.97 | 2,042.30 | −15,874.22 | −7,055.21 | 7,457.48 | 17,576.14 | 5,012.91 | −433.21 |

*Note*: Predicted expenditure for average income calculated as mean income value for each group, multiplied by the coefficient reported in Panel 2 of Table 5. Generally: $\hat{\beta}\bar{x}$. Predicted expenditure change is calculated as mean income for each group, plus or minus 10 percent of average income, multiplied by the coefficient reported in Panel 2 of Table 5. Generally: $\hat{\beta}(\bar{x} \pm (0.1)\bar{x})$.

# Appendix

## Unrestricted Overidentification Tests

Table 11 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 11: Unrestricted Overidentification Tests: Log of Consumption

| | (1) Aggregate | (2) Food | (3) Cigarettes and Alcohol | (4) Clothing | (5) Recreation | (6) Education | (7) Health | (8) Utilities and Maintenance |
|---|---|---|---|---|---|---|---|---|
| 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 12: 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 13: 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.