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*Full Length Research Paper*

# Poverty spatial polarization in Senegal

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**This paper aims at inquiring the impact of neighboring regions poverty rate on the poverty rate of a given region. This inquiry will help find out the best driving region in terms of poverty alleviation in Senegal. We applied basic spatial econometrics tools to Senegalese regions from 1994 to 2006. The results show that a decrease of 0.62% of the poverty rate in Dakar results from an increase of 1% of poverty rate in the other regions. Conversely, a decrease of 1% of poverty rate in a given region except Dakar is predicted to decrease poverty rate in the other regions by 0.53% on average. At this level, Thiès has been found to be most driving region in terms of poverty alleviation in Senegalese regions. Besides controlling for other variables, the results yields that poverty alleviation could be achieve through better education and health system.**

**Key words:** Poverty, polarization, regional.

## INTRODUCTION

Poverty alleviation has been a major concern for developing countries since the beginning of the last decade. In this framework, Senegal's government has set up major programs since 1990 and adopted in 2000 the first document for poverty alleviation strategies. Before this document, most of the programs were based on the Structural Adjustment Program designed by the IMF and WB to challenge the huge economic crisis faced by most country at the beginning of the 80s. Currently the county is heading to the adoption of the third document for poverty alleviation strategies.

In order to follow up the progress made through these programs, three major households' surveys have been conducted on a regular basis. It turns out that the poverty rate has decreased from 58% in 1994 to 39% in 2006 after being 50% in 2002. In spite of this downward evolution of the poverty rate, it does not reflect the overall efforts that have been made to alleviate poverty in Senegal. In addition, the level of poverty rate attain in 2006 remains very high compared to target planned on the strategy of poverty reduction paper. Then, before the adoption of a new document for poverty alleviation strategies, it is worthy to wonder what is wrong with the other.

The goal of this paper is to take into account a new approach in poverty alleviation. Indeed, since most of the programs are implemented at regional scale, it is likely that the poverty alleviation in one region can affect the neighboring regions; and the magnitude of the impact on the other regions depends on which region the program is implemented. Then the purpose of this working paper is to point out the most driving regions in terms of poverty alleviation by taking into account the geographic spillovers. This method called spatial polarization is inspired from a similar study1 conducted in Italy on criminal activities.

The rest of the document will be organized as followed. An overview of spatial polarization was given; light was shed on the empirical strategy used to solve the problem; information on data and some summary statistics was provided, and finally the results was presented.

## AN OVERVIEW OF SPATIAL POLARIZATION

This study can be related to the application of geographical economics theory to poverty issues. Recently, geographical economics has become a field of interest since there is a consensus that the isotropy of an economic space does not hold anymore. Then many scholars have tried to develop a theoretical ground for geographical economics and yet some empirical studies have been done in the fields. However, it is hard to find

JEL: C23, C33, C51

[1] Cracolici Maria Francesca and Uberti Teodora Erika. (2008); "Geographical Distribution of crime in Italian Provinces: A Spatial Econometric Analysis", Fondazione Eni Enrico Mattei

out an empirical study in geographical economics which dealt with poverty issues.

As theoretical ground, J.R. Boudeville provides a definition to the concept of spatial polarization. According to the author "*spatial polarization is a complex phenomenon, decomposable in some block of events which occur with time. It describes how development poles are formed and how the resulting impulsions spread in duration and geographic scope. In other words, it is a dynamic process of expansion and sequential evolution both technical and social*."[2] From that definition of spatial polarization, some empirical studies have been implemented on other issues than poverty.

Cracolli and Uberti, (2008) have conducted a study on spatial polarization of crime in Italy. In their paper, they use spatial econometrics tools to investigate how the crime rate in neighboring regions can affects the crime rate in a given region. For comparison purposes, they use a weight matrix based on the existence of border (contiguity matrix) and another based on distance between Italian regions. This implies that spatial econometrics tools are well adapted for conducting a study in spatial polarization.

Another study conducted by Sandy Freret on the interactions between French regions in terms of government expenses. The author also use spatial econometrics tools to point out how the level of government expenses in a given region can be influenced by the level of government expenses in the neighboring regions.

The spatial polarization seems to be a new concept which is not yet widespread in Sub-Saharan Africa as almost no publication has been found dealing with this topic. The empirical studies that inspire this working paper have been implemented in the European Union where poverty issues are not the major ones. Somehow, in the forthcoming sections, we are going to adapt the framework of these studies to poverty issues in Senegal.

## Empirical strategy

For reminders, the goal of this study is to explain the poverty rate in a given region by the poverty rate in its neighboring regions. Here it is assumed, under the theory of geographical economy, that any given region is influenced by the other regions in its vicinity due to the geographical spillover of poverty. As stated previously, the general approach used to deal with this problem is the spatial econometric tools. Without getting in the core of spatial econometrics, we are going to use some of its account in the regression model. The dependent variable is the poverty rate in a given region at a specific time. Indeed, since we only have 10 regions, it was useful for asymptotic inference to consider each region within a period of 13 years from 1994 to 2006.

The main independent variable is the one which gives the value of poverty rate in the other regions at a specific time. In terms of spatial econometrics, this variable is called "the spatially lagged endogenous variable". It represents the value of the influence of the other regions on the given one. The spatial lagged endogenous variable is computed by multiplying the Weight Matrix by the endogenous variable. In fact the weight matrix determines the transmission channel of the other regions' influence. In the literature, the most used transmission channels are the existence of border and the distance between a given region and the others. Many other transmission channels are used depending on the nature of the study; however, in this study, we assumed that the geographical spillover of poverty in Senegalese regions might be first due to the existence of border or the distance between regions.

On the one hand, assuming that the existence of border or the vicinity of two regions causes the geographical spillover of poverty, it implies that the effect of any damage, be it drought or flood, which affects a given region is likely to affect the neighboring regions because of their vicinity. We choose the example of flood or drought because those are the most exogenous variables that may increase poverty rate in most of the Senegalese regions which depends on agriculture. The matrix obtained in this case is called "contiguity matrix".

On the other hand, the choice of the distance as a transmission channel is first due to the following intuition: The farther is a region from a given one; the lower is the impact of the variation of the poverty rate in that given region. The second reason is related to population mobility. Indeed, the nearer is region to a given one, the more likely it is that the population immigrate towards the given region following a lack of opportunity in their region of origin. The matrix obtained in this case is called "distance weight matrix".

*Then, the border assumption is likely to provide a positive correlation between the poverty rate in a given region and the influence of the other regions while the distance assumption is likely to provide the opposite.*

The general expression of a weight matrix is the following:

$$W = \begin{pmatrix} M_{11}.....M_{1R} \\ . \\ . \\ . \\ M_{R1}.....M_{RR} \end{pmatrix}$$

$M_{ij}$ are matrixes corresponding to the link (border or distance) between regions i and j. The dimension of this matrix equals the number T of time observations on the regions. In this study, the regions were observed from 1994 to 2006.

[2] This is translation from the original French version.

**Table 1.** Source: Author.

| Category | Representative variable | Notation | Logarithm |
|---|---|---|---|
| Economy | Unemployment rate | Unr | lnUnr |
| Demography | Household size | Hs | lnHs |
| Health | Life expectancy at birth | Lexp | lnLexp |
| Education | Primary education registration rate | Primeduc | lnPrimeduc |
| | Illiteracy rate | Ir | lnIr |
| Public investment | Square kilometers of roads | R | lnR |

For a contiguity matrix, $M_{ij}$ is the nil matrix if I = j and the identity matrix $I_{TT}$ if regions i and j have a common border. This result implies that the border has remained fixed between regions throughout the period of the study.

For a distance based weight matrix, $M_{ij}$ is still nil if I = j. However if $i \neq j$, $M_{ij}$ is a diagonal matrix where the leading elements are all identical and equal the inverse of the distance between regions i and j; $M_{ij}$ = diag $(1/d_{ij},\ldots, 1/d_{ij})$. The inverse of the distance express "the farther, the lesser impact" intuition. In this study, we use the distance needed by a car to run from the main city of one region to the main city of another.

In order to have an appropriate interpretation, the line of the weight matrix is normalized by the sum of the given line.

Finally, the spatially lagged endogenous variable is computed by multiplying one of the weighted matrixes by the poverty rate variable. Then each element of the spatially lagged variable represents the weighted average of the neighboring regions poverty rate in the case of contiguity matrix. When using the distance matrix, each element of the spatially lagged variable is the weighted average of the poverty rate in the other regions by the inverse of their distance from the given region. If Pr denotes the poverty rate, and W the weight matrix, the spatially lagged variable is written as W*Pr.

Other independent variables have been added to the regression model as control variables. Indeed, the poverty rate in a given region not only depends on the geographical spillover but also on the per seconds characteristics of the region. Such characteristics could be related to the economy, demography, education, health, and public investment in the region. In each category, we choose only one available variable that can best summarize the effect of this category of variables; except for the education category where we have to take into account the difference between children and adults education. Table 1 provides the variable chosen in each category.

Due to lack of appropriate data, the public investment variable is dropped from the regression. Finally, the regression model writes:

$$\mathbf{Pr}_{it} = \alpha_{it} + \rho W_{it}\,\mathbf{Pr} + X_{it}\beta + \varepsilon_{it} \quad (1)$$

where I = 1 to R; t = 1 to T, with R been the number of regions and T the number of time observations.

$X_{it}$ contains the observations on the control variables for a given region i at time t.

The goal of this study is to estimate the parameter $\rho$ given the control variables and the transmission channel (type of weight matrix). Then we need a particular set of data which is going to be described subsequently.

## DATA AND SUMMARY STATISTICS

The estimation of the model specified above requires regional panel data. The use of panel data provides accurate estimate of the geographical spillover impact of poverty in Senegalese regions. In fact, the time dimension not only helps include the variation of such impact throughout the period, but also allow for normal asymptotic assumption. Since the 1994 currency devaluation has triggered major economic change in the country, and because of data availability, we choose to implement this study on the period from 1994 to 2006. In addition, we use the 10 available regions in 1994 although some changes occurred in 2002 with one additional region and in 2008 with three additional regions. Currently the country has 14 regions, but the results of this study are still applicable on the current regions because each new region comes from the split of a former big one.

All the data used in study have been acquired from "Agence Nationale de la Statistique et de la Démographie" of Senegal. Indeed, we use databases from three households' surveys namely "ESAM1", "ESAM2" and "ESPS 2005". The three households' surveys are national representative and provide information on households' consumption expenses, unemployment, and illiteracy. In addition, we use data from the censuses of 1988 and 2002 to get information on households' size. We also use some data sources provided on regular basis namely "Situation Economique et Sociale Régionale", National accounts, and price statistics. However, most of these data are provided at households' level. Specifically, the databases provide the poverty vector which assigns 1 to poor households and 0 to non-poor.

Then, we need to estimate data at regional level for the three households' surveys. An additional challenge is to estimate the poverty rate for all the years when the surveys do not take place. In fact, the three surveys were conducted respectively in 1994, 2002, and 2005 whereas we need regional panel data for the whole period from 1994 to 2006. As a consequence, we set up a method

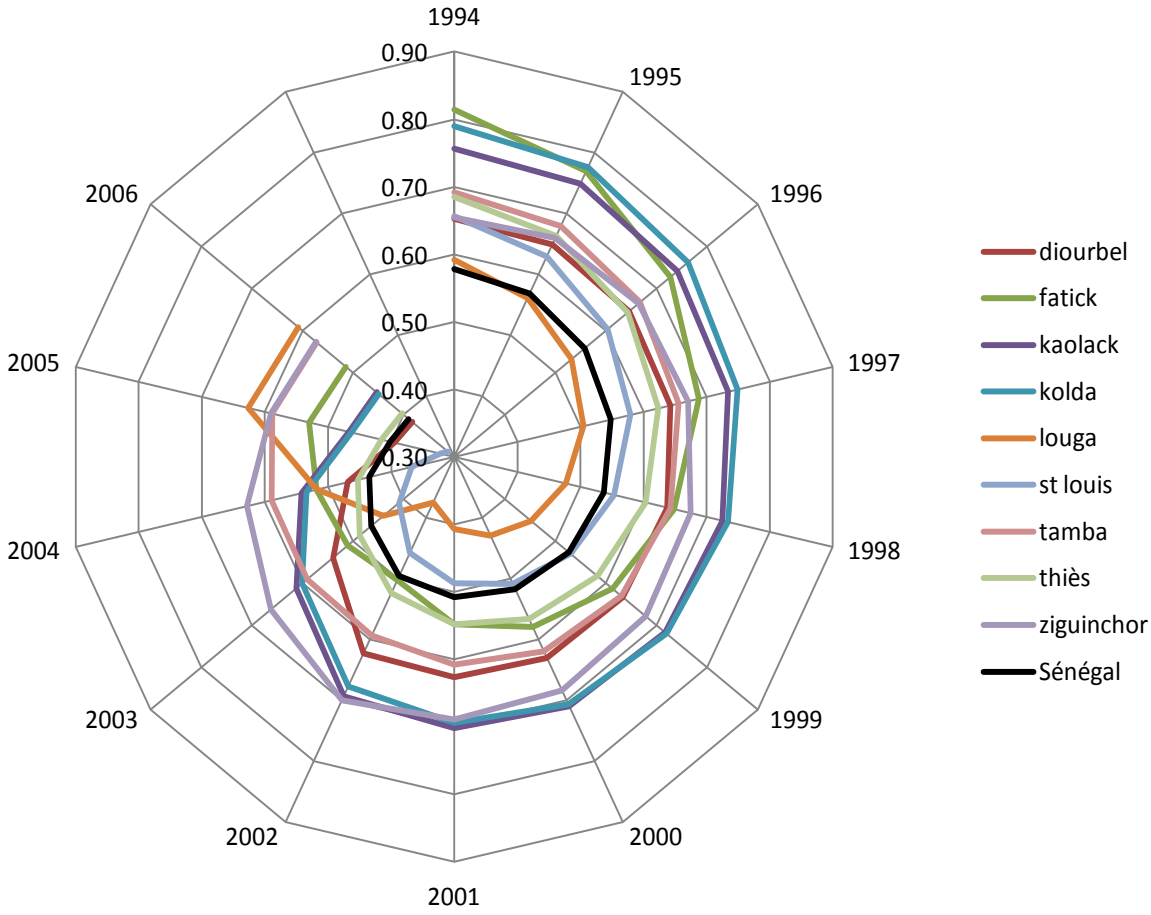


**Figure 1.** Evolution of regional poverty rate.

to estimate the regional poverty rate of the omitted years given the regional poverty rate provided by the three surveys. For the other variables, different classical methods of estimation have been used to assign values to the missing observations. The estimation of the regional poverty rate has followed two major steps. First, we established a formula for the annual growth rate of regional poverty rate. This formula is given as follow:

$$\tau_{it} = \frac{-\beta_{it}}{1+\eta_{it}} = -\frac{N_{it}}{N_{it-1}} * \beta_{it}$$

where $\beta_{it}$ is the growth rate of a poor adult equivalent consumption in the region i at time t; and $\eta_{it}$ is the growth of the population in region i at time from t-1 to t. The use of this formula appropriately, provides data throughout the whole period of study. However, these data need to be adjusted to the real observations since the first estimate from the formula is theoretical.

To adjust the theoretical estimation, we use an algorithm which computes first the regional poverty rate for missing year assuming that the evolution is linear between each survey year (1994, 2002 and 2005). Secondly, we compute the average of the theoretical data and the empirical data with the following iteration function:

Let $Pr_{it}(j)$ denotes the poverty rate computed at the $j^{th}$ iteration so that when j = 0, it equals the first theoretical poverty rate computed with the growth rate. Let $Pr_{it}$ denotes the empirical poverty rate computed for a given region i at time t. The general iteration formula writes:

$pr_{it}(0) = (1 + \tau_{it})* pr_{it-1}(0)$ , i = 1 to 10 and t = 1 to t.

$pr_{it}(j) = mean\ (pr_{it}(j-1)\ ;\ pr_{it})\ ;\ j = 1$ à j.

where J denotes the maximum number of iterations needed to adjust the theoretical data. For this study, we use 4 iterations to adjust the theoretical regional poverty rate.

Indeed, this study requires the use of regional macro data. However, this type of data is not directly provided by the available databases. Instead, we use the available micro data from surveys to estimate regional macro data. This method may be believed to affect the final results. However it is quite similar to all the complex methodology used to estimate usual statistical indicator such as GDP, inflation rate, etc.

Before getting to the modeling, the following descriptive statistics are provided. Figure 1 illustrates the evolution of the poverty rate in each region from 1994 to 2006.

Overall, poverty rate have been decreasing in all Senegalese regions from 1994 to 2006. The most important rate of decreasing has occur from 2002 and results in halving the poverty rate in many regions by 2006. However, two regions have followed particular path in terms of poverty rate evolution. Indeed, Diourbel which was the fourth poorest region just before 2002 has become the third less poor region after Saint-Louis and Dakar in 2006. In fact, its poverty

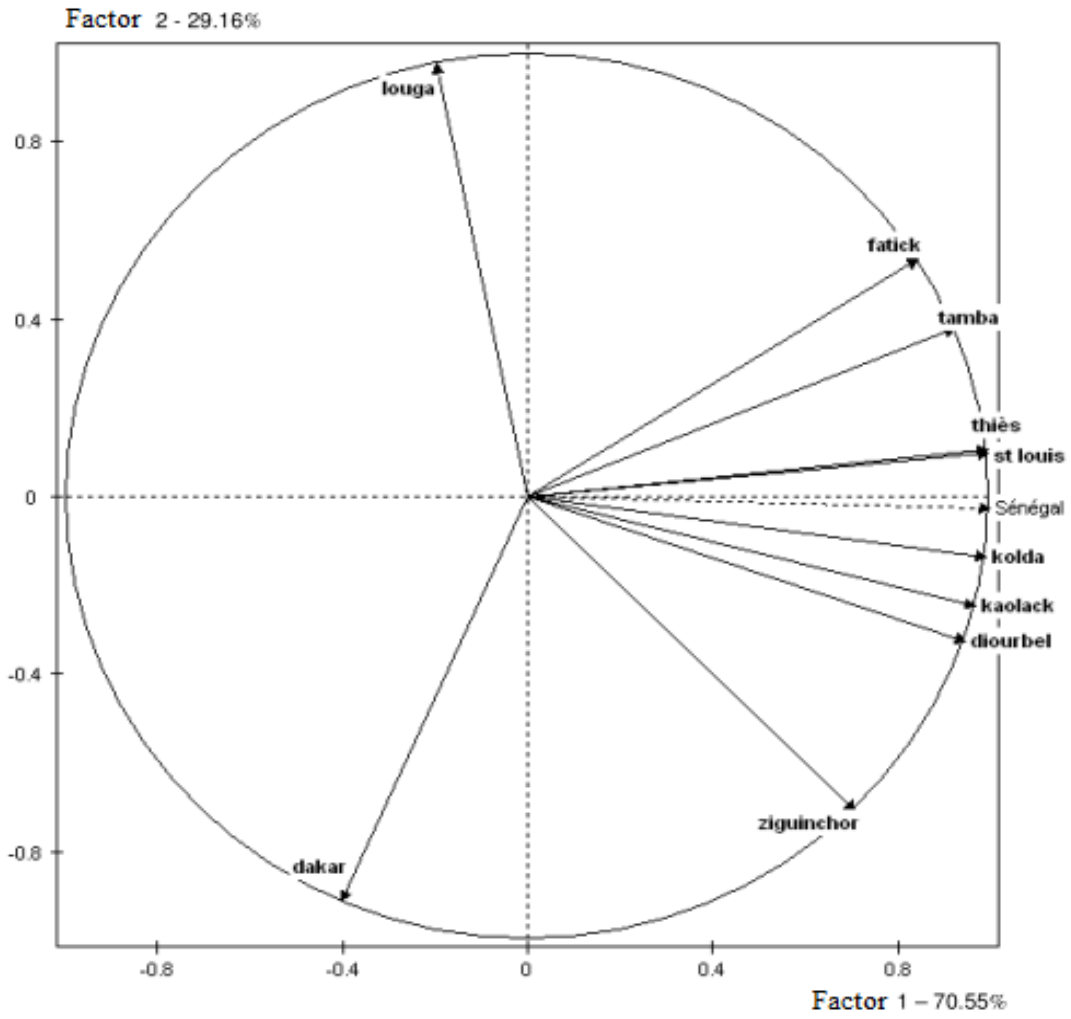


**Figure 2.** Correlation between regional poverty rate evolutions.

rate fell from 0.62 in 2002 to 0.39 in 2006. In contrast to Diourbel, the region of Louga which was the second less poor region just before 2002 with 0.37% has become poorest region in 2006 with 0.61% of poverty rate.

These two aberration can be explained by on one hand the huge investment in roads and buildings which has been implemented in Diourbel since 2002. On the other hand, the downturn of peanut agriculture due to the drought, and the counter-season rain occurred in 2002 which destroyed a major part of the cattle, and the decreasing of emigrants remittances are the major causes of this sudden increase of the poverty rate in Louga.

Figure 1 exclude the evolution of poverty rate in Dakar because of it is atypical. In fact, the poverty rate has remained very low during the overall period of study. Its value was within 0.2 and 0.25. Then including it could hide the evolution in the other region because of a scale problem.

Figure 2 shows the correlation between regions in terms of poverty rate evolution. Except from Louga and Dakar, the evolution of poverty rate in the other regions are positively correlated. Specifically, Thiès and Saint-Louis are in the centre of this correlation sphere such that they drive equally the evolution of poverty rate in the other regions. Then, a decrease of poverty rate in one of these regions is likely to trigger a decrease in the other regions. The econometric modelling will help to know the average value of the impact of that decrease.

However, the evolution of poverty rate in Dakar has shown to be negatively correlated to the evolution in all the other regions. Then a decrease of poverty rate in Dakar is likely to provoke an increase of poverty rate in the other region especially in Louga and Fatick.

## RESULTS

For reminders, the econometrics strategy consist of using the poverty rate as dependent variable, the spatially lagged endogenous variable as primary independent variable and five others variables as control ones. We use regional panel data and firstly specify the model with the whole sample including Dakar and secondly exclude Dakar in the next specification. This is due to the fact that Dakar is an extreme region with regard to the others regions. Then estimating a model with a sample including Dakar may lead to some misinterpretation and even

**Table 2.** Spatial econometrics estimation results.

| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **Sample** | **Whole regions with Dakar** | | | | **Whole regions without Dakar** | | | |
| **Estimator** | **OLS** | | Within | | **OLS** | | **Within** | |
| **Weight matrix** | **Border** | **Distance** | Border | **Distance** | **Border** | Distance | **Border** | **Distance** |
| $\rho$ | 0.08 | -0.26 | -0.62* | -0.34** | 0.01 | 0.53* | -0.52* | -0.12 |
| $lnUnr_{it}$ | -0.0005 | 0.003 | -0.01 | -0.007 | 0.02* | 0.02* | -0.01 | 0.001 |
| $lnLexp_{it}$ | -1.89* | -2.19* | -5.65* | -3.85* | -1.33* | -0.94* | -7.22* | -5.89* |
| $lnIr_{it}$ | 0.53* | 0.51* | 0.01 | -0.19 | -0.65* | -0.68* | -0.08 | -0.31 |
| $lnHs_{it}$ | 0.04 | 0.1 | -0.59* | -0.72* | -0.79* | -0.47* | -0.49* | -0.58* |
| $lnPrimeduc_{it}$ | -0.15* | -0.2* | -0.1 | -0.18 | -0.21* | -0.12* | -0.0005* | 0.005 |
| Intercept | 7.75* | 9.32* | 23.35* | 16.81* | 7.23* | 4.93* | 28.9* | 24.03* |
| $\alpha_i$ | | | * | * | | | * | * |
| $R^2$ | 0.40 | 0.40 | 0.64 | 0.58 | 0.62 | 0.67 | 0.70 | 0.65 |
| F-stat | 13.82 | 14.1 | 34.83 | 26.28 | 30.62 | 37.43 | 40.26 | 32.6 |
| P-value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

* and ** correspond to significant at 5 and 10%, respectively.

inaccurate results. In order to avoid this misleading effect of Dakar, we introduce regions' specific effect in the model obtained in a within estimate of the coefficients. By doing so, we capture any extreme variation in regions' poverty rates, and this method corrects the problem of Dakar effect when the whole sample including Dakar is used for estimation.

The coefficient $\rho$ in Table 2 denotes polarization coefficient. It provides the average impact of 1% variation of the poverty rate in neighboring regions. When using the whole sample, it is reasonable to include specific effects to control the variation of poverty rate in Dakar. As consequence, we use the within estimation of panel data regression (Models 3 and 4) since the Haussman test concludes that the specificities are fix effects. In addition, both Models 3 and 4 provide for the same variables the same significance. Their results only vary on R-square and the magnitude of the independent variables. As Model 3 has higher R-square (0.64) than Model 4, then the inclusion of contiguity matrix seems to explain more of the variation of regional poverty rate. As consequence, Model 3 estimated with fix effects, and the contiguity matrix is the best to explain regional poverty rate when considering the whole sample including Dakar. Besides, as Dakar is an extreme case in this study, the results of Model 3 which includes Dakar in the estimation more apply to Dakar than the other regions. Then, we are going to interpret the estimates as the impact of poverty rate in the other regions on poverty rate in Dakar.

When excluding Dakar from the sample, the descriptive statistics pointed out some similarities between the other regions except Dakar. Then it is better not to include region specificities in the model, and so we can just restrict the modeling to Models 5 and 6 when excluding Dakar in the regression sample. However, using distance based weight matrix yields significant polarization coefficient and higher R-square conversely to the results provided by the contiguity matrix. As consequence, we use Model 6 estimated with GLS, with the distance based matrix and without Dakar.

## Relationship between Dakar and the other regions in terms of poverty alleviation

The results of model 3 can allow drawing some conclusions on the relationship between Dakar and the other regions in terms of poverty alleviation in Senegalese regions. As we stated earlier, these results cannot well apply to the other regions because Dakar is an extreme case and is likely to shape the outcomes of the econometrics regression. According to Table 2 (Model 3), the geographical spillover has a significant impact on the poverty rate in Dakar. The magnitude of the geographical spillover (polarization coefficient) is such that a decrease of 0.62% of poverty rate in Dakar is done by accepting an increase of 1% of poverty rate in the other regions. In fact, this way of interpreting may be confusing. However, the geographical position of Dakar with respect to the other regions and the fact of using the contiguity matrix help understand the rationale behind this interpretation. Indeed, Dakar seems to be isolated from the rest of Senegalese regions and the sole link is done by the border between Dakar and Thiès. Then the transmission channel of spatial polarization is the border in this case; in other words, the direction of the causality is from Dakar to the other regions through the existence of border between Dakar and the others regions.

The relation found between Dakar and the other regions means that any further reduction of poverty in Dakar

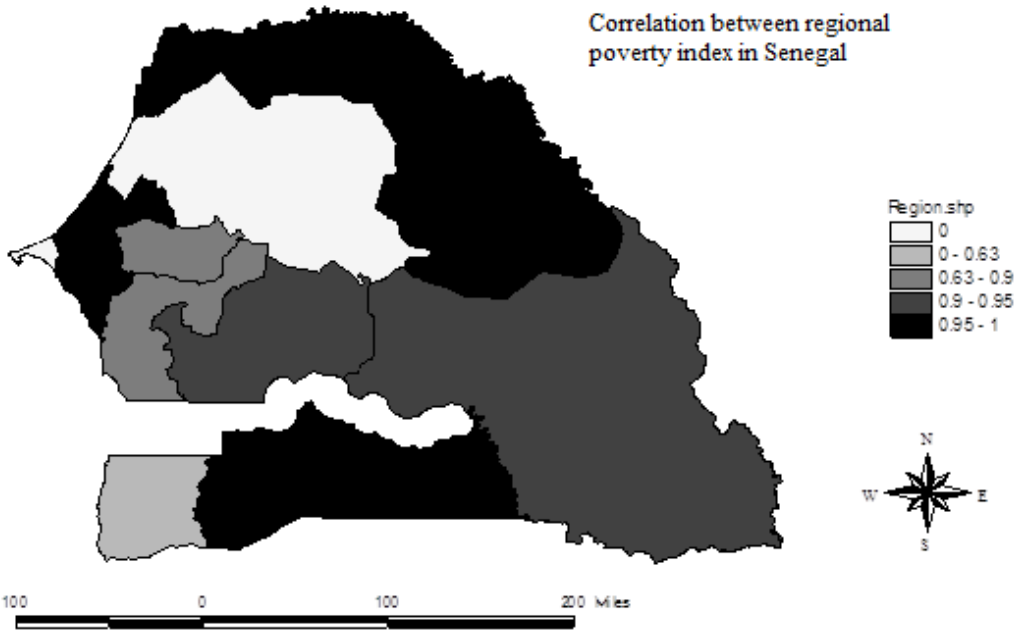


**Figure 3**. Source: Own computations. The dark color, the more important is the impact on the region.

cannot be done without leaving out the poverty rate to increase in the other regions. In fact, the allocation of financial resources and businesses are concentrated in Dakar such that the capital is more attractive than the other regions. Meanwhile, ecosystem destruction, drought and counter-season rains make life in rural areas harder and harder. As consequence, many young have migrated from the rural areas (which are the major part of the other regions) to Dakar and contribute to impoverish the other regions. This could be a possible explanation to the negative correlation between poverty rates evolution in Dakar and the other regions of Senegal. In addition, better healthcare system is predicted to decrease poverty rate in Dakar.

## Relationship within the other regions in terms of poverty alleviation

From the results of Model 6, we can infer about the relationship within the other regions[3]. Within the other regions, the transmission channels are the inter-regional roads which link the other regions pair wise. In fact, due to these roads, a decrease in 1% of the poverty rate in a given regions is predicted to decrease the poverty rate by 0.53% in the remaining regions. The underlying process behind this relationship within the other regions is mainly due to migration between the regions and exchange of goods. The reduction of unemployment rate in a given region through entrepreneurship program for young and women is likely to provide more income to households in that region. Afterwards, these households can afford buying goods and services from the nearest regions where they are available. This will also increase the income of the households in the latter regions; then they are likely to increase their consumption in return and escape the poverty line.

Given the correlation between the evolution of poverty rate in the other regions, we stated earlier that Thiès and Saint-louis are in the middle of this correlation such that all the others regions are correlated with them. In addition, when we take into account the geographical position of these two regions, Thiès is central region and a gateway for all Senegalese regions including Dakar. In fact, all the inter-regional roads cross at Thiès such that when travelling by roads from Dakar you are obliged to cross Thiès in order to get into the other regions and inversely. Now if we consider the impact of a reduction in one percent of poverty rate in Thiès, it is more likely to have a bigger impact not only in terms of magnitude but also in terms of number of regions affected. As consequence, Thiès happens to be the most driven region in terms of poverty alleviation in Senegalese regions. The following Figure 3 provides an illustration of the different regions could be affected after a reduction of poverty in Thiès.

## Conclusion

The outcomes of this study can be given in three main ideas. First, the reduction of poverty in Dakar cannot be done without letting the poverty rate rise in the other

[3] Except explicitly mentioned, « other regions » is put for all Senegalese regions except Dakar.

regions; then more equal resources allocation need to be done between Dakar and the others regions in order to ensure well-balanced alleviation of poverty in Senegalese regions. The more we focus on Dakar, the more unemployment rate we create in Dakar and the more poverty rate rise in the other regions.

Secondly, instead of focusing simultaneously the reduction efforts in all the other regions, it is better to pay more attention to Thiès because of the geographical spillovers that result from a reduction of poverty rate in that region. By doing so, Thiès is likely to be in the current position of Dakar including the other regions. However, in that case, the benefits in terms of poverty reduction for the other regions are more important.

Finally, a better health care system through the reduction of child mortality, a better education system through the enrollment of more children to school and a lower unemployment rate are the key levers for poverty alleviation in Senegalese regions.

This study may suffer from variables estimation and the fact that neighboring countries effects were not taken into account in the assessment of poverty rate in a given region. However, it might be interesting for further researches on the topic to look for the scope and the duration of the geographical spillover of poverty after a shock in a given region.

The analysis of poverty is generally made at the national and global level, from aggregate data. This approach is insufficient in terms of local development policies, especially when one focuses on the location of poverty and spatial differences in poverty at a more disaggregated level (in a country, region, etc.). This is particularly relevant in most countries (Lachaud, 1999a, b), there are strong spatial disparities between regions in terms of poverty and development, due to local conditions associated with each region (physical and environmental dimensions, demographic, socioeconomic, sociocultural).

It is therefore important in this perspective, to design a spatialized databases (GIS) on a disaggregated scale in order to visualize the spatial distribution of poverty and spatial inequalities between regions (Deichmann, 1999; Hentschel and Lanjouw, 1998).

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