Weather risk, Internal Migration and Urbanization: Evidence from Tanzania

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Abstract

In this paper, I analyze whether individuals in Tanzania engage in migration as a response to weather shocks. I model rural-rural and rural-urban migration within the context of both income maximization and risk minimization, with weather acting as the principal source of risk. I show that weather deviations foster both rural-rural, as well as rural-primary urban migration, but have no impact on mobility to smaller urban centres. However, severe droughts increase the probability of migration only within rural areas, but not to urban areas. These results suggest that above a certain threshold, weather shocks might amplify liquidity constraints and therefore inhibit individuals from moving to cities and reaping full benefits of migration.

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Introduction

"I can't make ends meet by farming these days," says a young farmer from Western Tanzania cited by the World Bank report (WB, 2014). "All my friends are moving to the city to find work. There is a better future there." The view that agriculture's vulnerability to climate change may provoke large-scale rural outmigration within the developing world is growing in popularity, rising expectations of the opportunities that urbanization has to offer, but also concerns about the pressure that a rapid influx of rural dwellers into urban areas will put on the existing infrastructure. Eastern Africa remains the world's least urbanized region; however, with the projected annual urban population growth rate of 5.35 per cent on average in the current decade, it is undergoing by far the most rapid urban transition in the world (UN-Habitat, 2014), and a widespread view holds that this process will involve "the movement of a significant proportion of the population away from rural areas and agriculture, and towards manufacturing and services in the cities" (WB, 2014).

Traditionally, such projections have their roots in the Lewis (Lewis, 1954) and Harris-Todaro (Todaro, 1969; Harris & Todaro, 1970) models where rural-urban migration is modeled as a function of rural-urban expected earning differentials. By enhancing the efficiency of resource deployment (Adelman & Robinson, 1978), migration is considered as a transfer of labour from a traditional, land-intensive to a human capital-intensive technology sector with an "unending potential for growth" (Lucas, 2004; Collier & Dercon, 2014). To date, however, urbanization in sub-Saharan Africa has not been successful in that it has not generated the expected growth-enhancing structural change (Collier, 2016; Timmer, de Vries, & de Vries, 2014, Fay & Opal, 2000). Instead, it has led to the labour moving into less productive activities, most notably informality (McMillan, Rodrik & Verduzco-Gallo, 2014) and to the development of what Gollin, Jedwab and Vollrath (2016) have dubbed “consumption cities”. Additionally, with the increasing importance of circular migration[2] (Beguy, Bocquier & Msiyaphazi Zulu, 2010; WB, 2009) and counter-urbanization in several African countries (Potts, 2012; Potts, 2010; Beauchemin, 2011), the patterns of migration and urban growth have become much more complex than those predicted by the early migration theory, and as a result, the contribution of in-migration to urban growth is lower than generally assumed[3] (Christiaensen, Gindelsky & Jedwab, 2013; Chen et al., 1998).

The ongoing climate change is expected to alter patterns of migration and urban growth even further (Adamo, 2011). Extreme weather events such as droughts as well as slow-onset changes such as rising temperatures and decreasing rainfall affect rural livelihoods, in particular because weather fluctuations translate directly into agricultural yields and income (Deschenes & Greenstone, 2007; Schlenker & Roberts, 2009; Deryng et al., 2011), with the poorest countries being particularly vulnerable (Dell, Jones & Olken, 2012). By exerting additional pressure on farmers predominantly dependent on rain-fed agriculture, climate change is therefore likely to act as a push factor fostering permanent or circular rural-urban mobility (IPCC, 2007).

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[2] Previously, such temporary mobility was conceptualized as reflecting the stage of development as in the migration transition theory (Zelinsky, 1971) or as in Skeldon’s (1997) spatial development tiers; formalized in the target saver model (Fan and Stretton, 1985) or simply explained as a result of a migrant’s failure (Lucas, 1997).

[3] In-migration and reclassification combined contribute to around 40 per cent of the urban growth in the median country, while natural growth accounts for the remaining 60 per cent (Chen et al., 1998).

These predictions are in line with the New Economics of Migration framework (Stark & Levhari, 1982; Lucas & Stark, 1985; Stark & Bloom, 1985; Katz & Stark, 1986) where the rationale behind migration is not only income maximization as in the Harris-Todaro model, but also risk minimization. In agriculture, weather constitutes by far the biggest risk, especially in the context of the growing incidence of extreme events (Mora et al., 2013). Because weather fluctuations translate into income fluctuations, migration may be considered as a measure of spatial diversification of income sources (Rosenzweig & Stark, 1989) and a growing body of literature has documented the use of migration as a response to climate change (Findley, 1994; Henry, Schoumaker & Beauchemin, 2004; Ezra & Kiros, 2001; Meze-Hausken, 2004; Feng, Krueger & Oppenheimer, 2010; Dillon, Mueller & Salau, 2011).

In particular, since agricultural activities are affected by climate variations to a much bigger extent than manufacturing (IPCC, 2007), it is often expected that rural outmigration, accompanied by the intersectoral mobility away from agriculture, will play a central role in climate change adaptation. Barrios, Bertinelli and Strobl (2006) come up with a theoretical model where a decline in rainfall, by changing the effective land input and therefore labour market equilibrium, leads to a rise in the urbanization rate. Henderson, Storeygard & Deichmann (2014) empirically support these predictions for arid African countries. Additionally, they find that such rural-urban mobility contributes to productivity growth in cities with large industrial base, but not those servicing the local agriculture. Finally, Marchiori, Maystadt, and Schumacher (2012) extend the basic framework by incorporating international migration, and their findings are confirmed by Maurel and Tucchio (2016).

The present paper is an attempt to give additional insight into the debate on migration and urbanization from the microeconomic perspective. In particular, I investigate the role of weather shocks as determinants of rural outmigration in Tanzania. In the context where the country’s urban population is expected to outnumber the rural population already by 2027

(WB, 2014), whereas the infrastructure remains inadequate especially in informal settlements (UNICEF, 2012), and the urban poverty and inequality are rising (NBS, 2013), the ongoing climate change may potentially exacerbate those transformations. Since spatial inequalities entail less inclusive growth (Kanbur & Venables, 2005), a better understanding of mobility patterns and their impact on the population distribution is essential for an informed policy debate that will contribute to the success of migration as an adaptation strategy, minimizing the destabilizing effects of in-migration on urban settlements, and allowing for inclusion of a larger share of population in the development process.

Several papers analyzed rural-urban migration in Tanzania, mainly within the Harris-Todaro framework (Barnum & Sabot, 1977; Collier, 1979). In a wider and more recent context, Beegle, De Weerdt, and Dercon (2011) study migration as a way out of poverty and show that over the period of more than ten years, migrants experienced a 36 percentage points higher consumption growth that non-migrants, and that this difference is twice as high in case of those who moved to urban areas, pointing to the persistent gap between the returns to labour in agricultural and non-agricultural sectors (Gollin, Lagakos, & Waugh, 2011). Mbonile (1996) analyzes labour mobility within the risk minimization framework and shows that for 90 per cent of migrant households[4], securing income sources is the main motivation behind relocating to urban areas; however, even though mobility brings about prospects of poverty alleviation, it is often thought of as a last resort solution, and other options, such as wage employment or business activities, are preferred in order to "break the vicious cycle of labour migration".

[4] Note that this figure is based on a small sample from Makete district only (see Makete Migration Survey).

Finally, the last strand of literature investigates the link between climate and migration. Based on a nationally representative sample, Kubik and Maurel (2016) demonstrate that rural households exposed to weather-related shocks use migration as a risk management strategy, but this effect is significant only for households in the middle of wealth distribution, suggesting that the choice of migration as an adaptation strategy depends on initial endowment. Hirvonen (2016) explores more in detail the link between initial wealth and migration rates in Kagera region; in his model, however, weather shocks affect migration by tightening liquidity constraints, and as a result, inhibit long-term mobility rather than act as a push factor.

In our paper, we model rural-rural and rural-urban migration within the context of both income maximization and risk minimization, with weather acting as the principal source of risk. We show that a one standard deviation negative shock in weather conditions act as a push factor fostering rural out-migration, but curbing rural-rural mobility. This study adds to the literature on migration by investigating how weather variability affects population mobility, and in particular, rural-urban migration, and thus, in the long run, how climate change potentially contributes to urban growth.

Estimation strategy

The principal objective of this study is to establish the link between weather shocks and migration within and out of rural areas, with weather acting as a major source of risk. The main assumption is that, with the exception of extreme events, weather is not a direct driver of migration, but instead, it affects migration decision through its impact on rural incomes, as discussed above. Individuals involved in agricultural production who constitute 97 per cent of the rural population[5] are directly affected by weather, and thus remain the most vulnerable. However, with the important linkages between farm and non-farm activities (Lanjouw & Lanjouw, 2001; Haggblade, Hazell, & Brown, 1998; Reardon, 1998), the potential impact of weather on rural livelihoods may be even larger.

On the other hand, the link between climate and urban incomes is less straightforward. It is often assumed that urban dwellers, whose incomes do not depend on farming[6], are not directly affected by weather-related production risks; however, their employment prospects and earnings might be influenced by the poor performance of the agricultural sector (Karfakis, Lipper, & Smulders, 2012), especially in case of smaller urban centres whose economic structure relies mainly on serving neighbouring rural areas (Henderson, Storeygard and Deichmann, 2014; Baker, 1995). In this study, where the limited time-span of the panel offers only a short-term perspective, I expect the weather-related shocks to have only a marginal impact on urban incomes, if any. If this is the case, then migration to urban areas should be preferred by migrants seeking to shield their income from weather variability.

Urban areas may appear as a more attractive destination to potential migrants also because they offer better earning opportunities than rural areas, as assumed in the traditional model of migration (Todaro, 1969; Harris & Todaro, 1970; Lucas, 2004). As it is going to be shown below, in average terms, this assumption holds for Tanzania as well. However, high average incomes in urban areas hide poverty concentration and increasing inequalities (Mitlin, 2004), and in some configurations, rural outmigration may actually lead to the urbanization of

[5] Based on the Tanzania National Panel Survey (TZNPS) 2008/09.

[6] Note that in the Tanzanian National Panel Survey 2008/09, 16 per cent of urban households are engaged in farm activities, and their share of farm income in total income amounts to 40 per cent against 65 per cent for rural households.

poverty (Dorosh & Thurlow, 2014; Adelman & Robinson, 1978). In this context, the disaggregation of urban areas into primary cities and secondary towns seems of interest, and particular attention should be put to the latter, or to “the missing middle” as described by Christiaensen and Todo (2014) who show that “migration out of agriculture into the rural non-farm economy and secondary towns is strongly associated with poverty reduction but migration to megacities is not”.

The following estimation strategy attempts to be inclusive of all the factors described above. Migration decision is modeled as a response to both risk minimization and income maximization incentives, as in the Harris-Todaro (Todaro, 1969; Harris & Todaro, 1970) and the New Economics of Migration approach (Stark and Levhari, 1982; Lucas and Stark, 1985; Stark and Bloom, 1985; Katz and Stark, 1986). It also draws upon Perloff, Lynch, and Gabbard (1998) and Fafchamps and Shilpi (2013) who included earning differentials in microeconomic empirical analyses of migration, albeit in different settings. The model predicts that for an individual *i*[7], the probability of migrating from the original location *o* to destination *d* is expected to increase in the difference between utilities $U_d^i - U_o^i$ and decrease in the pecuniary and nonpecuniary cost of migration C_{od}^i. In terms of possible destination locations, the individual enjoys a choice set *l (R, U)*, where *R* denotes rural, and *U* urban area. In a more fine-grained analysis below, I further distinguish between primary and secondary urban areas. By construction, all individuals live in rural areas at the baseline.

Assume individual *i*’s expected utility U_l^i in location *l* is a function of income y_l^i and of unemployment probability p_l^i that the individual is expected to face in a given location:

[7] In the New Economics of Migration approach, the typical unit of observation is a household; however, in order to construct the relevant measure of expected income and unemployment probabilities, I conduct the analysis at the individual level.

$$U_l^i = U^i(y_l^i, p_l^i)$$

Income y_l^i depends on a vector of individual i's characteristics X^i but also on a location's weather conditions $Clim_l$:

$$y_l^i = \alpha_l + \beta_l X^i + \gamma_l Clim_l + \varepsilon_l^i \qquad (1)$$

Note that parameters vary across locations, since it is reasonable to expect that due to differences in productive technologies between rural and urban areas, the returns to individual characteristics, in particular to education and experience, will differ. As noted earlier, I hypothesize that weather is the principal source of risk for rural income, but does not directly affect urban income in the short term, therefore I expect that $\gamma_l \neq 0$ for rural location, and $\gamma_l = 0$ for urban location.

Individuals choose the location that gives the highest expected utility. Let M_{od}^i denote individual i's choice from the following choice set *d*: no migration, rural-rural migration, and rural-urban migration. The relative benefit of moving to a new location decreases in the cost of migration representing physical and social distance between the origin and destination. Thus, the probability of migration can be denoted as follows:

$$\Pr\left(M_{od}^i = 1\right) = \lambda\left[E\left(U_d^i - U_o^i \middle| X^i, Clim_o\right), C_{od}^i\right] \qquad (2)$$

where $\lambda(\cdot)$ is a multinomial logit function.

Since income is observed only at the one original location at a time, it is impossible to directly calculate $U_d^i - U_o^i$. Therefore, I use the estimates of equation (1) to calculate the predicted values of the unobserved incomes and construct expected income differentials between rural and urban areas.

Data

I this analysis, I use the Tanzania National Panel Survey (TZNPS) which is a nationally representative living standard survey (WB's LSMS-ISA) collected by the National Bureau of Statistics (NBS). Up to date, three waves of the panel are available: 2008/09, 2010/11, and 2012/13. 16,709 individuals were interviewed at the baseline year[8], and the eligible individuals were followed in consecutive rounds with the overall attrition rate of 11 per cent between 2008 and 2013[9], which, as shown by Kubik and Maurel (2016), does not consistently bias the migration analysis. Because the focus of this paper is on economically-motivated rural outmigration, I limit my sample to individuals in working age[10] who resided in rural areas of mainland Tanzania[11] at the baseline. The final subset of data provides a two-year panel of 11,855 individuals.

Migrants are considered to be individuals who permanently moved out of the original location between the consecutive survey rounds and are identified based on their household's GPS coordinates[12]. The permanent character of migration is defined by two factors: its duration exceeding one year, and the concomitant loss of the original household member status, in contrast to temporary migrants who, despite their absence, still appear in the household roster.

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[8] Since individuals who migrated between survey rounds were re-interviewed together with all members of their new households, the total number of individuals interviewed at least once between 2008 and 2013 increased to 27,889.

[9] Individuals aged 15 years and above were eligible for re-interview. The attrition rate was 10% between 2008/09 and 2010/11, and 7% between 2010/11 and 2012/13.

[10] Between 15- and 64-year-old.

[11] The choice of not including Zanzibar is dictated by two factors. First of all, the political, economic, and livelihood system in Zanzibar is very distinct from mainland Tanzania. Second, the climate data which I use in the analysis is not available for islands.

[12] For confidentiality purposes, the random offset within a specified range has been applied to the households GPS coordinates; however, medium- or low-resolution spatial queries should be only minimally affected by this procedure. Only individuals who moved more than 10 km are counted as migrants. Note that, by construction, it is impossible to identify migrants from the third wave; the migration analysis is therefore limited to the two first rounds of data. In the income analysis, however, all three years of data are used.

Even though the analysis of temporary migration would be of much interest in the Tanzanian context, where low net migration conceals much higher turnover (Muzzini & Lindeboom, 2008), the lack of data on temporary migrants' destination does not allow to follow this path more in detail.

In my analysis, I distinguish between rural-rural and rural-urban migration; however, it has to be noted that even though the NBS' definition of rural and urban areas are considered to be relatively accurate[13], 17 per cent of the population live in high-density areas which are not officially recognized as urban (Muzzini and Lindeboom, 2008). Also, an important proportion of rural migrants move to peri-urban[14] rather than strictly urban destinations (UNICEF, 2012); it is therefore possible that the mobility to *de facto* urban areas will be underestimated in the present analysis. Besides, I further distinguish between primary and secondary urban areas, with the former including five most important cities, while the latter comprising municipalities and towns.[15] This information is not readily available in the TZNPS, but was obtained from the shapefiles provided by the NBS geo-database.[16]

The TZNPS offers a wealth of data, ranging from individual, household to community characteristics. The definitions, as well as means and standard deviations of the variables used

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[13] Muzzini and Lindeboom (2008) provide a detailed analysis of different rural and urban perspectives applied by the Tanzanian authorities. The definition adopted by the NBS is based on a small spatial unit Enumeration Area (EA) with a population size of 300 to 900 individuals. The decision as to whether an EA is urban or rural is made by the Region Census Committees. "Urban EAs are located within a predominantly urban area, contain 300 to 500 individuals, and usually have their own markets and social service providers (for example, schools and health centres) serving the surrounding vicinity. Rural EAs lack these amenities and contain 700 to 900 individuals."

[14] The first round of the TZNPS provided the distinction between rural, urban, and mixed (peri-urban) localities; this distinction has been abandoned in the consecutive rounds, however.

[15] According to the NBS classification, the five cities are: Dar es Salaam, Mwanza, Arusha, Tanga, and Mbeya; and the municipalities: Moshi, Tabora, Iringa, Dodoma, Songea, Mtwara, Sumbawanga, Singida, Kigoma, Bukoba, Musoma, Arumeru, Morogoro, and Shinyanga. The remaining urban areas are classified as towns.

[16] http://www.nbs.go.tz/nbstz/index.php/english/statistics-by-subject/population-and-housing-census/259-2012-phc-shapefiles-level-three

in the analysis are reported in table A1 in the Annex. The expected urban income, i.e. the level of income that a rural migrant with given characteristics can expect to earn in urban destination, is obtained by first estimating the income regression as in eq. (1) and then the coefficients from this regression being used to compute the predicted values for each individual. The fact that the expected income differentials at the individual level rather than the average earning gaps between rural and urban areas are used in the analysis is an important advancement in comparison to many microeconomic studies on migration[17] (Lucas, 2004).

Based on the detailed data on income-generating activities, i.e. agricultural production, wage-employment, and self-employment, I construct the income aggregates following the FAO Rural Income Generating Activities (RIGA) methodology (FAO, 2012), with two substantial differences. First of all, since the purpose of this exercise is to compare each individual's earning potential in rural and urban areas, I focus here on the income earned by actively engaging in income-generating activities, and thus excluding transfers[18]. Second, I construct the income measure for each individual based on her participation in income-generating activities[19] rather than using the total household income per capita. Also, it is well established that income measure in microeconomic data is prone to a large margin of error (Deaton, 1997), therefore, alternatively, I use consumption expenditures data as a robustness check. All values are in real terms, adjusted for both spatial and temporal differences in prices.[20]

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[17] Previously this strategy has been applied in empirical micro-level research on migration by Fafchamps and Shilpi (2013) and Perloff, Lynch and Gabbard (1998).

[18] Remittances and public transfers.

[19] Yearly wage income is reported at the individual level in the TZNPS. For self-employment, I divide the net yearly income from a business activity by the number of household members involved in its operations. For farm income, I divide the net yearly income by the number of household members of age 5 or older, which is consistent with the employment questionnaire of the TZNPS.

[20] Fischer price index is used for adjustment. See NBS (2014, 2012).

Based on the households GPS coordinates, I match the weather data from various sources with corresponding households in the TZNPS. For the most part, I employ the Standardized Precipitation Evapotranspiration Index (SPEI) from the high-resolution (0.5x0.5 degree) gridded dataset by Vicente-Serrano et al. (2010). SPEI is an index of deviations from the average water balance, i.e. precipitations minus potential evapotranspiration, and is normalized at zero, with positive values indicating wet and negative values dry conditions[21]. The advantage of SPEI over widely used measures such as temperature and rainfall lies in the fact that “it includes the role of temperature in drought severity by means of its influence on the atmospheric evaporation demand” (Vicente-Serrano et al., 2010). Furthermore, SPEI is a standardized variable; it is therefore comparable over time and space.

In order to account for the fact that Tanzania is characterized by both unimodal (November – April) and bimodal rainfall patterns (March – May and October – December)[22], I use the mean of SPEI monthly values from January to June. The index is available in different time-scales, from one to 48 months, each reporting water deficit at different hydrological level. Because of the nature of the panel with a two-year time span between consecutive data rounds, I focus the shorter time-scales (1, 6, and 12 months). Alternatively, instead of using the whole spectrum of the SPEI, I apply drought measure defined as occurring when the index values fall below minus one, as in McKee, Doesken, & Kleist (1993) and Van Oijen et al. (2014).

Descriptive statistics

[21] A SPEI equal to zero indicates a value corresponding to 50% of the cumulative probability of water deficit / water surplus according to log-logistic distribution (Vicente-Serrano et al., 2009).
[22] The hottest period occurs between November and February, and the coldest between May and August.

Six per cent of the sample engaged in migration between 2008 and 2012 and this seemingly low number goes in line with Mbonile (1996), Mary and Majule (2011), as well as Beegle, De Weerdt, and Dercon (2011) who show that mobility in Kagera region is lower than the potential benefits would imply. 69 per cent of migrants moved to another rural area, 13 per cent to a city, and 18 per cent to a secondary urban area. At eight per cent, migration rate in the second year is double the first year rate; however, a proportion of migrants who moved to urban areas fell from 36 to 28 per cent between waves. Interestingly, the rise in migration rate in the second round coincides with a substantial increase in the incidence of drought, from 9 per cent of individuals affected in the first year to 18 per cent in the second year; also, the occurrence of water stress of any level[23] was as high as 87 per cent in the second year, suggesting that extreme weather conditions might indeed have triggered geographic mobility. It has to be noted, however, that migration is rarely self-reported as a coping strategy by the households. Less than one per cent of households admit resorting to migration, while staggering 60 per cent report undertaking no action as a response to drought or flooding event.

Only internal migration is observed in the TZNPS, which is consistent with the figures from another Tanzanian household survey[24] and the results in Hansen (2012) who suggests that there is no tradition of international migration in the country, and only three per cent of population holds a passport. Women constitute 58 per cent of migrants, and this figure holds irrespective of the destination; only in case of migration to cities the proportion is slightly lower at 55 per cent. To some extent, this can be explained by patrilocality; indeed, 25 per cent of women in the dataset moved because of marriage. However, on the one hand, the importance of independent mobility of young unmarried women in search of better job

[23] SPEI below zero, based on the 6-month SPEI values.
[24] Kagera Health and Development Survey (KHDS). Note that KHDS covers only the Kagera region.

prospects has been increasing recently in Tanzania and elsewhere (Bah et al., 2003; Tacoli et al., 2015); on the other, weather factors were shown to have an impact on mobility related to marriage as well (Rosenzweig and Stark, 1989), thus, I do not exclude female migration from my analysis.

The figures in table 1 below suggest that there are substantial differences between migrants and non-migrants, not only in terms of individual and household characteristics, but also with respect to weather conditions observed in their villages of origin. As noted earlier, there are more women amongst migrants; migrants also differ along the lines of traditional features: they tend to be younger, better educated, and single without children; plus, a lower number of migrants are involved in agriculture as primary activity at the baseline.

The proportion of individuals with previous migration experience is more than twice higher amongst current migrants than amongst non-migrants; however, it applies only to a relatively recent (less than ten years), but not to a distant past experience; suggesting the importance of step or circular migration in Tanzania.[25] Interestingly, the expected urban incomes of migrants are actually lower on average than those of non-migrants, but the difference in expected income differentials is not statistically significant anymore. Similarly, migrants seem to move to a new destination despite being exposed to a higher risk of unemployment. This might, however, relate to migrants' young age, sex, and lack of professional experience.

[25] Due to the short time span of the TZNPS, I am not able to investigate this aspect more in detail.

Table 1. Characteristics of migrants and non-migrants

	Non-migrants	Migrants	Difference
Individual characteristics			
Male, dummy	0.49	0.418	0.0721***
Age, years	30.09	25.58	4.514***
Education, years	5.733	6.429	-0.695***
Married, dummy	0.525	0.348	0.177***
Household head, dummy	0.282	0.184	0.0984***
Number of children	1.232	0.772	0.460***
Agriculture as primary activity	0.641	0.55	0.0913***
Previous migrant < 10 years, dummy	0.109	0.245	-0.136***
Previous migrant > 10 years, dummy	0.148	0.119	0.0291*
Expected urban income*	569.6	516.9	52.65*
Expected income differentials**	351.5	306.5	45
Unemployment probability (broad definition)	0.0133	0.0215	-0.00822***
Household characteristics			
Migrants network	0.231	0.168	0.0632***
Rural network, dummy	0.205	0.153	0.0522***
Urban network, dummy	0.0696	0.0586	0.011
Household size	7.093	7.379	-0.286
Household labour	3.631	3.944	-0.313***
Household labour, male members	1.807	1.859	-0.0516
Household labour, female members	1.823	2.085	-0.262***
Female-headed household, dummy	0.189	0.257	-0.0680***
Area owned	7.608	7.324	0.284
Landless, dummy	0.111	0.206	-0.0958***
Livestock (TLU)	2.79	2.473	0.317
Wealth index***	-0.87	-0.801	-0.0687
Village characteristics			
Village population density	309.8	320.9	-11.1
Village dependence ratio	100.1	101.4	-1.286
Distance to town	57.42	54.99	2.429
Weather characteristics			
SPEI06	-0.269	-0.437	0.168***
SPEI06, 30 year mean	0.0529	0.053	0
SPEI06, 30 year standard deviation	0.799	0.81	-0.0114***
SPEI06 shock, no of st.dev.	-0.4	-0.595	0.195***
SPEI06 positive shock, no of st.dev.	0.167	0.127	0.0392***
SPEI06 negative shock, no of st.dev.	-0.567	-0.723	0.156***
Drought, dummy	0.134	0.213	-0.0788***
Observations	11.092	751	

*** p<0.01, ** p<0.05, * p<0.1.

* In thousands of TZ shillings.

** Expected income differentials between rural and urban areas; in thousands of TZ shillings.

*** Asset-based wealth index computed with polychoric PCA (Kolenikov and Angeles, 2004)

Migrants also differ from non-migrants in terms of household characteristics. In particular, migrants sending households have a higher number of members in working age, and this refers in particular to the number of female members; also, a bigger proportion of migrants come from female-headed households. There is some evidence that migrants are richer at the baseline, as suggested by the asset-based wealth index, even though there is no statistically significant difference in terms of traditional wealth proxies, such as the number of livestock or land owned. More migrants come from landless households, and it has to be noted that contrary to expectations, landlessness is not a sign of poverty. Actually, at around 20 per cent, the proportion of landless individuals in the richest quintile is twice as high as in the remaining quintiles of wealth distribution.

Finally, migrants experienced drier weather conditions in the year of migration, as suggested by the strongly negative SPEI mean value indicating important deviations from the water balance, and this result is unaffected by applying alternative definitions of weather shock, such as the number of standard deviations below or above the 30-year mean, or the drought dummy equal one for SPEI values lower than minus one. Also, even though there is no statistically significant difference in the SPEI long term mean, migrants originate from locations exposed to larger variations of climatic conditions. All those factors suggest that migration might indeed be considered as a viable coping strategy in case of weather shocks.

Rural-rural and rural-urban migrants differ along the same lines as migrants and non-migrants, especially with respect to demographic characteristics, as suggested by the figures in table 2. Rural-urban migrants tend to be single, much younger and better educated than those who move within rural areas. They also have better access to migrants' networks, especially in urban areas, which might reduce the pecuniary and non-pecuniary cost of relocation (Massey et al., 1993). On the other hand, the differences in terms of weather conditions that the migrants were exposed to prior to migration are less straightforward to interpret. The figures in table 2 show that the original locations of rural-urban migrants registered slightly less favourable weather conditions but also less variability over the last 30 years; also, with respect to contemporaneous weather shocks, while rural-rural migrants experienced more pronounced positive shocks, counterintuitively, there seem to be no statistically significant difference in terms of negative weather events.

Also, contrary to expectations arising from the Harris-Todaro model (Todaro, 1969; Harris & Todaro, 1970) discussed above, the expected income differentials are much lower for rural-urban migrants than their rural-rural counterparts. This might be related to the profile of rural-urban migrants who are typically at the early stages of their professional life and therefore, having little or no experience, can only expect their incomes to rise with time, as suggested by the literature on the standard Mincer earning equation (Lemieux, 2006). Alternatively, as rural-rural migrants are poorer than rural-urban migrants, liquidity constraints might prevent some individuals from moving to a city despite potentially higher gains.

Table 2. Characteristics of migrants to rural and urban areas

	Rural-rural migrants	Rural-urban migrants	Difference
Individual characteristics			
Male, dummy	0.414	0.428	-0.0142
Age, years	26.57	23.32	3.246***
Education, years	6.008	7.389	-1.381***
Married, dummy	0.4	0.227	0.173***
Household head, dummy	0.203	0.14	0.0633*
Number of children	0.895	0.493	0.401***
Agriculture as primary activity	0.632	0.362	0.270***
Previous migrant < 10 years, dummy	0.257	0.218	0.0384
Previous migrant > 10 years, dummy	0.134	0.083	0.0511*
Expected urban income*	568.9	398.4	170.5***
Expected income differentials**	371.5	158.1	213.3***
Unemployment probability (broad definition)	0.0186	0.0282	-0.00955***
Household characteristics			
Migrants network	0.146	0.218	-0.0727*
Rural network, dummy	0.136	0.192	-0.0561*
Urban network, dummy	0.0402	0.1	-0.0602**
Household size	7.73	6.581	1.149**
Household labour	4.067	3.664	0.403*
Household labour, male members	1.927	1.703	0.224*
Household labour, female members	2.14	1.961	0.179
Female-headed household, dummy	0.238	0.301	-0.0638
Area owned	8.424	4.816	3.608*
Landless, dummy	0.213	0.192	0.0205
Livestock (TLU)	2.895	1.512	1.384**
Wealth index***	-0.917	-0.537	-0.380***
Village characteristics			
Village population density	299.8	368.9	-69.07
Village dependence ratio	103.4	96.92	6.470***
Distance to town	56.58	51.36	5.224
Weather characteristics			
SPEI06	-0.429	-0.457	0.028
SPEI06, 30 year mean	0.0634	0.029	0.0344**
SPEI06, 30 year standard deviation	0.816	0.796	0.0199**
SPEI06 shock, no of st.dev.	-0.593	-0.601	0.00779
SPEI06 positive shock, no of st.dev.	0.142	0.0941	0.0480*
SPEI06 negative shock, no of st.dev.	-0.735	-0.695	-0.0402
Drought, dummy	0.228	0.179	0.0489
Observations	522	229	

*** p<0.01, ** p<0.05, * p<0.1.

* In thousands of TZ shillings.

** Expected income differentials between rural and urban areas; in thousands of TZ shillings.

*** Asset-based wealth index computed with polychoric PCA (Kolenikov and Angeles, 2004)

Weather shocks and income in rural and urban areas

Indeed, the analysis of income generating activities in rural and urban areas clearly points to a pronounced advantage of urban dwellers in this respect and suggests that important incentives exist for rural migrants to relocate into town or, even to a higher extent, into city. Based on the whole sample of adults in working age (15-64 year-old) living in both rural and urban areas of mainland Tanzania and present in all three waves of the TZNPS, the statistics in table 3 below show that urban dwellers enjoy incomes that are three and a half times higher on average than those of their rural counterparts, both in terms of earned income, i.e. excluding transfers and therefore representing strictly individual effort, and also total income; and this difference is even higher in case of off-farm income.

Table 3. Differences in income between rural and urban areas

	Rural	Urban	Difference
Total income	365	1272.8	-907.8***
Earned income	355.4	1262.3	-906.9***
Farm income	91.64	20.6	71.04***
Off-farm income	268.8	1242.6	-973.8***
Transfers	9.564	10.52	-0.955*
Consumption expenditures	493.2	1076.7	-583.6***
Food consumption expenditures	362.4	618.7	-256.4***
No of observations	12,116	6,772	

*** p<0.01, ** p<0.05, * p<0.1.

In thousands of Tanzanian shillings.

Real values, adjusted for price differences between regions and years.

On the other hand, the difference in transfers per capita received by the rural and urban households is almost negligible, which suggests that for the former, remittances[26] constitute an important component of the income portfolio. More importantly, the amount of remittances sent by the rural-urban migrants is on average 50 per cent higher than remittances sent from

[26] For more than 95 per cent of households, remittances constitute the only component of transfers.

the rural areas, giving evidence that for a rural household, it may be a better strategy to send a member to an urban rather than rural area.

Table 4. Income equation

	Earned income, log	Earned income, log	Earned income, log	Earned income, log	Total income, log	Consumption expenditures, log
	OLS	OLS	Heckman	Two-part model	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Male, dummy	0.537***	0.528***	0.556***	0.522***	0.571***	-0.0243**
	(0.0312)	(0.0305)	(0.0291)	(0.0290)	(0.0320)	(0.0117)
Education, years	0.112***	0.104***	0.0972***	0.0973***	0.105***	0.0554***
	(0.00490)	(0.00481)	(0.00506)	(0.00495)	(0.00505)	(0.00184)
Potential experience, years	0.108***	0.105***	0.108***	0.104***	0.119***	0.00920***
	(0.00361)	(0.00355)	(0.00380)	(0.00379)	(0.00365)	(0.00128)
Potential experience, squared	-0.00153***	-0.00148***	-0.00156***	-0.00150***	-0.00165***	-0.000135***
	(6.45e-05)	(6.33e-05)	(6.59e-05)	(6.58e-05)	(6.56e-05)	(2.32e-05)
Migrant < 10 years, dummy	0.468***	0.372***	0.451***	0.456***	0.385***	0.207***
	(0.0336)	(0.0337)	(0.0387)	(0.0385)	(0.0343)	(0.0114)
Migrant > 10 years, dummy	0.240***	0.194***	0.242***	0.229***	0.180***	0.0712***
	(0.0317)	(0.0314)	(0.0347)	(0.0345)	(0.0323)	(0.0109)
Weather index	0.0913***	0.0978***	0.0679***	0.0667***	0.0872***	-0.0203***
	(0.0186)	(0.0185)	(0.0186)	(0.0187)	(0.0191)	(0.00638)
Area (baseline: rural)						
Urban	0.833***					
	(0.0334)					
Primary urban		1.380***	1.232***	1.478***	0.726***	0.635***
		(0.0444)	(0.0550)	(0.0491)	(0.0439)	(0.0149)
Secondary urban		0.436***	0.384***	0.483***	0.206***	0.239***
		(0.0396)	(0.0478)	(0.0462)	(0.0408)	(0.0142)
Constant	9.304***	9.415***	9.319***	9.467***	9.267***	12.47***
	(0.0629)	(0.0619)	(0.0641)	(0.0627)	(0.0645)	(0.0232)
Observations	15,880	15,880	18,591	18,888	16,773	18,345
Individual observations	5,943	5,943			6,135	6,235
R-squared				0.284		
Within	0.024	0.0256			0.0226	0.0134
Between	0.3456	0.3746			0.2806	0.4856
Overall	0.2592	0.2828			0.2114	0.3686
Wald test of indep. eqns. (rho = 0):						
chi2(1)			157.18			
Prob > chi2			0.000			

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Weather index: SPEI06.

I investigate the issue more in detail by estimating the income equation as in eq. (1) and figures in table 4 confirm the preliminary findings from the descriptive statistics. Controlling for sex, education, potential experience and its square term as in standard Mincer equation[27], I find that income generated by individuals with the same characteristics is 80 per cent higher in urban areas, as shown in col. (1). In col. (2), I further disaggregate urban areas into primary and secondary, according to the classification described in the data section. The difference between rural areas and five biggest cities in the country is even more striking: incomes earned in primary urban areas are three times higher than in rural areas.

Despite this evident advantage of urban areas, rural-urban migrants might be exposed to different wages than native workers in the urban labour market, at least in the period directly after migration. Therefore, I also control for the previous migrant status, and, drawing upon Vijverberg and Zeager (1994) who analyzed this issue more in detail in the Tanzanian context, I distinguish between seniority of migration lower or higher than ten years. Contrary to the authors who found an initial wage gap that is eliminated within ten years or less after which migrants surpass the earnings of native workers, my results suggest that the incomes of all migrants are higher than those of native workers, but in particular, this difference is more important for individuals who moved in less than ten years ago. Even though I do not correct for the selection bias and thus the coefficients for migration dummies might potentially be overestimated, my results are in line with Galor and Stark's (1991) hypothesis of bigger work effort of migrants, especially those with intention of return to the original location.

Since the focus of this analysis is on earned income, i.e. income generated by actively participating in labour market, off-farm self-employment, or/ and farming, the problem encountered when estimating eq. (1) is that a substantial fraction of the sample, amounting to 15 per cent of individuals, record zero or, to a lesser degree, negative values. Therefore,

[27] Potential experience is computed as age minus schooling minus five, as in the standard Mincer equation (Lemieux, 2006).

applying simple OLS with the logarithmic transformation as in cols. (1) and (2) implies that those non-positive observations are discarded which might seriously bias the results. I correct for this issue in several ways: first, by applying the Heckman method (Heckman, 1979; Diamond & Hausman, 1984), second, the two-part model (Cragg, 1971; Belotti et al., 2015), and finally, the inverse hyperbolic sine transformation (Pence, 2006).[28]

In columns (3) and (4), I present the results for the Heckman and the two-part models respectively. The selection equations are not reported here; however, the characteristics of individuals with non-positive income are very similar to those formally unemployed, which goes in line with the widely accepted view that even though open unemployment rates are generally low in developing countries, the official figures hide pervasive underemployment, especially in agriculture and urban informal sectors (Golub & Hayat, 2014). More importantly, not only the χ^2 of 157.18 in col. (3) clearly justifies the Heckman selection with these data, but also the results from cols. (1) and (2) hold when correcting for the selection bias. Since it has been shown that two-part models behave better in similar context than sample selection models (Madden, 2008; Manning, Duan, & Rogers, 1987), for the remaining part I adopt the two-part model as my preferred specification.

Finally, since in this analysis, I focus on the rural-urban migration in the context of climate change, I also investigate if weather affects urban and rural incomes in a distinct way using a 6-month SPEI as a proxy of weather conditions. Recall that negative values of SPEI indicate dry and positive values wet conditions, and the figures in table 4 suggest that overall, weather conditions do have an impact on incomes, with a one standard deviation change in wetness level incurring around 9 per cent change in income. These results hold when I employ SPEI at

[28] Results for the inverse hyperbolic sine transformation not reported here.

longer timescales[29]; however, the results for total income are less stable when using 24- and, in particular, 48-month SPEI, suggesting that in a long term, the impact of climate variability on income is more complex.

Table 5. Income equation by area and components

	Earned income, log			Farm income, log	Off-far income, log	Transfers, log
	Rural	Primary urban	Secondary urban			
	(1)	(2)	(3)	(4)	(5)	(6)
Male, dummy	0.451***	0.668***	0.696***	0.0986***	0.574***	-0.0713**
	(0.0322)	(0.0777)	(0.0831)	(0.0290)	(0.0369)	(0.0347)
Education, years	0.0743***	0.137***	0.157***	-0.00542	0.147***	0.00874
	(0.00595)	(0.0102)	(0.0138)	(0.00467)	(0.00581)	(0.00557)
Potential experience, years	0.0791***	0.150***	0.173***	0.0112***	0.0562***	-0.00212
	(0.00401)	(0.0129)	(0.0103)	(0.00327)	(0.00520)	(0.00410)
Potential experience, squared	-0.00114***	-0.00212***	-0.00257***	-0.000149**	-0.000686***	0.000132*
	(6.87e-05)	(0.000234)	(0.000191)	(5.81e-05)	(9.28e-05)	(7.31e-05)
Migrant < 10 years, dummy	0.392***	0.389***	0.683***	-0.0681**	0.321***	0.156***
	(0.0469)	(0.117)	(0.0958)	(0.0339)	(0.0445)	(0.0465)
Migrant > 10 years, dummy	0.210***	0.219*	0.146	-0.0408	0.209***	0.0230
	(0.0388)	(0.125)	(0.0950)	(0.0286)	(0.0438)	(0.0426)
Weather index	0.0645***	-0.0356	0.0700	0.0520***	-0.0546**	-0.170***
	(0.0199)	(0.0875)	(0.0626)	(0.0164)	(0.0277)	(0.0280)
Location (baseline: rural)						
Primary urban				-0.870***	1.443***	0.670***
				(0.0664)	(0.0467)	(0.0563)
Secondary urban				-0.417***	0.919***	0.125***
				(0.0389)	(0.0460)	(0.0468)
Constant	9.949***	9.926***	8.599***	10.84***	9.918***	8.645***
	(0.0717)	(0.214)	(0.188)	(0.0584)	(0.0855)	(0.0716)
Observations	12,116	3,761	3,011	12,774	15,832	9,594
R-squared	0.1002	0.2109	0.2461	0.0443	0.3744	0.0362

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Weather index: SPEI06.
Two-part model in col. (1)-(3) and (5); OLS in col. (4) and (6).
Farm income: crop and livestock.
Off-farm income: wage and self-employment.
Transfers: remittances and public transfers.

Finally, as previously noted, I expect the coefficients in the income equation to vary by location. Therefore, I estimate eq. (1) separately for rural, primary and secondary urban areas in col. (1) – (3) in table 3. Indeed, important differences can be observed in terms of returns to education and experience, but also with respect to the impact of weather conditions, which

[29] Results not reported here.

turns out significant in case of rural, but not urban income. I explore those differences further in cols. (4) and (5). As expected, whereas farm income is significantly affected by weather, with farm income increasing together with the wetness level, the relation between weather and off-farm income goes in the opposite direction. When accounting for the disproportions in shares of farm and off-farm income in total rural and urban incomes, this evidence might explain why income generated in urban areas is shielded from weather shocks. Last but not least, the negative relationship between the wetness index and transfers points to the fact that remittances flow increases following negative weather events.

Weather shocks and rural-urban migration

The factors described above, i.e. better returns to education and experience, and overall higher incomes that are shielded from the negative impact of weather events, as well as expectation of larger remittances in case of shocks, create objective incentives for individuals living in rural areas, and in particular those exposed to risky environments, to migrate into urban rather than rural destinations, not only in order to maximize their incomes but also to minimize the weather risk. On the other hand, descriptive statistics suggest that despite all those potential benefits of urban areas, the vast majority of rural migrants relocate into another rural area. In the following analysis, I therefore investigate to what extent both rural-urban income differentials, as well as weather shocks, affect the decision to migrate into urban vs. rural destinations.

I apply multinomial logit estimation[30] to the sample of rural dwellers from mainland Tanzania in working age. I hypothesize that an individual faces the following choice set: no migration, migration to another rural area, and migration to a primary or to a secondary urban area.[31]

Table 6. Migration and weather shocks

		Migration			Migration			Migration	
	Rural-rural	Rural-primary urban	Rural-secondary urban	Rural-rural	Rural-primary urban	Rural-secondary urban	Rural-rural	Rural-primary urban	Rural-secondary urban
		SPEI06			Drought			Self-reported drought	
	dx/dy	dx/dy	dx/dy	dx/dy	dx/dy	dx/dy	dx/dy	dx/dy	dx/dy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Male, dummy	-0.021***	-0.003	-0.005**	-0.022***	-0.003	-0.006**	-0.022***	-0.003	-0.005**
	(-5.15)	(-1.72)	(-2.70)	(-5.27)	(-1.86)	(-2.70)	(-5.28)	(-1.90)	(-2.68)
Expected_income, log	0.012***	0.001	0.002*	0.013***	0.001	0.002*	0.013***	0.001	0.002*
	-6.28	-1.28	-2.07	-6.46	-1.55	-2.08	-6.55	-1.53	-2.03
Unemployment probability	0.223**	0.061*	0.150***	0.211**	0.067*	0.158***	0.245**	0.077**	0.149***
	-2.84	-2.21	-4.38	-2.69	-2.38	-4.52	-3.08	-2.73	-4.39
Married, dummy	-0.026***	-0.013***	-0.009***	-0.026***	-0.013***	-0.009***	-0.026***	-0.013***	-0.009***
	(-5.53)	(-4.39)	(-3.35)	(-5.50)	(-4.33)	(-3.33)	(-5.49)	(-4.31)	(-3.35)
Number of children	-0.005**	-0.002	-0.002*	-0.005**	-0.002	-0.002*	-0.005**	-0.002	-0.002*
	(-3.02)	(-1.49)	(-1.98)	(-3.21)	(-1.60)	(-1.99)	(-3.24)	(-1.64)	(-1.97)
Landless	0.021***	-0.001	0.001	0.019***	0	0.002	0.023***	0.002	0.001
	-3.86	(-0.49)	-0.33	-3.33	(-0.14)	-0.72	-4.46	-0.77	-0.25
Wealth quintile									
2nd	0.012	0.006**	-0.001	0.011	0.006*	-0.001	0.011	0.006*	-0.001
	-1.94	-2.58	(-0.43)	-1.81	-2.45	(-0.39)	-1.92	-2.5	(-0.45)
3rd	-0.011*	0.003	0	-0.012*	0.003	0	-0.011*	0.003	0
	(-2.04)	-1.61	(-0.01)	(-2.26)	-1.43	-0.05	(-2.09)	-1.54	(-0.05)
4th	-0.012*	0.005*	0	-0.013*	0.005*	0.001	-0.012*	0.005*	0
	(-2.18)	-2.3	-0.13	(-2.43)	-2.19	-0.23	(-2.12)	-2.26	-0.06
Urban network, dummy	-0.018	0.004	0.001	-0.018	0.004	0.001	-0.018	0.005*	0
	(-1.90)	-1.82	-0.17	(-1.95)	-1.87	-0.18	(-1.92)	-1.97	-0.13
Rural network, dummy	-0.014**	0.001	-0.003	-0.017**	-0.001	-0.003	-0.018***	-0.001	-0.003
	(-2.76)	-0.74	(-1.03)	(-3.16)	(-0.44)	(-1.22)	(-3.49)	(-0.74)	(-1.08)
Weather shock	-0.009*	-0.007***	0	0.017***	0.004	-0.004	0.004	0.006***	-0.002
	(-2.51)	(-4.60)	(-0.21)	-3.39	-1.81	(-1.37)	-1.1	-3.38	(-0.90)
Observations	11,852	11,852	11,852	11,852	11,852	11,852	11,852	11,852	11,852

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
mlogit with clusters at individual level in col. (1)-(9).
Results presented as average marginal effects.
Base outcome non reported.
Results for distance to major road not reported.
Weather shock: SPEI06 in col. (1)-(3); drought dummy in col. (4)-(6); self-reported drought in col. (7)-(9).

[30] I apply clustering at the individual level to account for the fact that the dataset is a panel.

[31] For comparison, Fafchamps and Shilpi (2013) model the choice of migration destination as conditional on migration decision; their analysis, however, is conducted at a highly disaggregated district level which justifies such approach to a much greater extent than the setting adopted in my study.

The results in table 6 are presented in terms of average marginal effects. Note that those marginal effects on the probability of migration tend to be really small, even though the coefficients of the linear prediction of the latent variable are much higher. The ratio of migrants in the sample is very small: rural-rural migrants constitute around four per cent, and rural-urban around two per cent of the total sample. The model also correctly predicts the probabilities of migration.

The findings in col. (1) – (3) suggest that contrary to my expectations, the weather shock, considered at the whole spectrum of deviations from the predicted water balance, fosters mobility to another rural and to a primary urban areas, but has no impact on mobility to secondary urban areas. Contrary to expectations, while the expected income affects rural-rural, and to a lesser extent, rural-secondary urban migration, it has no impact on mobility towards cities. On the other hand, the results show that mobility patterns depend on the initial wealth: being in higher quartiles of wealth distribution decreases rural-rural mobility while increases relocation towards cities. Those findings suggest that liquidity constraints may inhibit individuals with the highest potential from reaping the benefits of moving into cities.

In the remaining columns, in order to control for the impact of a weather shock of a certain degree of intensity, instead of the SPEI index, I apply the drought dummy[32] (col. (4) - (6)), and the self-reported drought dummy. Interestingly, the drought conditions act as a push factor only in case of rural-rural but not rural-urban migration; also, the magnitude of the coefficient is much higher than in any other case. These results might suggest that whereas a moderate weather shock act as a push factor for both types of mobility, a severe shock such as drought amplifies liquidity constraints and therefore inhibits the typically more costly

[32] Drought dummy equal one when SPEI index is lower than -1.

relocation towards cities; in line with Hirvonen (2016). Additionally, the results change when I apply the self-reported measure of drought; indicating that drought fosters mobility to primary urban areas; this might be explained by the perceptions of potential benefits to be reaped from migration to cities, especially in the context of distress.

Robustness check

Since both the descriptive statistics as well as results in table 6 indicate that migration in Tanzania is a female phenomenon, it can be argued that mobility relates to marriage and patrilocality to a higher degree than to weather shocks. Therefore, as a robustness check, I conduct the same analysis excluding marriage migration. I also apply alternative definitions of primary and secondary urban areas, or I distinguish specifically the economic capital of Tanzania, Dar es Salaam. Finally, since it can be argued that farmers exposed to a prolonged water stress might have adapted to changing conditions over time, in robustness check, I apply the number of standard deviations below or above the 30-year mean[33] as an alternative measure of SPEI shock. Alternatively, I use monthly temperature and precipitation from a high-resolution[34] gridded dataset by the Climate Research Unit of the University of East Anglia (Harris, Jones, Osborn, & Lister, 2014). The results, not reported here, remain unchanged.

[33] The 30 year is a typical reference period in climate studies (Aufhammer et al., 2013), but I test weather shock variables defined over 50-year or 15-year period.

[34] SPEI dataset is computed based on the data from CRU, therefore, both datasets have the same resolution.

Conclusion

In this paper, I model rural-rural and rural-urban migration within the context of both income maximization and risk minimization, with weather acting as the principal source of risk. I first show that the potential benefits of relocating to urban areas are important for rural dwellers from both income and risk perspectives. Not only incomes earned in urban areas, and in particular, returns to education and experience, are much higher than in rural areas, but also in the short run, they are shielded from weather shocks.

In this context, my analysis confirms that weather acts as a migration driver, but its role is different in rural-rural and rural-urban migration. Negative deviations from water balance, as proxied by SPEI index, foster migration within rural areas or migration to cities, but not to secondary towns. Contrary to expectations, severe drought conditions increase the probability of relocating to another rural area, but not to urban areas, suggesting that passed a certain threshold, weather shocks amplify the liquidity constraints, and therefore limit potentially more beneficial but also more costly mobility towards cities. Liquidity constraints also inhibit individuals with the highest potential from reaping the benefits of moving into cities.

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