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Accepted in September 2012

WEATHER VARIABILITY AND AGRICULTURE: IMPLICATIONS FOR LONG AND SHORT-TERM MIGRATION IN INDIA

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Working Paper No. 220

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Weather Variability and Agriculture: Implications for Long and Short-term Migration in India

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Abstract

While a wide range of factors influence rural-rural and rural-urban migration in developing countries, there is significant interest in analyzing the role of agricultural distress and growing inter-regional differences in fuelling such movement. Given climate sensitivity of agriculture, there is also interest in exploring three-way linkage between agriculture, migration and weather anomalies. This strand of research acquires importance in the context of climate change adaptation. In the Indian context this analysis gets further complicated due to significant presence of short-term migration. Acknowledging the specific features of migration in India and with evidence from multiple data sources, this paper, (a) analyses the role of weather variability in inducing short-term migration using NSS (2007-08) data; and (b) estimates elasticity of long-term migration with respect to weather variability using Census data over the period 1981-2001. The results suggest that weather variability has an important role to play in both long-term and short-term migration in India.

Key words: Climate Change; Agricultural Impacts; Migration; Developing Countries
JEL Classification: O15; Q54; R11

[#] We thank Centre for Development Economics, Delhi School of Economics for financial support through UK Department of International Development (DfID) Purchase Order No. 40048622. We alone are responsible for the findings and conclusions.

1.0 Introduction

Rural-urban migration in India presents a set of complex and challenging issues for analysis. There are at least three distinct strands of literature that seem relevant in this context: (a) studies on urbanization and the factors facilitating and hindering rural-urban migration; (b) studies on distress migration; and (c) role of climate variability and climate change in accelerating rural-urban migration.

When compared to other parts of the world, the rate of urbanization in India (and South Asia) is relatively slow despite rapid economic growth, with the urbanization rate doubling in almost sixty years (Gupta and Rayadurgam, 2009). Further, about 60 percent of the urban population growth in South Asia is attributed to the natural growth and the remaining to the rural-urban migration. Ozden and Swadeh (2010) also observe that despite large potential gains, the migration in South Asia is paradoxically low. Through an analysis based on India they argue that socio-cultural and policy induced barriers could be responsible for low rural-urban migration rates. While multiple languages could form part of socio-cultural barriers, the policy induced barriers could include state-specific welfare programs which are not accessible once a household migrates to different state. Another reason for slow urbanization in India could be slow growth of agricultural productivity leading to inadequate release of agricultural laborers from rural areas. Also, it is often argued that India's industrialization has not been able to absorb unskilled and semi-skilled labor force resulting in too many laborers in the rural areas.

On the other hand, it is also observed that the official statistics focusing on permanent migration often show higher migration rates among better off groups compared to the low

income households (Deshingkar and Akter, 2009). Decile-wise incidence of short-term migrants sourced from 64th Round of National Sample Survey data clearly show that rural male undertake short term movements mostly. Thus, persons with lower income undertake short-term migration as a livelihood strategy, as almost all short term migrants migrated for employment related reasons. In other words, in the absence of permanent employment options in the destination areas, the low-skilled laborers indulge in circular and seasonal movements. While detailed migration data from the latest census for 2011 in India is not yet available, Sainath (2011) argues that there has been a substantially high migration rate from the rural areas compared to the earlier inter-Census period attributed to a distress conditions in agriculture. The short-term as well as the distress driven migration would reflect vulnerable conditions of the food insecure people moving in search of livelihoods.

In developing countries – which are largely dependent on climate sensitive economic activities such as agriculture – climate extremes and changing climatic conditions may accelerate growing levels of rural-to-urban migration (McLeman and Hunter 2010). Further, climate related migration largely takes place at intra-national and/or intra-regional scales, and it is likely to continue under the climate change conditions (Massey et al., 2010). While people at the upper end of the socioeconomic spectrum may be tied-up with their household/business capital which would also help them resist climate change induced hardships and avoid migration, the people at the lower end of the spectrum (such as landless labourers) may easily be displaced by climate hardships. Though the mechanism through which climate change would induce migration are not carefully studied, the likely adverse impacts of climate change on agricultural crops may

necessitate rural-to-urban and rural-to-rural migration. Cyclical migration for short-duration in response to droughts may continue or even grow due to climate change (Deshingkar and Start, 2003). International migration in the context of climate change has largely been studied with reference to sea level rise and inundation of coastal regions. Unlike other causes that force people to migrate, sea-level rise poses a permanent problem, with little or no scope for migrants to return home. Byravan and Chella Rajan (2009) argued that existing institutional arrangements may not be sufficiently equipped to handle within and across country migration resulting from sea-level rise. Black et al. (2011) and Perch-Nielsen et al. (2008) provide a synthesis of existing literature linking environmental change on human migration. Proposing a new conceptual framework for the drivers of migration, Black et al. (2011) categorize the drivers under the heads of economic, political, demographic, social and environmental. Hassani-Mahmooei and Parris (2012) use agent-based modelling framework to analyse the effects of climate change on internal migration in Bangladesh and predict that depending on the severity of various climate extremes there could be between 3 to 10 million internal migrants over next 40 years. The linkages between weather variability and migration are analysed through agriculture channel by several studies recently (Feng et al., 2010, 2012; Barbieri et al., 2010; Dillon et al., 2011; and Marchiori et al., 2012). These studies point towards existence of such channel through rigorous econometric analysis.

Against this backdrop, acknowledging the specific features of migration in India (including significant presence of short-term migration) and using evidence from multiple data sources, the present study attempts to, (a) analyse the broad patterns of short-term and long-term migration revealed by NSS (2007-08) and Census data; (b) explore the

determinants of short-term and long-term migration with special focus on weather variability; and (c) estimate the elasticity of migration with respect to weather variability operating through changes in agricultural productivity. The analyses presented focuses on rural sector.

The rest of the paper is organized as follows: The next section provides a brief review of broad trends of internal migration in India based on the 64th Round of NSS (2007-08) and Census data. The third section describes the modelling framework adopted for identifying the determinants of short-term and long-term migration and presents results from a probit model based on NSS data. The fourth section describes the modelling framework adopted for estimating the elasticity of migration with respect to weather variability and discusses the estimates obtained from the analysis based on Census data. The fifth section provides conclusions.

2.0 Broad Trends of Internal Migration in India

Data on internal migration in India is available through two different sources: Census and National Sample Survey[1]. Bhagat (2008) provides a comprehensive overview on these two data sources highlighting their differences and measurement problems. Bhagat (2008) argues that the Census definition of migration based on both place of birth and place of last residence makes it difficult to distinguish between permanent, semi-permanent and temporary migrants. While NSS definition of migrant is clearer (compared to Census definition), the sample weights have to be used to arrive at macro-level estimates on migration. Main features of migration in India include: (a) significant

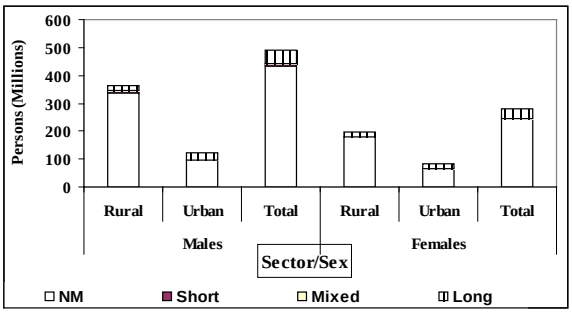
[1] Since both these sources record information on migration based on place of enumeration, they do not capture the emigration patterns. Further, since emigrants from India are less than one percent of the total migrants, most studies focus on trends in internal migration.

increase in the number of internal migrants especially in the post-liberalization period; (b) the inter-Censal growth rates however have not been monotonically positive; (c) marriage remains the dominant reason reported for female migration; and (d) the official statistics show steady decline in incidence (migrants per 1000 people) of rural to urban migration partly due to its inability to capture the short-term migration. A more detailed discussion on internal migration trends based on secondary data from both Census and NSS data is provided in Viswanathan and Kavi Kumar (2012). The rest of this section discusses the broad trends of internal migration in India estimated using the unit record data of the NSS corresponding to the period 2007-08.

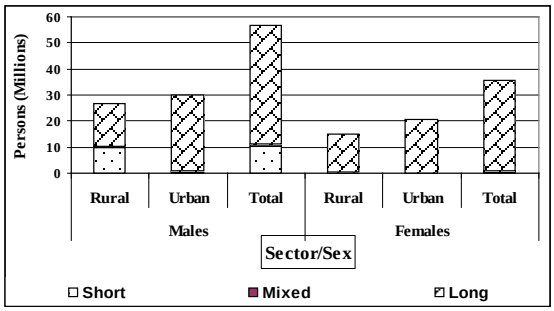
Migration Across Rural and Urban Sectors

Figure 1 provides an overview of the distribution of different types of migrants across rural and urban sectors and among male and female population groups. From the figure on the left hand side it can be seen that as a proportion of the total population, the migrants form a very small percentage. Since the data excludes migrants who cite marriage or transfer of job etc., as reason for migration, male members form the dominant group of migrants and that too among the urban population. The figure on the right hand side shows distribution of migrants among different categories – short-term, long-term and mixed-term[2]. Short-term migration is mostly observed among rural men, while mixed-term migration is visible among the urban men. Long-term migration dominates otherwise among all categories.

[2] Mixed-term migrants refer to those who are primarily long-term migrants, and yet undertake short-duration movements.



(a) Non-Migrants and Migrant Types



(b) Across Migrant Types

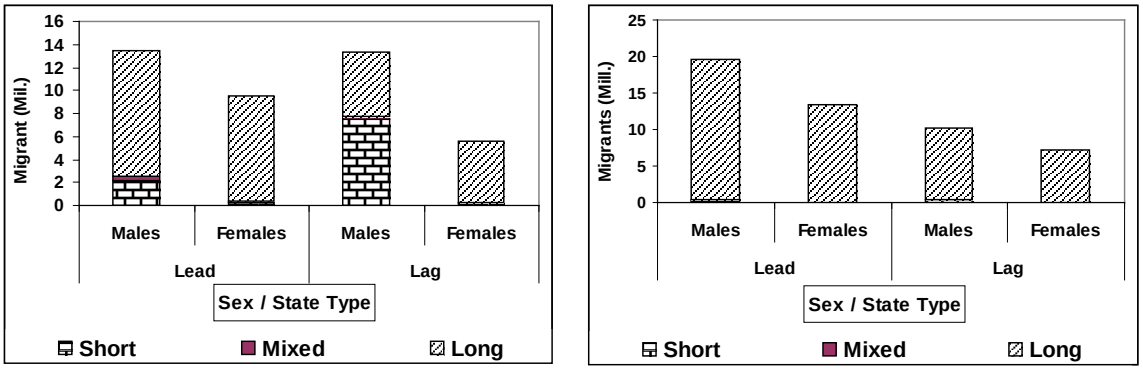
Source: NSS unit record data

Notes: (i) Short refers to migrants who move out for a period within 6 months; (ii) Long refers to permanent migrants who have moved into an area and includes less than one year duration of stay; (iii) Mixed refers to those who are permanent migrants yet undertake short-duration movements; (iv) Excludes migrants who cite marriage or transfer from jobs etc. as reason for migration.

Figure 1: Distribution of Migrant Types across Rural and Urban Sectors: Male and Female

Migration Across 'Lead' and 'Lag' States

Following Ozden and Swadeh (2010) it could be instructive to assess short, mixed and long-term migration from the 'lead' and 'lag' states across rural and urban sectors. The 'lead' ('lag') states are defined as those with lower (higher) population share in the bottom monthly per-capita expenditure quintile compared to its share in the all-India population. From figure 2 it can be seen that men from the rural areas of 'lag' states are mostly involved in short-term migration. Otherwise all segments are dominated by the long-duration migrants.



(a) Rural (b) Urban

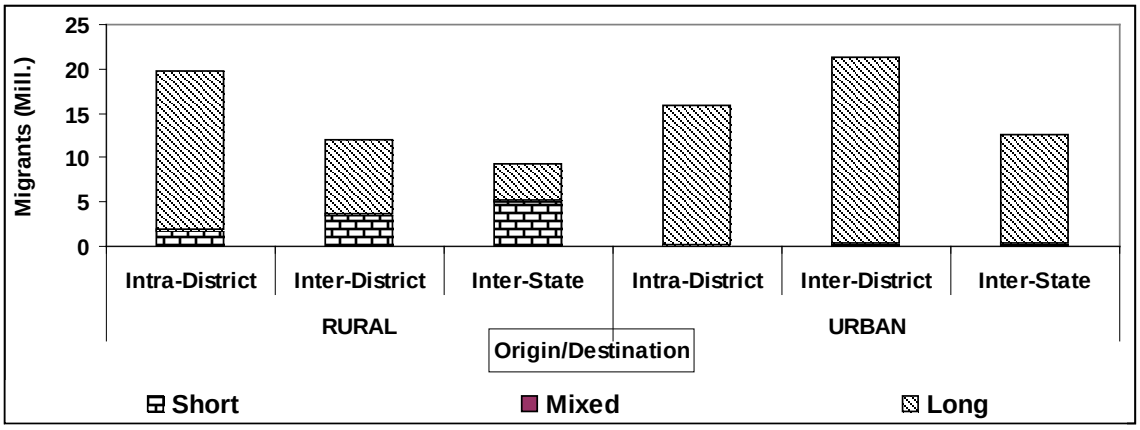
Source: NSS unit record data.

Notes: (i) See figure 1 for definition of migrant types; (ii) Lead and lag states have been classified on the basis of the proportion of people that they have in the bottom quintile.

Figure 2: Distribution of Migrant Types across Lead and Lag States for Males and Females: Rural and Urban

Migration Across Regions

If the migrants are further classified on the basis of their current residence and movement to other regions then it can be observed that (see figure 3): (i) among the rural residents inter-district movement dominates followed by inter-district and inter-state movement; (ii) the urban residents moved in mainly from other districts followed by intra-district movement and inter-state movement. Irrespective of the sector, the intra-state movement dominates over inter-state movements with the exception among short-duration rural migrants whose movement paradoxically exhibits a reverse pattern.

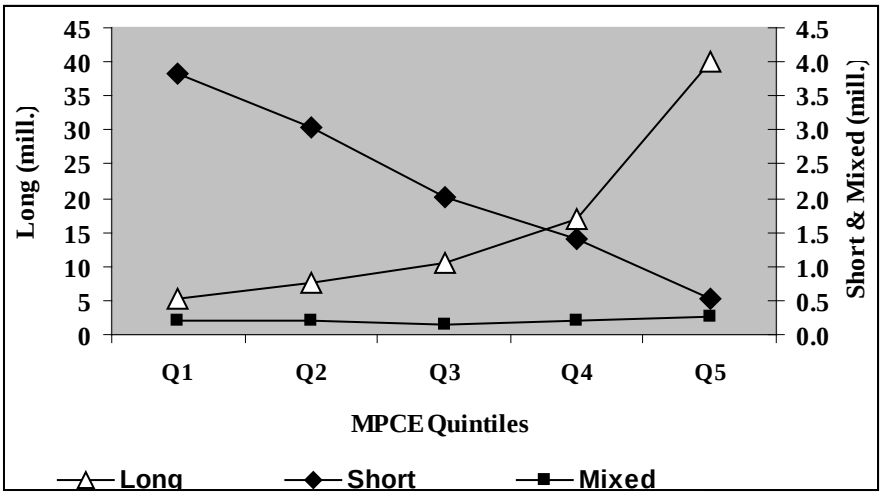


Source: NSS unit record data.
Notes: (i) See figure 1 for definition of migrant types.

Figure 3: Distribution of Migrant Types across Regions for Rural and Urban Sectors

Migration Across MPCE Quintiles

To supplement the migration patterns observed above it will be useful to study the trend of the migration types (long-term, short-term, and mixed-term) across the expenditure classes. Figure 4 shows such trend across monthly per-capita expenditure quintiles. It can be seen from the figure that the long-term migrants are among the richer segments, while the short-term migrants are mostly among the poorer segments of the society. The data also supports a faint U-shaped pattern among the mixed-term migrants.



Source: NSS unit record data.
Notes: The left y-axis is to be used for the long-duration migrants while the right y-axis is to be used for the short duration and mixed duration migrants.

Figure 4: Migration Trend across MPCE Quintiles for Different Migration Types

Distribution of Migrants across Economic Activities

A final pattern worth examining will be the distribution of migrants across economic activities. One would of course expect the migration out of primary sector. The distribution presented in table 1 corroborates this expectation. The patterns presented in table 1 show that the movement out of primary sector is mainly noticed among short-term migrants who predominantly move to work in the secondary sector. Among long-term migrants the largest proportion is to the primary sector while the gap between those who have moved to the other two sectors in this case is minimal. The tertiary sector acts as the main pull sector for long-duration migrants, while short-term and mixed-term migrants are attracted by the secondary and primary sectors, respectively. Further the table also shows that a substantial number of people who were economically active migrated and took jobs mainly in the tertiary sector.

Table 1: Distribution of Persons for different Migrant Types across Primary, Secondary and Tertiary Economic Activities (in millions)

Before Migration	After Migration				
	Primary	Secondary	Tertiary	NA	Total
Non-Migrants					
Primary	140	-	-	-	140
Secondary	-	47	-	-	47
Tertiary	-	-	63	-	63
NA	-	-	-	427	427
Total	140	47	63	427	677
Short Duration Out-Migrants					
Primary	1.8	2.9	0.7	-	5.4
Secondary	0.1	2.9	0.1	-	3.0
Tertiary	0.0	0.2	0.9	-	1.1
NA	0.1	0.2	0.1	-	0.4
Total	2.1	6.1	1.8		10.0
Mixed Migrants					
Primary	0.14	0.07	0.02	0.01	0.2
Secondary	0.09	0.13	0.02	0.01	0.3
Tertiary	0.02	0.02	0.12	0.02	0.2
NA	0.07	0.06	0.04	0.19	0.4
Total	0.32	0.28	0.21	0.23	1.0
Long Duration In-Migrants					
Primary	3.8	2.8	2.6	1.6	10.8
Secondary	0.5	4.0	0.8	0.6	5.9
Tertiary	0.5	0.6	6.2	1.2	8.4
NA	2.1	5.0	7.5	40.8	55.4
Total	6.9	12.4	17.1	44.2	80.5

Source: NSS unit record data.

Note: (i) The economic activities have been classified into the three main sectors: primary (agriculture and allied activities), secondary (industrial and construction) and services. NA or not applicable refers to all those who are not economically active like students, elderly and young children and home-makers; (ii) Since non-migrants are not mobile the off-diagonal elements are empty. The short-duration migrants are by definition moving out for employment and hence the 'NA' column is empty.

3.0 Is Weather Variability an Important Determinant of Migration?

The influence of weather variability on migration can be analysed in a number of ways. However, in the present study the focus is on assessing such influence of weather variability on migration operating through the agriculture channel. While both the Census and the NSS data provide scope for undertaking such analysis there are relative merits and demerits. Since the Census data does not provide satisfactory evidence on short-term migration and since weather variability induced distress migration from agriculture could largely manifest in the short-term migration, this section focuses on migration data sourced from the NSS. The analysis presented in this section assesses whether weather variability acts as an important determinant of (both short-term and long-term) migration. The analysis is based on a discrete choice model for the likelihood of migration - separately for short-term and long-term - in rural areas using the NSS unit record data.

Determinants of Migration: Modelling Framework

The discrete choice model for the probability of short-term migration is specified as follows:

$$Y_i = \Phi(\boldsymbol{X_i}\boldsymbol{\beta}) + u_i$$

where, $Y_i = 1$ when the individual undertakes short-term (or long-term) movement out of (into) rural areas;

$Y_i = 0$ otherwise, which includes non-migrants;

$\boldsymbol{X_i}$ = set of independent variables including, individual characteristics (like sex, age, employment status, sector of economic activity), household characteristics (like monthly per-capita expenditure, household size, religion, caste, landholding class), regional

characteristics (like weather variability including district level average of maximum temperature over the past twenty years, district level standard deviation of annual rainfall over the past twenty years; dummy variable representing the 'lagging' states);

β = coefficient vector associated with the independent variables.

The data for estimating the above model is sourced from the 64th Round of NSS. The weather data for all the districts of India over the past twenty years preceding the year 2007-08 (the year to which the NSS data corresponds) is based on the gridded data of 1^{o}x1^{o} latitude/longitude resolution for temperature and rainfall released recently by the India Meteorological Department (Rajeevan et al., 2005; Srivastava et al., 2009).

Table 2 presents the descriptive statistics of the variables used for the estimation. A few points are worth noticing from the table: (i) close to 70 percent of the short-term migrants are less educated ('Not Literate' and 'Literate & Primary'), whereas 45 percent of the long-term migrants relatively more educated ('Middle & Secondary' and 'Higher Secondary and Above'); (ii) while about 57 percent of the short-term migrants are labourers ('Agricultural Labour' or 'Other Labour'); (iii) the long-term migrants typically move with families as reflected in the large percentage of 'Not in Labour Force' category under the employment status of these migrants; (iv) short-term migrants typically have large household size and are from poorer families compared to the long-term migrants; (v) people belonging to Scheduled Castes and Tribes constitute higher (about 41) percentage of the short-term migrants compared to the long-term migrants (about 26 percentage); and (vi) a large majority (close to 74 percent) of short-term migrants are from 'lagging' states.

Table 2: Descriptive Statistics of Variables

Variable	Non-Migrant	Short Duration	Long Duration	All
Migrant Type	0.890	0.034	0.076	1.000
Females	0.247	0.052	0.468	0.257
Age	35.250	30.227	38.602	35.337
Household Size	5.555	5.839	4.569	5.490
Log (MPCE)	6.433	6.259	6.738	6.451
Level of Education				
Not Literate	0.315	0.348	0.322	0.316
Literate & Primary	0.263	0.345	0.231	0.263
Middle & Secondary	0.325	0.249	0.292	0.320
Higher Secondary and Above	0.097	0.058	0.155	0.100
Employment Status and Agricultural/Non-Agricultural Employment				
Self Employed in Agriculture	0.285	0.220	0.072	0.266
Self Employed in Non-Agriculture	0.096	0.094	0.075	0.094
Agricultural Labour	0.187	0.326	0.142	0.188
Other Labour	0.063	0.250	0.068	0.070
Unemployed	0.016	0.028	0.034	0.018
Regular Wages	0.056	0.053	0.089	0.058
Not in Labour Force	0.297	0.028	0.520	0.305
Landholding Class				
Less than 0.4 ha	0.568	0.668	0.764	0.587
0.4-1 ha	0.194	0.182	0.106	0.186
1.01-4 ha	0.209	0.137	0.107	0.199
> 4 ha	0.029	0.012	0.023	0.028
Religious Groups				
Hindus	0.849	0.837	0.850	0.849
Muslims	0.108	0.140	0.086	0.107
Christians	0.017	0.010	0.034	0.018
Other Religions	0.026	0.013	0.030	0.026
Caste groups				
Other Castes	0.241	0.176	0.309	0.244
Schedule Castes and Tribes	0.310	0.414	0.266	0.310
Other Backward Castes	0.449	0.410	0.426	0.446
Lagging States	0.576	0.742	0.349	0.565
Weather Variables				
Maximum Annual Temperature	25.581	25.679	25.686	25.593
Std. Dev. of Annual Total Rainfall	259.707	275.230	266.390	260.735

Note: The migrant categories exclude migration due to marriage and job transfer/change; See Table 3 for definition of short and long duration migrant.

Determinants of Short-term Migration

Table 3 reports the estimated coefficients based on probit regression model for short-term and long-term migration in India using the unit record data of the 64th Round of NSS corresponding to 2007-08. The results show that women are less likely to be short term migrants compared to men. Similarly short term migrants are more likely to be younger in age. In contrast the women are more likely than men to be long-term migrants as they tend to move from their natal home after marriage[3]. Less educated people are more likely to be short-term migrants compared to those with middle level education. The probability of short-term migration is highest among not-literate category. In contrast, people with more education are more likely to be long-term migrants, even though less educated people also have positive probability to undertake long-term migration.

With regard to the employment status, casual labour (agricultural and non-agricultural) and unemployed are more likely to be short-term migrants compared to those who are not in labour force. Individuals from households with lower monthly per capita expenditure (after controlling for education, employment status etc.) are more likely to undertake short-term migration. This is in congruence with the pattern observed earlier (refer Figure 4 above). Individuals with lower as well as higher land holding are less likely (compared to those with 0.4 to 1.0 hectare land) to be short-term migrants. Overall, individuals with very small amount of land holding or even no land, after controlling for other variables, seem to be constrained even to undertake short-term migration. The individuals from households with larger land holdings of course do not see the need for short-term

[3] It may be noted that even though the respondents who state their reason for migration as marriage are not included in the analysis, a number of respondents have not specified their reason for migration. Presumably many of such respondents could be women.

migration[4]. Thus the results show that individuals with some resources – but not adequate resources – undertake short-term migration to supplement their livelihoods.

The corresponding coefficients of the variables for employment status, income and land possessed are difficult to interpret for a long-term migrant as the NSS collects information on these variables after a person has undertaken migration. Thus, it will be difficult to assess the influence of such characteristics in shaping an individuals' decision before he/she migrated.

As expected individuals from larger households have higher probability to go on short-term migration, whereas the probability to undertake long-term migration decreases as household size increases. Clearly availability of surplus labour within the household enables a member of the family to move out for a short period to supplement the family's income. On the other hand, since a long term migrant moves in permanently, moving with a smaller family would involve lesser costs.

Similar to household size, individuals belonging to scheduled caste and tribes (SC/ST) and other backward classes (OBC) have greater probability to be short-term migrants while the reverse is observed for long-term migrants. Individuals belonging to 'lagging' state are more likely to be short-term migrants while such states are less likely to be the destination for the long-term migrants.

Importantly, weather variability – captured through the average maximum temperature and standard deviation of total rainfall over a twenty year period, has significant influence on short-term migration. Greater weather variability in the region of residence will increase the probability of an individual to undertake short-term migration seeking

[4] However, individuals from such households have greater probability to undertake long-term migration.

alternative livelihoods and additional incomes. This is in line with the findings of a recent study based on migration data from NSS and classification of regions on the basis of rainfall (Krishnapriya, 2012).

As explained above, the information from long-term migrants is collected at their destination. Hence one could expect that individuals may undertake long-term migration to regions with less weather variability. However, the results reported in Table 3 indicate that weather variables do not influence the choice of long-term migration destination. Perhaps this could be due to relatively weak influence that weather variability (available at aggregated regional level) could have on long-term migration decision and the difficulty in capturing the same using a dataset with disaggregated individual level data. An associated issue is the potential link between the weather variability and agricultural productivity, which in turn would influence the migration decision. The analysis based on NSS data does not allow the capture of such a three-way linkage as there is no agriculture related information in this dataset. Consequently, the probit estimations discussed in this section identify only the determinants of migration.

Since migration is viewed as a potential adaptation option under changed conditions of climate or higher weather variability, in addition to establishing weather variability as an important determinant of migration, it will be useful to get an estimate of the elasticity of migration with respect to weather variability. To address these issues the analysis in the next section uses migration data sourced from Census of India.

Table 3: Estimated Coefficients of Probit Model for Determinants of Migration

Probability of →	**Short Duration Migration**[1]		**Long Duration Migration**[2]	
Variable	**Coeff**	**p-value**	**Coeff**	**p-value**
Female=1	-0.456***	0.000	0.358	0.000
Age	-0.017***	0.000	0.008***	0.000
Education Level – Middle + Secondary (Reference)				
Not literate	0.194***	0.000	0.086***	0.000
Literate + Primary	0.139***	0.000	0.077***	0.000
Higher Secondary and Above	0.020	0.669	0.096***	0.000
Employment Status – Not in Labour Force **(Reference)**				
Self Employed in Agriculture	0.752***	0.000	-0.652***	0.000
Self Employed in Non-Agriculture	0.805***	0.000	-0.310***	0.000
Casual Labour in Agriculture	1.044***	0.000	-0.298***	0.000
Casual Labour in Non-Agriculture	1.409***	0.000	-0.022	0.496
Unemployed	0.954***	0.000	0.241***	0.000
Regular Wage Earners	0.896***	0.000	-0.042	0.180
Logarithm of MPCE	0.016***	0.000	-0.019***	0.000
Household Size	-0.148***	0.006	0.518***	0.000
Religion – Hindu (Reference)				
Muslim	0.058**	0.029	-0.139***	0.000
Christian	-0.031	0.675	-0.015	0.776
Other Religion	-0.023	0.718	-0.138***	0.002
Caste – Others (Reference)				
SC/ST	0.093***	0.000	-0.109***	0.000
OBC	0.056**	0.027	-0.120***	0.000
Land Possessed – 0.4 to 1.0 ha (Reference)				
< 0.4 ha	-0.062**	0.013	0.328***	0.000
1-.01-4ha	-0.083***	0.002	-0.027	0.344
>4 ha	-0.160**	0.010	0.077	0.120
Weather Variables				
Average Max. Temp	0.058***	0.000	0.002	0.639
Std. Dev of Total Rainfall	0.001***	0.000	-0.0001	0.282
Lag state=1	0.328***	0.000	-0.239***	0.000
Intercept	-3.153***	0.000	-5.003***	0.000
Pseudo R^2	0.145		0.140	
Number of Observations	124582		129652	

Note: (1) Dependent Variable is 1 for short duration migration and 0 for non-migrants; (2) Dependent Variable is 1 for long duration migration and 0 for non-migrants; (3) A short duration migrant is one who has taken up employment elsewhere for less than six months and long duration migrants is one who is residing in the place of enumeration for one year or more; (4) Estimated for individuals with age>=15 excluding marriage migrants and migrants due to transfer from jobs; (5) *** denotes significance at 1% level, ** denotes significance at 5% level, * denotes significance at 10% level.

4.0 Estimating Elasticity of Migration to Weather Variability

Census data facilitates a more accurate aggregation of migration data to district and state levels and one can combine the migration data (at state or district level) with the corresponding agricultural productivity data and weather data to estimate the elasticity of migration to the weather changes. Following the approach suggested by Feng et al. (2010, 2012) and used recently in Indian context by Viswanathan and Kavi Kumar (2012) this section describes the modelling framework and elasticity estimates based on Census data from 1981 to 2001.

Elasticity of Migration to Weather Variability: Modelling Framework

Using secondary data sources, Feng et al. (2010; 2012) capture climate change impacts on migration by estimating a simultaneous equation model specified as follows:

$$M_{it} = \alpha + \beta Y_{it} + d_i + f(t) + \varepsilon_{it}, \text{ and} \quad (1)$$

$$Y_{it} = \gamma + \delta T_{it} + p_i + g(t) + \nu_{it} \quad (2)$$

where, M_{it} is the net-out-migration/emigration from region 'i' at period 't'

Y_{it} is the corn/wheat yield of region 'i' at period 't',

T_{it} is the climate (represented through temperature and rainfall) of region 'i' at period 't',

d_i and p_i are regional dummies

$f(t)$ and $g(t)$ are fixed effects on time, i.e., r_t and c_t are dummy variables representing time

(In Feng et al., 2012, $f(t)$ and $g(t)$ are specified as time trends)

ε_{it} and ν_{it} represent the error terms.

Since Y_{it} and ε_{it} could be correlated, fixed-effects two-stage least-squares and limited-information maximum-likelihood techniques are used for estimating the model (Feng et al., 2010; 2012). The climate link is established through the vector T_{it} in the second equation which would affect the crop yields. A crucial assumption here is that climatic factors influence migration only through their effect on crop-yields, and that they do not influence migration directly. The methodology would facilitate estimation of (semi) elasticity of migration to crop yield.

Given the specific focus of this study it may relevant to link poorer agricultural performance (as influenced by weather variables) of a given region with a higher out-migration rate from that region. The inter-state data on out-migration rates from rural areas available in Census facilitates such analysis. The state level data for out-migration is organized in the following manner for the purpose of the study. The out-migration data from the rural areas of any given state as reported directly in the Census for the years 1981, 1991 and 2001 is used. Based on the information available under 'reason for migration', only those group of migrants who have specified their reason for migration as employment or other are included in the database. Thus, the migrants whose reason for migration is either marriage or place of birth are excluded from the analysis. The sample size is further enhanced by including migrants for two durations of stay (i.e., 1 to 4 years and 5 to 9 years) under each Census.

The analysis presented here is based on a panel dataset of 90 observations formed out of fifteen cross-section (states) units for six time points (that are five-year averages covering the period from 1972 to 2000). The relevant agriculture variable is taken as rice and wheat yield separately. The econometric analysis described above uses the fraction of out

migrants – defined as the ratio of total rural out-migrants from a state to the rural population of the sending state, as dependent variable. The independent variables include, (i) total annual rainfall, average annual temperature and rainfall/temperature corresponding to various seasons; and (ii) crop yield (for rice or wheat). Since wheat is not grown in some parts of the country, some observations reporting close to zero yields are excluded from the analysis while using wheat yield. Table 4 provides summary of data used for the analysis. The results reported below in table 5 are described separately for the wheat and rice crop.

Table 4: Summary of Data Used for the Analysis based on Census Data

Sl. No.	Variable	Source/Definition	Unit
1.	Rural 'Out' Migrants	Census of India	Numbers
2.	Rural Population	EOPP India States Data (http://sticerd.lse.ac.uk/eopp/_new/data/Indian_Data/default.asp)	Numbers
3.	Rural Out Migration Rate	Ratio of rural out migrants to total rural population of origin state	Proportion
4.	Total and Seasonal Rainfall (Independent Variables)	India Meteorological Department	Millimeters
5.	Average and Seasonal Temperature (Independent Variables)	India Meteorological Department	Degrees centigrade
6.	(Logarithm of) Rice Yield (Independent Variable)	www.indiastat.com/agriculture; *India Harvest* (CMIE)	Tones per hectare
7.	(Logarithm of) Wheat Yield (Independent Variable)	www.indiastat.com/agriculture; *India Harvest* (CMIE)	Tones per hectare

Wheat Yield

In the agriculture equation (i.e., equation 2 above) three weather variables – June-September mean temperature, October-November mean temperature, and standard deviation of January-March rainfall – are identified as appropriate instruments after examining several other combinations of temperature and rainfall variables. While the

temperature prior to the sowing season (June-September temperature) has positive influence on wheat yield, increase in growing period temperature (October-November) negatively influences the yield. On the other hand, increase in the variability of rainfall during the harvest period of wheat could adversely affect the yield. Wu-Hausman test statistic is significant at 9 percent indicating that wheat yield is endogenous in the migration equation. The semi-elasticity of wheat yield in the migration equation suggests that a 10% decrease in wheat yield will lead to 0.034% increase in out-migration rate.

Rice Yield

In case of rice yield, only annual average temperature and its square term are identified as appropriate instruments in the agriculture equation. Though several combinations of rainfall variables are tried out none were found to be significant. This is perhaps due to the aggregation of data over five year time-periods and across significantly large geographical areas. Increase in average annual temperature has negative influence on rice yield, while the non-linear effect (captured through the square term) has positive effect. Both the variables are significant only at 13-14%. The Wu-Hausman test statistic strongly supports endogeneity of rice yield in the migration equation. The semi-elasticity of rice yield suggests that a 10% decrease in rice yield will lead to 0.074% increase in out-migration rate. The higher value of semi-elasticity of rice yields compared to the wheat yields may be due to greater dependency of population on rice cultivation compared to wheat cultivation leading to higher mobility rates when yields decline.

Several studies (see, Ozden and Swadeh, 2010) have argued that inter-state migration in India is influenced by the socio-cultural factors including language. These studies in turn have suggested that specific migration corridors exist in India for the inter-state

movement. The analysis based on the sub-sample of the states Bihar, Karnataka, Haryana, Madhya Pradesh, Maharashtra, Punjab, West Bengal, Gujarat, Rajasthan and Uttar Pradesh representing the dominant migration corridor of inter-state movement in India did not provide support for greater elasticity of migration to crop yield changes. The time-fixed effects in the agriculture equation for both wheat and rice are significant and increase monotonically over time, capturing the productivity increases over time. Unlike in the case of the yield equation time fixed effects are insignificant in migration equation indicating that rural out-migration rates are not very different over time.

Table 5: Estimated Coefficients of Yield and Migration Equations: Census Data

Variable	Coefficient	p-value	Coefficient	p-value
Yield Equation				
	Wheat		**Rice**	
June-September Temp.	0.328**	0.027		
October-November Temp.	-0.169	0.136		
Std. Dev. of January-March Rainfall	-0.002**	0.041		
Average Annual Temp.			-1.467	0.135
Square of Avg. Ann. Temp.			0.028	0.136
Dummy Variable for Time Periods (Reference year = 1972-1977)				
1977-1981	0.204**	0.013	0.123**	0.010
1982-1986	0.181*	0.009	0.189*	0.000
1987-1991	0.288*	0.000	0.317*	0.000
1992-1996	0.401*	0.000	0.395*	0.000
1997-2001	0.417*	0.000	0.445*	0.000
Intercept	-5.657	0.147	19.381	0.128
Adjusted R^2	0.9361		0.9318	
F-statistic for overall Model significance	F(21,58)= 301.32*	0.00	F(21,68)= 130.45*	0.00
Migration Equation				
logarithm of Yield, lnY	-0.0036**	0.054	-0.0074***	0.094
Dummy Variable for Time Periods (Reference year = 1972-1977)				
1977-1981	0.001*	0.000	0.002*	0.003
1982-1986	0.000	0.572	0.001	0.612
1987-1991	0.001	0.271	0.002	0.127
1992-1996	0.001	0.198	0.002	0.161
1997-2001	0.002**	0.036	0.004***	0.064
Intercept	-0.00036	0.799	0.0059**	0.011
R^2	0.808		0.657	
Wald Chi^2	$\chi^2(19)=671.3$*	0.000	$\chi^2(20)= 467.1$*	0.000
Number of Observations	80		90	
Test for Endogeneity				
Robust score Chi^2	$\chi^2(1) =2.75$***	0.097	$\chi^2(1) =5.70$**	0.0166

Notes: 1) * denotes *p*-value ≤0.01, ** denotes *p*-value ≤ 0.05 and *** denotes *p*-value≤0.10.

5.0 Conclusions

Internal migration in India is a complex issue with multiple factors affecting it. While on one hand there are concerns that the economic growth in India is not contributing significantly to foster rapid urbanization in-line with the mainstream development arguments, there are also concerns that agricultural distress could be forcing migration of people (attached to agriculture) to other economic sectors and regions in the short to medium term. In the later context, the role of weather variability in reducing agricultural productivity and hence contributing to migration is fast acquiring great importance as such evidence may provide insights about the scope for migration as an adaptation strategy in the event of climate change. This paper contributes to this strand of literature with its focus on India.

The paper uses two large datasets – the Census and the NSS, and rigorous econometric analysis to assess the influence of weather variability on migration. The results indicate that, (a) the elasticity of state-level out migration rate (sourced from the Census data over 1981 to 2001) to agricultural performance (captured through changes in wheat and rice yields caused by weather variability) ranges between -0.90 to -1.85; and (b) the weather variability (captured through increasing maximum temperature and standard deviation of annual rainfall) is an important positive determinant of short-term migration. The second result – suggesting that the probability of short-term migration is higher for individuals residing in regions experiencing greater weather volatility – is based a detailed analysis using the NSS data for the year 2007-08.

While these results on their own merit may not decisively provide a quantitative estimate of climate change impact on migration, they give important policy pointers on what could be in store for migration under potential future changes in climate. The influence of weather variability on short-term migration established in this paper points towards potential coping role that such migration may have, now and in future. The elasticity of long-term migration with respect to weather variability estimated on the other hand suggests the adaptation possibilities that such migration may offer, now and in future.

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