Market Participation, Weather Shocks and Welfare: Evidence from Malawi

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Abstract:

This paper explores the interaction between climate shocks, market regimes choices and welfare outcomes using Malawi's panel household data combined with long-term historical climate records. The study first examines how climate variability affects household market participation regime and then estimates the impact of market participation on several measure of household welfare. This study also provide a comprehensive picture of how market participation impacts household welfare in the wake of climate variability. The possibility for households to self-selection in a specific market regime is addressed through a multinomial endogenous treatment model. We find that rainfall variability is a push factor for Malawian household farmers who are more prone to participate in the market in order to guarantee their assets against the adverse effects of rainfall uncertainty. Furthermore, being a net seller is, on average, empirically associated with an increase in total and food consumption. The heterogeneity checks support the average results, in particular for female-headed households and large landowners. However, they also highlight that being net-sellers is associated with greater welfare only in Malawi's central region while in the northern and the southern regions, being net-buyer accrues a greater consumption. Furthermore, the net-sellers' welfare superiority disappears in the wake of anomalous low rainfall events.

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Abstract

This paper analyses how climatic variability impacts market regime choices of rural households in Malawi. Combining household data from a georeferenced-nationally representative-panel dataset with long-term historical climate records, it explores the interaction between climate shocks, market regimes choices and welfare outcomes. The study first examines how climate variability affects the nature of household farmer market participation regime decision making (autarkic, net buyers, net sellers). It then estimates the impact of market participation choices on several measure of household welfare (total consumption per capita, food consumption per capita, non-food consumption per capita). The possibility for households to self-select themselves to participate in a specific market regime is addressed through a multinomial endogenous treatment model, using the long-term exposure to extreme rainfall events as an additional identification instrument. The final objective of this study is to provide a comprehensive picture of how taking part in the market impacts household farmers' welfare in the wake of climate variability. The paper concludes that climate variables affect market participation decisions. More specifically, rainfall variability is a push factor for Malawian household farmers who are more prone to participate in the market in order to guarantee their assets against the adverse effects of rainfall uncertainty. Furthermore, being a net seller is, on average, empirically associated with an increase in total and food consumption. The heterogeneity checks support the average results, in particular for female-headed households and large landowners. However, they also highlight that being net-sellers is associated with greater welfare only in Malawi's central region while in the northern and the southern regions, being net-buyer accrues a greater consumption. Furthermore, the net-sellers' welfare superiority disappears in the wake of anomalous low rainfall events.

Keywords: Market regimes, Food consumption, Weather Shocks, Multinomial treatment

1. Introduction

Market participation is important for households to ensure a flow of cash income, which is crucial for their livelihood improvement. However, relying on markets for food security is a risky strategy, especially for poor farmers. As a result, a number of households take part in the market (Renkow 1990; Barker et al. 1985; Omamo 1998) using a variety of crop produce but relying on their own-production of staple food for their livelihoods. These households are defined as autarkic. Other households choose an intermediate strategy, allocating a major portion of their resources to staple food production, which is used for self-consumption. These households are defined either as net-buyers or net-sellers according to the negative or the positive differential in the consumption expenditure. Therefore, for the household farmers to decide whether and how to participate in the market is a crucial choice to protect themselves, at least to a certain extent, from market-related volatility and shocks (WFP 2009a).

Previous literature on market participation mostly focuses on two major issues: staple crops and other crops prices, and transaction costs (e.g., Strauss 1984; Sadoulet and de Janvry 1995; Pender and Alemu 2007; Renkow 1990; Taylor 2003; Fafchamps and Minten 2001; de Janvry et al. 1991; Omamo 1998). The results from this strand of literature show that changes in staple and/or other crop prices affect market participation decisions. However, the effects of the price changes on household farmers' marketed surplus is ambiguous because this depends in turn on the market regime. In addition, market participation decisions can be also affected by transaction costs (which include costs related to search, bargaining, monitoring, transportation, and contract enforcement). When the transaction costs are too high, the households potentially can decide to not participate in the market, as the utility of the participation becomes negative (de Janvry et al. 1991; Sadoulet and de Janvry 1995). Besides income, price, and transaction costs, the empirical literature shows that certain fixed assets and household characteristics contribute in shaping market participation decisions. These assets generally include land endowment and household head education, amongst others (e.g. Pender and Alemu 2007; Edmeades 2006).

Although the above-mentioned studies have added many important insights in understanding household farmer market participation behavior, they do not address the specific interlinkages between participation choices and climate variability. To the best of our knowledge only Mottaleb et al. (2013), using the case study of rice farm households in Bangladesh, demonstrates that rainfall (beyond the optimum level), drought spells, and flood incidences can weaken market linkages by reducing their marketable surplus through decreased production.

The majority of climate-economic literature addresses the negative impacts of climate variability on welfare dimensions such as production, health, and livelihoods. This is more prominent in developing countries, in particular in Sub-Saharan Africa (SSA), where frequent weather shocks are primarily responsible for affecting household welfare sustainability, threatening their economic and development gains (Jury, 2002; Brown et al., 2011 Hellmuth et al., 2007). It is widely recognized that the impact of climate variability usually depends on households' adaptive capacity to adopt different adaptation strategies and their ability to insure themselves against shocks. Unfortunately, household farmers, especially those located in poor and remote areas, do not have the capacity to adopt ex-ante and ex-post strategies for managing such climate risks (Calzadilla et al., 2013; Elliott et al., 2014; Knox et al., 2012; Sultan et al., 2013; Turral et al. 2011).

Investigating the relationship between market participation, climate variability and farm households' welfare is a relevant empirical research question in light of smallholder farms' climate vulnerability.

This study aims to contribute to this literature by using nationally representative and geo-referenced data on Malawi. This is to investigate the drivers and the impacts of household market participation decisions, taking explicitly into account climate variability. Its main objective is twofold: First, it addresses the determinants of market participation decisions considering several measures of risk exposure to extreme rainfall events. Secondly, it studies the impact of this decision on different measures of household's welfare.

The paper is structured as follows. Section 2 provides an overview of the selected literature on the linkages between weather shocks and household welfare in Malawi. Section 3 introduces the data sources and explains the construction of dependent and main independent variables. Section 4 is devoted to the empirical strategy adopted. Section 5 discusses the main results of the paper on average and disentangle the impact across different household characteristics. These heterogeneity checks are expected to increase the robustness of the average results and provide further policy implications. Section 7 provides conclusions.

2. Country background and climate variability in Malawi

Before delving into analysis, a comprehensive background on Malawi will be provided. The country's information relevant to the study will allow for a more in depth investigation. Malawi is one of the most densely populated countries in SSA, with a population count of more than 17 million. The exponential growth of the population (2.8 % per annum) combined with the country's GDP per capita, which is one of the lowest levels in the world (USD 300 in 2016), influences a number of interrelated and complex economic and environmental problems. The country is characterized by four agro-ecological zone (AEZ) based on the moisture (water availability), climate and thermal zones (warm or cool based on elevation):

- A tropical warm/semiarid zone covers low lands of semi-arid areas found mainly on the shores of Lake Malawi and in the Rift valley areas of the Lower Shire. It lies between 500 – 1,000m above sea level (m.a.s.l) and receives less than 1000 mm annual rainfalll;
- A tropical warm/sub-humid zone covers the northern coast of Lake Malawi, the shore of Lake Chilwa, Blantyre and the areas around Makoko. This zone includes the lowest elevation point of the country (junction of the Shire River and international boundary with Mozambique 37 m) and receives about 1000 mm annual rainfall;
- A tropical cool/semiarid zone covers highland plains of the Shire Highlands, Lilongwe, Kasungu and Mzimba lying at 1,000 – 1,500 m.a.s.l. This zone receives 1,000 – 1,500 mm annual rainfall;
- A tropical cool/sub-humid zone covers high altitude areas of the Vipya Plateau, Nyika plateau, Dowa and Dedza hills lying over 1,500 m.a.s.l. It has a total annual rainfall of over 1,500 mm. A high proportion of this zone encompasses forest reserves and national parks.

Malawi's economy is heavily dependent on the agricultural sector, which accounts for 40% of its GDP and 80% of its foreign exchange. This sector is dominated by smallholder production. Almost two-thirds of Malawian rural farmers are smallholders, possessing less than 2 hectares of land. Subsistence smallholders contribute more than 75 per cent of Malawi's total agricultural output. Agriculture is largely rain-fed with less than 2% of cultivatable land owing to limited irrigation. This increases the likelihood of losses during extreme weather events (Chirwa and Quinion, 2005). Malawi is among the world's twelve countries which are most vulnerable to the effects of climate change. This is because it experiences frequent extreme events such as droughts and floods, which consequently affect smallholders who depend on rainfall (Denning et al., 2009 and Chinsinga, 2012, World Bank, 2010). The World Bank's climatic data indicates that in the period 1960 to 2006, mean annual temperature in Malawi increased by 0.9°C (World Bank, 2012). This increase in temperature occurred mainly in the rainy season (December–February). Due to the country's highly varied inter-annual rainfall patterns, long-term rainfall trends are difficult to characterize. In addition, such assessments on climate-change impacts on Malawian agriculture are highly variable across agro-ecological zones (Boko et al., 2007; Seo et al., 2009).

The country's real gross domestic product (GDP) grew by 5.7% in 2014 but slowed down to 2.8% in 2015 since it suffered from adverse weather conditions and macroeconomic instability. Flooding in southern districts, followed by countrywide drought conditions caused a contraction in agricultural production. Maize, the country's key crop, saw a 30.2% year-on-year drop in production. As a result, an estimated 2.8 million people (17% of the population) were unable to meet their 2015/16 food requirements (Word Bank 2015 website).

3. Data sources and summary statistics

In order to address the determinants of market participation decisions and investigate how the different market regimes affect household welfare in rural Malawi, the paper will use three main types of data:
(a) socio-economic panel household data from the Malawi Integrated Household Panel Survey;
(b) Historical data on rainfall from the National Oceanic and Atmospheric Administration (NOAA);
(c) Biophysical information from Harmonized World Soil Database (HWSD).

The primary source of socioeconomic indicators is the household level data from the Integrated Household Panel Survey (IHPS), which is part of a series of Integrated Household Surveys (IHS) created by the Government of Malawi through the National Statistical Office. It is supported by the World Bank Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) initiative. The household survey consists of a multi-topic questionnaire aimed at collecting information on household characteristics, health, wage, consumption, food security, agricultural assets and production. The final panel sample of the IHPS is shaped from the third edition of the IHS (IHS3) that was conducted during the 2010/2011 period. The paper restricts its analysis to original rural households that cultivated land in the 2009/10 and 2012/13 agricultural seasons. This allows for a more balanced panel sample of 1,715 households in each wave.
Since the IPHS survey data are geo-referenced at household and Enumeration Area (EA) level, with the latitude and longitude coordinates obtained through hand-held global-positioning system (GPS) devices, the socio-economic data was able to be merged with climatic data. Climate data were collected from secondary historical rainfall and temperature sources. Rainfall data are derived from the Africa Rainfall Climatology version 2 (ARC2) of the National Oceanic and Atmospheric Administration's Climate Prediction Centre (NOAA-CPC) for each dekad (*i.e.*, 10-day intervals), covering the period of 1983-2014. ARC2 data are based on the latest estimation techniques, conducted on a daily basis and have a spatial resolution of 0.1 degrees (~10km). The long-term average of the precipitation and the relative coefficient of variation for each enumeration area were calculated and included in the household survey (Figure 1).

[FIGURE 1 ABOUT HERE]

Starting from rainfall data, the Standard Precipitation Index (SPI) was calculated for each household, which was then included in the SAPP baseline survey. The Standardized Precipitation Index is a tool developed primarily for defining and monitoring drought. SPI determines the rarity of a drought at a given time scale (temporal resolution) of interest for any rainfall station with historic data[1]. Mathematically, the SPI is based on the cumulative probability of a given rainfall event occurring at a station. The historic rainfall data of

[1] However, it is useful also to determine floods or periods of anomalously wet events.

the station is smoothed using a moving width equal to the number of months desired[2] before it is fitted to a gamma distribution through a maximum likelihood estimator. The long-term series of the SPI index (Figure 2), allows us to identify the anomalous dry or wet conditions (SPI <-1 or SPI>1), dry or wet shocks (SPI <-1.5 or SPI>1.5), and the drought or floods episodes (SPI <-2 or SPI>2). Once the drought and flood events have been identified, it is possible an index of risk exposure to anomalous\extreme rainfall events can be created, depending on the household geographical location. Finally, information from the Harmonized World Soil Database (HWSD) was also included to account for the effects of soil nutrient availability constraints.

[FIGURE 2 ABOUT HERE]

Table 1 shows descriptive statistics by survey wave and market participation regime. The mean and standard deviation (in parenthesis) of all variables for the three different market participation regimes was reported. A mean comparison analysis was also conducted between market participation regimes, taking an autarkic regime as a base category.
In 2010 around 28% of the sample is an autarkic regime, while about 54% is a net buyer and the remaining 18% is a net-seller. In the second wave, about 17% of the sample is an autarkic regime while 64% is a net buyer and the remaining 19% is a net-seller. Therefore, market participants are better off than autarkic in all welfare outcome variables considered in this paper (i.e., total per-capita consumption expenditure, total per-capita food and non-food expenditure and per-capita caloric intake). This is confirmed for both years. Regarding market regimes, overall net buyers are the category with the best welfare status. Between the two waves, a positive change for welfare related variables is registered. The average amount of money spent on total consumption and food consumption over time increases. Households increase the quantity of calories taken in by around 4%. Turning to the shock indicators, the drought shock indicator registers an increase from 0.05 °C during 2010/2011 to 0.37 °C during 2012/2013, indicating that, on average, the maximum temperature was higher. It consequently deviates largely from the confidence band, during the second wave. The average value of flood shocks (expressed in mm of precipitation) increase from 8.32 mm to 25.20 mm in the second wave, underlining the occurrence of higher rainfall shocks during 2012/2013. Among the demographic household’s variables, a change in the average age of the household head, the dependency ratio and household size is registered, expressed in adult equivalent and average education. Approximately 24% of the households are female headed: this percentage is stable between the two waves. Among the indicators for institutions and village development committees within the community, only the percentage of households engaged in agricultural collective action and the ones receiving a coupon decreased between 2010 and 2013. Conversely, the percentages of households having access to extension services, credit and benefiting from the MASAF increased between the two waves at EA level.

[TABLE 1 ABOUT HERE]

4. Empirical strategy

The empirical analysis consists of two steps: firstly, the decision of households’ market participation is modelled, particularly focusing on the role of climatic variables, using a multinomial logit model. Secondly,

[2] In the case of Malawi we choose to calculate the SPI index based on 6 months starting from April to estimate the cumulative probability function including the whole rainfall season.

a welfare analysis detecting the role of market participation on households' welfare is conducted. In so doing, the endogeneity of the multinomial treatment variable and the market participation is addressed using a multinomial treatment effect model.

4.1 Modelling the decision of market participation

The decision to participate in the market is modelled as a trichotomous variable, referring to the three different market participation regimes: the agent can choose to be (a) an autarkic, (b) a net seller, or (c) a net buyer.

The participation decision takes the following form:

$$Y_{ijt} = \alpha + \beta \boldsymbol{X}_{ijt} + \gamma \boldsymbol{C}_t + \partial \boldsymbol{W}_{ijt} + \omega \boldsymbol{V}_{ijt} + \varepsilon_{ijt}$$

The outcome Y_{ijt} represents household's i market participation choice, j, chosen at time t and can take three values: $j = 1$ in the case in which the market regime adopted is "autarkic", $j = 2$ for "net buyer" household's preferences and, finally, $j = 3$ for "net seller" households.

$\boldsymbol{X}_{ijt}$ represents a vector of exogenous variables at household level. The analysis controls for household characteristics such as household head gender, the average level of education achieved, household size and total size of land owned. The analysis also controls for a set of factors characterizing the location of the household: distance (expressed in km) from the nearest population centre, access to road, public transportation, access to infrastructure and presence of market in the community, natural logarithm of price of inputs and maize.

Vector $\boldsymbol{W}_{ijt}$displays some wealth measures as well as two wealth indexes (a non-agricultural wealth index and an agricultural wealth index).

Climatic variables are captured by vector $\boldsymbol{C}_t$and include long-run geo-referenced climatic indicators: the historical CoV (1983-2012), the drought and flood shocks for the period 1983-2012 and the mean-average of the long-term rain.

Finally, the analysis includes a vector of service variables at EA level, captured by $\boldsymbol{V}_{ijt}$. This vector includes a dummy variable at community level for the presence of an extension officer, coupon reception and credit collective actions and MASAF program. Binary variables indicate whether the household resides in the northern region and in the southern region, and a year dummy. The idiosyncratic error component, capturing unobserved factors influencing market participation, is expressed by $\varepsilon_{\mathrm{ijt}}$.

Households participate in a market regime with the aim to maximize their expected utility over time which, however, is not observable. What can be observed for is the decision to participate in the market. The household choice of market regime can therefore be represented as follows:

$$Y_{ijt} = \begin{cases} 1 \;\; if \; y_{ijt} \leq \partial_1 \\ 2 \;\; if \;\; \partial_1 < y_{ijt} \leq \partial_2 \\ 3 \;\; if \;\; \partial_2 < y_{ijt} \leq \partial_3 \end{cases}$$

Where $\partial\partial_1$, $\partial\partial_2$, and$\partial\partial_3$ are, respectively, unknown autarkic, net buyer and net seller threshold parameters are to be estimated together with other parameters in the model. To identify the model, the "autarkic" category was set as the base category. The interpretation of the remaining coefficients provide a measure of the change with respect to the base category group when the selected market regime is autarkic.

Empirically, the household's decision to participate in market regime $j$at time t, given the base category $j = 1$ is specified as follows (Cameron and Trivedi, 2009):

$$\Pr(y_{it} = 2, y_{it} = 3 \mid y_{it} = 1) = \frac{\Pr(y_{it} = 2, y_{it} = 3)}{\Pr(y_{it} = 2, y_{it} = 3) + \Pr(y_{it} = 1)} = \frac{\exp(x'_{it}\beta_j)}{1 + exp(x'_{it}\beta_j)}$$

The odds-ratio or the relative-risk ratio of choosing alternative $j = \{2,3\}$ (net buyer or netseller) rather than alternative $j = 1$ (autarkic) is given by:

$$\frac{\Pr(y_i = j)}{\Pr(y_i = 1)} = \exp(X'_i\beta_j)$$

The above equation displays the proportionate change in the relative risk of being a net buyer or net seller with respect to adopting an autarkic market regime.

4.2 Welfare analysis

To account for the impact of market participation choice on welfare, a multinomial endogenous treatment-effect model is displayed, as presented in Deb and Trivedi (2006).

The multinomial endogenous treatment effect model consists of two stages. In the first stage, households will decide to choose one out of the three market participation regimes at their disposal as mentioned in the previous section.

Following Deb and Trivedi (2006), U_{ijt} denotes the indirect utility function of household i associated to the j^{th} market participation regime:

$$U^*_{ijt} = \boldsymbol{Z}'_{it}\alpha_{jt} + \sum_{k=1}^{j} \delta_{jkt} l_{ikt} + n_{ijt}$$

The vector $\boldsymbol{Z_{it}}$denotes the set of explanatory variables with associated parameter α_{jt} .The exogenous controls used are household characteristics, welfare indicators and EA services, which are adopted for the market participation choice in the same way as described in the previous section.

Moreover, U^*_{ijt} includes a latent factor, represented by l_{ikt}, capturing unobserved characteristics common to household'si treatment choice and outcome variables. They are assumed to be independent of the error component represented by n_{ij}.

Letting $j = 0$be the control group category and $U^*_{i0} = 0$. The control group is the autarkic market participation regime, meaning when households decide not to take part in the market. Letting d_j be the observable variables representing market participation regime and $l_i = (l_{i1}, l_{i2} \ldots l_{ij})$represent a vector of latent variables, the probability of treatment can be represented as:

$$\Pr\left(d_j \middle| z_i l_i\right) = g(z'_i\alpha_1 + \delta_1 l_{i1}, z'_i\alpha_2 + \delta_2 l_{i2}, \ldots, z'_i\alpha_j + \delta_j l_{ij})$$

The vector g represents a multinomial probability distribution and is expected to show a Mixed Multinomial Logit (MMNL) structure defined as:

$$\Pr(d_i|z_i l_i) = \frac{\exp(z'\alpha_j + \delta_j l_{ij})}{1 + \sum_{K=1}^{j} \exp(z'\alpha_k + \delta_k l_{ik})}$$

The second step of the analysis consists in defining the impact of market participation regimes on households' welfare outcomes. The expected outcome equation can be defined as follows:

$$E(y_{it}|d_{it}x_{it}l_{it}) = x_{it}'\beta + \sum_{j=1}^{j} \gamma_{jt}d_{ijt} + \sum_{j=1}^{j} \lambda_{jt}l_{ijt}$$

The parameter y_{it} represents welfare outcomes (i.e., total per-capita consumption expenditure, total per-capita food and non-food expenditure and per-capita caloric intake) of household i at time t, whilex_i denotes a set of exogenous variables with associated parameters vector β.

The treatment effects is captured by γ_j and are estimated relative to the base control group "being an autarkic". The expected outcome $E(y_i|d_i x_i l_i)$ is a function of each of the latent factors l_{ijt}. This implies that the outcome is affected by unobserved characteristics also affecting the selection into treatment (Deb and Trivedi, 2006). When the factor loading parameter, here represented by λ_{jt}, is positive (negative), the treatment and outcomes are positively (negatively) correlated throughout unobserved characteristics (Deb and Trivedi, 2006). Since continuous outcome variables are being dealt with, it is assumed that a Normal (Gaussian) distribution function. Finally, the model is estimated throughout a Maximum likelihood simulated approach (MSL)[3].

To overcome treatment endogeneity, the Instrumental Variable strategy is employed. As pointed out by Deb and Trivedi (2006), the parameters of the model which are estimated through control variables included in the treatment equation are also the same used in the welfare equation: the use of exclusion restriction and instruments will provide more robust estimates.

The analysis adds three instrumental variables which exert an effect on the endogenous treatment effect, but are uncorrelated with the welfare outcomes as well as with the error component. These instruments are in the long run denominated as CoV; the historical probability to suffer a drought calculated over the time period span going from 1983 to 2012 and, finally, the historical probability to experiment a flood, calculated over the same time period. Setting as base category the autarkic market regime, allows for the impact of the decision to take part to the market to be observed and for net buyer or net seller market regimes on welfare outcomes in rural households in Malawi to be compared.

5. Results and discussion

5.1 Determinants of market participation

Table 2 displays results for the determinants of market participation choice using a maximum-likelihood multinomial logit approach. It sets as a base category the autarkic market participation regime, $j = 1$. The complete results are reported in Table 2. The results suggest that the long-term CoV and the long-term historical mean of the rainfall are both positively associated with the market participation. Specifically, the CoV predicts a high significant probability of being a net buyer rather than an autarkic household, while no effect is observed for net sellers. This result suggests that, on the one hand, households subjected to higher rainfall variability are more likely to be net-buyers rather than autarkic agents. The coefficient associated with the long-term historical mean suggests that households located in the relative higher moisture areas prefer to take part in the market rather than be autarkic. On the other hand, market participation choice is not affected by extreme rainfall shocks, the risk exposure to dry shocks events is negatively associated with the decision to participate in the market as a net seller. Overall, results obtained suggest that climatic

[3]The Stata command used is *mtreatreg*, implemented by Ded (2009). We used 100 simulation draws.

variability affects market participation choice, predicting a positive probability of market participation to insure against climatic shocks.

[TABLE 2 ABOUT HERE]

5.2 Effect of market participation on welfare

Table 3 displays results for the welfare analysis. The coefficients assess the impacts of the different market regimes adopted on welfare outcomes.

[TABLE 3 ABOUT HERE]

For market participation, the base category is set to be "autarkic". On the one hand, being a net seller exerts a positive and statistically more significant impact on the log per-capita consumption expenditure and the log per-capita food consumption, while no significant impact is detected for non-food consumption. On the other hand, no impact on any outcomes is detected when a net buyer market participation regime is chosen. Turning to other coefficients (Table 2a in the appendix), the results highlight a negative association between the three consumption outcomes and both the number of individuals in the household and the dependency ratio. As expected, land area owned and the wealth indexes are all positively associated with the household consumption. Proximity to the road and infrastructure are both positively associated with the three consumption outcomes. Finally, among the policy variables considered, only participation in the MASAF program is positive correlated with total consumption.

Overall, results obtained from the welfare analysis suggest that the net-seller market regime positively affects the household food consumption and through it the household total consumption.

5.3 Analysis of Heterogeneity

To check the robustness of the results the full-sample results were tested by re-implementing the welfare analysis into several sub-samples. For the purpose of this study, the following tables report only the the treatment effects i.e. the coefficient associated with the market regimes[4].

The first heterogeneity check is related to the gender of the household head. Table 4 shows the main results obtained on the female and male headed households sub-samples.

[TABLE 4 ABOUT HERE]

The results show that choosing to participate in the market as a net-seller positively impacts food and total consumption of both male and female-headed households. The male-headed net-seller households also increase the consumption expenditure for non-food items relatively to the autarkic male-headed household. Pertaining to only the male headed-households, choosing a net-buyer regime lowers the expenditure in food consumption relatively to the autarkic households. These findings support the robustness of the full sample reported in Table 3. Comparing the magnitude of the coefficients, they also highlight that market participation as a net-seller increases relatively more the welfare of the female-headed households.

[4] The full table are available upon request

According to this paper's findings, policy makers' interventions, aimed at improving the market access, will increase relatively more the consumption of female-headed households that are the most poor and vulnerable. On the other hand, the negative coefficient associated with food consumption of the male-headed net-buyer households highlights that participating in the market as a net buyer exposes the household to price shocks that could worsen welfare relatively to the autarkic household.

The second heterogeneity checks is related to household fixed assets availability. Market participation behaviours may vary depending on household wealth endowment: richer households may value differently market participation choice and could have different preferences among the preferred market regime to adopt. Since the analysis focuses on rural households, proxy for household wealth (the amount of land owned: the greater the land own, the wealthier the household will be) is used. Table 5 displays the main results for the first, second and third tertile of land owned by the sub-samples.

[TABLE 5 ABOUT HERE]

The results show the impact of the market regimes on welfare changes according to the household asset endowment. For the lesser endowed household, located at the lowest tertile of the land distribution, market participation does not provide any welfare benefits relative to the autarkic households, except for the non-food consumption expenditure of the net-buyer. Moving toward the upper part of land distribution, the results for the second and third tertile show that the net seller regime has a positive impact on almost all the welfare measures. The only exception is regarding the negative association estimated on the non-food consumption of the most endowed sub-sample. These results show that the autarkic regime is still a good strategy for the less endowed household. This is probably because they are more risk-adverse and the fluctuation of the market prices could severely affect their livelihood. However, for the household relatively more endowed, the participation in the market as a net-seller positively impacts their consumption. The policy interventions oriented to increase the market access should consider these potential negative distributional effects.

The third heterogeneity check is on the geographic location. Malawi has different weather conditions and climate variability across its three main regions: North, Centre and South. Table 6 shows the main results from the three region sub-samples (northern, central and southern).

[TABLE 6 ABOUT HERE]

The results suggest that in the northern part of the country, choosing the net-buyer regime positively impacts the three consumption expenditure outcomes. Being a net seller is positively associated with the food consumption outcome. In the central region, the results are completely different. The net buyer regime has a negative impact on both per-capita consumption expenditure and food expenditure, while net sellers' market participation regime have a positive impact on the same welfare outcomes. Finally, in the southern part of the country, the net buyer regime positively impacts all the consumption outcomes, while participating as a net seller negatively impacts food consumption. The high regional heterogeneity of the country means that the full sample results need to be interpreted carefully. The full-sample results are led by the central region sub-sample. This is probably because most of the infrastructure and markets are located in this region. In the north and southern regions, where the institutions and the infrastructures are less developed, the decision to take part in the market as a net buyer increase the household welfare relatively to the other market regimes.

Finally, the last checks take into account the rainfall anomaly in the considered year. This is to test if adopting a specific market regime differently affects the welfare of households which have experienced a climatic shock. Two different sub-samples are distinguished, taking as a threshold a SPI level of -1. When the index is below the threshold, the households have experienced an anomalous dry event. Otherwise, the index signals no shocks (there are no anomalous wet episodes in the considered period). The analysis on this sub-sample therefore estimates the welfare impact of market regimes choice in "normal periods".

[TABLE 7 ABOUT HERE]

The results confirm that net seller market participation regimes have positive impacts on households which did not experience any rainfall shock. These findings are in line with those obtained using the full-sample. However, no statistically significant impact related to the market participation were found, except in one case, the sub-sample of households that experienced a dry shock in the considered period. These findings are probably due to the higher risk exposure related with market participation. The transmission of climate shocks to agricultural prices limits market participation benefits, especially in terms of food consumption. In this case the autarkic strategy, although not associated with any welfare improvement, is an effective alternative strategy because it reduces the farmers' exposure to prices shocks.

6. Concluding remarks

Current empirical literature does not address the specific interlinkages between participation choices and climate variability. The majority of climate-economic literature addresses the negative impacts of climate variability on welfare dimensions such as production, health, and livelihoods. This paper investigates the relationship between market participation, climate variability and farm households' welfare. It addressed the determinants of market participation decisions considering several measures of risk exposure to extreme rainfall events and studied the impacts of this decision on different measures of household welfare. By using nationally representative and geo-referenced data from the Integrated Panel Household Survey and long-term information on rainfall at enumeration areas level, it investigated the drivers and the impacts of household market participation decisions, taking explicitly into account climate variability. In order to take into account the multinomial dimension of the treatment and the potential selection bias, this study implements a multinomial treatment effect model. The related findings indicate that long-term mean and rainfall variability affect the probability of market participation. Furthermore the welfare analysis shows that the choice of the net-seller regime increases the welfare of Malawian household farmers. In order to test the robustness of these results, the analysis has been repeated, dividing the original full-sample into several sub-samples. This heterogeneity checks support the general findings although they highlight that in the northern and the southern regions, the welfare benefits of participating in the market stem from participate in the market as net-buyer rather than as net seller. Furthermore, they question the effectiveness of the market participation strategy of smallholders (households located in the first tertile of the land distribution) and the households exposed to anomalous dry events.

Further studies are needed to explore the distributional effects of policy interventions aimed at increasing market participation, especially in the areas hit by frequent-extreme-low rainfall events.

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List of tables

Table 1 - Descriptive statistics by year and market regime

	2010			2013		
	Autarkic	*Net buyer*	*Net seller*	*Autarkic*	*Net buyer*	*Net seller*
Outcomes						
Total consumption per capita (pc) (ln)	11.403	11.607**	11.537**	11.454	11.609*	11.625*
	(0.605)	(0.623)	(0.567)	(0.612)	(0.618)	(0.587)
Food consumption pc (ln)	10.893	11.068**	11.022**	10.975	11.114***	11.159***
	(0.642)	(0.659)	(0.612)	(0.653)	(0.662)	(0.623)
Non-food consumption pc (ln)	10.388	10.627**	10.508**	10.359	10.571**	10.528
	(0.720)	(0.737)	(0.682)	(0.710)	(0.742)	(0.693)
Caloric intake (ln)	7.394	7.452*	7.435*	7.381	7.492**	7.487**
	(0.608)	(0.617)	(0.524)	(0.628)	(0.623)	(0.543)
Climatic Variables						
Total seasonal rainfall (mm)	798.787	798.140***	824.637***	796.571	803.179***	812.342***
	(114.27)	(115.78)	(123.87)	(124.89)	(118.56)	(113.65)
% Probabilities of Positive shock (1983-2012)	7.115	6.928**	7.443***	7.214	6.981***	7.363***
	(3.29)	(3.02)	(3.57)	(3.76)	(3.32)	(3.69)
% Probabilities of Negative shock (1983-2012)	10.256	10.298	9.523***	10.326	10.380	9.356**
	(3.54)	(3.67)	(3.24)	(3.98)	(3.65)	(3.24)
SPI<-1 (2010/2013)	0.094	0.089*	0.090	0.094	0.096	0.095
	(0.292)	(0.278)	(0.346)	(0.292)	(0.267)	(0.279)
Coefficient of variation of rainfall (CoV)	0.227	0.234	0.213	0.221	0.224	0.201
	(0.385)	(0.390)	(0.042)	(0.035)	(0.035)	(0.036)
HH Characteristics						
Age of household head (years)	48.029	41.930***	43.675***	50.966	45.405***	46.099***
	(16.83)	(16.78)	(16.34)	(16.83)	(16.45)	(16.38)
Dependency ratio	1.102	1.231**	1.212**	1.270	1.288*	1.214**
	(1.01)	(1.09)	(1.07)	(1.02)	(1.05)	(1.07)
Average education of household members (years)	4.245	5.093**	4.938**	4.284	5.097**	4.874**
	(2.47)	(2.09)	(2.67)	(2.07)	(2.08)	(2.76)
Household size (number)	4.689	5.114***	5.046***	4.860	5.610***	5.290***
	(2.300)	(2.745)	(2.034)	(2.302)	(2.874)	(2.084)
Female head (1=yes)	0.275	0.240**	0.197**	0.325	0.245**	0.205**
	(0.434)	(0.567)	(0.678)	(0.578)	(0.257)	(0.260)
Land owned (ha)	0.654	0.606*	0.848***	0.649	0.617**	0.856***
	(0.730)	(0.765)	(0.785)	(0.704)	(0.598)	
Infrastructures						
Infrastructural access index	-0.421	-0.167***	-0.350**	-0.500	-0.208***	-0.398***
	(0.545)	(0.363)	(0.256)	(0.589)	(0.535)	(0.604)
Ln distance population center (km)	3.529	3.449*	3.555*	3.515	3.487*	3.520*
	(2.568)	(2.765)	(2.598)	(2.695)	(2.486)	(2.401)
Daily market in EA (1=yes)	0.175	0.298**	0.164*	0.292	0.379**	0.379**
	(0.393)	(0.375)	(0.369)	(0.385)	(0.375)	(0.402)
MASAF in EA (1=yes)	0.118	0.124*	0.136*	0.643	0.653*	0.696**
	(0.322)	(0.378)	(0.467)	(0.486)	(0.397)	(0.386)
Agricultural collective action in EA (1=yes)	0.309	0.343**	0.297*	0.234	0.260*	0.319**
	(0.461)	(0.478)	(0.487)	(0.426)	(0.376)	(0.403)
Price maize (MKW/kg) (ln)	3.695	3.724*	3.418*	5.883	5.774*	6.171**
	(1.082)	(1.367)	(1.578)	(1.078)	(1.045)	(1.176)
Price fertilizer (MKW/kg) (ln)	5.791	5.919*	6.197**	8.207	8.340*	8.504**
	(1.547)	(1.679)	(1.985)	(1.542)	(1.765)	(1.632)
Ganyu labor (MKW/person) (ln)	5.469	5.500*	5.486*	6.145	6.159	6.119**
	(0.262)	(0.267)	(0.259)	(0.267)	(0.275)	(0.268)
Extension service in EA (1=yes)	0.393	0.455**	0.486**	0.571	0.642**	0.737***
	(0.474)	(0.458)	(0.497)	(0.368)	(0.218)	(0.275)
Public transport (1=yes)	0.443	0.549***	0.491**	0.415	0.432**	0.401*
	(0.500)	(0.568)	(0.587)	(0.543)	(0.574)	(0.376)
Microfinance in EA (1 yes)	0.035	0.089***	0.079***	0.134	0.152***	0.116*
	(0.237)	(0.265)	(0.257)	(0.123)	(0.125)	(0.116
Access to safe water (1yes)	0.863	0.826***	0.854**	0.173	0.195***	0.217***
	(0.363)	(0.257)	(0.249)	(0.124)	(0.206)	(0.236)
Population density	4340.58	3932.093***	4039.637***	3338.348	5037.057***	5449.454***
	(4630)	(3478)	(4798)	(3567)	(5098)	(5689)
Wealth						
Agricultural wealth index	0.181	0.347***	0.448***	0.010	0.216***	0.338***
	(0.965)	(0.968)	(0.684)	(0.001)	(0.160)	(0.345)
National wealth index	-0.333	-0.137***	-0.233**	-0.326	-0.088***	-0.166***
	(0.512)	(0.578)	(0.479)	(0.356)	(0.467)	(0.166)
Mean credit at EA	0.150	0.173**	0.157*	0.157	0.163***	0.171***
	(0.325)	(0.378)	(0.478)	(0.124)	(0.278)	(0.182)
Mean dummy FISP coupon at EA	0.546	0.522**	0.566**	0.534	0.534	0.543*
	(0.233)	(0.267)	(0.289)	(0.233)	(0.267)	(0.289)
Observations	593	1141	391	359	1352	414

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.

Table 2 - Multinomial logit estimates of market participation regime

	Net Buyer=1	Net seller=1
Climatic variables		
Coefficient of Variation (long-term)	6.599***	-0.609
	(1.816)	(2.246)
Negative shock probability (1983-2012)	-0.018	-0.031*
	(0.015)	(0.018)
Positive shock probability (1983-2012)	-0.009	-0.000
	(0.015)	(0.019)
Mean total rain (mm) long-term	0.004***	0.014***
	(0.004)	(0.001)
HH Characteristics		
Age head of hh	-0.019***	-0.014***
	(0.003)	(0.003)
Dependency ratio	0.029	0.051
	(0.047)	(0.059)
Average education of hh	0.062**	0.049
	(0.021)	(0.026)
Number of people in the hh	0.062**	-0.023
	(0.023)	(0.028)
Female headed hh	0.199	-0.015
	(0.109)	(0.139)
Land owned in hectares	-0.124	0.523***
	(0.105)	(0.199)
Household has safe drinking water	-0.109	0.202
	(0.116)	(0.144)
Infrastructures		
Infrastructural access index	0.313**	0.005
	(0.109)	(0.135)
Weekly market in the community	0.202*	-0.074
	(0.102)	(0.127)
Daily market in the community	0.285*	0.301*
	(0.122)	(0.151)
Log of prices		
Natural log of price of fertilizer	0.106***	0.085*
	(0.031)	(0.039)
Natural log price maize	-0.055	-0.074
	(0.030)	(0.039)
Natural log of daily ganyu labour	-0.079	-0.065
	(0.115)	(0.142)
EA characteristics		
E: Coupon was redeemed	-0.092	0.099
	(0.207)	(0.257)
Access road surface in the EA	0.015	0.051**
	(0.057)	(0.134)
Public transports at EA	0.038	0.062
	(0.099)	(0.122)
MASAF in the EA	0.142	0.240
	(0.117)	(0.141)
Collective action in EA	0.096	0.209
	(0.170)	(0.126)
Extension in the EA	0.133	0.222
	(0.093)	(0.116)
Dummy microfinance in the EA	0.315	0.146
	(0.179)	(0.215)
Population in the community	0.000	-0.000
	(0.000)	(0.000)
Wealth		
Wealth index agricultural goods	0.086	0.130
	(0.058)	(0.070)
National: non-agricultural wealth index	0.348*	0.293
	(0.140)	(0.163)
Credit in the EA	-0.033	0.480
	(0.376)	(0.464)
Year 2013	0.494***	0.500*
	(0.187)	(0.236)
North	-0.529*	-1.607***
	(0.216)	(0.288)
Center	-0.096	0.134
	(0.159)	(0.224)
Constant	-2.912*	-9.129***
Observations	3580	3580

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3 - Multinomial endogenous treatment effect

	(1) **Ln per capita consumption**	(2) **Ln per capita food consumption**	(3) **Ln per capita non- food consumption**
Market participation			
Net Buyers vs Autarchic	0.024	-0.029	0.094
	(0.051)	(0.077)	(0.178)
Net sellers vs Autarchic	0.254***	0.225***	0.194
	(0.060)	(0.725)	(0.179)
Climatic Variables			
Average mean total rain (mm)	- 0.000	- 0.000	-0.000
	(0.000)	(0.000)	(0.000)
SPI<-1.5 (droughts)	0.021	-0.002	-0.000
	(0.054)	(0.064)	(0.000)
HH Characteristics			
Age head of hh	-0.001	0.000	-0.002
	(0.000)	(0.000)	(0.000)
Dependency ratio	-0.042***	-0.030**	-0.060***
	(0.008)	(0.009)	(0.009)
Average education of hh	0.017***	0.017***	0.016***
	(0.004)	(0.004)	(0.004)
Number of people in the hh	-0.132***	-0.130***	-0.146***
	(0.004)	(0.005)	(0.005)
Female headed hh	0.020	0.006	0.022
	(0.040)	(0.022)	(0.023)
Land owned in hectares	0.180	0.112***	0.202***
	(0.019)	(0.025)	(0.025)
Log of prices			
Natural log of price of fertilizer	0.009	0.006	0.004
	(0.005)	(0.006)	(0.063)
Natural log price maize	0.038	0.000	0.008
	(0.005)	(0.006)	(0.006)
Natural log of daily ganyu labour	0.008	0.025	-0.028
	(0.005)	(0.022)	(0.022)
Institution in the EA			
E: Coupon was redeemed	0.166***	0.184***	0.147***
	(0.036)	(0.042)	(0.102)
Access to road surface inthe EA	0.021**	0.031*	0.051
	(0.031)	(0.024)	(0.027)
Ln distance to population center	0.012**	0.008*	0.022
	(0.034)	(0.067)	(0.042)
Access to public transportation	-0.026	-0.041*	-0.013
	(0.017)	(0.020)	(0.020)
MASAF in the EA	0.003	-0.016	0.030
	(0.019)	(0.023)	(0.023)
Collective action in EA	-0.047**	-0.001	-0.101***
	(0.018)	(0.021)	(0.021)
Extension in the EA	0.026	0.040*	0.032
	(0.016)	(0.019)	(0.019)
Dummy microfinance in the EA	0.047	0.034	0.055
	(0.028)	(0.033)	(0.033)
Household has safe drinking water	0.040	0.046	0.054**
	(0.021)	(0.024)	(0.024)
Population in the community	0.001**	0.000	0.000
	(0.000)	(0.000)	(0.000)
Wealth			
Wealth index agricultural goods	0.097***	0.102***	0.087***
	(0.009)	(0.011)	(0.011)
National: non-agricultural wealth index	0.285***	0.260***	0.312***
	(0.019)	(0.022)	(0.022)
Infrastructural access index	0.163***	0.078***	0.271***
	(0.018)	(0.021)	(0.021)
Credit in the EA	0.163**	0.112	0.222**
	(0.063)	(0.073)	(0.074)
Weekly market in the community	0.050**	0.051*	0.064
	(0.018)	(0.021)	(0.022)
Daily market in the community	-0.017	-0.025	-0.008
	(0.020)	(0.024)	(0.024)
Year dummy (2013)	0.102**	0.156***	0.346***
	(0.031)	(0.036)	(0.036)
Centre	0.071**	-0.002**	-0.253***
	(0.027)	(0.049)	(0.034)
South	0.19**	0.19***	0.12***
	(0.034)	(0.033)	(0.049)
Constant	11.72***	11.07***	12.09***
Observations	3580	3580	3580

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1

Table 4 - Heterogeneity analysis: Female Vs Male household head

	(1) Ln per capita consumption	(2) Ln per capita food consumption	(3) Ln per capita non-food consumption
Female headed			
Net Buyers *vs* Autarkic	0.031	- 0.083	0.126
	(0.108)	(0.097)	(0.196)
Net sellers *vs* Autarkic	0.315***	0.321*	0.183
	(0.097)	(0.140)	(0.178)
Observations	928	927	927
Male headed			
Net Buyers *vs* Autarkic	-0.105	-0.153***	0.079
	(0.048)	(0.051)	(0.0853)
Net sellers *vs* Autarkic	0.189***	0.171***	0.336***
	(0.058)	(0.057)	(0.068)
Observations	2.655	2.655	2.655

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5 - Heterogeneity analysis: tertile of land own

	(1) Ln per capita consumption	(2) Ln per capita food consumption	(3) Ln per capita non-food consumption
Land owner (1st tertile)			
Net Buyers vs Autarkic	0.253	0.238	0.475***
	(0.189)	(0.174)	(0.043)
Net Sellers vs Autarkic	0.165	0,171	0.019
	(0.165)	(0.103)	(0.066)
Observations	1197	1197	1197
Land owner (2nd tertile)			
Net Buyers vs Autarkic	0.095	-0.001	0.197
	(0.079)	(0.130)	(0.123)
Net Sellers vs Autarkic	0 .297*	0.250**	0.311*
	(0.116)	(0.125)	(0.138)
Observations	1200	1200	1200
Land owner (3rd tertile)			
Net Buyers vs Autarkic	0.084	-0.013	0.402***
	(0.162)	(0.077)	(0.066)
Net Sellers vs Autarkic	0 .259*	0.273***	-0.237***
	(0.121)	(0.078)	(0.065)
Observations	1182	1182	1182

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 - Heterogeneity analysis: Northern, central and southern regions

	(1) **Ln per capita consumption**	(2) **Ln per capita food consumption**	(3) **Ln per capita non-food consumption**
Northern region			
Net Buyers vs Autarkic	0.396***	0.463*	0.382***
	(0.021)	(0.056)	(0.079)
Net Sellers vs Autarkic	-0.049	0.062*	-0.036
	(0.074)	(0.043)	(0.100)
Observations	801	801	801
Central region			
Net Buyers vs Autarkic	-0.152***	-0.235***	-0.077
	(0.054)	(0.053)	(0.071)
Net Sellers vs Autarkic	0 .151*	0.289***	-0.064
	(0.060)	(0.057)	(0.158)
Observations	1.307	1.307	1.307
Southern region			
Net Buyers vs Autarkic	0.372**	0.289***	0.461**
	(0.034)	(0.032)	(0.023)
Net Sellers vs Autarkic	-0.101	-0.192***	0.000
	(0.0234)	(0.056)	(0.000)
Observation	1.473	1.473	1.473

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1.

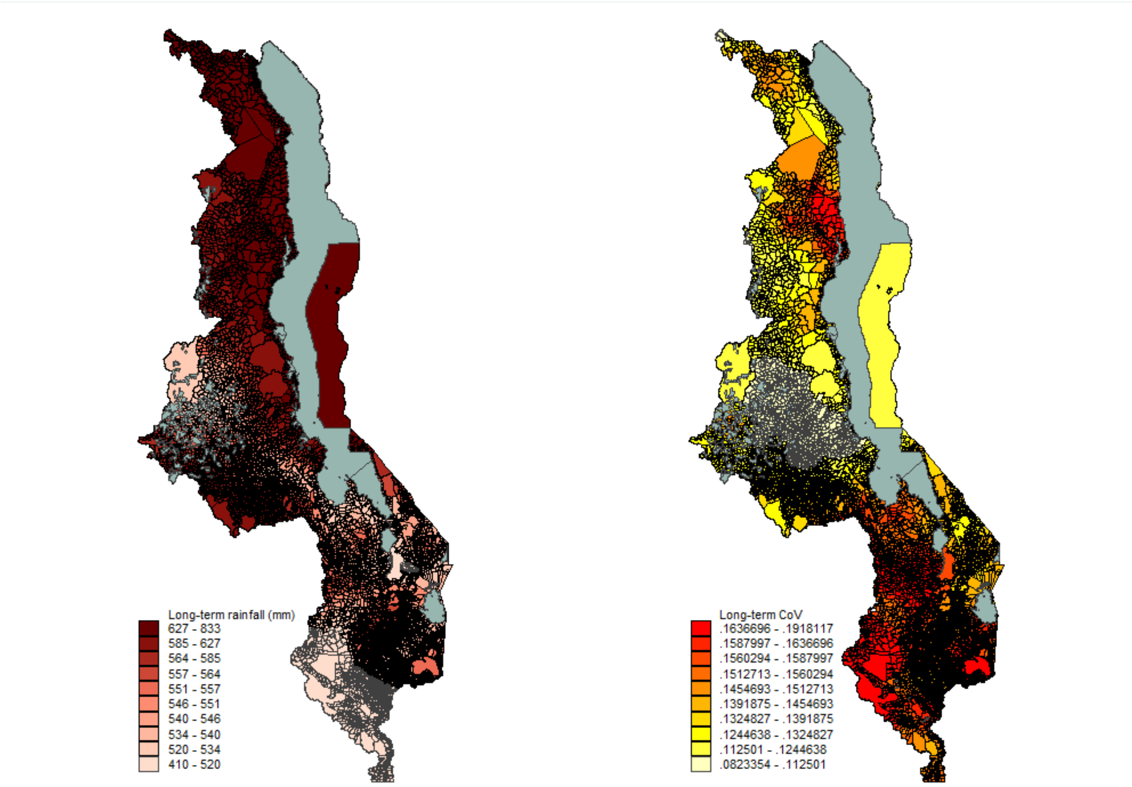
Table 7 - Heterogeneity analysis: Standard Precipitation Index sub-samples

	(1) **Ln per capita consumption**	(2) **Ln per capita food consumption**	(3) **Ln per capita non-food consumption**
SPI<-1			
Net Buyers vs Autarkic	0.198	-0.099	0.384***
	(0.142)	(0.392)	(0.143)
Net Sellers vs Autarkic	0.257	0.225	-0.007
	(0.247)	(0.535)	(0.159)
Observations	411	411	411
-1<SPI<1			
Net Buyers vs Autarkic	-0.070	-0.004	0.247***
	(0.049)	(0.051)	(0.087)
Net Sellers vs Autarkic	0.247***	0.258***	0.300***
	(0.044)	(0.056)	(0.066)
Observations	3160	3160	3160

Note: Robust standard errors clustered at EA level. *** p<0.01, ** p<0.05, * p<0.1.

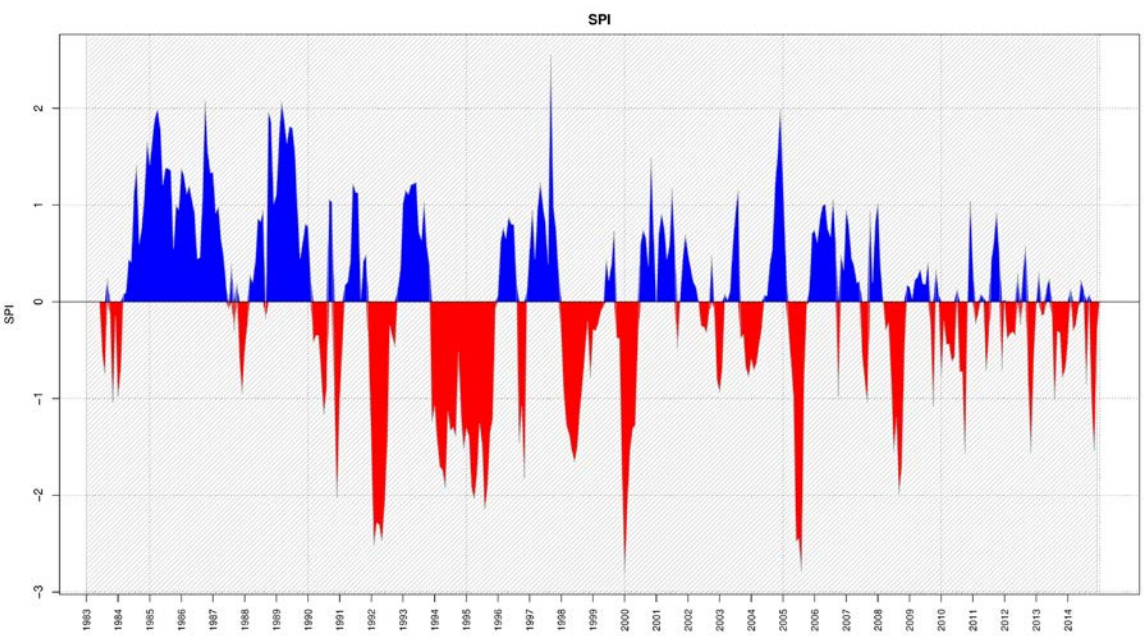
List of figures

Figure 1 - Malawi historical rainfall average and CoV by deciles at enumeration areas level



Source: Authors 'elaboration on ARC2 data

Figure 2 - Long-Term Average National SPI Index



Source: Authors 'elaboration on ARC2 data