# Regional Migration, Co-Insurance and Economic Shocks: Evidence from Nicaragua

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**Abstract**

The large majority of migrants from developing countries moves inside their own countries or to neighboring regions, yet there is limited evidence on whether internal migrants represent a source of insurance for the household of origin and vice-versa. To test whether transfers received and sent by migrants represent a co-insurance mechanism, this paper estimates the causal impact of income shocks in origin and in migrant's destination on the transfer of funds. Rainfall shocks in rural Nicaragua are found to lead to changes in income but not in food consumption, indicating that households are able to smooth consumption. This paper finds that migrants between the ages of 15 and 21 years old provide unilateral insurance to their household in origin. Distinguishing by destination and economic activity I show that the level of insurance increases when migrants and households are exposed to less correlated rainfall shocks. Bilateral insurance is observed among migrants with non-agricultural income and rural migrants exposed to rainfall shocks which are low correlated to shocks in origin. These results provide evidence of co-insurance arrangements among households members geographically spread inside a country.

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**Keywords:** Internal migration, remittances, risk, insurance, inter-households transfers, weather shocks

## 1 Introduction

Rural households in developing countries are exposed to many kinds of risks, including extreme weather conditions, illnesses, and other unpredictable shocks. There is a large literature studying different mechanisms through which households, with no access to credit and to insurance markets, cope with risk (Townsend, 1994; Udry, 1994; Fafchamps and Lund, 2003; De Weerdt and Dercon, 2006; Rosenzweig and Wolpin, 1993). One common strategy is informal insurance by reciprocal loans

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and gifts from friends and relatives. It has been shown that informal risk-sharing arrangements in the household network fails to perfectly insure households in face of income shocks, especially weather shocks, as they affect every network member in a local area (Dercon and Krishnan, 2000; Duflo and Udry, 2004). However, we can extend the household network beyond local areas by looking at regional migrants who were former household members. The spatial mobility of households members creates an insurance mechanism to face income shocks, specially covariates shocks. To investigate informal insurance arrangements between permanent migrants and their household in origin this paper analyzes if the transfer of funds between both parties have an insurance role. The efficiency of this insurance mechanism will rely on the degree of correlation between migrants' and origin households' income and on the level of commitment between both parties.

The hypothesis that risk diversification is behind the decision to migrate was established by the New Economics of Labor Migration (NELM) (Stark, 1980). Under the assumption that migrants and non-migrating household members are risk averse but incur different risks at different times, this theory predicts that remittances should be highest when households in origin are exposed to income shocks. This hypothesis has been tested in several studies (Lucas and Stark, 1985; De la Briere et al., 2002; Cox et al., 1998; Gubert, 2002). These studies rely on household data and on regional proxy for the identification of income shocks rather than data on exogenous shocks[1]. In recent years, a brand of the new experimental literature on migration has focused on understanding the role of remittances as an instrument to cope with economic shocks. These studies focus on exogenous shocks which have a credibly impact on household income to estimate adjustment on the flow of remittances. Clarke and Wallsten (2003) find that international remittances in Jamaica replaced 25 percent of damages from Hurricane Gilbert. In Philippines, Yang and Choi (2007) find that changes in income coming from rainfall shocks lead to changes in overseas remittances in the opposite direction. They find larger levels of insurance, with remittances replacing 60% of income changes. At the country level, Yang (2008a) compile further evidence on this insurance mechanism. He finds that for the poorest developing countries hurricanes lead to increases in migrants' remittances, which account for 20% of experienced damages.

All these studies have in common that they are focused on how overseas remittances adjust to income shocks in migrants' original community. Few studies look at how remittances are affected by exogenous shocks in destination. Yang et al. (2005) and Yang (2008b) analyze how outcomes in non-migrating households members in Philippines react to different variations of international exchange rates. They find that exogenous increases in migrant resources have positive effects on investment outcomes in the household of origin, suggesting a positive income effect on the amount of remittances sent.

I contribute to this literature in two ways. First, I simultaneously examine exogenous income shocks at origin and at destination. This allows me to look at the efficiency of the insurance mechanism in face of income shocks at different levels of correlation between both locations. I use a two agents risk-sharing model to show that transfers between both agents are a function of income uncertainty at origin and at destination. While risk-pooling will be more efficient when network's income is less correlated, large distances among networks members may increase information and enforcement costs.

Second, while most of the recent literature has been focused on international migration, this

[1]See Rapoport and Docquier (2006) for a model on the remittance sending decision and Yang (2011) for a review of the literature on remittances dimensions.

paper is focused on domestic and regional migration. International migration is expensive and risky and is less common among poor households from rural areas than domestic migration. Internal and regional migration is more frequently observed, with household members moving to close and non-close locations for work or family reasons. Household networks extended across different locations provide the opportunity to implement risk insurance mechanism benefiting both non-migrating household members and migrants. To capture whether this is the case, I extend the analysis to the impact of income shocks on transfers from the migrant to the household in origin (from hereon, remittances) as well as transfers from the household in origin to the migrant (from hereon, transfers). Thus, I analyze not only whether households in origin are insured by migrants, but also whether migrants are insured by their household in origin. I refer to this as co-insurance. Hence, this paper relates to De Weerdt and Hirvonen (2013) who examine how income shocks and household consumption co-vary across linked households in Tanzania. They find that internal migrants share about 2.7% of their consumption growth by insuring family members at their original location. My analysis differs by focusing on the actual flows of transfers between households and migrants. My empirical strategy allows me to break down the net effect of rainfall shocks on the flow of transfers, into an income and an insurance component.

To investigate risk arrangements between migrants and their household in origin this papers uses two rounds of data from a household survey implemented in poor rural communities in Nicaragua (2000-2010). 50% of the households in the original communities have at least one permanent migrant in 2010 and only 2.5% of them are international migrants. Rain-fed agriculture is the main income source among non-migrating households and rainfall deficits during the main growing season are negatively affecting household income. Therefore I can use rainfall shocks at the household and migrant level to analyze how exogenous income variations affect transfers. I restrict the analysis to young migrants adult between the ages of 15 and 21 in 2010. This cohort comprises the ages in which important life transitions, such as finishing school, beginning work, getting married, and leaving home occur in developing countries. The realization of this transition may haul some risks and uncertainties which affect the economic relationship with other households members. By focusing on this age cohort I analyze informal arrangements in a sample where all migrants where long term household members prior to migration, in particular they were living during their childhood in the household in origin. This age group formed part of the targeted population during the follow-up survey in 2010, thus they were traced across Nicaragua and surveyed at their new location in 2010. After 10 years, the attrition rate for this group is around 11%.

I analyze the insurance mechanism by estimating the impact of rainfall shocks on the probability to send and receive transfers and on the annual amount of funds transferred. I split the sample of migrants into local and non-local migrants. Being local migrants those who are exposed to the same weather shock as their household in origin and non-local migrants those who are exposed to different weather shocks (see Section 3). As expected, transfers between local migrants and their household in origin do not adjust in face of rainfall shocks. Notice, that by looking at weather shocks, this paper examines insurance behavior in face of aggregate shocks which are usually more difficult to insure locally than non-locally. Among non-local migrants, the results provide evidence that young migrants provide unilateral insurance to their households in origin. Remittances are adjusted by shocks in origin but transfer receipts are not adjusted by shocks occurring at destination. This result indicates the presence of unilateral insurance contracts in line with the findings in the literature focused on international remittances.

I find that remittances received from a non-local migrant compensate for 6% of the reduction in household income due to a one standard deviation decrease of accumulated rainfall. In net values, considering that the household reduces the transfers sent in face of rainfall deficits in origin, the effect of the shock on the transfers per migrant represents 10% of the income lost. This amount is far from full insurance, but it shows the prevalence of informal risk-arrangements beyond the community level.

A key contribution of this paper is to look at how different levels of correlation between income shocks at origin and at destination affect the flow of transfers. Therefore, I look at insurance arrangement by migrants' destination and economic activities.

I split the sample between urban and rural migrants. I find that while urban migrants are unilaterally insuring their household in origin, rural migrants do not provide neither receive insurance from the household in origin. Rural and urban migrants differ in several ways, among other things rural migrants are exposed to shocks which are highly correlated to income shocks happening at their location of origin. Thus, I look at samples of rural migrants who are exposed to different level of shocks correlation with respect to their household in origin. The results show that when the difference between rainfall shocks in origin and destination increases migrants provide larger level of insurance to their household in origin. The adjustment on the annual amount of remittances accounts for two thirds of the adjustment observed among urban migrants. The results also show that households in origin provide insurance to migrants exposed to different rainfall shocks but located close to them. This result points out to the existence of a trade-off between the level of correlation among rainfall shocks and the access to information on migrant's economic situation.

Then, I analyze this insurance arrangement looking at migrant's economic activity. Migrants who are involved in non-agricultural activities are less vulnerable to weather shocks and more likely to provide insurance. My results support this hypothesis and show that households in origin provide insurance at the extensive margin to migrants who are participating in both agricultural and non-agricultural activities. This result indicates a household strategy such as households being interested on co-insurance contracts with migrants who are a priori vulnerable to other type of income shocks.

Finally, this paper shows that exogenous reductions in income coming from rainfall shocks reduce transfers receipts by non-local migrants. This income effect on households' transfers occur regardless of migrants' characteristics, suggesting that is not correlated with the insurance mechanism. Looking at an older cohort of migrants I find that while this income effect vanishes, older migrants still providing insurance to their household in origin. This result suggests that the income effect may be explained by a life cycle component and by cohort-specific characteristics of the pool of migrants analyzed.

On the policy side, there has been a significant interest on policies targeting international and seasonal migration[2]. Recent policy experiments on international migrants have shown that migrants remit and save more when they have higher control over their bank accounts in their country of origin (Aycinena et al., 2010; Ashraf et al., 2014) or when they face lower monitoring cost over the use of remittances at origin (Batista and Narciso, 2013). Looking at seasonal migrants, Bryan et al. (2013) show that small incentives to seasonal migration led to an increase in the number of seasonal migrants, to an improvement in terms of consumption and to an increase rate of seasonal

[2] see McKenzie (2012) for a overview of policy experiments and research designed experiments on determinants of migration self-selection.

migrants in the following years. Policies targeting domestic and regional migration have received less attention, an exception are the studies focused on the impact of mobile money on risk sharing strategies (Blumenstock and Fafchamps, 2013; Jack and Suri, 2014). In Kenya,Jack and Suri (2014) find that mobile users are 13 percentage points more likely to receive remittances in face of negative shocks and that they receive remittances from a more diverse network. Only 1% of total remittances received came from international migrants. Overall, these studies suggest that improving communication between internal migrants and their household in origin increase the level of protection of households in rural areas through an increase in domestic remittances. This paper provides further evidence on the importance of analyzing the returns of domestic and regional migration in developing countries.

The remainder of the paper is set out as follows. Section 2 presence the insurance model from which reduced forms are derived. Section 3 summarizes the data, describes the sample of migrants and the remittances behavior. Section 4 present the weather shocks. In section 5 I present the specification strategy, in section 6 I discuss the results and the mechanism driven the main results. Section 7 investigates other risk coping mechanisms analyzed in the literature and section 8 provides a concluding discussion.

## 2 Conceptual Framework

Among the several motives why remittances may occur, the literature usually distinguish four groups: self interest (ie: inheritance), pure altruism, exchange (ie: repayment of a intra-family loan) and co-insurance. Remittances may combine all of them as was pointed out by Lucas and Stark (1985), making it difficult to empirically distinguish between different motives. Even if it is difficult to correctly identify the motive behind the decision to remit, it is possible to test whether the remittances and transfers among migrants and their household of origin play an insurance role. To do so, I follow the literature on risk sharing and I set up a simple model from which I derive the reduced form equations to test the insurance hypothesis. This section builds on Fafchamps and Lund (2003) and Yang and Choi (2007) [3].

The risk-sharing theory states that if there is a Pareto-efficient allocation of risk across network's members consumption should not be affected by individual income shocks. About 75% of original households have only one migrant in this age cohort, therefore I simplify the risk sharing model to a two individuals model. Consider two risk-averse members coming from a former household: the household head ($h$) who has stayed in the community of origin ($o$) and a young migrant ($m$) who was formally a member of the household and is currently living in a different location ($d$). I assume that all members have identical preferences and that they cannot borrow or save. I take the decision to migrate as given, and analyze the decisions to send transfers and remittances, condition on migration by the young adult. The migrant and the household head have a contract which objective is to insure income risks faced by any of them.

Both individual are working and able to actively participate in an insurance contract by sending transfers back and forth to each other. Individuals have an uncertain income $y^i_{s^g}$, where $s^g \in S$ stands for the state of nature in location $g$ ($g \in G = \{o, d\}$), and $i = \{h, m\}$. They consume $c^i_{s^g}$ and derive instantaneous utility $U_i(c^i_{s^g})$. Utility is separable and it's twice differentiable, with $U'_i > 0$ and $U''_i < 0$.

[3] See also (Mace, 1991; Altonji et al., 1992; Townsend, 1994)

The model can be solved as a simple Social Planner Maximization problem in which a weighted sum of each individual utility is maximized,

$$\max_{c^m_{sd}, c^h_{so}} \{\omega_m U(c^m_{sd}) + \omega_h U(c^h_{so})\} \tag{1}$$

Pareto efficiency requires the ratio of marginal utilities between members to be constant in any state of nature:

$$\frac{U'_h(c^h_{so})}{U'_m(c^m_{sd})} = \frac{U'_h(c^h_{so'})}{U'_m(c^m_{sd'})} = \frac{\omega_m}{\omega_h} \tag{2}$$

with the planner's weights $\omega_i$ satisfying $0 < \omega_i < 1$ and $\omega_h + \omega_m = 1$. Let assume individual utility take the form of a constant absolute risk aversion function with all individuals having the same coefficient of absolute risk aversion $\theta$,

$$U_i(c^i_{sg}) = -\frac{1}{\theta} e^{-\theta c^i_{sg}} \tag{3}$$

The first-order conditions for individual i include

$$\omega_i e^{-\theta c^i_{sg}} = \lambda \tag{4}$$

where $\lambda$ is the Lagrange multiplier associated with individual i's resource constraint. Because, I'm only interested in the flows between two individuals and $\lambda$ is the same for all individuals, I can equalize the marginal utilities by each individual, then taking logs and re-arranging, I get:

$$\frac{1}{\theta}(\ln \omega_m - \ln \omega_h) = c^m_{sd} - c^h_{so} \tag{5}$$

The planner's weights do not depend on the state of nature, thus they are constant, individual consumption depends on the realization of consumption of the other network's member. I follow Fafchamps and Lund (2003) and Yang and Choi (2007) and define the budget constraint for each individual $i$ as,

$$c^i_{sg} = y^i_{sg} + T^i_j \tag{6}$$

where $T^i_j$ accounts for the net value of transfers received by individual $i$ and sent by individual $j$. Notice that $T^i_j$ enters individual i's budget constraint positive but individuals j's budget constraint negatively,

$$c^j_{sg'} = y^j_{sg'} - T^i_j \tag{7}$$

Individual income $y^i_{sg}$ is decomposed into a permanent component ($\tilde{y}^i$) and a transitory component ($y'^i_{sg}$), such that $y^i_{sg} = \tilde{y}^i + y'^i_{sg}$. Re-arranging equation 5, I get the equation for the net value of transfers received by the migrant:

$$T^m_h = \frac{1}{2}\{(\tilde{y}^h_{so} - \tilde{y}^m_{sd}) + (y'^h_{so} - y'^m_{sd}) + \frac{1}{\theta}(\ln \omega_m - \ln \omega_h)\} \tag{8}$$

Given that rain-fed agriculture is the main economic activity at the communities of origin, transitory income in this study is going to depend on observed agricultural shocks, rainfall shocks, which can be represented by $z^i_{s^g}$, such that

$$\frac{\partial y'^i_{s^g}}{\partial z^i_g} < 0 \tag{9}$$

Income response to rainfall shocks is allowed to be heterogeneous across locations,

$$\frac{\partial y^i_{s^g}}{\partial z^i_g} \neq \frac{\partial y^i_{s^{g'}}}{\partial z^i_g} \qquad \forall i, g, g' \tag{10}$$

where $g \neq g'$. This assumption allows for differences in productivity and in income diversification across locations, which makes sense given the distribution of migrant across different economic areas in Nicaragua and Costa Rica.

The model also assumes that the state of nature is heterogeneous across locations, $s^g \neq s^{g'}$, a reasonable assumption in the case of Nicaragua,which is a small mountainous country with multiple micro-climates (Macours et al., 2012). Under this set of assumptions, I can derive a reduced form equation from Equation 8:

$$T^m_h(s^o_t, s^d) = \alpha + \beta_o z^h_o + \beta_d z^m_d + \gamma X_{mh} + \epsilon_{m_t} \tag{11}$$

Where $\epsilon$ is a mean-zero error term. The function of Pareto weights and the permanent income component $\tilde{y}_i$ for the migrant and for the household in origin can be captured by a vector of individual and household characteristics $X_{ij}$ [4]. I allow $\beta_o$ to differ from $\beta_d$ as the impact of rainfall shocks on agricultural income may differ among locations. In Section 6 I test whether a decrease of one standard deviation in accumulated rainfall at origin and at location of destination has the same impact in magnitude (it should have the opposite sign) on the net value of transfers receipts, that is I test whether $\beta_o + \beta_d = 0$. I do not impose any assumption on the income response to shocks among households living in the same location ($g$). Equation 8 suggests that when income shocks experienced by both agents are exactly the same there would be no adjustment on the net amount of funds transferred. I test this result using migrants who are experienced the same rainfall shock that the household in origin. If the impact of the rainfall shock is larger in one side than in other I should observe an adjustment on the net value of transfers.

Equation 11 allows me to test whether migrants' net amount of transfers received by the migrant varies with shocks in origin and in destination. Negative income shocks affecting the household in origin are expected to reduce the net value of transfers received by the migrant through two mechanisms. First, the amount of transfers received by the migrant (in-flow) is reduced as a consequence of a drop on income in origin. Second, the amount of remittances sent by the migrant (out-flow) to the origin household increases to compensate the income lost in origin (insurance mechanism). Therefore, to test whether the adjustment on the net value of transfers received is driven by an insurance behavior or whether it is driven by other factors, I split equation 11 into two equations, one for remittances (transfers sent from the migrant to the household in origin) and the other for transfers (transfers sent from the household in origin to the migrant). I assume that migrant's and household head's decision on what they send doesn't depend on receiving or not transfers from the other party simultaneously,

[4] In risk sharing literature the term average consumption is replaced by village or network shocks, Yang and Choi (2007) replace it by time effects. I don't have that aggregate component, instead I have permanent income from the household in origin, which can be proxy by initial assets, location and household members, and the transitory component of income at origin, captured by the agricultural shock in origin.

but on the income shocks on each location. For this insurance contract to work, households in origin and migrants need to have information on income shocks occurring at recipients' location. It might be reasonable to expect migrants to have reasonable good information on weather conditions at home due to social networks and return visits during holiday periods. But possibly it is harder for origin households to have good information about weather conditions at destination. As such there might be a trade-off between having less correlated shocks and information. I derive two different equations from equation 11 accounting for the direction of the flow from migrant's perspective.

1. Transfers: transfers from the household head in origin to the migrant

$$Tr_h^m(s^o, s^d) = \alpha^{Tr} + \beta_o^{Tr} z_{s^o}^h + \beta_d^{Tr} z_{s^d}^m + \gamma^{Tr} X_{mh} + \epsilon_m^{Tr} \tag{12}$$

2. Remittances: transfers from the migrant to the household head in origin

$$R_h^m(s^o, s^d) = \alpha^R + \beta_o^R z_{s^o}^h + \beta_d^R z_{s^d}^m + \gamma^R X_{mh} + \epsilon_m^R \tag{13}$$

Equations 12-13 enable to test whether rainfall shocks are insured via inter-households transfers. I test two hypothesis:

**Hypothesis 1** The household in origin insures the migrant: $\beta_d^{Tr} > 0$

**Hypothesis 2** The migrant insures the household in origin: $\beta_o^R > 0$

If income shortfalls from weather shocks are co-insured $\beta_d^{Tr}$ and $\beta_o^R$ should be positive. My identification strategy allows me to directly test both hypothesis, in addition I can estimate the impact of income shocks at the sender's location on the out-flow of transfers,captured by $\beta_d^R$ and $\beta_o^T$. I expect the negative income shock on sender's location to decrease the amount of transfers sent (direct income effect). The size of $\beta_d^{Tr}$ relative to $\beta_o^R$ provides some insight on whether the insurance contract is symmetric and both parties are insured in the same magnitude or is asymmetric and one party is better insured than the other. Nevertheless, the difference between coefficients might be driven also by differences on the vulnerability to weather shocks in each location.

## 3 Data

I use two years of panel data from a household survey in rural Nicaragua. These data was collected to evaluate a Conditional Cash Transfer (CCT) program, *Red de Protección Social*, which was implemented in 2000 based on a randomized phase in [5] [6]. I use data from a baseline census-level data collected in May 2000 and a long-term follow up survey conduced between November 2009 and November 2011 (2010 survey from hereon)[7]. This round of data includes all households in the 4-years

[5]The RPS intervention comprised two phases over six years. The pilot phase, started in 2000 and lasted 3 years. In 2003, the control group was phased in for three more years and the treatment communities stopped to receive the transfers.

[6]See (Flores and Maluccio, 2004; Maluccio, 2010) for results on the short-term effects of the program and (Barham et al., 2013b,a) for results on the long-term effects.

[7]This survey is part of a research project conducted by Tania Barham, Karen Macours, John Maluccio and Ferdinando Regalia

panel dataset and a sample of additional households who had children of ages critical to the long term evaluation (Barham et al., 2013b).

The 2000 census includes questions about the characteristics and composition of the household, education and economic activities of household members, ownership of durable goods, land property and information on agriculture activity. The 2010 survey was modeled following the 1998 Nicaragua Living Standards Measurement Study (LSMS) instrument. This round of data was collected making a significant effort on tracking individuals to reduce as much as possible attrition due to migration and to household split off. Households and individuals in the target group [8] were tracked across Nicaragua and to Costa Rica. Multiple visits to the original communities reduced attrition due to seasonal migration. At the household level the attrition rate is below 8 percent. The target sample included 2,711 original households, during the follow-up the survey team interviewed 2,505 original households and 1,375 new households.

At the individual level, the sample used in this paper is restricted to respondents between the ages of 15 and 21 in 2010 (see Figure 1). My target sample contains 1,948 girls and 2,050 boys, among whom 1,675 girls and 1,834 boys were surveyed in 2010 [9]. The attrition rate for girls is below 14 percent and for boys below 10 percent (see Tables A1-A3 in Appendix A). For those who were not found in 2010, I have data on remittances and transfers, and proxy information on education and economic activities. Information from the household survey and from the tracking records provide reliable data on current location and allow me to conduct a robustness check by adding this group to the analysis (see Section 6.3). My final sample is restricted to those migrants from whom I have data on their household of origin, leaving out household migration and 10 migrants from whom the original household was never found.

These low attrition rates, in such a mobile cohort (McKenzie, 2007), combined with the geographical spread of the sample and the rich information available at origin and at destination, including gps-coordinates, make this database an excellent tool to analyze migration outcomes. Figure 2 shows the geographical distribution of young migrants in Nicaragua and Costa Rica. The map shows three flows of migrations: migrants staying in their municipalities of origin (dashed regions) or in neighboring municipalities, migrants moving to the agricultural frontier (north-east) and to remote rural areas, and finally migrants moving to the Pacific Coast and around Managua and San José (Costa Rica). The latter flow is formed mainly by urban migrants, while the first two flows are formed by rural migrants and migrants moving to small urban areas. The distribution of rural migrants across space allows me to exploit the space-variation of rainfall shocks at destination. Table 1 shows the rate of migration by type of destination.

### 3.1 Migration from the sampled communities

This paper analyzes the insurance role of transfers between migrants and their household in origin regardless of the motivations behind the decision to migrate. Migrants in my sample were observed in 2000 as household members of their corresponding household in origin. Ten years after, when the follow

[8] All households that have split off, including both local and long-distance migrants, and that contain the original titular, an original panel household member under 21 (in 2010), or a child (under 21 in 2010) of an original household member

[9] This number does not include deceased, 11 girls and 21 boys

up survey was conducted, they were not members of the households in origin anymore. They have moved to different locations where they have formed or joined new households. As mentioned above, I take the decision to migrate as given, and analyze the decisions to send transfers and remittances conditional on being a migrant[10]. I assume that among those who have migrated, those who remit and/or receive transfers self-select differently [11].

To identify the impact of income shocks on transfers I use standardized deviations of accumulated rainfall from the historical mean. The exogenous shock allows me to identify the causal effect of income shocks due to rainfall fluctuations on senders' behavior. Given the dispersion of migrants, I can look at different levels of correlation between shocks. To do so, I distinguish between local and non-local migrants using as a reference the rainfall data cell in which each household is contained. The rainfall data used in this paper comes in the form of grids of proximately 8 km, I define local migrants as those who live in the same rainfall grid than their origin household. Non-local migrants are contained in different rainfall grids and therefore have different shocks that their household in origin. The average distance between the household of origin and the migrant destination is 900 meters for local migrants and around 40 kilometers for non-local migrants.

Theoretical and applied literature on migration suggest that rural and urban migration are motivated by different factors. To exploit this fact, I distinguish between urban and rural migrants. I link the household database to DMSP-OLS Nighttime Lights [12] to get accurate measures of urban areas. The images obtained identify lights from cities, towns, and other sites with persistent lighting. Using this data I define urban areas as those locations where the level of light intensity at night is above a threshold of 7 (of the 6-bit 0-63.0 range of the DSMP-OLS city lights produce). This process allows me to have an objective measure of urbanization in Costa Rica and Nicaragua. The level of light intensity is highly correlated with urban development[13], in the case of Nicaragua, I use a threshold of seven based on urban sites observed using google maps and data collected in the household survey. Migrants not located in these areas are considered rural migrants.

Because I am interested on the insurance mechanisms between migrants and non-migrating household members I restrict the sample to permanents migrants. Permanent migrants are defined as those being absent for more than 9 months in the last 12 months or people that have left more recently but have no plans of returning in the short run independently of the distance between the location of origin and of destination. Apart from these migrants, my sample also have information on household migration, which occurs when all members migrate to the same location. In case of household split-off those moving with the beneficiary of the CCT are considered migrants households and the others are considered just individual migrants. A household member who migrates from a migrant household is reclassified as individual migrant and I include it in the corresponding category.

Surveyed migrants in my sample represent 40% of female young adults and 15.5% of male young

[10] Tables B1- B2 in Appendix C shows that the decision to migrate in my sample is neither correlated with rainfall shocks in 2009 or with the dispersion of accumulated rainfall in the last 10 years at origin and at destination.

[11] In a comparative study on remittances in urban areas, Funkhouser (1995) found that besides similarities on observables characteristics between migrants those remitting differ on unobservables characteristics from other migrants who do not remit.

[12] NOAA: The DMSP is a Department of Defense (DoD) program run by the Air Force Space and Missile Systems Center (SMC)

[13] Elvidge et al. (1997); Henderson et al. (2011) show that light density at night is a robust proxy of economic activity. These studies establish a strong within-country correlation between light density at night and GDP levels and growth rates.

adults (see Table A2 in Appendix A). These rates are in line with the fact that in Nicaraguan rural society young men are more likely to stay at their parents house once they are married while young women moved to their husband communities. Table 1 shows the distribution of migrants by destination. Around 80% of men and women moved to rural areas while around 20% of our sample migrated to urban areas. 5% of male migrants and only 1% of female migrants moved to Costa Rica. Differences on baseline characteristics are driven by urban migrants who on average come from wealthier households and had more years of education in 2000 than the rest of the sample (see Table A4 in Appendix A). In general, the sample analyzed presents high levels of extreme poverty and low levels of education (household head had on average 2 years of education in 2000). The main economic activity at the communities of origin is rain-fed agriculture and only 16% of them had livestock at baseline.

Table 2 shows descriptive statistics for the cohort of interest in 2010. Those who stayed in their household of origin are less likely to be married in 2010 and to be the household head or his/her spouse[14] than those who migrated. These differences are especially large for local and rural non-local migrants. Almost all young adults in the sample were working at the date of the interview, and only 36% are still at school. Even if one third of the sample is enrolled, 92% of them are working, which suggests that this cohort is old enough to be actively participating in economic transactions. Not working migrants and those who are attending school are more likely in urban areas than in rural ares. The difference with respect the rest of the sample is driven by women who are married but are not working. In terms of education, local migrants have less years of education than non-local migrants, and the difference is driven again by urban migrants who have on average two more years of education. Around 60% of local migrants and rural non-local migrants have moved to get married (mainly women), while migrants to urban areas are more heterogeneous and move also to study, work or to find a better economic situation (see Table A5 in Appendix A).

To better understand the mechanisms behind the flow of transfers I analyze how the main results are affected by looking at different pools of migrants based on observables characteristics, like civil status, age, destination etc. A large part of the literature on migration is focused on understanding the determinants behind the decision to migrate. While my identification strategy allows me to estimate the causal impact of income shocks on remittances and transfers adjustments, the self-selection process of migrants restricts me to do any inference on the impact of migration on individuals and households outcomes [15].

### 3.2 Remittances

I have information on the amount of remittances sent and transfers received for 90% of my sample of migrants [16]. The data on remittances and transfers on each migrant is reported by a member in the origin household (usually the household head) and not by the migrant. As a result, even when the migrant was found and interviewed later than the origin household, I have information on his or her transactions at the date when the origin household was surveyed [17]. The data refer to transfers

[14]In the rest of the text, the term "household head" refers to the household head and to her/his spouse

[15]Experimental literature on migrations uses policy experiments and researcher-designed experiments to overcome these selection issues see McKenzie (2012) for a review of experimental literature on selection into migration)

[16]Missing data on reporting only transfers and no remittances account for 3.6% of the sample

[17]96% of the households in origin were interviewed before the start of the first crop season of 2010.

of funds done during the twelve months prior to the follow up survey in 2010.

One third of the total sample of migrants received transfers and/or send remittances (34% and 33% respectively). Table 3 shows that at the extensive margin the rate of migrants sending and receiving remittances are not significant difference among destinations. At the intensive margin, urban migrants send more remittances (annual values) than rural migrants and than local migrants. These results are in line with previous findings in the literature on the positive correlation between education and remittances (Bollard et al., 2011). Rural migrants to no-local areas received on average less transfers from the household in origin than other migrants (local and urban migrants). Among urban migrants, both married and non-married received transfers from the original communities, although they are more common among those who are still studying. Intuitively this makes sense, households are still investing in the education of their children, who on average have one more year of education that those who did not receive transfers in 2010.

Urban migrants send remittances for the value of 110 USD. While men are on average net payers (receive on average only 31 USD), women receive yearly almost the same that what they send (105 USD). Rural migrants are net contributors although the difference is very small. Finally local migrants are receiving around 15 USD more than what they contribute. In relative terms with respect the level of consumption in senders' household, urban migrants send remittances that accounts for 6% of expenditures on total consumption in destination and they receive transfers for the value of 11.5% of total expenditures in origin. These percentages are smaller among rural migrants in local and non-local areas.

In general, those who remit tend to be child of the head of the origin household, and they come from nuclear households with less young adults members. Among male migrants, I also observe some differences in land size holdings, those who send remittances and receive transfers come from households with smaller lands holdings, this hold at the intensive margin, which goes against the hypothesis that remittances are sent to improve migrants inheritance outcomes. Summing up, those receiving transfers from their household in origin are similar in baseline characteristics to those sending remittances, which support the hypothesis of a cooperative contract in which both parts actively involved. The only group in which I do not observe this behavior it is in the one formed by female migrants to urban areas. In this case, differences between those that send remittances and those that do not are almost none, but those receiving transfers have more years of education than those who do not receive transfers and come from wealthier households.

# 4 Weather and Agricultural Outcomes

## 4.1 Weather Shocks

The historical rainfall data are taken from the "Gridded Analysis of Meteorological Variables in Nicaragua" (Uribe, 2011) and is available from 1979 to 2009. The rainfall data are available for a grid of 0.075° (approximately every 8km) and are interpolated from existing weather stations (from the Nicaraguan Institute of Territorial Studies, INETER) and satellite data measured at a resolution of 0.1875° (approximately every 20km) from NARR (the North American Regional Reanalysis) (Macours et al., 2012). For the sample of households in origin I use data from 53 nodes and for the sample of young migrants the data comes from 127 nodes. Rainfall variables are constructed by node separately and households are assigned the rainfall data for the node geo-graphically closest to their location in origin and in destination using gps-coordinates.

Drought events are important for agricultural output in Nicaragua. Insufficient rainfall over an extended period has particularly negative consequences for yields. The 2010 household survey does not include questions on economic shocks experienced at the household level, but data from the community questionnaire shows that 93% of the community leaders who completed the survey reported experiencing a drought in the previous 12 months.

In Nicaragua there are two main growing season: from May to end of August (*Primera*) and from the end of August to November (*Postrera*). Between both seasons there is a dry period, known as *canícula* which occurs between July 15th and August 15th and marks the change of the season.

In 2009, Nicaragua experienced a severe drought driven by *El Niño*, the Nicaraguan Institute of Territorial Studies (INETER, Spanish acronym) recorded deficit rainfall ranging between -14% and -50% during the rainy season of 2009. The direct consequences were felt in the production of basic grain, especially in the Dry Corridor where grain losses reached 50% of production (FAO, 2010). The rainfall deficit was especially large from the end of June to the beginning of October, delaying the start of the second season on average by 15 days. As a result, the data on agricultural outputs for the second agricultural season in 2009 may be incomplete as the data collection for the household follow-up survey starts at the beginning of November 2009. Therefore, I focus on the first agriculture season of 2009, from May to August. As the agronomy literature indicates the large losses of grain yields are caused by water deficits during the flowering season (Calvache et al., 1997), which depending of the crop variety occurs 48-60 days after sowing (corn) and 31-38 days after sowing (beans).This paper follows Macours et al. (2012) and focuses on water deficits during critical windows in the growth cycles, in particular I look at accumulated rain between June and July for the first growing season. The measure of rainfall shocks is defined as deviations of accumulated rain during the growing season from the historical mean [18] divided by the standard deviation for each node (z-scores) at the grid level.

For households in the municipalities of origin the first growing season in 2009 was dryer than normal, Figure 3 shows the distribution of rainfall in standard deviation units for households in origin and for migrants who were found. Both figures show that very few households and slightly more of migrants experienced positive deviations on accumulated rain for this period. While almost 37% of the total households in origin experienced positive rainfall deviations, only 6% of the total sample actually experienced accumulated rainfall above 0.5 standard deviations from the historical mean. On the other side, almost 17% of households in origin were exposed to rainfall deficits one standard deviation or more below the historical mean. For ease of interpretation, the z-score rainfall variables are multiplied by minus one so they can be read as negative shocks.

[18] Macours et al. (2012) provides evidence that drought shocks became more frequent after Hurricane Mitch in 1998. Post-1998 rainfall is lower during the first growing season and during the last months of the second growing season. I follow their specification and compute the historical mean using data from 1979 to 1998. The results are robust to computing the historical mean using data from 1979 to 2008.

### 4.2 Agricultural outcomes and rainfall shocks

The most common activity in this sample is farming, 89% of the household heads were involved in agricultural activities in 2000 and 90% of the land cultivated was used to grow temporal crops, basically beans and maize, only 10% was allocated to permanent crops [19].

Given that most original households in my sample depend principally on the cultivation of rain-fed crops, I expect weather fluctuations to drive changes in consumption or to trigger risk coping mechanisms. Table 4 shows the effect of rainfall on food production, on the value of grains bought and produced and on the final outcome of the harvest. The first column presents the estimated coefficients on rainfall z-scores and the second column presents the estimated coefficients on a drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation. A one standard deviation increase in accumulated rain raises annual food production among households in the original communities by 15%[20]. This increase is driven by a raise (41% increase) in the production of basic grains (maize and beans) and is confirmed by a reduction in the amount of grains bought by 25%. The bottom panel of Table 4 presents the impact of weather shocks in the probability to sell, consume or lose the harvest at the end of the season. One standard deviation increase in rainfall raises the probability to sell grains by almost 10% and to consume them by 45%, while it decreases the likelihood to lose the harvest by 3%. These results highlight the importance of the first growing season in food production and it provides evidence of the direct effects of rainfall deficits on the main source of income for the region.

Are households exposed to adverse shocks able to smooth consumption? First two rows of Table 5 show the impact of rainfall fluctuations on the log of household income, first on agricultural income plus income from other economic activities, and secondly on household income regardless of the source. As expected by the results from Table 4, weather shocks have a large effect on income, one standard deviation increase in rainfall raises household income by 12% indicating that household income is quite sensitive to weather shocks. Bottom panel of Table 5 presents the impact of rainfall fluctuations on the logarithm of total per capita consumption, food per capita consumption and non-food per capita consumption. The lack of impact of weather shocks on consumption suggests that households are smoothing consumption in face of rainfall fluctuations. Taken together, these results show that households manage to protect against shocks even when their sources of income are jeopardized.

## 5 Empirical Specification

Understanding whether transfers act as an insurance mechanism requires estimating the causal effect of income shocks both on migrant and original household side. As mentioned I have rainfall grid data covering all Nicaragua, I match survey data from each migrant (including data on their household in origin) to the rainfall data using gps-coordinates of the household in origin and on migrant's current location. The size of the rainfall cells is small enough (8 km) to have households living in the same *comarcas* [21] being exposed to different shocks. The previous section shows that rainfall deficits in

[19] Statistics from The National Agricultural Census in 2001 show that in theses regions 79% of land used is allocated to grow basic grains (36% to maize and 30% to beans) and 15% is used to grow coffee

[20] Given the timing of the survey I focus on the impact of weather shocks in the households at the community of origin

[21] Census comarcas are administrative areas within municipalities based on the 1995 National Population and Housing Census that, on average, included 10 small communities for a total of approximately 250 households.

my sample represent credible income shocks among households in rural areas. For urban migrants I assume rainfall fluctuations equal to zero, as their income should not be affected by changes in seasonal rain [22][23]. As a robustness check I look at non-linear negative shocks using a dummy to capture whether the household and/or the migrant is exposed to a drought. I define drought as a binary variable taking value one if accumulated rainfall is equal or less than the historical mean minus one standard deviation, and zero otherwise.

I estimate the following reduced-form equations for migrant ($m$) derived in Section 2 (Equations 12 and 13):

1. Transfers: transfers from the household in origin to the migrant

$$Tr_h^m(s^o, s^d) = \alpha^{Tr} + \beta_o^{Tr} z_{s^o}^h + \beta_d^{Tr} z_{s^d}^m + \gamma^{Tr} X_{mh} + \epsilon_m^{Tr} \tag{14}$$

2. Remittances: transfers from the migrant to the household in origin

$$R_h^m(s^o, s^d) = \alpha^R + \beta_o^R z_{s^o}^h + \beta_d^R z_{s^d}^m + \gamma^R X_{mh} + \epsilon_m^R \tag{15}$$

Where $R_h^m$ accounts for the probability to remit or the annual amount of remittances sent by the migrant, and $T_h^m$ accounts for the probability of receiving transfers from the household in origin or the annual amount of transfers received; $z_{s^d}^m$ are a measure of rainfall shocks at the migrant destination while $z_{s^o}^h$ are shocks at the household in origin; $X_{mh}$ includes regional fixed effects at origin and at destination [24], location variables including altitude, vegetation index, distance to school and level of urbanization in 2000, and a set of baseline control variables at the household and at the individual level. $z_{s^o}^h$ and $z_{s^d}^m$ are measured as negative standardized deviations of accumulated rain during the first growing season (positive deviations account for periods with rainfall deficits compared to the historical mean). The coefficients of interest are $\beta_o$ and $\beta_d$ the impact of an decrease of one standard deviation in seasonal rainfall on the outcome variables. Finally, I can look at the net impact of shocks on the flow of transfers. The net value of transfers for each migrant is defined as,

$$NTr_h^m(s^g) = Tr_h^m(s^g) - R_h^m(s^g)$$

$$NTr_h^m(s^o, s^d) = \alpha^{NTr} + \beta_o^{NTr} z_{s^o}^h + \beta_d^{NTr} z_{s^d}^m + \gamma^{NTr} X_{mh} + \epsilon_m^{NTr} \tag{16}$$

I assume that the decision to send any transfer is taken jointly with the decision on the amount transfered, so I focus on the impact effect of rainfall shocks on the intensive margin. For each specification I look at five outcomes: probability to receive transfers from the household in origin (column 1), probability to remit (column 2), amount of annual transfers (column 3), amount of annual remittances (column 4) and net amount of annual transfers received by the migrant (column 5 [3 -4]). I estimate Equations 14-16 by OLS, standard errors are adjusted for clustering at the *comarca* level. In order to test coefficients of the different models simultaneously, I also estimate Equations

[22] Rainfall may affect food prices at the regional level, but it is very unlikely to affect market prices in Managua and San José

[23] For the only migrant in non-urban areas in Costa Rica I assign him the shock of the nearest location in Nicaragua, the results do not change if I drop him from the sample

[24] At origin regional I define regional fixed effects by area: Madrid, Matagalpa-West and EL Tuma -La Dalia. At destination I include regional fixed effects at the departmental level (17) in Nicaragua and at the country level for those who moved to Costa Rica.

14- 16 by carrying out seemingly unrelated regressions (SURE).

# 6 Results

## 6.1 Main Results

Table 6 shows the estimated coefficients for non-local migrants regardless of their final destination. One standard deviation decrease in rainfall in origin reduces the net value of transfers received by the migrant by 20 USD. Migrants are net contributors, the value of the remittances they send is larger than the value of the transfers they received. Conversely, when migrants are exposed to negative shocks in destination they become net beneficiaries. The adjustment accounts for almost 9 USD, half of the impact of rainfall shocks happening in origin. Both coefficients have the expected sign, those exposed to negative income shocks are net recipients of funds. They establish the importance of weather shocks on the flow of transfers.

Next, I decompose the net value of transfers on the amount of transfers received and the amount of remittances sent by the migrant to distinguish between the insurance and income effect.One standard deviation decrease in rainfall at origin raises the amount of remittances sent by the migrant by 10 USD. This result indicates that migrants provide insurance to their household in origin. On the other hand, rainfall shocks in destination do not have any impact on the amount of transfers receipts, suggesting that migrants are not insured by their household in origin. Thus, migrants would be unilaterally insuring their household in origin: the amount of remittances sent increases ($\beta_o^R > 0$) when the household in origin is exposed to negative shocks, while shocks in destination do not increase the amount of transfers received (I cannot reject that $\beta_d^{Tr} \neq 0$).

On the income effect, table 6 shows that both flows of funds (transfers and remittances) are adjusted by shocks happening on sender's location (the impact of shocks in destination on remittances is large but not significant at the 10% level). A drop in household income due to rainfall shocks reduce the amount of transfers and remittances sent, suggesting that households and migrants in this environment are liquidity constrained. This result is in line with the findings by Yang (2008b) in Philippines, who finds that exogenous increases in senders' resource have positive effects on the amount of fund transferred.

Last row of Table 6 contains the p-value for testing whether a rainfall shocks in origin is the additive inverse of a shock in destination, that is $\beta_o + \beta_d = 0$. First, I cannot reject the hypothesis that the coefficients are opposite-signed and equal in magnitude in the equation on remittances. This result indicates that migrants adjust the amount of remittances sent by the same value regardless of whether the negative rainfall shock occur in their current location or in their location of origin. Second, on the equation of transfers receipts, the effects of rainfall shocks in origin and in destination are significantly different in magnitude ($\beta_o \neq -\beta_d$) indicating that households behave differently depending on who is exposed to negative income shocks. They adjust the amount of transfers sent to shocks happening in origin but not in migrant's destination. Furthermore, table 3 in section 3.2 shows that the rate and the value of transfers and remittances between non-local migrants and their household in origin are very similar, suggesting that the flow of fund from origin to destination as large as the reverse. Then, the lack of insurance provided by the household in origin to the migrant could be due to households having less information on income shocks affecting migrants' income. In this case, asymmetric information on shocks would hampered the presence of co-insurance to a certain extent.

The lack of impact of rainfall shocks on the probability to remit and to receive transfers indicate that the adjustments on the annual amount of remittances and transfers is mainly coming from migrants who were already participating in economic transactions (around 34% of the sample of non-local migrants). The magnitude of the effect on this sample is about three times the size of the coefficients estimates in Table 6 [25]. Table 7 presents the estimates at the intensive margin, conditional on being participating in any economic transaction. One standard deviation decrease in rainfall in origin raises the amount of remittances sent by the migrant by 63 USD and decrease the amount of transfers received by the migrant by 26 USD. Shocks in destination also are larger, the income effect of one standard deviation decrease in rainfall drop the amount of remittances sent by 61 USD. These estimates are more suggestive as they rely on the assumption that there is no selection on the extensive margin [26].

As a robustness check I restrict the sample to young adults between the ages of 18 and 21. This group is more likely to be economically independent and it is reasonable to expect that if migrants are actually insuring the households of origin the results should be stronger. Tables 8 shows the results for this cohort of migrants. The impact effect of rainfall shocks in the amount of remittances and transfers it is slightly larger than in the benchmark cohort and the coefficients are more precisely estimated. These results also confirm that the income effect on transfers receipts ($\beta_o^{Tr}$) is not driven exclusively by the youngest group of migrants (15-17 years old). Indeed, one standard deviation decrease in rainfall in origin decreases the probability to receive transfers from the origin household by 11 percentages points, indicating that income effects affect not only the amount of transfers by also the participation on the economic arrangement. The results are consistent with the findings on the sample of 15 to 21 years old.

How large is the unilateral insurance provided by the migrant? Table 5 shows that one standard deviation decrease of accumulated rainfall decreases household annual income at origin by 12%, which translates on a loss of annual household income of 183 USD. Remittances from this pool of migrants compensate for 6% of the reduction in household income due to a one standard deviation decrease of accumulated rainfall (one third of the reduction in household income per capita). This level of insurance although small is relatively large when compared to the average annual value of remittances in the sample.

Overall, these results confirm that households in poor-rural areas exploit the spatial distribution of members of their extended network, in this case young migrants, to face agricultural shocks. In the rest of section 6 I focus on understanding the mechanisms behind the insurance contract and the trade-offs between correlated shocks and asymmetric information by looking at different pools of migrants.

[25] As a robustness check Appendix B contains the tables for the main results under different specifications: non-linear rainfall shocks, results for impacts of rainfall shocks on the inverse hyperbolic sine transformations and the square root of transfers and remittances annual values, this specification reduces the influence of outliers

[26] The coefficients on the net value of transfers doesn't reflect the difference on the effect on transfers and remittances as in this case it doesn't include any value equal to zero. Therefore, in case a migrant receives transfers from home but doesn't sent remittances , he or she is included in the regression on transfers and on net value of transfer but he or she won't be included in the regression on remittances

## 6.2 Interpretation and Mechanisms

Equation 8 suggests than when income shocks at origin and at destination are exactly the same there would be no adjustments on the net amount of funds transferred. Table 9 shows the results for all young local migrants, that is, migrants laying in the same rainfall grid than their household in origin. Notice that the rate of migrants receiving transfers and sending remittances is very similar to the rate among non-local migrants, around 0.32% of local migrants and 34% of non-local migrants are involved in inter-household transfers. But as expected, rainfall shocks do not have any impact on the amount of transfers received and remittances sent. As have been pointed out in the literature (Dercon and Krishnan, 2000; Duflo and Udry, 2004), high correlated income shocks are difficult to insure at the local level. Both sides may be suffering equally the deficits of rainfall, indicating that income response to rainfall shocks may be homogeneous among households living in the same location:

$$\frac{\partial y^i_{sg}}{\partial z^i_g} = \frac{\partial y^j_{sg}}{\partial z^j_g} \qquad \forall i, j, g$$

To analyze how correlation between income shocks affect the insurance role of remittances and transfers, I look at different level of correlations between shocks first by destination and second by economic activity.

*Spatial Distribution of Migrants*

As mentioned in Section 3 urban and rural migrants to no-local areas differ from each other. The pool of migrants moving to urban areas come from wealthier households and have more years of education than other migrants. Their income is less vulnerable to rainfall fluctuations and therefore less correlated to income shocks occurring at their location of origin. On the other hand, around 60% of non-local migrants moved to rural areas where they work mainly in agricultural activities which makes this group highly vulnerable to rainfall shocks. To account for these differences and for different levels of correlation between income shocks at origin and at destination I split the sample into migrants moving to urban areas and migrants moving to rural areas.

Table 10 shows the estimated coefficients by non-local migrants' current location. The top panel presents the results for non-local rural migrants and the bottom panel for urban migrants. Coefficients among non-local rural migrants are neither significant for remittances or for transfers. There is not evidence of any insurance mechanism taking place between rural migrants and their household in origin. The estimated coefficient on the net value of transfers received by rural migrants suggests that they are receive less transfers when their household in origin is exposed to negative rainfall shocks.

The bottom panel shows the results for urban migrants and gives strong evidence on the unilateral insurance mechanism by which household in origin are insured by young migrants. One standard deviation decrease in rainfall in origin raises the amount in remittances sent by the migrant by about 16 USD, double than the effect found in Table 6. The income effect is also strong and large, migrants' transfers receipts decrease by 18 USD in face of negative shocks in origin and the net amount of transfers fails to 35 USD. Remittances from young urban migrants compensate for 9% of the reduction in household income due to a one standard deviation decrease of accumulated rainfall.

Differences between both types of migrants could be explained by differences in migrants' socio-economic situation, for example urban migrants may be less liquidity constrained than rural migrants (see Table 2). Still, the lack of insurance provided by rural migrants could be explained by the fact that them and their household in origin may be exposed to correlated weather shocks. If that is the case, would be difficult to insure rainfall shocks in this setting. Using the rainfall grid to distinguish local and non-local migrants has the inconvenience that rural non-local migrants may still be living very close to their communities of origin and therefore be exposed to highly correlated shocks.

To analyze whether high levels of correlation between rainfall fluctuations in origin and destination are driven the results among rural migrants I compute the absolute value of the difference between rainfall deviations and based on it construct different samples of migrants. This strategy allows me to reduce spatial correlation, without imposing any assumption on the income effect of rainfall fluctuations in each location ($z^i_{s^o}$, $z^i_{s^d}$) [27]. Figure 4 and 5 show the results for running Equations 14 and 15 on different samples of migrants. The vertical axis shows the coefficients capturing the insurance role of transfers and remittances, that is $\beta^{Tr}_d$ and $\beta^R_o$ respectively. The values in the horizontal axis represents the minimum difference in absolute values between rainfall deviations in origin and destination in each sample ($\delta_{abs} = |z^o - z^d|$).

Both graphs show a positive relation between the absolute difference between shocks and the level of insurance. Consistent with previous findings, this tendency is especially significant when shocks occurs at origin. Migrants living in areas who are exposed to shocks at least 0.45 points different than the community of origin adjust their remittances by almost 10 USD which accounts for two thirds of the impact observed among urban migrants. Figure 5 shows that when the correlation between rainfall shocks shrinks young rural migrants provide insurance to their household in origin. This result is important as it indicates that even migrants with low level of education (around 5 years of schooling in 2010), working in agricultural activities (85% of them works only in agriculture) and who are married and economically independent (77% are married and 62% are household heads in 2010) still providing insurance to their household in origin. Are they also receiving insurance?

Figure 4 shows that the level of insurance increases as shocks between locations are less correlated but it decreases again when differences between shocks increase. The peck of insurance gets as far as 6 USD when the absolute difference between shocks is between 0.2 and 0.3 point. Although small this result suggests that households in origin may provide some insurance to migrants exposed to negative rainfall shocks. But, the figure also shows that distance between locations may complicate the implementation of insurance mechanism protecting the migrants. The reduction on the insurance effect as the difference between shocks increases indicates the presence of information costs.

All together, these results point to the presence of co-insurance informal arrangements, in which households receive higher level of protection. The estimated coefficients on the net value of transfers show that taking into account the income effect does not change this result, households in origin are net beneficiaries when they are exposed to negative shocks (see Figures 6-7 in Appendix B).

*Economic Activity*

In this section I investigate the implications of income correlation between the household in ori-

[27] The absolute value of the difference does not capture whom is exposed to the larger shock. Given that I do not have self-reported data on shocks intensity, I do not know whose income is more vulnerable to rainfall deviations and therefore I can not establish whether the household in origin or the migrant are better or worse off.

gin and the migrant by looking at migrants' economic activity. Instead of analyzing the correlation between rainfall shocks, I look at whether migrants who are involved only in agricultural activities provide the same level of insurance than migrants working in non-agricultural activities and/or agricultural activities (25% of migrants working on non-agricultural activities are also working on the agricultural sector). Those working only in agricultural activities are not only more likely to be vulnerable to rainfall shocks but also their income is presumably more correlated to their origin household's income.

Table 11 shows the result for the pool of migrants divided on those working only on agricultural activities (top panel) and those combining agriculture and non-agriculture or working only in non-agricultural activities (bottom panel). The results are in line with the findings on the spatial distribution of migrants. Those working only in agricultural activities do not provide, neither receive, any insurance through the flow of transfers. As it happens among rural migrants, they receive less transfers when households are exposed to shocks in origin.

On the other hand, I find that those migrants working in non-agricultural activities provide insurance to their household in origin. One standard deviation decrease in accumulated rainfall raises the annual amount of remittances by 23 USD. Notice, that around 34% of non-local migrants working on non-agricultural activities are rural migrants, thus this result is not driven only by urban migration. On the other hand, the results at the extensive margin suggests that migrants working on both sectors are insured by their household in origin. One standard deviation decrease in rainfall in destination raises the probability to receive transfers from the household in origin by 18 percentage points. This result may reflect a strategic behavior from part of the household in origin, agricultural households in rural areas are interested in contracts with migrants whom income is diversify, especially if it's diversify with respect to themselves.

To analyze whether this strategic behavior explains the results, I restrict the sample to migrants whom household head in origin works only on the agricultural sector. Table 12 shows the results for this sub-sample of migrants. One standard deviation decrease in rainfall in origin raises the amount of remittances sent by the migrant by 19 USD, a 50% more than the adjustment on remittances observed on the whole sample (the differences between coefficients is significantly different from zero, see Table B1 in Appendix B [28]). Contrary to the results obtained in the whole sample, in this sub-sample of migrants the effects of rainfall shocks in origin and in destination on the amount of remittances differ in size, suggesting that a negative rainfall shock in origin leads to a larger adjustment by the migrant than a shock in destination. This result is in line with the hypothesis that households rely on remittances sent from migrants whose income is less vulnerable to rainfall shocks. Finally, the income effect of a shock in origin is similar between samples, indicating that it may be independent of the insurance arrangement.

Table 13 presents the results for the pool of migrants whom household head in origin works only in the agricultural sector by economic activity. Migrants working only in agricultural activities provide insurance to households whose income come only for the agricultural sector, but there is no evidence

[28] To capture heterogeneity effects between different samples of migrants or households in origin, I introduce in Equations 14-16 a dummy variable capturing characteristic $K$ and an interaction term between characteristic $K$ and each rainfall shock:

$$T_h^m(s^o, s^d) = \alpha^T + \beta_o^T z_{s^o}^h + \delta_o^T (z_{s^o}^h * K) + \beta_d^T z_{s^d}^m + \delta_d^T (z_{s^d}^m * K) + \lambda K + \gamma^T X_{mh} + \epsilon_m^T$$

of insurance in the opposite direction.

The bottom panel shows the results for those migrants working on the non-agricultural sector. The effect of rainfall shocks in origin on the magnitude of transfers received and remittances sent is especially large (households adjust their transfers by 26 USD and migrants by 44 USD), while the effect of rainfall shocks in destination is not significantly different from zero. This result is in line with the idea that this group of migrants is less vulnerable to rainfall shocks as they diversify their labor portfolio across sectors. Finally, migrants working in both sectors are co-insured by their households in origin at the extensive margin. The adjustment on the value of transfers is very small and not significant, which suggest that the adjustment occurs at the extensive margin.

The results above point out that risk sharing arrangements between migrants and their household in origin are heterogeneous by destination and economic activity. As expected, those who are exposed to less correlated shocks are more likely to participate in an insurance arrangement. The effect of rainfall shocks in the net value of transfers received by non-local migrants differ in magnitude depending on the location of the shock, suggesting that the economic contract is not symmetric. On average, the adjustment on the transfer of funds is larger when negative shocks occur in the location of origin.

In the following section I analyze whether this economic arrangement holds when the information between households and migrants decreases (attritors). In this case, the term attritors refers only to those migrants in the cohort of interest (15-21 years old) who were traced but not found during 2010 follow-up survey. Adding this sample, I expect households in origin to be less likely to react to shocks in destination as they may have less information on migrant's current location and therefore economic situation.

### 6.3 Attrition

During the 2010 follow-up survey the research team made a great effort on minimizing attrition at the households and at the individual level. As a result, attrition rates for the cohort of interest are below 10% for men and 14% for women for a period of 10 years. Among them 20% moved with their entire households, 27% were untraceable (the survey team could not find anything on their destination), less than 1% refused to be surveyed and the rest were individual migrants (53%). This latter group can be added to the previous analysis using information reported by other household members who were found during the tracking protocol. As before, the data on transfers and remittances come from the questionnaire filled by the household in origin and the sample is restricted to those whom household in origin was interviewed before the harvest of the first season in 2010. This group is not included in the analysis from the beginning because in order to look at shocks in destination I have to rely on proxy information on migrant's location. Adding the sample of attritors increase the sample size, but it also introduce noise in the regression, as the shocks in destination are less precise [29].

To construct migrants' shocks, I use data reported by the household and information collected during the tracking protocol by the enumerator team. Of the 241 individual migrants not found but traceable, 165 migrants were assigned to a micro-region [30], for 32 I only have data on the municipality

[29] Also, the fact that these migrants were not found during the tracking protocol could be in part because the enumerator team did not get the correct information on their location to start.

[30] A micro-region is an administrative area smaller than a municipality and bigger than a *comarca*, defined by the

of destination and 44 were reporting to be living in another country (64% of them in Costa Rica). Depending on the level of information available I follow different strategies to merge the sample of non-found migrants to the rainfall data: at the micro-region level I compute geo-graphic centroid of each micro-region and I assign them to the nearest rainfall grid. For those from whom I only have the name of the municipality, I assign them the shock of the most common micro-region destination in my sample of migrants for each municipality and in case they were the only ones moving to a municipality I compute rainfall shocks at the municipality level by taking the average of all the rain grids inside each municipality. I restrict the analysis to migrants staying in Nicaragua or in Costa Rica[31].

Table 14 shows the main results after adding the sample of attritors from whom I have information on the household of origin and on the location at destination. The rate of migrants not found in this cohort sending remittances to their household in origin is almost the same as the rate among those found (31% versus 33% respectively), but the rate of those receiving transfers is much smaller (17% versus 34%). The top panel presents the results for migrants found and not found inside Nicaragua. One standard deviation fall in accumulated rainfall decrease transfers receipts by 3.7 USD and remittances sent by 6.6 USD (only the coefficient estimated on transfers receipts is significantly different from zero). This result indicates that there is a decrease on the size of the insurance effect on remittances and specially on the income effect on transfers (the difference between those found and not found is not significantly different from zero). The coefficient on the impact of shocks in destination on transfers receipts is almost zero, supporting the hypothesis that information on migrant's situation could partially explained the lack of insurance provided by the household in origin.

Overall, they confirm the presence of an economic arrangement between regional migrants and households in their communities of origin. In the bottom panel I extend the sample to include migrants to Costa Rica, the coefficients decrease as I introduce migrants located farther away. These results should be taken cautiously as they might be driven by measurement errors on the weather shocks.

## 6.4 Income Effect

Besides the insurance effect, the results show a strong negative impact of negative rainfall shocks in origin on transfers receipts. Whether this income effect responds to an altruistic motive, is part of the insurance contract or is driven by other purposes is hard to test. For example, in a exchange model, migrants would be providing loans which would be repaid when the household experiences an income surplus. In that case, the income effect ($\beta_o^{Tr}$) and the "insurance" effect ($\beta_o^{R}$) should be observed together. The results on migrants working in agricultural activities (top panel of Table 11) and on rural migrants (top panel of Table 10) already suggest that the income effect is present even when migrants do not provide insurance. To better understand the mechanisms behind the income effect and whether is correlated with the insurance effect I analyze how the main results are affected by looking at different pools of migrants based on observables characteristics.

Around 70% of female and 30% of male migrants were married at the time of the follow up survey. Almost 21% of married migrants in my sample are living with their partner's household (specially women migrants) or with other relatives of their partner. Presumably they have less access

National Institute of Information and Development (INIDE) and it represents geographic areas which are similar in terms of socio-economic outcomes

[31] I have information on remittances and transfers for only 15 international migrants (without counting those moving to Costa Rica)

to household income and therefore are less likely to send remittances to their household in origin. Table 15 presents the results of running equations 14-16 including interactions effects for non-married migrants and migrants who are not the household head or his/her spouse. The top panel of Table 15 shows that the income effect of one standard deviation decrease in accumulated rainfall in origin prevails among married and non married migrants (the difference is not significant) while non-married migrants are the ones insuring their household in origin. The interaction term between not being married in 2009 and the shock in origin is large and significant at the extensive margin (twelve percentage points), while the coefficient on the amount of remittances sent is large but not significantly different from zero.

These findings suggest that the income effect due to rainfall fluctuations in origin could not be explained as a repayment mechanism of remittances received. The fact that the income effect is observed among married migrants and migrants who have became the household head (see bottom panel of Table 15) indicates that the income effect is not explained neither by households investing in migrants who are likely to return to the communities of origin. Table 16 shows that the income effect of shocks in origin is also independent on whether the migrant is enrolled or not.

These findings indicate that exogenous drops in income at origin decrease transfers receipts regardless of whether the migrant is insuring his/her household in origin or not. By looking only at young adult migrants I cannot say whether the insurance contract is permanent, and respond to a long-term strategy or is just temporary. It is reasonable to think that the observed flow of transfers from the household in origin to the migrant may be driven by a life cycle component. Households help young adults to emancipate and settle during good seasons and reduce their transfers during lean seasons. In this case, the insurance provided by the migrant could be also temporary and be observed among young migrants during the period of life transition. To test this hypothesis I analyze the flow of transfers and remittances among migrants in the next age cohort (22-30 years old). If the life cycle hypothesis is true I expect transfers and remittances to drop as migrants get older.

### 6.5 Older cohort

Using data from the questionnaire filled during the follow up survey by the origin household I can look at the impact of weather shocks on remittances sent and transfers received by migrants who in 2010 were between 22 and 30 years old. I restrict the sample to migrants below 30 as I only have information on migrants who were household members in 2000. The attrition rate in this group is about 49%, 31% of the migrants who were found were living in a non-local area. I replicate the steps followed in Section 6.3, because this cohort was not part of the tracking sample I use data on their location reported by the household in origin. Among those not found, I locate 64% (47% at the micro-region level, 7% at the municipality level and the remaining 10% are living in another country).

Table 17 presents the results for this sample of migrants. The top panel is restricted to migrants inside Nicaragua. One standard deviation decrease in rainfall in origin raises the amount of remittances sent by the migrant by 6 USD and it has no effect on the level of transfers received. Almost 30% of non-local migrants in this cohort are receiving transfers from the household in origin, but the decision to send transfers or the amount sent is not affected by income shocks, neither in origin or in destination. Compared to the results in the youngest cohort (Table 6), the income effect of rainfall shocks in origin on the value of remittances is very similar in magnitude.

All together, these results provide further evidence of the lack of relationship between the insurance and the income effect. The income effect seems to respond to a life cycle model in which the household in origin transfers funds to young migrants during ages of life transition. On the other side, older migrants still sending remittances and provide similar level of insurance than migrants in younger cohorts. These estimates should be used cautiously because of the use of proxy information, there is more measurement error in the variable measuring shocks in destination. This measurement error does not affect the shocks at origin, so the coefficients on the income effect of shocks at origin are comparable with those of the younger cohort.

## 7 Other risk coping mechanisms

Are households not receiving remittances smoothing consumption? Tables 5 shows that households are able to smooth consumption even if their income has shrunk, splitting the sample by those receiving or not remittances do not change the results. Table 19 Including income from non-agricultural activities does not cancel the lost income, but it might reduce the impact of rainfall deficits.

Previous studies on risk management in rural areas have looked at changes on asset levels to buffer against income shocks, among them, livestock has been considered a key asset that households may use to cope with risk (Rosenzweig and Wolpin, 1993; Fafchamps et al., 1998). Table 18 displays the impact of weather shocks on the level of assets and on livestock by households who received remittances and those who do not receive remittances from migrants living in other communities. The assets index is constructed using principal-component factor analysis on a list of assets [32]. Table 18 reveals that households in this framework use durable assets and livestock as buffer stock in face of rainfall deficits. These results are mainly driven by households not receiving remittances from outside the community. Even if the estimated coefficients are not large, they point out that households receiving remittances might be less vulnerable to shocks.

Table 19 shows the impact of weather shocks on the share of households members involved in different economic activities . The size of the coefficient suggests that households do not rely on seasonal migration or labor diversification ex-ante to be fully insured. The estimated coefficient point out that households in face of weather shocks substitute sales of food product and services [33] by sales of other manufacturing products, especially among those not receiving remittances. These results should be taken cautiously as both types of households are not really comparable, as I show in Section 3 migrants come from households with different observables and unobservables characteristics. These characteristics, which could be correlated with the decision to migrate,with the choice of destination and with the implementation of an insurance mechanism, also determine the degree of vulnerability of each household.

## 8 Conclusion

Domestic and regional migration represents almost 75% of an estimated 1 billion migrants worldwide (UNDP, 2009). In poor rural areas with no access to credit and insurance markets, remittances from

[32] The list of assets includes: pumping machine,draft animals, corn grinder machine, television, radio, small tools, sewing machine, oven

[33] Self-employed services provided at home are correlated with food production at home

internal migrants represent an important source of income and a plausible mechanism to cope with income shocks. The potential impact of internal migrants is intensified by the fact that internal remittances although they are smaller in amount in terms of individual transfers they tend to be redistributed back to the poorest sectors of society in greater and more regular amounts than international remittances (Deshingkar and Grimm, 2004; Hickey et al., 2013). Using household survey data on poor rural areas in Nicaragua this paper examines how inter-household transfers between migrants and their household in origin are adjusted in face of income shocks. Taking advantage of the data on migrants destination, I look at the impact of income shocks in origin as well as in destination by different type of migrants (rural versus urban, economic activity) and show that households in rural areas receive more remittances in face of negative agricultural shocks.

For households with non-local migrants, one standard deviation decrease in accumulated rainfall in origin increases the remittances receipts by 10 USD. This increases to 19 USD for migrants whose household in origin works only on the agricultural sector, and are especially vulnerable to rainfall shocks. The adjustment on the amount of remittances is especially large among migrants who might be exposed to different economic shocks that their household in origin. For instance, urban migrants and migrants diversifying economic activities provide the larger level of insurance. Among rural migrants, the transfer of fund increases as the correlation between rainfall fluctuations at origin and destination decrease. There is evidence at the extensive margin of the presence of a co-insurance mechanism in which both parties are insured. This co-insurance agreement is observed among migrants combining agricultural and non-agricultural activities, or among rural migrants when the correlation between shocks is reduced. This result may be driven by the fact that male migrants exposed to agricultural shocks are more likely to move to the agricultural frontier farer away from their communities of origin. Nevertheless, the difference on the level of insurance provided by the migrant and by the household in origin is may be partially explained by the lack of proper income shocks affecting migrants moving to urban areas.

Besides the insurance mechanism, households also adjust their flows of transfers when they are the ones experiencing rainfall shocks. The sign of the causal effect indicates an income effect, the outflow of transfers decreases with rainfall negative shocks. This income effect on households' transfers occur regardless of migrants' characteristics, which suggest that is not correlated with the insurance mechanism. These findings suggest that the transfer of funds between migrants and their household in origin may not be permanent indicating the presence of a life-cycle component. Estimates on a sample of older migrants (22-30 years old) confirm this hypothesis.

How important are these informal arrangements? the economic value of the exchange is not too large and households not receiving remittances in my sample are able to smooth consumption using other risk coping strategies. On average, remittances received from non-local migrants compensate for 6% of the reduction in household income due to a one standard deviation decrease of accumulated rainfall (one third of the reduction in household income per capita). The level of insurance increases among households with migrants involved in non-agricultural activities, in this case remittances compensate for 13% of the reduction in household income. Smoothing is considerable when considering that transfers and remittances are only small percentage of consumption per capita (see Tables 3). There is a remaining question on whether those families who keep actively networks across space are better off than other households, and even, how are these links affecting migrants' outcomes. In Section 7, I analyze other mechanisms that households may use to face income shocks and smooth consumption. The results indicate that adverse rainfall shocks lead to a reduction on assets and livestock and to some labor diversification specially among households not receiving remittances. Uninsured risk results in welfare losses at the short run and leads to poverty traps, temporary support not only reduces the odds to fall into the trap (De Weerdt and Dercon, 2006) but also enables those who are insure to take advantage of more profitability opportunities.

On the policy side, there has been a significant interest on policies targeting international and seasonal migration while policies targeting domestic and regional migration have received less attention. Transfers and remittances between origin households and their regional migrants help insure both sides against negative income shocks. The results on rural migrants also suggest that this insurance mechanism is activated when shocks between locations are no-highly correlated. On the other hand, this mechanism can be limited due to information asymmetries on rainfall and income shocks. In this light recent evidence on the impact of mobile technologies suggest that could be important to facilitate these information flows and to reduce other transaction cost (Blumenstock and Fafchamps, 2013; Jack and Suri, 2014). This paper provides further evidence on the importance of analyzing the returns of domestic and regional migration in developing countries. Overall, the welfare implications of this insurance mechanism at the household and at the migrant level are unknown and they constitute an important matter for further research.

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# Tables and Figures

## Descriptive Statistics

Figure 1: Diagram: Young Adults 15-21 years old in 2010

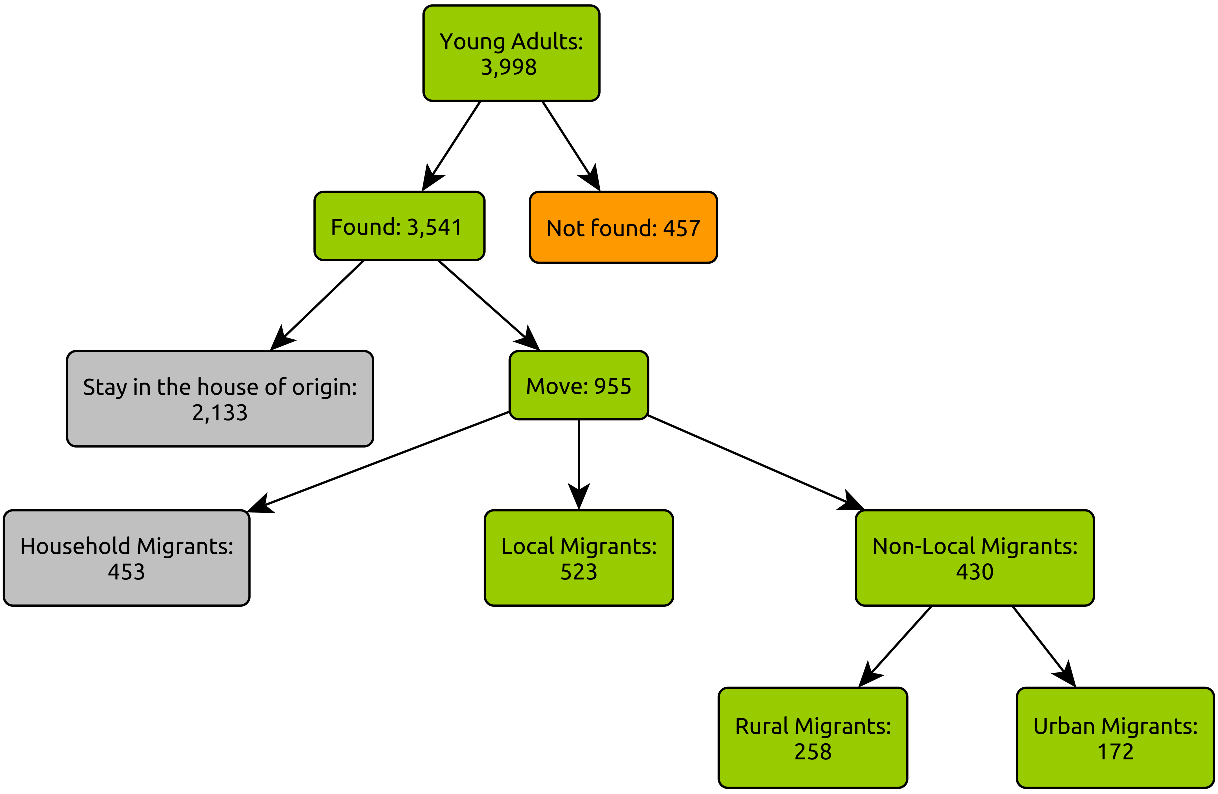



Table 1: Surveyed Individual Migrants by destination: Cohort 15-21 years old in 2010 found and surveyed

| | **Females** | | **Males** | | **Total** | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Local Migrants (rural areas) | 357 | 53.6 | 166 | 57.83 | 523 | 53.97 |
| Non-Local Migrants: | 309 | 46.19 | 121 | 42.16 | 430 | 44.98 |
| Rural | 190 | 28.4 | 68 | 23.69 | 258 | 26.99 |
| Urban | 119 | 17.79 | 53 | 18.47 | 172 | 17.99 |
| Individual Migrants | 666 | | 287 | | 955 | |

Notes: Household migration includes migrants who moved with the caregiver of children in 2000. Local migrants are defined as those sharing weather shocks with the household of origin.

Figure 2: Young Migrants by Destination: 2010

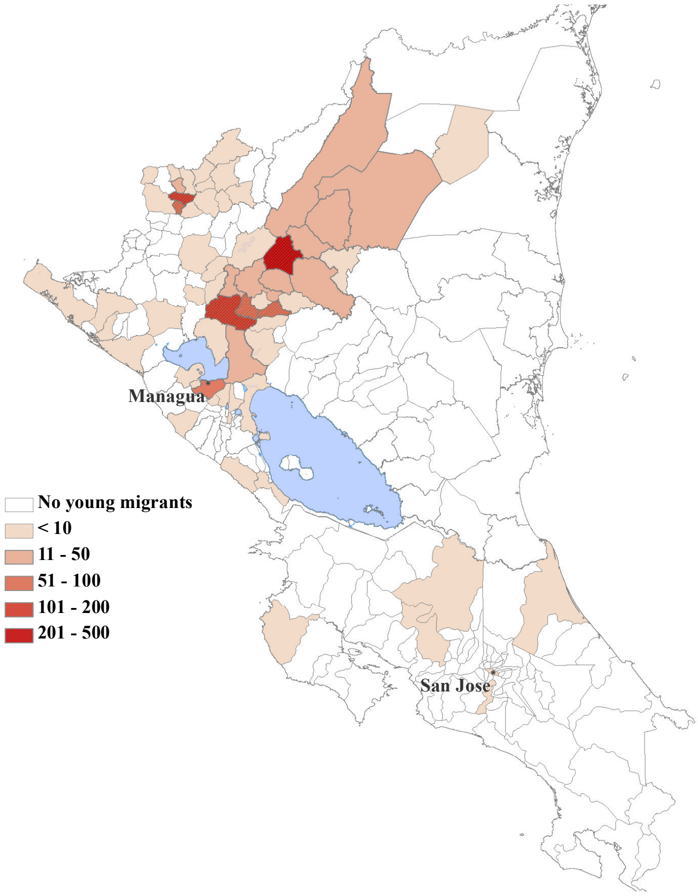



Table 2: Individual Characteristics- Follow -up Survey 2010). Young Adults by current location.

| | Complete Sample | Stayers | Local Migrants | Non-Local Migrants | Non-Local Migrants: Rural Migrants | Non-Local Migrants: Urban Migrants |
|---|---|---|---|---|---|---|
| Age (Jan, 1st 2010) | 18.03 | 0.00 | 0.01 | -0.02 | -0.01 | -0.04 |
| | | (0.01) | (0.02) | (0.02) | (0.02) | (0.02) |
| Marry | 0.25 | -0.56*** | 0.54*** | 0.38*** | 0.50*** | 0.13** |
| | | (0.02) | (0.03) | (0.03) | (0.04) | (0.06) |
| Hh head or Spouse | 0.14 | -0.49*** | 0.41*** | 0.40*** | 0.41*** | 0.32*** |
| | | (0.02) | (0.03) | (0.03) | (0.04) | (0.04) |
| Years of school | 6.08 | 0.07 | -0.60*** | 0.65*** | -0.27 | 1.94*** |
| | | (0.14) | (0.14) | (0.24) | (0.25) | (0.34) |
| Enrolled | 0.36 | 0.11*** | -0.14*** | -0.04 | -0.14*** | 0.10* |
| | | (0.02) | (0.02) | (0.04) | (0.04) | (0.06) |
| Working | 0.92 | 0.04** | 0.02 | -0.10*** | -0.03 | -0.18*** |
| | | (0.01) | (0.02) | (0.03) | (0.02) | (0.04) |

Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01
Column 1 presents the average value for the complete sample, while Columns 2-5 report the differences in means (standard errors in parentheses) by destination with respect to the rest of the sample.

Table 3: Descriptive Statistics: Remittances and Transfers

| | | | | Non-Local Migrants | |
|---|---|---|---|---|---|
| | **Complete Sample** | **Local Migrants** | **Non-Local Migrants** | **Rural Migrants** | **Urban Migrants** |
| Probability to remit | 0.33 | -0.01 | 0.02 | -0.02 | 0.06 |
| | | (0.03) | (0.03) | (0.03) | (0.04) |
| Probability to receive transfers | 0.34 | -0.02 | 0.02 | 0.00 | 0.03 |
| | | (0.04) | (0.04) | (0.03) | (0.05) |
| Annual value remittances (USD) | 45.90 | -24.98** | 30.10** | -23.35*** | 72.44*** |
| | | (11.50) | (14.36) | (7.43) | (21.33) |
| Annual value transfers (USD) | 46.62 | -0.41 | 0.30 | -24.57* | 32.31 |
| | | (18.79) | (18.66) | (14.00) | (27.06) |
| Net annual value transfers (USD) | -5.83 | 17.94** | -17.82** | 2.47 | -39.16*** |
| | | (8.85) | (8.70) | (6.76) | (13.18) |
| **Total Annual Consumption per capita in 2010** | | | | | |
| Consumption in household of origin | 559.82 | 29.16 | 60.46** | 11.89 | 124.04*** |
| | | (19.68) | (23.00) | (25.39) | (40.07) |
| Consumption in household of destination | 653.62 | 76.42** | 659.29*** | 188.35*** | 1271.72*** |
| | | (31.28) | (90.32) | (49.17) | (150.32) |

Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01
Column 1 presents the average value for the complete sample, while Columns 2-5 report the differences in means (standard errors in parentheses) by destination with respect to the rest of the sample.

# Weathers Shocks: Production and Consumption

Figure 3: Distribution Weather Shocks (z-score)

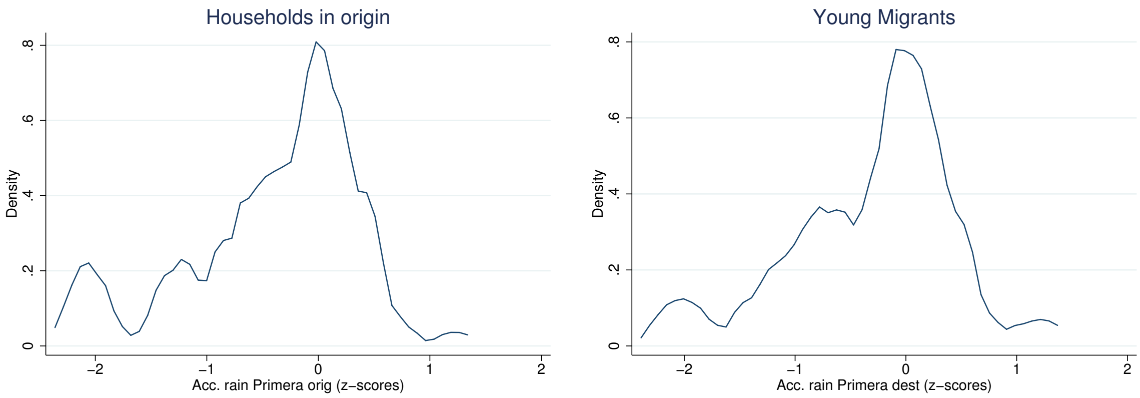



Table 4: Impact of weather shocks on household food production and harvest. Households in Original Communities

| *Outcome* | **Sample** | **Mean** | **Rainfall Deficit†** Negative SD | **Drought‡** Dummy |
|---|---|---|---|---|
| Log Food Production | 2361 | 4.54 | -0.152*** | -0.326*** |
| | | | (0.06) | (0.1) |
| Grains produced (USD) | 2361 | 2.84 | -0.416*** | -0.773*** |
| | | | (0.09) | (0.2) |
| Grains bought (USD) | 2361 | 2.88 | 0.251** | 0.522** |
| | | | (0.1) | (0.2) |
| **Harvest Final Outcome:** | | | | |
| Sale *Primera* | 2361 | 0.28 | -0.0968*** | -0.158*** |
| | | | (0.03) | (0.05) |
| Consume *Primera* | 2361 | 0.77 | -0.0362** | -0.0994*** |
| | | | (0.02) | (0.03) |
| Harvest Lost *Primera* | 2361 | 0.062 | 0.0316** | 0.0608** |
| | | | (0.01) | (0.02) |
| Cultivated Land Lost (sq meters) *Primera* | 2361 | 654.8 | -295.1* | 636.8** |
| | | | (164.0) | (292.1) |
| Mean | | | 0.40 | 0.21 |

†Deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
‡Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household level controls, regional fixed effects, location controls and treatment controls.Values of grains produced and bought are trimmed for 5% outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table 5: Impact of weather shocks on household income and household per capita consumption. Households in Original Communities

| *Outcome* | **Sample** | **Mean** | **Rainfall Deficit†** Negative SD | **Drought‡** Dummy |
|---|---|---|---|---|
| **Log Household Annual Income** | | | | |
| Economic Activity and Agricultural Income | 2361 | 6.05 | -0.172*** | -0.137 |
| | | | (0.06) | (0.10) |
| All sources of Income | 2361 | 6.76 | -0.123*** | -0.131 |
| | | | (0.05) | (0.08) |
| **Consumption Smoothing** | | | | |
| Log Total Consumption p.c. | 2360 | 6.24 | 0.0143 | 0.0330 |
| | | | (0.02) | (0.03) |
| Log Food Consumption p.c. | 2360 | 5.74 | 0.0149 | 0.0315 |
| | | | (0.03) | (0.04) |
| Log No-Food Consumption p.c. | 2360 | 5.19 | 0.0116 | 0.0359 |
| | | | (0.02) | (0.03) |
| Mean | | | 0.40 | 0.21 |

†Deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
‡Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household level controls, regional fixed effects, location controls and treatment controls. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

# Results

## Main Results

Table 6: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -0.06 | 0.03 | -8.86*** | 10.22* | -19.56** |
| | (0.05) | (0.05) | (2.86) | (5.53) | (7.41) |
| Negative Rainfall SD: destination | 0.04 | -0.04 | 2.04 | -6.95 | 8.68 |
| | (0.05) | (0.04) | (3.72) | (5.00) | (6.14) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 357 | 348 | 355 | 347 | 346 |
| P-value: $\beta_o + \beta_d = 0$ | 0.709 | 0.916 | 0.140 | 0.440 | 0.087 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table 7: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants. Intensive Margin (15-21 years old)

| | **Intensive Margin Total Annual Value (USD)** | | |
|---|---|---|---|
| | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -26.24** | 63.24** | -72.52*** |
| | (12.49) | (28.19) | (26.84) |
| Negative Rainfall SD: destination | 30.06 | -61.24** | 62.36** |
| | (27.67) | (26.58) | (25.73) |
| Outcome mean | 45.60 | 61.78 | -9.75 |
| Mean shock origin | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 |
| Obs | 126 | 119 | 175 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca.* *p<0.1, **p<0.05, ***p< 0.01

Table 8: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (18-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -0.11** | -0.00 | -13.98*** | 16.24** | -30.48*** |
| | (0.05) | (0.04) | (4.83) | (7.27) | (10.44) |
| Negative Rainfall SD: destination | 0.05 | -0.05 | 4.32 | -12.02 | 16.45* |
| | (0.05) | (0.06) | (4.57) | (7.49) | (8.21) |
| Outcome mean | 0.34 | 0.37 | 12.14 | 24.66 | -12.43 |
| Mean shock origin | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 |
| Mean shock destination | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Obs | 236 | 236 | 234 | 235 | 234 |
| P-value: $\beta_o + \beta_d = 0$ | 0.284 | 0.429 | 0.065 | 0.548 | 0.096 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca.* *p<0.1, **p<0.05, ***p< 0.01

## Income Shocks: Correlation

### Spatial Distribution of Migrants

Table 9: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Local Migrants( 15-21 years old)

| | Probability to | | Total Annual Value (USD) | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -0.02 | 0.01 | 0.04 | -2.13 | 2.68 |
| | (0.04) | (0.04) | (2.23) | (1.93) | (2.87) |
| Outcome mean | 0.33 | 0.32 | 9.97 | 9.80 | 0.71 |
| Mean shock origin | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| Obs | 471 | 446 | 468 | 443 | 442 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

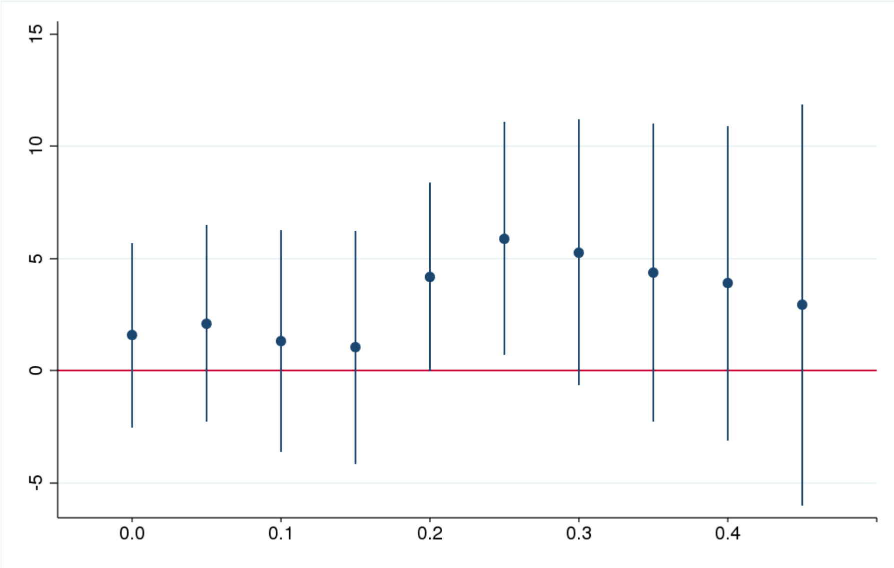
Table 10: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants by Destination (15-21 years old)

| | Probability to | | Total Annual Value (USD) | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Rural Non-Local Migrants** | | |
| Negative Rainfall SD: origin | -0.03 | 0.05 | -6.63 | 1.22 | -8.13* |
| | (0.08) | (0.07) | (4.53) | (1.78) | (4.77) |
| Negative Rainfall SD: destination | 0.04 | -0.04 | 1.58 | -0.79 | 2.45 |
| | (0.06) | (0.06) | (2.44) | (2.21) | (3.27) |
| Outcome mean | 0.34 | 0.31 | 7.79 | 7.32 | 0.66 |
| Mean shock origin | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Mean shock destination | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Obs | 215 | 209 | 214 | 208 | 208 |
| P-value: $\beta_o + \beta_d = 0$ | 0.829 | 0.834 | 0.214 | 0.843 | 0.186 |
| | | | **Urban Non-Local Migrants** | | |
| Negative Rainfall SD: origin | -0.16** | -0.02 | -18.17** | 15.87** | -34.94*** |
| | (0.07) | (0.05) | (7.83) | (7.30) | (11.84) |
| Outcome mean | 0.36 | 0.39 | 19.58 | 36.56 | -16.49 |
| Mean shock origin | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| Obs | 142 | 139 | 141 | 139 | 138 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

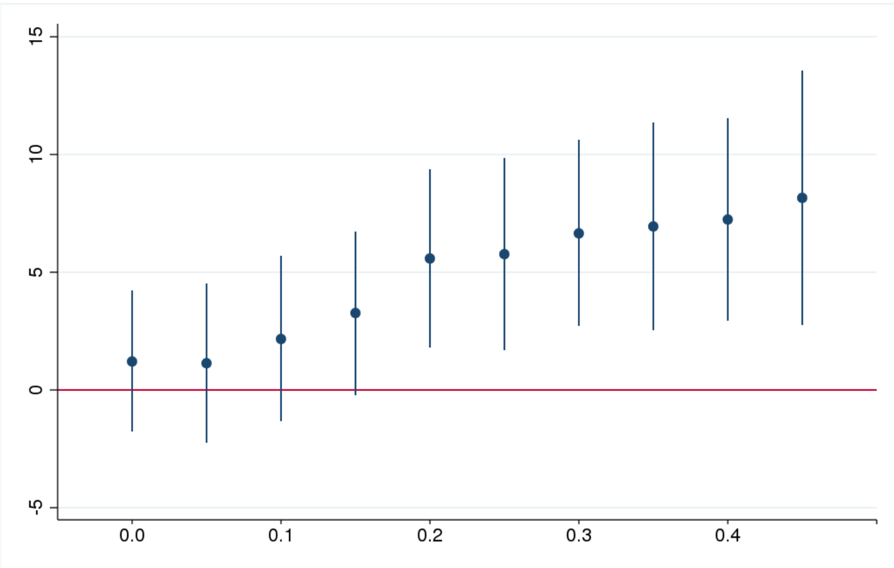
**Rural Migrants: Differences between rainfall fluctuations in origin and in destination**

Figure 4: Impact of Negative Rainfall SD in destination
on the Value of Transfers Receipts ($\beta^d_{Tr}$)




$|z^h_o - z^m_d|$

Figure 5: Impact of Negative Rainfall SD in origin
on the Value of Remittances Sent ($\beta^o_R$)




$|z^h_o - z^m_d|$

*Notes (Figures 4 & 5):* Each figure plots coefficient estimates ($\beta^d_{Tr}$ and $\beta^o_R$ respectively) of running Equation 14 and 15 on the pool of migrants satisfying $|z^h_o - z^m_d| > x$, where x takes values from 0 to 0.45 in 0.05 intervals. Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean. Confidence Intervals are set at 90%. All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*.

## Economic Activity

Table 11: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants. Economic Sector (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Only Agricultural Activities** | | |
| Negative Rainfall SD: origin | 0.01 | 0.06 | -12.83* | -0.86 | -11.40 |
| | (0.09) | (0.09) | (7.35) | (3.13) | (7.06) |
| Negative Rainfall SD: destination | -0.03 | -0.05 | -0.31 | -0.79 | -0.49 |
| | (0.06) | (0.07) | (3.20) | (2.44) | (3.92) |
| Outcome mean | 0.33 | 0.34 | 9.04 | 9.77 | -0.45 |
| Mean shock origin | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| Mean shock destination | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Obs | 157 | 152 | 156 | 151 | 151 |
| P-value: $\beta_o + \beta_d = 0$ | 0.737 | 0.927 | 0.043 | 0.642 | 0.093 |
| | | | **Agricultural and Non-Agricultural Activities** | | |
| Negative Rainfall SD: origin | -0.16* | 0.05 | -15.93** | 22.81** | -38.49*** |
| | (0.08) | (0.08) | (7.51) | (9.26) | (13.37) |
| Negative Rainfall SD: destination | 0.18* | 0.09 | 5.82 | -17.80 | 25.49 |
| | (0.10) | (0.11) | (6.47) | (13.51) | (19.23) |
| Outcome mean | 0.35 | 0.40 | 12.31 | 32.66 | -20.15 |
| Mean shock origin | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 |
| Mean shock destination | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 |
| Obs | 139 | 138 | 138 | 138 | 137 |
| P-value: $\beta_o + \beta_d = 0$ | 0.906 | 0.280 | 0.227 | 0.703 | 0.439 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table 12: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants Whom Origin Household Head Works Only In Agriculture (15-21 years old)

| | **Probability** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -0.07 | 0.08 | -9.64** | 18.93** | -29.37*** |
| | (0.08) | (0.05) | (4.12) | (7.68) | (10.55) |
| Negative Rainfall SD: destination | 0.07 | -0.02 | 2.15 | -6.25 | 7.90 |
| | (0.07) | (0.06) | (4.59) | (5.72) | (7.69) |
| Outcome mean | 0.37 | 0.36 | 13.31 | 18.01 | -4.24 |
| Mean shock origin | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 290 | 282 | 288 | 281 | 280 |
| P-value: $\beta_o + \beta_d = 0$ | 0.918 | 0.385 | 0.122 | 0.028 | 0.023 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table 13: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Migrants Whom Origin Household Head Works Only In Agriculture By Migrants' Economic Sector (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Only Agricultural Activities** | | |
| Negative Rainfall SD: origin | 0.12 | 0.16 | -8.31 | 6.57* | -12.82 |
| | (0.10) | (0.11) | (7.02) | (3.34) | (7.99) |
| Negative Rainfall SD: destination | -0.03 | -0.04 | -0.58 | -1.71 | -0.88 |
| | (0.07) | (0.08) | (4.38) | (2.79) | (5.29) |
| Outcome mean | 0.34 | 0.36 | 9.72 | 9.35 | 0.73 |
| Mean shock origin | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 |
| Mean shock destination | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Obs | 132 | 127 | 131 | 126 | 126 |
| P-value: $\beta_o + \beta_d = 0$ | 0.366 | 0.257 | 0.159 | 0.244 | 0.070 |
| | | | **Agricultural and Non-Agricultural Activities** | | |
| Negative Rainfall SD: origin | -0.32*** | 0.14 | -26.62*** | 44.00** | -70.55*** |
| | (0.09) | (0.11) | (7.75) | (16.27) | (20.00) |
| Negative Rainfall SD: destination | 0.23** | 0.15 | 3.88 | -13.83 | 18.47 |
| | (0.10) | (0.16) | (6.06) | (14.33) | (17.98) |
| Outcome mean | 0.38 | 0.44 | 13.63 | 32.87 | -18.99 |
| Mean shock origin | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 |
| Mean shock destination | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Obs | 113 | 112 | 112 | 112 | 111 |
| P-value: $\beta_o + \beta_d = 0$ | 0.508 | 0.159 | 0.020 | 0.157 | 0.034 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.

All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

## Attrition

Table 14: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Nicaragua** | | |
| Negative Rainfall SD: origin | -0.03 | 0.04 | -3.74** | 6.64 | -10.04* |
| | (0.04) | (0.04) | (1.72) | (4.19) | (5.01) |
| Negative Rainfall SD: destination | 0.04 | -0.01 | 0.94 | -2.89 | 3.45 |
| | (0.04) | (0.03) | (1.94) | (4.44) | (4.62) |
| Outcome mean | 0.31 | 0.33 | 8.82 | 21.25 | -12.66 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| Obs | 466 | 450 | 463 | 449 | 447 |
| P-value: $\beta_o + \beta_d = 0$ | 0.816 | 0.579 | 0.343 | 0.359 | 0.194 |
| | | | **Migrants: Nicaragua and Costa Rica** | | |
| Negative Rainfall SD: origin | -0.02 | 0.04 | -3.10* | 6.39 | -9.46* |
| | (0.04) | (0.04) | (1.65) | (4.62) | (5.32) |
| Negative Rainfall SD: destination | 0.04 | -0.01 | 0.71 | -1.87 | 2.36 |
| | (0.04) | (0.03) | (1.92) | (4.42) | (4.48) |
| Outcome mean | 0.30 | 0.34 | 8.67 | 24.40 | -16.17 |
| Mean shock origin | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Mean shock destination | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Obs | 488 | 472 | 485 | 471 | 469 |
| P-value: $\beta_o + \beta_d = 0$ | 0.694 | 0.556 | 0.400 | 0.313 | 0.198 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.

All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

## Income Effect

Table 15: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants. Civil Status (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **No Married Migrants** | | |
| Negative Rainfall SD: origin | -0.03 | -0.02 | -8.56** | 0.98 | -10.10 |
| | (0.06) | (0.05) | (3.21) | (5.22) | (6.02) |
| No Married*Shock origin | -0.07 | 0.12* | -2.59 | 21.09 | -23.69 |
| | (0.09) | (0.07) | (5.49) | (14.26) | (16.72) |
| Negative Rainfall SD: destination | 0.01 | 0.01 | 5.49 | 3.65 | 1.88 |
| | (0.05) | (0.05) | (3.95) | (3.94) | (5.38) |
| No Married*Shock destination | 0.10 | -0.19 | -10.12 | -30.17** | 18.35 |
| | (0.14) | (0.13) | (6.04) | (11.92) | (12.57) |
| No Married | -0.03 | -0.06 | 8.99 | 10.75* | -1.69 |
| | (0.08) | (0.06) | (6.58) | (6.32) | (10.38) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 357 | 348 | 355 | 347 | 346 |
| P-value: shock orig | 0.358 | 0.244 | 0.009 | 0.134 | 0.018 |
| P-value: shock dest | 0.723 | 0.213 | 0.203 | 0.047 | 0.208 |
| | | | **No Hh head or Spouse** | | |
| Negative Rainfall SD: origin | -0.01 | -0.00 | -7.95** | 7.13 | -15.64** |
| | (0.06) | (0.05) | (3.56) | (4.44) | (6.26) |
| No Hh Head*Shock origin | -0.11 | 0.07 | -2.72 | 6.04 | -8.81 |
| | (0.07) | (0.08) | (6.01) | (9.91) | (12.33) |
| Negative Rainfall SD: destination | 0.03 | 0.02 | 6.20 | -2.40 | 8.56 |
| | (0.06) | (0.06) | (4.87) | (5.02) | (6.09) |
| No Hh Head*Shock destination | 0.02 | -0.14* | -8.21 | -9.29 | 0.43 |
| | (0.09) | (0.08) | (6.03) | (5.75) | (8.44) |
| No hh head | -0.08 | -0.11 | 1.14 | 4.29 | -3.42 |
| | (0.06) | (0.07) | (4.60) | (4.57) | (6.85) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 357 | 348 | 355 | 347 | 346 |
| P-value: shock orig | 0.104 | 0.682 | 0.010 | 0.155 | 0.022 |
| P-value: shock dest | 0.707 | 0.149 | 0.364 | 0.164 | 0.331 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.

All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table 16: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants. Enrolled in School (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Negative Rainfall SD: origin | -0.10 | 0.02 | -10.81*** | 14.54 | -25.84** |
| | (0.06) | (0.06) | (2.95) | (9.29) | (11.01) |
| Enrolled*Shock origin | 0.09 | 0.06 | 3.45 | -10.51 | 13.55 |
| | (0.09) | (0.08) | (5.47) | (10.79) | (10.78) |
| Negative Rainfall SD: destination | 0.04 | -0.03 | 4.46 | -9.12 | 13.46* |
| | (0.06) | (0.05) | (3.91) | (7.47) | (7.64) |
| Enrolled*Shock destination | 0.10 | -0.03 | -6.67 | 3.66 | -11.89 |
| | (0.16) | (0.14) | (6.38) | (9.02) | (10.54) |
| Enrolled in school | 0.05 | -0.06 | 10.81 | 1.86 | 10.26 |
| | (0.08) | (0.07) | (6.98) | (4.93) | (9.00) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean interaction | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 356 | 347 | 354 | 346 | 345 |
| P-value: shock orig | 0.291 | 0.587 | 0.002 | 0.193 | 0.031 |
| P-value: shock dest | 0.373 | 0.710 | 0.429 | 0.431 | 0.202 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca.* *p<0.1, **p<0.05, ***p< 0.01

## Older Cohort (22-30 years old)

Table 17: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (22-30 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Migrants: Nicaragua** | | |
| Negative Rainfall SD: origin | -0.01 | -0.00 | -0.18 | 6.31* | -6.46* |
| | (0.03) | (0.03) | (1.23) | (3.71) | (3.48) |
| Negative Rainfall SD: destination | -0.01 | -0.04 | -0.66 | -5.68* | 5.33* |
| | (0.03) | (0.04) | (0.96) | (3.32) | (3.16) |
| Outcome mean | 0.29 | 0.41 | 7.77 | 32.06 | -23.90 |
| Mean shock origin | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| Mean shock destination | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 |
| Obs | 896 | 893 | 893 | 891 | 889 |
| P-value: $\beta_o + \beta_d = 0$ | 0.605 | 0.213 | 0.517 | 0.890 | 0.787 |
| | | | **Migrants: Nicaragua and Costa Rica** | | |
| Negative Rainfall SD: origin | 0.00 | 0.00 | -0.28 | 7.16 | -7.52* |
| | (0.03) | (0.03) | (1.07) | (4.72) | (4.14) |
| Negative Rainfall SD: destination | -0.01 | -0.04 | -0.76 | -8.54** | 8.09* |
| | (0.03) | (0.04) | (0.93) | (4.13) | (4.06) |
| P-value: $\beta_o + \beta_d = 0$ | 0.739 | 0.267 | 0.385 | 0.797 | 0.908 |
| Outcome mean | 0.27 | 0.43 | 7.08 | 42.32 | -34.86 |
| Mean shock origin | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| Mean shock destination | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Obs | 1024 | 1021 | 1016 | 1019 | 1012 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.

All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

## Other Risk Coping Mechanisms

Table 18: Impact of weather shocks on household assets and livestocks. Households in Original Communities

| | Households Receiving Remittances | | Household Not Receiving Remittances | |
|---|---|---|---|---|
| *Outcome* | **Mean** | **Drought†** dummy | **Mean** | **Drought†** dummy |
| **Assets** | | | | |
| Index assets: use | 0.13 | 0.0317 | -0.0064 | -0.0931 |
| | | (0.14) | | (0.087) |
| Index assets: own | 0.091 | -0.0799 | -0.013 | -0.131** |
| | | (0.12) | | (0.061) |
| **Livestock** | | | | |
| TLU Livestock: 2009 | 0.56 | -0.0444 | 0.51 | -0.0457 |
| | | (0.071) | | (0.029) |
| Numb. pigs | 0.81 | -0.0770 | 0.84 | -0.224** |
| | | (0.15) | | (0.10) |
| Numb. chickens | 10.4 | -1.177 | 9.86 | -2.042** |
| | | (1.08) | | (0.87) |
| Numb. cows | 1.81 | -0.138 | 1.69 | -0.729 |
| | | (0.57) | | (0.48) |
| Numb. goats | 0.095 | 0.0671 | 0.12 | -0.0392 |
| | | (0.075) | | (0.038) |
| Obs. | | 484 | | 1877 |

†Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household level controls, regional fixed effects, location controls and treatment controls. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01
Households receiving remittances from migrants between 15 and 30 years old in 2010 living in other communities

Table 19: Impact of weather shocks on economic activities. Households in Original Communities

| | Households Receiving Remittances | | Household Not Receiving Remittances | |
|---|---|---|---|---|
| *Outcome* | **Mean** | **Drought†** dummy | **Mean** | **Drought†** dummy |
| **Seasonal Migration** | | | | |
| Income from seasonal migration | 394.0 | -22.76 | 489.9 | 36.16 |
| | | (101.7) | | (56.8) |
| Share of adults temp mig | 0.24 | 0.00646 | 0.21 | -0.0202 |
| | | (0.024) | | (0.016) |
| **Share of household members: Economic Activities** | | | | |
| Agric. self-employed | 0.80 | -0.0202 | 0.76 | 0.000164 |
| | | (0.035) | | (0.025) |
| Agric. wage-employed | 0.31 | 0.0130 | 0.32 | 0.000894 |
| | | (0.030) | | (0.026) |
| Sale food produced at home | 0.061 | -0.00864 | 0.057 | -0.0169* |
| | | (0.021) | | (0.0093) |
| Sale manuf. produced at home | 0.013 | 0.00904 | 0.013 | 0.0174* |
| | | (0.0063) | | (0.0086) |
| Sale products no produced at home | 0.051 | 0.0143 | 0.058 | 0.00526 |
| | | (0.021) | | (0.012) |
| Services self-employed | 0.034 | -0.00550 | 0.025 | -0.00818* |
| | | (0.0097) | | (0.0041) |
| No skill wage-employed | 0.075 | 0.0168 | 0.071 | 0.00955 |
| | | (0.017) | | (0.0075) |
| Skill wage-employed | 0.025 | -0.00164 | 0.020 | 0.00433 |
| | | (0.0094) | | (0.0043) |
| Obs. | | 484 | | 1877 |

†Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household level controls, regional fixed effects, location controls and treatment controls. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01
Households receiving remittances from migrants between 15 and 30 years old in 2010 living in other communities

# A Appendix. Descriptive Statistics Migrants

Table A1: Respondents rates: Cohort 15-21 years old in 2010.

| | **Females** | | **Males** | | **Total** | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Surveyed | 1,686 | 86.6 | 1,855 | 90.5 | 3,541 | 88.6 |
| Not surveyed | 262 | 13.4 | 195 | 9.5 | 457 | 11.4 |
| Total | 1,948 | | 2,050 | | 3,998 | |

Table A2: Surveyed Migrant Status: Cohort 15-21 years old in 2010 found and surveyed

| | **Females** | | **Males** | | **Total** | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| No migrants | 831 | 49.2 | 1,304 | 70.3 | 2,133 | 60.2 |
| Individual Migrants | 666 | 39.6 | 287 | 15.5 | 955 | 27.0 |
| Household Migration | 189 | 11.2 | 264 | 14.2 | 453 | 12.8 |
| Total | 1,686 | | 1,855 | | 3,541 | |

Notes: Household migration includes migrants who moved with the caregiver of children in 2000. Local migrants are defined as those sharing weather shocks with the household of origin.

Table A3: Not Surveyed Sample: Cohort 15-21 years old in 2010

| | **Females** | | **Males** | | **Total** | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| **Migrant status: No Respondents** | | | | | | |
| Individual Migrants | 151 | 57.6 | 90 | 46.2 | 241 | 52.7 |
| Household Migration | 51 | 19.5 | 40 | 20.5 | 91 | 19.9 |
| Untraceable | 58 | 22.1 | 64 | 32.8 | 122 | 26.7 |
| Refused | 2 | 0.8 | 1 | 0.5 | 3 | 0.7 |
| Total | 262 | | 195 | | 457 | |

Notes: Untraceable implies that there is no information on the final location.

Table A4: Baseline Characteristics (2000). Young Adults by current location.

| | Complete Sample | Local Migrants | Non-Local Migrants | Non-Local Migrants: Rural Migrants | Non-Local Migrants: Urban Migrants |
|---|---|---|---|---|---|
| Phase I *RPS* | 0.51 | 0.04 | -0.01 | 0.05 | -0.10 |
| | | (0.03) | (0.03) | (0.04) | (0.08) |
| **Individual Characteristics in 2000** | | | | | |
| Female | 0.48 | 0.25*** | 0.31*** | 0.32*** | 0.25*** |
| | | (0.03) | (0.03) | (0.03) | (0.04) |
| Years of education | 0.79 | 0.11* | 0.37*** | 0.09 | 0.73*** |
| | | (0.06) | (0.09) | (0.09) | (0.12) |
| Work last week | 0.08 | -0.03** | -0.01 | -0.01 | -0.01 |
| | | (0.01) | (0.01) | (0.02) | (0.02) |
| Child of the hh head | 0.83 | -0.20*** | -0.15*** | -0.16*** | -0.12** |
| | | (0.03) | (0.03) | (0.03) | (0.05) |
| **Household head Characteristics in 2000** | | | | | |
| Female | 0.11 | 0.03 | 0.02 | -0.01 | 0.07 |
| | | (0.02) | (0.03) | (0.02) | (0.05) |
| Age | 44.16 | 3.80*** | 2.61*** | 2.00** | 3.15** |
| | | (0.72) | (0.72) | (0.88) | (1.19) |
| Years of education | 1.56 | -0.35*** | -0.10 | -0.08 | -0.12 |
| | | (0.11) | (0.12) | (0.16) | (0.18) |
| Agriculture activity | 0.88 | 0.01 | 0.01 | 0.03 | -0.01 |
| | | (0.01) | (0.02) | (0.02) | (0.03) |
| **Household Characteristics** | | | | | |
| House ownership | 0.85 | -0.03 | 0.01 | -0.03 | 0.07* |
| | | (0.02) | (0.02) | (0.03) | (0.04) |
| Land ownership | 0.86 | -0.02 | 0.05** | 0.01 | 0.09*** |
| | | (0.02) | (0.02) | (0.03) | (0.03) |
| Livestock | 0.16 | -0.02 | 0.04 | -0.02 | 0.12** |
| | | (0.02) | (0.02) | (0.03) | (0.05) |
| Log Total Consumption p.c | 7.72 | -0.08*** | 0.01 | -0.01 | 0.03 |
| | | (0.02) | (0.02) | (0.03) | (0.03) |
| Extreme poverty | 0.54 | 0.09*** | 0.01 | 0.00 | 0.01 |
| | | (0.03) | (0.03) | (0.04) | (0.05) |
| Distance school (min) | 25.58 | 1.44 | -0.29 | 3.61 | -6.12** |
| | | (1.87) | (1.47) | (2.62) | (2.83) |
| Vegetation index | 0.88 | 0.00 | -0.00 | 0.02*** | -0.03*** |
| | | (0.00) | (0.00) | (0.00) | (0.01) |
| **Household Composition in 2000** | | | | | |
| Household members: ages 0-4 yrs old | 1.10 | 0.16*** | -0.06 | -0.00 | -0.13** |
| | | (0.05) | (0.05) | (0.07) | (0.06) |
| Household members: ages 5-15 yrs old | 3.56 | 0.18** | 0.08 | 0.08 | 0.08 |
| | | (0.07) | (0.07) | (0.09) | (0.15) |
| Household members: ages 16-30 yrs old | 1.73 | 0.18* | 0.34*** | 0.25** | 0.43** |
| | | (0.09) | (0.11) | (0.11) | (0.18) |
| Household members: ages 31-60 yrs old | 1.62 | 0.14** | 0.04 | 0.01 | 0.09 |
| | | (0.07) | (0.04) | (0.06) | (0.07) |
| Household members: ages over 61 yrs old | 0.19 | 0.11*** | 0.07* | 0.10* | 0.01 |
| | | (0.03) | (0.04) | (0.06) | (0.05) |

Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01
Column 1 presents the average value for the complete sample, while Columns 2-4 report the differences in means (standard errors in parentheses) by destination with respect to the rest of the sample (including those who did not move).

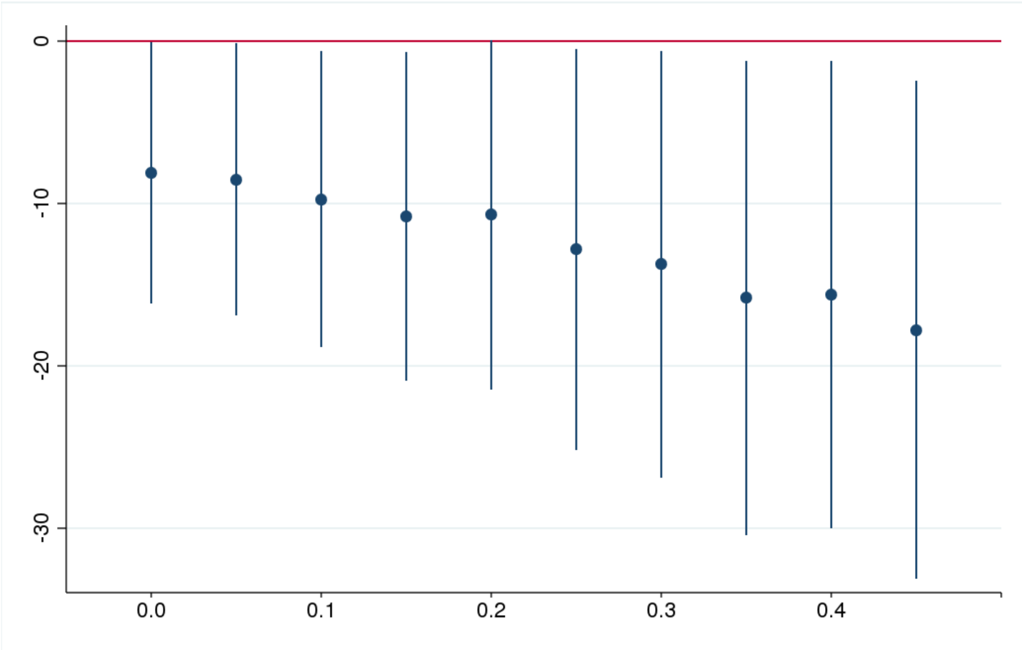
Table A5: Motives behind the decision to migrate by destination. Reported by a member of the household in origin.

| | **Local Migrants** | | **Non-Local Migrants** | | **Non-Local Migrants** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **Rural Migrants** | | **Urban Migrants** | |
| | No. | % | No. | % | No. | % | No. | % |
| Work | 9 | 1.9 | 55 | 15.1 | 12 | 5.3 | 43 | 31.4 |
| Taken | 95 | 20 | 50 | 13.7 | 32 | 14 | 18 | 13.1 |
| Change civil stat | 303 | 63.8 | 168 | 46 | 142 | 62.3 | 26 | 19 |
| Study | 1 | 0.2 | 41 | 11.2 | 12 | 5.3 | 29 | 21.2 |
| Better econ. situation | 22 | 4.6 | 37 | 10.1 | 21 | 9.2 | 16 | 11.7 |
| Emancipate | 37 | 7.8 | 10 | 2.7 | 6 | 2.6 | 4 | 2.9 |
| Other | 8 | 1.7 | 4 | 1.1 | 3 | 1.3 | 1 | 0.7 |

# B Appendix. Robustness Checks.Non-Local Migrants 15-21 years old

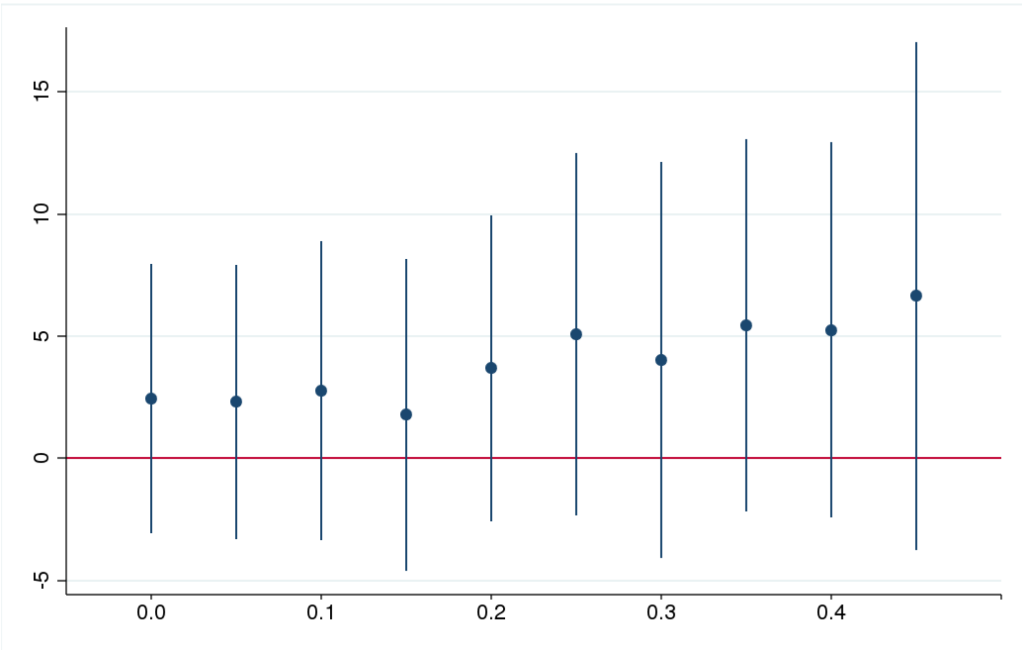
**Rural Migrants: Differences between rainfall fluctuations in origin and in destination**

Figure 6: Impact of Negative Rainfall SD in destination on the Net Value of Transfers ($\beta^{o}_{NTr}$)




$|z^h_o - z^m_d|$

Figure 7: Impact of Negative Rainfall SD in destination on the Net Value of Transfers ($\beta^{d}_{NTr}$)




$|z^h_o - z^m_d|$

*Notes (Figures 4 & 5):* Each figure plots coefficient estimates ($\beta^d_{Tr}$ and $\beta^o_R$ respectively) of running Equation 14 and 15 on the pool of migrants satisfying $|z^h_o - z^m_d| > x$, where x takes values from 0 to 0.45 in 0.05 intervals. Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean. Confidence Intervals are set at 90%. All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*.

### Economic Activity

Table B1: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants Whom Origin Household Head Works Only In Agriculture (15-21 years old)

| | Probability | | Total Annual Value (USD) | | |
|---|---|---|---|---|---|
| | Receive Transfers | Remit | Transfers | Remittances | Net Transfers |
| Negative Rainfall SD: origin | -0.00 | 0.05 | -10.00** | -3.81 | -6.21 |
| | (0.08) | (0.05) | (4.46) | (5.45) | (8.21) |
| Head orig agric*Shock origin | -0.06 | 0.00 | 2.31 | 19.21* | -17.49 |
| | (0.11) | (0.07) | (5.41) | (10.44) | (13.18) |
| Negative Rainfall SD: destination | -0.05 | -0.15*** | 4.80 | -6.56 | 10.89 |
| | (0.12) | (0.04) | (9.08) | (5.24) | (8.89) |
| Head orig agric*Shock destination | 0.11 | 0.14* | -3.88 | 0.85 | -4.65 |
| | (0.16) | (0.08) | (9.71) | (6.77) | (10.88) |
| Head orig agriculure | 0.15* | 0.17*** | 8.97 | -4.44 | 14.64 |
| | (0.08) | (0.05) | (5.60) | (6.12) | (9.42) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean interaction | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 357 | 348 | 355 | 347 | 346 |
| Pvalue: shock orig | 0.628 | 0.442 | 0.011 | 0.118 | 0.034 |
| Pvalue: shock dest | 0.643 | 0.004 | 0.850 | 0.342 | 0.349 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

### Seemingly Unrelated Regressions

Table B2: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (15-21 years old)

| | Probability to | | Total Annual Value (USD) | | |
|---|---|---|---|---|---|
| | Receive Transfers | Remit | Transfers | Remittances | Net Transfers |
| Negative Rainfall SD: origin | -0.07 | 0.03 | -9.26*** | 10.22** | -19.56*** |
| | (0.049) | (0.043) | (2.66) | (5.09) | (6.81) |
| Negative Rainfall SD: destination | 0.04 | -0.04 | 1.76 | -6.95 | 8.68 |
| | (0.044) | (0.038) | (3.56) | (4.60) | (5.65) |
| Obs | 348 | 348 | 348 | 348 | 348 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

### Non-Linear Rainfall Shocks

Table B3: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Drought origin | -0.09 | 0.10 | -14.12*** | 13.98 | -28.62** |
| | (0.09) | (0.09) | (4.27) | (9.72) | (12.53) |
| Drought destination | 0.09 | -0.08 | 2.07 | -13.64 | 14.96 |
| | (0.08) | (0.08) | (6.07) | (8.93) | (10.03) |
| Outcome mean | 0.35 | 0.34 | 12.33 | 18.66 | -5.96 |
| Mean shock origin | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Mean shock destination | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Obs | 367 | 358 | 365 | 357 | 356 |
| P-value: $\beta_o + \beta_d = 0$ | 0.962 | 0.856 | 0.124 | 0.962 | 0.177 |

Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B4: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants by Destination (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Rural Non-Local Migrants** | | |
| Drought origin | -0.03 | 0.16 | -9.19 | 6.74* | -16.78** |
| | (0.14) | (0.13) | (6.69) | (3.87) | (8.27) |
| Drought destination | 0.12 | -0.09 | 2.38 | -4.57 | 7.08 |
| | (0.11) | (0.10) | (5.36) | (3.56) | (5.74) |
| Outcome mean | 0.34 | 0.31 | 7.79 | 7.32 | 0.66 |
| Mean shock origin | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Mean shock destination | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| Obs | 225 | 219 | 224 | 218 | 218 |
| P-value: $\beta_o + \beta_d = 0$ | 0.445 | 0.513 | 0.343 | 0.455 | 0.171 |
| | | | **Urban Non-Local Migrants** | | |
| Drought origin | -0.26** | 0.06 | -27.50** | 27.45* | -56.31** |
| | (0.11) | (0.10) | (11.13) | (14.53) | (20.72) |
| Outcome mean | 0.36 | 0.39 | 19.58 | 36.56 | -16.49 |
| Mean shock origin | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 |
| Obs | 142 | 139 | 141 | 139 | 138 |

Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B5: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants by Economic Activity (15-21 years old)

| | **Probability to** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| | | | **Only Agricultural Activities** | | |
| Drought origin | 0.04 | 0.15 | -14.97* | 5.25 | -19.50* |
| | (0.14) | (0.15) | (8.56) | (5.37) | (9.86) |
| Drought destination | -0.04 | -0.11 | -7.03 | -9.87* | 2.76 |
| | (0.11) | (0.11) | (5.60) | (5.41) | (7.29) |
| Outcome mean | 0.33 | 0.34 | 9.04 | 9.77 | -0.45 |
| Mean shock origin | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Mean shock destination | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Obs | 166 | 161 | 165 | 160 | 160 |
| P-value: $\beta_o + \beta_d = 0$ | 0.978 | 0.813 | 0.045 | 0.390 | 0.133 |
| | | | **Agricultural and Non-Agricultural Activities** | | |
| Drought origin | -0.21 | 0.09 | -24.02** | 37.90* | -62.37** |
| | (0.13) | (0.13) | (11.73) | (19.67) | (26.23) |
| Drought destination | 0.08 | 0.13 | -0.98 | -22.63 | 23.57 |
| | (0.19) | (0.18) | (8.24) | (19.43) | (23.05) |
| Outcome mean | 0.35 | 0.40 | 12.31 | 32.66 | -20.15 |
| Mean shock origin | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| Mean shock destination | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Obs | 141 | 140 | 140 | 140 | 139 |
| P-value: $\beta_o + \beta_d = 0$ | 0.479 | 0.306 | 0.078 | 0.478 | 0.146 |

Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B6: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants Whom Origin Household Head Works Only In Agriculture

| | **Probability** | | **Total Annual Value (USD)** | | |
|---|---|---|---|---|---|
| | **Receive Transfers** | **Remit** | **Transfers** | **Remittances** | **Net Transfers** |
| Drought origin | -0.06 | 0.19* | -16.25** | 27.63** | -44.68** |
| | (0.12) | (0.10) | (6.42) | (13.56) | (17.84) |
| Drought destination | 0.18* | -0.04 | 3.62 | -10.16 | 12.83 |
| | (0.10) | (0.10) | (6.95) | (9.79) | (11.94) |
| Outcome mean | 0.37 | 0.36 | 13.31 | 18.01 | -4.24 |
| Mean shock origin | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Mean shock destination | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Obs | 298 | 290 | 296 | 289 | 288 |
| P-value: $\beta_o + \beta_d = 0$ | 0.376 | 0.258 | 0.116 | 0.050 | 0.029 |

Drought dummy taking value equal to one if rainfall is equal or less than the historical grid mean minus one standard deviation.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

## Logarithm and Square Root Transformation

Table B7: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants (15-21 years old)

| | Log (hyperbolic transformation) | | | Square Root | |
|---|---|---|---|---|---|
| | Transfers | Remittances | Net Transfers | Transfers | Remittances |
| Negative Rainfall SD: origin | -0.33 | 0.22 | -0.54** | -1.53** | 0.73* |
| | (0.20) | (0.18) | (0.26) | (0.72) | (0.37) |
| Negative Rainfall SD: destination | 0.21 | -0.32* | 0.44 | 0.37 | -0.67* |
| | (0.19) | (0.17) | (0.28) | (0.42) | (0.36) |
| Outcome mean | 1.21 | 1.34 | -0.27 | 2.00 | 2.17 |
| Mean shock origin | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 355 | 347 | 346 | 355 | 347 |
| P-value: $\beta_o + \beta_d = 0$ | 0.646 | 0.640 | 0.740 | 0.112 | 0.861 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B8: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants by Destination (15-21 years old)

| | Log (hyperbolic transformation) | | | Square Root | |
|---|---|---|---|---|---|
| | Transfers | Remittances | Net Transfers | Transfers | Remittances |
| | | | **Rural Non-Local Migrants** | | |
| Negative Rainfall SD: origin | -0.19 | 0.16 | -0.42 | -0.58 | 0.21 |
| | (0.31) | (0.22) | (0.35) | (0.51) | (0.28) |
| Negative Rainfall SD: destination | 0.17 | -0.22 | 0.35 | 0.26 | -0.27 |
| | (0.21) | (0.21) | (0.32) | (0.29) | (0.29) |
| Outcome mean | 1.08 | 1.00 | -0.02 | 1.40 | 1.29 |
| Mean shock origin | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Mean shock destination | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Obs | 214 | 208 | 208 | 214 | 208 |
| P-value: $\beta_o + \beta_d = 0$ | 0.938 | 0.780 | 0.833 | 0.468 | 0.853 |
| | | | **Urban Non-Local Migrants** | | |
| Negative Rainfall SD: origin | -0.82** | 0.07 | -0.83** | -4.72 | 0.85* |
| | (0.30) | (0.22) | (0.39) | (3.30) | (0.49) |
| Outcome mean | 1.40 | 1.89 | -0.66 | 2.96 | 3.56 |
| Mean shock origin | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| Obs | 141 | 139 | 138 | 141 | 139 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B9: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants by Economic Activity (15-21 years old)

| | Log (hyperbolic transformation) | | | Square Root | |
|---|---|---|---|---|---|
| | Transfers | Remittances | Net Transfers | Transfers | Remittances |
| | **Only Agricultural Activities** | | | | |
| Negative Rainfall SD: origin | -0.20 | 0.12 | -0.42 | -0.98 | 0.07 |
| | (0.35) | (0.32) | (0.39) | (0.72) | (0.43) |
| Negative Rainfall SD: destination | -0.12 | -0.23 | 0.00 | -0.12 | -0.28 |
| | (0.21) | (0.23) | (0.28) | (0.33) | (0.31) |
| Outcome mean | 1.09 | 1.14 | -0.07 | 1.49 | 1.54 |
| Mean shock origin | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| Mean shock destination | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Obs | 156 | 151 | 151 | 156 | 151 |
| P-value: $\beta_o + \beta_d = 0$ | 0.321 | 0.727 | 0.359 | 0.087 | 0.642 |
| | **Agricultural and Non-Agricultural Activities** | | | | |
| Negative Rainfall SD: origin | -0.62 | 0.47 | -0.97** | -1.28* | 1.60** |
| | (0.39) | (0.34) | (0.42) | (0.68) | (0.66) |
| Negative Rainfall SD: destination | 0.47 | 0.02 | 0.53 | 0.70 | -0.89 |
| | (0.39) | (0.51) | (0.91) | (0.67) | (1.04) |
| Outcome mean | 1.22 | 1.80 | -0.84 | 1.74 | 3.29 |
| Mean shock origin | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 |
| Mean shock destination | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 |
| Obs | 138 | 138 | 137 | 138 | 138 |
| P-value: $\beta_o + \beta_d = 0$ | 0.758 | 0.422 | 0.614 | 0.492 | 0.551 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B10: OLS: Impact of Weather Shocks on Remittances and Transfers Receipts. Non-Local Migrants Whom Origin Household Head Works Only In Agriculture

| | Log (hyperbolic transformation) | | | Square Root | |
|---|---|---|---|---|---|
| | Transfers | Remittances | Net Transfers | Transfers | Remittances |
| Negative Rainfall SD: origin | -0.33 | 0.49** | -0.90*** | -1.79* | 1.40*** |
| | (0.28) | (0.19) | (0.30) | (1.01) | (0.46) |
| Negative Rainfall SD: destination | 0.35 | -0.27 | 0.47 | 0.70 | -0.58 |
| | (0.24) | (0.24) | (0.38) | (0.65) | (0.44) |
| Outcome mean | 1.27 | 1.41 | -0.26 | 2.17 | 2.22 |
| Mean shock origin | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 |
| Mean shock destination | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Obs | 288 | 281 | 280 | 288 | 281 |
| P-value: $\beta_o + \beta_d = 0$ | 0.949 | 0.426 | 0.320 | 0.175 | 0.092 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean.
All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls.Dependent values inputed max and min values for the 1% highest and lowest outliers. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

# C Appendix. Migrants Selection

Table B1: OLS: Impact of Weather Shocks on Probability to Migrate by Destination

| | | | Non-Local Migrants | |
|---|---|---|---|---|
| | **Local Migrants** | **Non-Local Migrants** | **Rural Migrants** | **Urban Migrants** |
| Negative Rainfall SD: origin | 0.00 | 0.02 | -0.06 | 0.00 |
| | (0.01) | (0.08) | (0.05) | (0.00) |
| Negative Rainfall SD: destination | | -0.05 | 0.04 | |
| | | (0.08) | (0.06) | |
| Outcome mean | 0.15 | 0.11 | 0.07 | 0.05 |
| Obs | 3464 | 3464 | 3464 | 3464 |

*Notes:* Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each node multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean. All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01

Table B2: OLS: Impact of Rainfall Historical Variation on Probability to Migrate by Destination

| | | | Non-Local Migrants | |
|---|---|---|---|---|
| | **Local Migrants** | **Non-Local Migrants** | **Rural Migrants** | **Urban Migrants** |
| Coef. Variation: orig | 0.10* | 0.07 | -0.01 | 0.10 |
| | (0.06) | (0.14) | (0.13) | (0.08) |
| Coef. Variation: dest | | -0.00 | -0.03 | |
| | | (0.15) | (0.15) | |
| Outcome mean | 0.15 | 0.11 | 0.07 | 0.05 |
| Obs | 3464 | 3440 | 3440 | 3464 |

*Notes:* Coefficient of Variation of accumulated rain between June-July from 2000 to 2009 at migrants' location of origin and of destination.CV= $\frac{STD_{(00-09)}}{MEAN_{(00-09)}}$ All regressions include household and individual level controls, regional fixed effects at origin and at destination, location controls and treatment controls. Robust Standard errors, in parentheses, are clustered by *comarca*. *p<0.1, **p<0.05, ***p< 0.01