Economics Bulletin

Volume 35, Issue 4

Spatial Modeling of Origin-Destination flows of farmers in Senegal

Ligane Massamba Séne
International Food Policy Research Institute (IFPRI)

Abstract

Migration is not limited to international migration and a complete picture of the movements of actors in the agricultural sector could be insightful. The paper identifies the different patterns of internal migration of farmers across the different locations using a conventional spatial autoregressive interaction model and the most recent household survey in Senegal. Findings highlight the existence of spatial dependencies between flows. Poverty, unemployment, education and water access appear to be among the pull and push factors explaining farmers migrations. Climate variability, specifically the succession of bad rain-fed cropping seasons, is likely to compound the livelihood problems faced by farmers and push them to migrate, in a country where many farmers depend largely upon rain-fed agriculture and cattle-raising. This paper provides empirical evidence to deepen our understanding of the internal and in-migration of farmers. A clearer picture of the driving force of farmer´s migration would help policy makers to devise suitable strategies for sustainable national migration policies.

Citation: Ligane Massamba Séne, (2015) "Spatial Modeling of Origin-Destination flows of farmers in Senegal", *Economics Bulletin*, Volume 35, Issue 4, pages 2742-2749
Contact: Ligane Massamba Séne - jalimase@yahoo.fr.
Submitted: October 20, 2014. **Published:** December 13, 2015.

1. Introduction

Internal migration of farmers needs a special attention as labor move non-randomly from one location to another depending on both the characteristics on the origin and the destination. Many factors can influence migration and this paper attempts to focus on the economics as well as non-economics push-factors and pull-factors and explains the variation of the flows of farmers within the economy, as locations do not have the same dotation in terms of natural resources, housing and socioeconomic facilities. International migration in Senegal, especially illegal immigration that often leads to a bitter end are widely explored, but no study looked empirically at the internal migration and the specific situation of agricultural workers, in a context where the debate about the subdivision of the country in viable and sustainable carriers territories resurged through the Act III of decentralization, which aims also to make a readjustment of the national territory in geographical perspective and the transformation of many rural communities into townships. This is a valuable contribution as putting the emphasis on the agricultural sector and investigating all the relevant factors that may drive migration flows. Despite the importance of migration of agricultural as well as non-agricultural workers, there is no significant national migration policy set by the government. According to the household poverty monitoring survey (ESPS II), the overall stock of the immigrant is estimated at 3 504 245 individuals and there are 154 266 farmers among them. The volume of internal migrants grew significantly over the last decades and individuals generally move from the rural areas to the less rural areas. Face to the high poverty rate in Senegal, especially in rural areas and the huge differences between locations in terms of opportunities, migration become one scope for individuals that are seeking for Eldorado to get better living conditions. The bad rainy seasons and the lack of market opportunities may also be factors that explain the high frequency of migration in rural areas where agriculture is the primary source of income. Agriculture contributes to around 15% of the national GDP and around 45% of the employment share at the national level.

Many studies on migration are based on labor market model and focused on the wage difference (Lewis, 1954; Ranis and Fei, 1961; Borjas, 2003). However, several other factors might be meaningful in explaining the migration of people, especially farmers. The wage differential between rural and urban areas is in the background of the first models. The latter were based on the assumption that wage differential induces migration until wages, net of migration costs in the two areas become equal. These models were followed by those derived from the Harris-Todarro model (Todaro, 1969; Harris and Todaro, 1970; Todaro and Maruszko; 1987) that suggest that the differential in expected wages is the driver of migration rather than the previous idea of actual wage differentials. The more recent trend of migration models is based on the theory of the New Economics of Labour Migration (NELM) that considers migration as a family strategy to reduce risk and maximize income (Mincer, 1978; Stark and Lucas, 1988). Some recent papers have analyzed the drivers of migration (McKenzie and Rapoport, 2007; Dell et al. (2009) Barrios et al., 2010). However, most of them did not deal with the spatial dependence in their estimates and paid less attention to internal migration of farmers.

This paper uses a spatial autoregressive interaction model to provide an insightful overview of the movement of farmers between regions and captures the spatial dependence of flows. Several studies have been conducted to analyze the origin-destinations flows around the worlds and in different fields such as trade, transport and capital investment. However, as earlier stated a few studies deal with intra-regional flows and to our knowledge, no study has especially looked at the situation in the agricultural sector in Senegal.

2. Methodology

2.1. Sampling and data

The 2011 poverty monitoring survey is used in this study. This survey highlights the socioeconomic characteristics of the different households and a detailed module related to migration and employment that are used to compute most of the variables used in this study. It is a random sample survey at the national level that uses a two-stage cluster sampling method with stratification in the first stage. Statistical units of the first stage are districts. Secondary units are constituted by households drawn from the district in the first stage. The overall survey sample covers 17891 households with around 8 310 farmers.

2.2. Spatial Autoregressive Interaction Model

Spatial interaction models rely on a function of the distance between an origin and a destination and on variables reflecting characteristics of both origin and destinations.

The traditional gravity model is applied in general as

$m_{od}=\frac{X_o^{\alpha} X_d^{\beta}}{D_{oj}}$, where m_{od} is the migration from region o to d, X_o^{α} and X_d^{β} variables related to the characteristics of the origin and destination variables that may impact inflows or outflows and D_{oj} the physical distance between o and d.

However, following Lesage and Pace (2008, 2009), and in contrast to the traditional regression-based gravity model, a spatial econometric model integrating different schemes of spatial dependence and relying on spatial lags of the dependent variable as well as the error terms will be estimated.

This suggests three different types of contiguity to capture the spatial dependence of flows (origin based, destination based and origin to destination based dependence).

The resulting general spatial autoregressive interaction model can be expressed as follows:

$\xi\, m = \alpha_0\, I_{n^2} + \alpha\, X_o + \beta\, X_d + \delta\, \mathrm{D} + \varepsilon$ (1)

with $\xi = (I_{n^2} - \rho_o \mathrm{W}_o)(I_{n^2} - \rho_d\, \mathrm{W}_d) = I_{n^2} - \rho_o\, \mathrm{W}_o - \rho_d\, \mathrm{W}_d + \rho_w\, \mathrm{W}_w$ (2)

and W_o and W_d are spatial weight matrix based on the Kronecker products.

$\mathrm{W}_o = W \otimes I_n$ (3)

$\mathrm{W}_d = I_n \otimes W$ (4)

And $\mathrm{W}_w = \mathrm{W}_o \otimes \mathrm{W}_d = \mathrm{W}_d \otimes \mathrm{W}_o = W \otimes W$ (5)

W is a row-normalized spatial weighting matrix and W_o captures the origin based dependence, W_d the destination based dependence and W_w the origin to destination based dependence and the parameters ρ_o, ρ_d and ρ_w capture the amplitude of these dependencies.I_n is the identity matrix of size n.

Defining $Z = (I_{n^2}, X_o, X_d, \mathrm{D})$ and $\varsigma = (\alpha_0 , \alpha, \beta, \delta)$

The model can be presented as follows $m = (I_{n^2} - \rho_o \mathrm{W}_o - \rho_d \mathrm{W}_d + \rho_w \mathrm{W}_w)^{-1} (\mathrm{Z}\, \varsigma + \varepsilon)$ (6)

The least squares estimation is no longer valid in the presence of spatial dependence, thus the maximum likelihood method is used and the log-likelihood function for the model specifications will take the form in

$$Ln\, L = \kappa + \ln| I_{n^2} - \rho_o \mathrm{W}_o - \rho_d \mathrm{W}_d + \rho_w \mathrm{W}_w | - \frac{n}{2} \ln(\mathrm{S}(\rho_o, \rho_d, \rho_w)) \qquad (7)$$

Where $\mathrm{S}(\rho_o, \rho_d, \rho_w)$ represents the sum of squared errors expressed as a function of the scalar dependence parameters alone after concentrating out the parameters $\alpha_0 , \alpha, \beta, \delta$ and σ^2, and the constant κ is independent on ρ_o, ρ_d and ρ_w. LeSage and Pace (2008) show that the log-determinant of the $n\ x\ n$ matrix can be calculated using only traces of the $n\ x\ n$ matrix W which greatly simplifies the estimation of model. The estimates are conducted using Matlab through efficient methods set in LeSage and Pace (2008) for the optimization of the likelihood function.

3. Results and discussion

The results show evidence that the model using the three separate spatial weight matrices with no restriction on spatial lag coefficients best captures the spatial dependence in flows of agricultural workers based on the likelihood values. Results from the models show that the restriction $\rho_w = -\rho_o \rho_d$, that constraints the strength of the origin to destination based dependence in order to interpret the filter as two successive filters based on both W_o and W_d and the restriction $\rho_w = 0$, that assumes no origin to destination based dependence, are not valid. In the unrestricted spatial autoregressive interaction model, all the three types of dependencies are significant, hence the relevance of taking into account all the different types of spatial dependencies.

Table 1: Estimates of the spatial autoregressive interaction models for flows of farmers.

m_{od}	Unrestricted model			Model with $\rho_w = -\rho_o\rho_d$			Model with $\rho_w = 0$		
	Coef.	t-stats	Prob.	Coef.	t-stats	Prob.	Coef.	t-stats	Prob.
Constant	5.557	5.377	0.000	3.329	3.690	0.000	3.748	4.020	0.000
I_constant	-0.576	-0.989	0.324	-0.519	-0.873	0.384	-0.539	-0.919	0.359
D_Poverty	-0.048	-2.063	0.041	-0.054	-2.287	0.023	-0.054	-2.305	0.022
D_Schooling	-0.019	-1.356	0.177	-0.018	-1.242	0.216	-0.018	-1.289	0.199
D_unemplement_rate	-0.091	-1.941	0.054	-0.114	-2.385	0.018	-0.112	-2.366	0.019
D_Transfer migrants	0.549	2.357	0.019	0.592	2.498	0.013	0.592	2.527	0.012
D_Population	0.840	0.927	0.355	1.089	1.177	0.241	1.055	1.156	0.249
D_Avg_Precipitation	0.175	1.684	0.094	0.215	2.038	0.043	0.211	2.023	0.045
D_Water accessibility	-0.014	-0.519	0.605	-0.021	-0.778	0.437	-0.020	-0.742	0.459
O_Poverty	-0.013	-0.558	0.578	-0.022	-0.925	0.356	-0.018	-0.786	0.433
O_Schooling	0.048	2.820	0.005	0.027	1.654	0.100	0.031	1.888	0.061
O_unempl_rate	0.074	1.576	0.117	0.093	1.937	0.054	0.083	1.752	0.081
O_ Transfer migrants	0.783	2.888	0.004	0.537	2.033	0.043	0.559	2.117	0.036
O_ Population	3.749	3.393	0.001	2.772	2.583	0.011	2.829	2.633	0.009
O_ Avg_Precipitation	-0.073	-0.650	0.517	0.060	0.529	0.597	0.018	0.164	0.870
O_ Water accessibility	-0.047	-1.720	0.087	-0.048	-1.705	0.090	-0.044	-1.596	0.112
I_Poverty	0.021	0.247	0.805	0.007	0.078	0.938	0.010	0.116	0.908
I_Schooling	0.078	1.360	0.175	0.072	1.242	0.216	0.073	1.278	0.203
I_ unemplement_rate	-0.015	-0.082	0.935	-0.043	-0.239	0.811	-0.036	-0.202	0.840
I_ Transfer migrants	0.743	0.879	0.381	0.563	0.657	0.512	0.606	0.717	0.474
I_ Population	1.455	0.452	0.652	0.989	0.302	0.763	1.122	0.347	0.729
I_ Avg_Precipitation	0.040	0.101	0.920	0.071	0.177	0.860	0.069	0.173	0.863
I_ Water accessibility	0.043	0.423	0.673	0.051	0.489	0.625	0.047	0.462	0.644
Distance	-0.598	-3.551	0.001	-0.469	-2.768	0.006	-0.498	-2.972	0.003
ρ_o	0.228	2.199	0.029	0.329	3.516	0.001	0.340	3.541	0.001
ρ_d	-0.364	-2.918	0.004	-0.458	-3.662	0.000	-0.461	-3.699	0.000
ρ_w	-0.406	-1.851	0.066	0.203	1.009	0.314	0.079	0.381	0.704
Log-likelihood	-350.819			-354.628			-352.80		

Note: O_, D_, and I_ are labeled before the variable names to indicate whether they are origin variables, destination variables, or intra-regional variables. The model is estimated based on the 196 components of the matrix of inter and intra-regional flows of farmers. Avg = average

The variables can be classified into socio-economic factors (poverty, schooling, transfers, population size, education, and unemployment) and environmental variables (rainfall conditions and water accessibility). Furthermore, lack of water access and population density/congestion might be push factors for migration while better employment, economic opportunities, and good climatic conditions could pull people into new destinations.

The estimates show the importance of spatial dependence when studying flows of farmers in Senegal. The destination effect of poverty is significant and negative, suggesting that the farmers, in general, do not move in poor regions. The impact of the average recent amount of precipitation at the destination is positive and significant. This indicates that farmers when moving generally go towards the rainiest regions. Therefore, the climate appears as being a strong driver of farmers' migration. Indeed, climate change can affect farmers´ access to employment and food in weather-dependent sectors like agriculture. Beyond climate, it is mostly the scarcity of water in the regions of origin (proxied by the inverse of availability of water) that contributes to farmer movements. In fact, we found a negative and statistically significant origin effect for availability of water. Migration is a key adaptive response to environmental change, mostly due to low amount of precipitation, however, availability of water source can limit farmers' climate variability-related migration. An interesting point is that the locations where migration looks like a family strategy, proxied by the overall level of internal remittance transfers, are those that have observed higher inflows and outflows of farmers. This association between remittances and flows of farmers shows that the support of relatives back home or region of origin is a major incentive for migration.

The origin effect of schooling (overall primary schooling rate considering farm-household members) is significant and positive, suggesting that education is an important factor explaining the trend of migration of farmers. The limitation in high quality educational services in the regions of origin might be a pushing factor, especially for the highest educated household members having the desire to improve their skills, but unfortunately living in areas that offer only opportunities for some years of primary education. In a broad sense, the correlation between education and outflows can also be explained by the fact that more educated farmers are more likely to migrate in order to get better off-farm opportunities or productive alternatives to seasonal farm work. The government should try to reduce the differences in access to public higher education. This could reduce the opportunity cost for those who migrate just because of insufficient schooling opportunities.

Low regional unemployment rate appears to be associated with low inflow, as shown in the models. Population size in the origin is positively associated with outflow, probably owing to the lack of land opportunity for farming or absence of additional sources of income. The negative coefficient of distance implies that the migration flows will fall as the distance increases.

4. Conclusion

In this paper, I have applied existing methods on spatial econometrics to internal migration of farmers. The study shows empirically that origin, destination and origin to destination based spatial dependencies should be integrated when modeling migration flows, in contrast to traditional gravity models. I find several pull and push factors of migration of farmers, such as availability of water, regional poverty rate, unemployment, etc. The government should regulate internal migration and promote regional strategies to avoid the decrease of agricultural production in less favored locations and limit regional development imbalances. This can include building facilities such as irrigation or retention basins for a better water access for farmers and promotion of the adoption of drought resistant crops.

References

Barrios, S., Bertinelli, L. and E. Strobl (2010). Trends in rainfall and economic growth in Africa: a neglected cause of the African growth tragedy *The Review of Economics and Statistics* **92** (2), 350–366.

Borjas, G. J. (2003) "Welfare reform, labor supply, and health insurance in the immigrant population" *Journal of Health Economics*, Elsevier, **22** (6).

Dell, M., Jones, B.F., and B.A. Olken (2009). “Temperature and income: reconciling new cross-sectional and panel estimates” *American Economic Review Papers and Proceedings* **99** (2), 198–204.

Lewis, W.A. (1954) “Economic development with unlimited supplies of labour” *The Manchester School of Economic and Social Studies* **22** (2), 139–191.

Harris, J.R. and M.P. Todaro (1970) “Migration, unemployment and development: a two-sector analysis” *The American Economic Review* **60** (1), 126–142.

LeSage, J.P. and R.K. Pace (2008) “Spatial Econometric Modeling of Origin-Destination Flows” *Journal of Regional Science*, **48** (5), 941–967.

LeSage, J.P. and R.K. Pace (2009) Introduction to Spatial Econometrics, Boca Raton, FL: CRC Press, Taylor & Francis Group.

McKenzie, D. and H. Rapoport (2007) “Network effects and the dynamics of migration and inequality: theory and evidence from Mexico” *Journal of Development Economics* **84** (1), 1–24.

Mincer, J. (1978) “Family migration decisions” *Journal of Political Economy* **86** (5), 749–773.

Ranis, G. and J.C.H. Fei (1961) “A theory of economic development” *The American Economic Review* **51** (4), 533–565.

Stark, O. and R.E.B. Lucas (1988) “Migration, remittances, and the family” *Economic Development and Cultural Change* **36** (3), 465–481.

Todaro, M.P. (1969) “A model of labor migration and urban unemployment in Less Developed Countries”. *The American Economic Review* **59** (1), 138–148.

Todaro, M.P. and L. Maruszko (1987) “Illegal migration and US immigration reform: a conceptual framework”. *Population and Development Review* **13**, 101–114.