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# Regional Employment Growth and Spatial Dependencies in Algeria

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**Abstract:** An analysis of the determinants of Algerian industrial employment growth in a framework that includes a spatial dependency effect reveals that there is no convergence process between the Algerian regions. Nonetheless, a convergence club gathering three wilayates appears when spatial heterogeneity of industrial employment growth is considered. Furthermore, our paper demonstrates that the hydrocarbon and the construction and public works sectors did not have externality effects on local industrial employment growth. Accordingly, Algerian public plans had some impact on unemployment, but mainly on informal unemployment through the support of the construction and public work sector.

**Keywords:** Bayesian, spatial, regional, growth, employment, Algeria

**JEL Classification:** 0 40, 0 18, C 11, C 31

## 1 Industrialization and Regional Growth: A Strategic Challenge for Algeria

Algeria opted in 1962 for a development strategy based on industrialization of the country. Indeed, industrialization had always been a political objective in Algeria. For instance, the 1976 National Act clearly identifies an industrial development strategy for Algeria: to support the industrial sectors, especially the chemical, steel and hydrocarbon industries, which are supposed to have external effects on other sectors, either agricultural or industrial, and to try to reduce the mass unemployment inherited from the colonial period. This development strategy had been financed with the oil rent that allowed a dramatic increase of investment in capital in the years following the independence of Algeria. The average investment rate was equal to 28.3% between 1970 and 1973 and even rose to 40.4% between 1973 and 1978,

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reaching a peak of 47.8% in 1978 when it was one of the highest rates of investment in the world (World Bank 2003, 12). In that perspective, Algeria embarked in the 1960s on an import-substitution strategy that led to the rapid development of a public manufacturing sector. From independence to the 1990s, the economy was under the control of state enterprises. Therefore, employment was mainly public and industrial. About 1,300 local public enterprises and 400 national companies accounted for about 80% of value added and 75% of employment in the manufacturing sector in 1993 (IMF 1998, 17). Moreover, public sector employment at the end of 1991 accounted for 70% of industry, more than half of construction and 30% of services (IMF 1998). Nevertheless, this Algerian development strategy had been a failure, at both the economic and the political levels.

Algeria suffered from a series of political troubles from 1988 to 1998, which certain observers described as a civil war. These events followed years of economic downturn which the country experienced in the 1980s after the oil price slump that caused a deterioration of Algeria's deficits and public debt. The Algerian authorities were then unable to continue sustaining the manufacturing public sector. Consequently, as was the case in many transition economies, by the 1980s, Algerian public enterprises were incurring major losses that caused a rise in industrial unemployment. During this period, Algeria benefited from two stabilization programs: a macroeconomic stabilization program from April 1994 to March 1995 and a structural adjustment program from April 1995 to March 1998. These programs were designed to revitalize the Algerian economy which was then experiencing a recession with huge unemployment, a large deficit on the balance of trade and high inflation. To achieve macroeconomic stabilization, the 1994 program relied on strong fiscal adjustment supported by tight monetary policy, exchange-rate adjustment (Adam and Cobham 2009) and a strict incomes policy. Algeria obtained a rescheduling of its external public debt at the Paris Club and of its external private debt at the London Club. Algeria obtained multilateral loans from international institutions, notably the World Bank and the IMF. It should be noted that these programs also aimed to revive Algeria's transition process from socialism to a market-oriented economy.

Indeed, the Algerian authorities committed to a new economic strategy whose objective was to liberalize the economy. The new reform strategy initiated in 1994 was geared toward the creation of an open, market-oriented, private sector-led economy in Algeria. At the end of the 1990s, this new strategy benefited from a favorable context because of two main changes. On the political side, and despite the continuing troubles, Algeria benefited from a more peaceful climate than in the 1990s. On the economical side, oil prices had been continuously rising from US $13 per barrel in June 1998 until US $60 in August 2005. Higher oil prices helped to achieve the objectives of the adjustment

program, by strengthening the fiscal and external accounts. These changes that Algeria experienced from 1998 to 2005 gave more flexibility and liberty to the government to conduct reforms. It is worth noting that these reforms did not only affect the national but also had an impact at the regional level.

In the new scheme, the revival of industrial employment would be caused by the emergence of a private sphere in regions known as *wilayates* which, since independence, correspond to administrative areas. In other words, reforms towards a market-oriented economy whose aim was to promote employment should respect the traditional Algerian industrial development strategy. Algeria's regional organization had evolved in several steps. During the first step, from 1962 to 1974, the Algerian authorities were mainly concerned about their control of the territory. In the second step, from 1974 to 1984, the administration aimed to reduce spatial disparities between wilayates. In 1984, the objective of the new territorial reform had been to give more coherence to the geographical distribution of the Algerian population. The current spatial organization results from this reform which led to 48 wilayates and 1,541 municipal authorities.

Even if the Algerian authorities did not initiate specific regional programs in the period studied, a descriptive analysis of the distribution in equipment spending between 1998 and 2007 reveals a clear differentiation in the spatial distribution of these public expenditures. In particular, during this period, Algeria launched an Economic Recovery Program (ERP) for 2001–2004. The aim of this program was to stimulate aggregate demand and to absorb high unemployment through public investment in infrastructure and support to agricultural production and to small and medium enterprises (Figure 1).

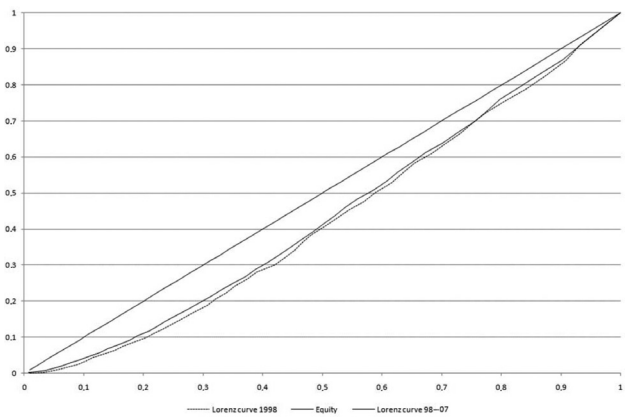


**Figure 1:** Lorenz curve of regional public equipment spending in Algeria (1998–2007).
Source: Calculated by the authors with data from the Algerian Ministry of Finance.

The Gini coefficient decreased from 0.15 in 1998 to 0.130 for the whole spending realized between 1998 and 2007. A more refined analysis of public infrastructure per wilaya and per capita from 1998 to 2007 (Table 1) reveals a high concentration of values per capita to the benefit of isolated and less developed regions mainly located in the South.

**Table 1:** Rank in social and economic infrastructure spending (1998–2007).

| Category | Wilaya | Absolute value | Value per capita | Industrial employment growth rate, 1998–2005 |
|---|---|---|---|---|
| Wilayat in the North covering 27% of total population | Algiers | 1 | 43 | 0.81 |
| | Oran | 2 | 26 | 0.18 |
| | Batna | 3 | 27 | 0.59 |
| | Sétif | 4 | 45 | 0.45 |
| | Tizi Ouzou | 5 | 33 | −0.06 |
| | Tlemcen | 6 | 20 | 0.42 |
| Wilayat in the South covering 3% of total population | Illizi | 46 | 1 | 0.49 |
| | Tindouf | 48 | 2 | −1.67 |
| | Tamanrasset | 38 | 3 | −0.51 |
| | El Bayyada | 40 | 4 | −0.37 |
| | Naâma | 47 | 5 | 0.04 |
| | Béchar | 39 | 6 | −1.07 |

Source: Calculated by the authors with data from the Algerian Ministry of Finance.

One of the challenges facing Algeria was thus to mitigate the inequalities between regions without abandoning its development strategy based on the industrialization of the country in accordance with the principles of market-oriented economies. This paper deals with this challenge through two questions. What are the determinants of regional industrial employment growth? Are there spatial dependencies between regions? The choice of the period studied – from 1998 to 2005 – is constrained by the availability of the data. The Algerian national bureau ("Office National des Statistiques", ONS) does not collect regional GDP. What we have at our disposal is regional industrial employment data which were collected in 1998 and 2005 by the Algerian national statistical bureau (ONS).

The response to the challenge will then be given in two parts. First, this paper studies the relation between industrial employment growth per capita in 48 Algerian regions and the geographical location of those regions in terms of their immediate neighborhood. The first regional observations highlight the regional heterogeneity, notably in terms of employment

per capita (cf. Figure 2). In some areas, regional employment growth is significant whereas other regions suffer from weak activity. Second, this paper examines the economic forces that explain industrial regional employment growth in Algeria in the period 1998–2005. In particular, one main issue is to determine if Algeria experienced regional convergence in terms of industrial employment per capita. The paper is organized as follows. Section 2 gives the theoretical framework. Section 3 presents the results derived from an econometric model including different spatial specifications. Section 4 examines if the interpretation of our results is modified when one makes the distinction between direct and indirect effects. Section 5 concludes and draws the lessons from the results as regards the development strategy Algeria followed in this period.

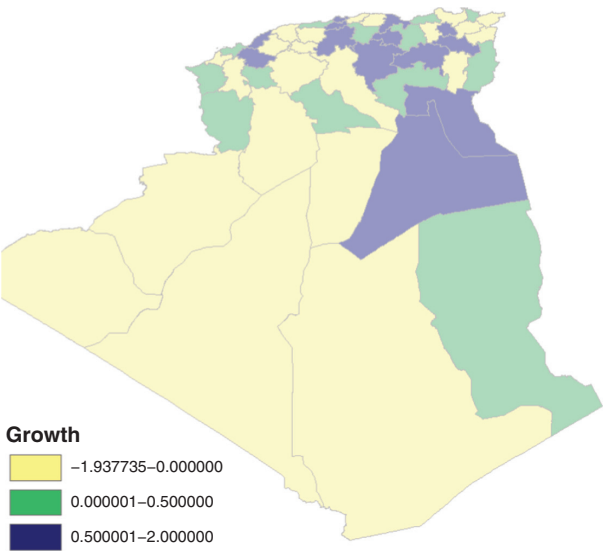


**Figure 2:** Industrial employment growth rate (1998–2005).

## 2 The Framework

Urban economics provides the economics of growth with two crucial insights: the "enormously strong connection between urbanization and income across space" (Glaeser and Gottlieb 2009, 1015) and "the dramatic connection between density and income" (Glaeser and Gottlieb 2009, 984). One interesting lesson that can be drawn from this literature is "that the transition to dense, urban living seems to be part of the process of countries becoming richer over time" (Glaeser and Gottlieb 2009, 1016).

Taking these insights in consideration, our approach is in line with Glaeser et al. (1992), Henderson, Kuncoro, Turner (1995) and Rappaport (1999a). Glaeser et al. (1992) highlighted the impact of the local industrial structure and of the induced technological externalities on employment growth. Henderson, Kuncoro, Turner (1995) find a strong convergence in local industrial employment from a specification close to that of Barro and Sala-i-Martin (1992) conditioned by the historical and current characteristics of local markets. Rappaport (1999b) suggests that population density offers a better natural metric to capture regional variations in productivity and life quality. Rappaport and Sachs (2003) explain the correlation between population density and proximity to the coast by the combined effect of productivity and of life quality. Those characteristics positively contribute to household utility (productivity through wage increases). Several studies, including Barro and Sala-i-Martin (1995), found a greater convergence between regions than between states. According to Glaeser, Scheinkman, Shleifer (1995), examining regional convergence presents two advantages. First, regions are open economies. There are no barriers to the mobility of capital, labor and ideas. Regions are economic units more specialized than states, which gives more sense to the study of regional rather than state convergence. Second, new growth theory insists on the diffusion of ideas. Glaeser et al. (1992) find strong evidence for the impact of technological externalities on the growth of regions in a country.

Our framework is inspired by Glaeser et al. (1992, 1995) and Henderson, Kuncoro, Turner (1995). We assume a simple production function. Regions are considered as separated economies composed of the same capital and labor market area. In other words, labor and capital markets are perfectly integrated. Regional GDP growth divergences can thus not arise from saving rate differences or from differences in the exogenous endowment of resources. Because of the assumption of perfect labor and capital mobility, regions can only diverge relatively to the productivity level and life quality.

The production function in a region $i$ at a period $t$ is

$$\begin{aligned} &Y_{it} = A_{it} f(l_{it}) = A_{it} {l_{it}}^{1-\alpha} \\ &0 \prec \alpha \prec 1 \\ &i = \overline{1,48} \\ &t = \{1998, 2005\} \end{aligned} \qquad [1]$$

$A_{it}$ represents the productivity level in the $i$ region at time $t$. According to Glaeser, Scheinkman, Shleifer (1995), $A$ is interpreted in a manner such that social, technological and political forces acting at the regional level determine

total productivity. Explanatory variables integrated in the model are considered as affecting $A_{it}$ seen as the efficient level or the effective level of technological growth (Henderson 2000). $\alpha$ is a parameter of national production. It is not specific to a region but affects all regions.

The lack of accurate data on regional GDP implies that we cannot directly estimate the production function. To resolve this issue, we use the method developed in Glaeser et al. (1992) and Henderson, Kuncoro, Turner (1995) who study urban growth through employment growth. The basic idea of this approach is that agglomeration economies improve productivity and cause a faster growth in productive regions. Following Rosenthal and Strange (2004), this approach allows us to indirectly evaluate Algerian regional dynamics through the study of employment growth per region. The main advantage is that data on regional industrial employment growth are available in Algeria in the period studied. Furthermore, those data are more in accordance with a linear specification.

Nevertheless, the a priori choice of the employment level is conditioned on the level and the kind of capital existing in the region. The choice of a sufficient period allowing significant variation in employment lowers the effect of regional fixed factors and strengthens the influence of dynamics induced by changes in the initial structure of investment and capital. The simultaneity between the employment growth effect and the regional employment structure effect may cause an endogeneity problem in the model specification. Indeed, employment growth in a region is sensitive to the regional composition of employment (an agglomeration effect). At the same time, it affects the level and the composition of employment. To take care of this problem, and following Glaeser et al. (1992) and Henderson, Kuncoro, Turner (1995), the method adopted in this paper is to take as regressors regional variables delayed relatively to the initial period. Rappaport (1999b) demonstrates that, when one examines adjustment dynamics resulting from specific regional shocks, working with the employment variable leads to similar results as using either the wage variable or the income variable. Glaeser, Scheinkman, Shleifer (1995) and Rappaport (1999b) show that income growth and population growth evolve in the same direction. Moreover, the population variable is usually very close to the employment variable (Glaeser 2000).

To consider a single input in this production function means that we cannot capture technological innovations induced by additional physical capital accumulation. In each region, the technological level, prices and wages are supposed to be perfectly known. If we assume the equilibrium condition, the maximization of the profit function is given by

$$A_{it}f(l_{it}) - w_{it}l_{it} \quad [2]$$

which implies

$$A_{it}f'(l_{it}) = w_{it} \quad [3]$$

Equation [3] can be rewritten as follows:

$$\log\frac{A_{i,t+1}}{A_{it}} = \log\frac{w_{i,t+1}}{w_{it}} - \log\frac{f'(l_{i,t+1})}{f'(l_{it})} \quad [4]$$

The local technological level $A$ is supposed to capture different regional technological externalities. The variable $A$, a key variable in our specification, measures the degree of local productivity, the technical knowledge of production, the advantages of local production and further particular characteristics linked to the $i$ region such as the method of organization and the local industrial structure.

We can look at $A$ as a function of all region-specific characteristics:

$$\log\frac{A_{i,t+1}}{A_{it}} = g_{it}\,(\text{Industrial structure, initial conditions and other variables}) \quad [5]$$

Rappaport (1999b) shows that the wage growth differential induced by productivity growth is partly balanced by the rise in land price due to the population density growth. Under those conditions, Glaeser (2000) explains that the wage growth variable could be utilized as a measure of local productivity growth. Yet, Rappaport (1999b) underlines that the difficulty of controlling for the local and inter-regional heterogeneity in labor and land supply makes the utilization of the variables land price and wages rather tedious. He then suggests the population density variable as a better metric to grasp productivity variations and life quality. From that perspective, in our estimation we propose to instrumentalize the wage variable by the population density per square kilometer:

$$\log\left(\frac{w_{i,t+1}}{w_{it}}\right) = h_{it}(\text{variation in the population density}) \quad [6]$$

Initial employment and labor mobility are included in the initial conditions. According to Blanchard and Katz (1992), differences in average employment growth rates between regions are due to immigration rather than to differences between birth growth rates. They find correlation coefficients of 0.84 and 0.91, respectively, for the periods 1950–1987 and 1970–1987 in the United States.

Combining eqs [4], [5] and [6] gives the following functional form:

$$\log\frac{l_{i,t+1}}{l_{it}} = cnst + \beta \times \text{population density} + g_i(\text{industrial structure, initial conditions and other variables}) + \varepsilon_i \quad [7]$$

Taking account of the dominant industrial structure highlights the kind of externalities in a region and how knowledge spills over industries. In Glaeser et al. (1992) terms, we can distinguish two kinds of technological externalities. One type is Marshall, Arrow and Romer (MAR) localization externalities, which are more auspicious to the accumulation of technological knowledge inside industries; and the second type is urban externalities (Jacobs 1969) which allow an accumulation of technological knowledge between industries. A highly specialized region is affected more by MAR externalities than a less-specialized region. The dominant industrial structure variable catches the impact of local technological externalities on the speed of regional employment growth.

# 3 Employment Regional Convergence and Spatial Dependencies

This section is organized around four points. First, we explain why the choice of an appropriate spatial specification has an influence on the interpretation of the growth process in a developing country. Second, we question if per capita employment growth in a region is related to the growth of neighboring regions. In particular, does this relation reveal a spatial dependency? Spatial autocorrelation means that the observation of a variable in a region is dependent on the observation in neighboring regions. Two elements are at the origin of this autocorrelation. The first comes from the way activities are spatially distributed (Odland 1988; Haining 2003). In economic geography, this distribution is conditioned by proximity, labor mobility and capital mobility. The second may derive from an erroneous model specification, like omitted variables which are spatially autocorrelated. Third, we will examine the impact of spatial dependency on regional convergence in Algeria. Fourth, we show that the introduction of spatial heterogeneity reveals a local convergence club around three wilayates located in the Center/East of Algeria.

## 3.1 Spatial Specifications and Growth Determinants

Several empirical studies in growth theory have integrated spatial effects into their specifications. Spatial dependency is often justified by externalities

between regions. Rey and Montouri (1999) show that factor mobility and payment transfers, used to explain regional convergence, have explicit geographical components. To ignore the spatial localization factors can lead to biased estimators and incomplete explanations. In order to correct for this issue, Armstrong (1995), Rey and Montouri (1999), and López-Bazo et al. (1999) propose assumptions in line with the economic geography literature and the theory of endogenous growth. Economic geography literature shows that interactions between economic agents lead to the spatial agglomeration of economic activities in a limited number of regions (Fujita, Krugman, Venables 1999). Externalities effects are supposed to be linked to the market size, the access to services, the intensity of economic relations between regions, technological diffusion and the institutional and political similarity between regions. Interactions between heterogeneous firms located in different regions lead to heterogeneous and interdependent regions.

Bernat (1996) and Rey and Montouri (1999) are among the first authors who explicitly included the spatial effect in growth econometric specifications. Bernat (1996) tested a simple version of Kaldor's laws for several North American states. Rey and Montouri (1999) tested the absolute $\beta$-convergence under spatial heterogeneity and spatial dependence. Those studies have been followed by several others (Fingleton and McCombie 1999; López-Bazo et al. 1999; Fingleton 1999). The suggested specifications include spatial dependence, either through spatial autocorrelation among errors or under a spatial model. The selection among those models is based on statistical criteria proposed in Anselin and Rey (1991) and Florax and Folmer (1992). Apart from the fact that externalities and interactions between regions are the main source of spatial dependencies, those studies have allowed for the incorporation of spatial effects in an ad hoc manner in empirical specifications. Fingleton and Lopez-Bazo (2006) conclude that the empirical evidence on a preferred specification seems to depend on regions and on the periods.

The choice of a correct spatial specification (substantive or nuisance) has alternative impacts on the interpretation of growth. Within a spatial autocorrelation model, Bernat (1996) explains that the growth of a region is affected by the growth of neighboring regions only through the extent of the difference (positive or negative) between the growth of neighboring regions and the average growth. In the spatial autoregressive model, growth in a region is directly affected by growth in neighboring regions. This effect is independent of the effect of exogenous variables. For a spatial autoregressive model, Rey and Montouri (1999) explain that the distance to the equilibrium growth path is not only a function of

shocks specific to the region but rather of a complex whole of shocks that spill over. Nevertheless, in a specification with an endogenous spatial lagged variable, the growth rate in a region may be linked to neighboring regions' growth rates after conditioning by the initial level of income.

One of the issues when dealing with spatial data is the "enclave effect." It means that a specific region may present a different behavior from the majority of spatial observations. This effect leads to a skewed distribution of errors following a Student law. Indeed, this phenomenon can be observed both through the non-constancy of the variance of the errors and through the presence of spatial outliers.

In the empirical literature, the presence of outliers affecting estimation in convergence models has been noticed in De Long and Summers (1991) and Temple (1998, 1999). The heteroskedasticity hypothesis seems to be more appropriate than the traditional Gauss–Markov hypothesis according to which the variance of the errors is constant in space. Geweke (1993), taking inspiration from Lange, Little, Taylor (1989), proposes a heteroskedastic linear Bayesian model. He shows that this way of modeling errors is similar to a model that assumes a Student distribution of errors. This approach has been extended to spatial models (Parent and LeSage 2007, 2010; LeSage 1997, 1999).

To take account of the enclave effect in our estimations, our model will utilize a heteroskedastic Bayesian approach. Heteroskedastic Bayesian models assume that the error variances are not constant. Those errors take the form $\varepsilon_i \rightarrow N(0, \sigma^2 V)$ where $V$ is a diagonal matrix containing parameters $(v_1 \quad v_2 \quad \cdots \quad v_n)$ to be estimated by the Markov chain Monte Carlo (MCMC) method and representing the size of variance differences. The terms $(v_1 \quad v_2 \quad \cdots \quad v_n)$ have the function of counterbalancing observations that present large variances. The a priori distribution of the $v_i$ terms takes the form of a distribution independent of $\chi(r)/r$. LeSage (1997) proposes, for the hyperparameter $r$, to choose a priori values evolving between 2 and 7 for all models. If data do not contain extreme values or non-constant variances, those values of $r$ produce relatively constant estimated $v_i$ or values close to 1.

## 3.2 The Impact of Per Capita Employment in Neighboring Regions

The first specification highlights the influence of spatial dependency (externality) without the introduction of the conditional effect of control variables. A first-order autoregressive model is given by the following system:

$$e_i = \rho \sum_{j=1}^{n} w_{ij} e_j + \varepsilon_i \, i = 1 \cdots n$$

where

$$e_i = \ln\left(\frac{l_{i,05}/N_{i,05}}{l_{i,98}/N_{i,98}}\right) \quad [8]$$

The matrix form is given by

$$(1 - \rho W)E = \varepsilon$$

$$\varepsilon_i \to N\left(0, \sigma^2 V\right)$$

$e_i$ is the (Napierian) logarithm of the per capita employment growth rate. $W$ is the contiguity matrix of size ($n \times n$). In that specification, the growth of industrial employment in a region $i$ depends on the weighted average of growth rates in neighboring regions.

Table 2 presents estimations for a normal distribution of errors with a constant variance and the results when we introduce the heteroskedastic effect on estimations ($r = 4$). Both approaches confirm the presence of a spatial dependency in the per capita industrial employment growth rate. There is an externality effect of 0.438 (heteroskedastic model, with contiguity matrix) or 0.446 (heteroskedastic model, with squared inverse distance matrix). These results show the scope of the effect of the weighted average growth rate of neighboring regions on a region $i$. An average growth rate of per capita employment of 1%, weighted by the proximity effect, in the neighboring regions is approximately associated with a growth rate of 0.438% (or 0.446%) in the

**Table 2:** Test of growth externalities (dependent variable: per capita employment growth rate).

| Dependence matrix | $W$ (first-order) contiguity matrix | | $W$ ($1/d^2$) matrix of inverse distances | |
|---|---|---|---|---|
| Parameters | Homoskedastic model $r = 100$ | Heteroskedastic model $r = 4$ | Homoskedastic model $r = 100$ | Heteroskedastic model $r = 4$ |
| $\rho$ | 0.4547 | 0.4379 | 0.4966 | 0.4462 |
| $p$-Level | 0.0125 | 0.0115 | 0.0266 | 0.0287 |
| $R^2$ | 0.1825 | 0.6490 | 0.1555 | 0.6349 |

$i$ region. On the whole, the contiguity matrix or the inverse squared-distance matrix gives the same results on the presence of a spatial dependency in the per capita growth rate of industrial employment.

Let us note that this specification does not give any information on the causes of observed externalities. It may reflect the effects of shocks due to a whole complex of factors specific to the Algerian regions: labor mobility, complementary industrial structures or similar education levels in nearby regions. Table 2 only shows that growth in a region is dependent on growth in the neighboring regions. In other words, regions with similar levels of per capita employment growth rates tend to gather in space.

Differences between the two approaches in the estimations of Table 2 are explained through the inclusion of robustness in the estimations. This robustness appears when we take account of the enclave effect in the observations. The presence of outliers is confirmed by strong values of $v_i$ estimated with a value of $r = 4$. For values $v_i > 3$, the extreme values correspond to two regions in the North – Algiers and Oran – and two southern regions (Illizi and Tindouf). These regions have extreme values in term of per capita industrial employment growth rates. This reflects the great dispersion between agglomerated regions where industrial activities are concentrated and low-populated regions where industries are more or less absent.

## 3.3 Spatial Dependency and Regional Convergence

In this section, we investigate if the regional behavior of growth that we found in the former section reflects a regional distribution of certain growth determinants. Accordingly, we estimate an econometric form more general than eq. [8]:

$$E = \text{const} + \rho WE + \beta \ln\left(\frac{l_{98}}{N_{98}}\right) + X\delta + \varepsilon$$

where [9]

$$E = (1 - \rho W)^{-1}\left(\text{const} + \beta \ln\left(\frac{l_{98}}{N_{98}}\right) + X\delta + \varepsilon\right)$$

$E$ is a $n \times 1$ vector, $W$ is the $n \times n$ contiguity matrix, $X$ the matrix of exogenous variables of a size $k \times 1$ and $\varepsilon \rightarrow N(0, \sigma^2 V)$. This specification assumes that employment growth in a region $i$ depends on the average growth rate in the neighboring regions, the initial level of per capita industrial employment and a range of exogenous variables in the $X$ matrix. This matrix introduces the conditionality factors in the regional convergence process. The parameter

$\beta$ measures the convergence speed between regions. When $\beta < 0$ and the elements of the $\delta$ vector are not significant, there is $\beta$-absolute convergence. When $\beta < 0$ and the elements of the $\delta$ vector are significant, there is $\beta$-conditional convergence.

Equation [9] highlights the externality effects in the growth rate of regions when one takes into account the effects of region-specific variables. It must be noted that normally the conditional variables would not be very different in contiguous regions. Accordingly, their introduction can be considered as a robustness test of the results obtained on externalities with eq. [8]. The lagged growth variable in eq. [8] can capture the effect of omitted but spatially correlated regional variables. In order to reduce the endogeneity effect, all data on conditional variables refer to the initial period, that is, 1998.

In eq. [10], the $Z$ matrix integrates factors which are at the sources of differences in growth rates between regions. This matrix may produce spatial autocorrelation in the errors. Externalities between regions can be expressed through spatial dependencies of the errors in the growth equations. We can thus re-write eq. [9] as follows:

$$E = (1 - \rho W)^{-1}(Zb + \varepsilon) = (1 - \rho W)^{-1}Zb + (1 - \rho W)^{-1}\varepsilon \qquad [10]$$

According to Anselin's (2003) classification, this structure may be associated with the presence of global externalities in the growth process. Growth in each region is influenced by initial employment, by conditional variables and by the scope of the position of the region in the regional system. The intensity of this influence is inversely related to the distance between regions. This is represented in the second term of eq. [10], which is the product of the $Z$ matrix and the inverse of the spatial transformation $(1 - \rho W)$. Moreover, growth in each region is affected by random internal shocks and by shocks coming from the rest of the regional system integrated in $(1 - \rho W)^{-1}\varepsilon$ and whose effect decreases with distance. Model [10] sets an important constraint on the structure of spatial externalities so that the spatial diffusion channel is identical in $Z$ and $\varepsilon$.

Table 3 (columns 1 and 3) presents a synthesis of the results obtained for the estimation of eq. [9] with externalities between Algerian regions. The first column shows that growth in per capita employment is not inversely correlated to initial per capita employment. This result shows that there is no convergence toward the equilibrium growth path. This is contrary to what the neo-classical growth theory predicts. Applying the matrix of the squared distance (column 3) does not change the results obtained with the weighting of the contiguity matrix. Spatial dependency remains significant and the convergence parameter does not change.

**Table 3:** Test of growth externalities conditioned by exogenous variables, β-convergence and conditional variable effects test (dependent variable: per capita employment growth rate).

| | ***W*** **(first-order) weighted contiguity matrix** | ***W*** **$(1/d^2)$inverse distances matrix** |
|---|---|---|
| Constant | −8.214871*** | −8.299107*** |
| Log per capita initial employment | 0.370065** | 0.359018** |
| Industrial concentration index | 0.323425** | 0.364423** |
| Hydrocarbon and BP concentration index | 0.023542 | −0.012336 |
| Variation in population density | 0.136992*** | 0.147988*** |
| Labor mobility | −2.348945*** | −2.043922*** |
| AEP | 1.941121** | 1.568971** |
| Education | 3.458271 | 4.606444 |
| $\rho$ | 0.441875 | 0.561723 |
| $p$-Level | 0.010586 | 0.028343 |
| $R^2$ | 0.2126 | 0.2849 |
| Moran's-$I$ statistic | 2.84639540 | 3.16486828 |
| $p$-Level of Moran's-$I$ statistic | 0.00442 | 0.00155153 |

Note: *, ** and ***, respectively, denote significance at the 10%, 5% and 1% probability levels.

The conditional variables in the specification (columns 2 and 4) control the factors that govern divergences in regional growth paths. The significant character of $\beta$ and of the parameters associated with the rest of the exogenous variables highlights the conditional $\beta$-convergence. Considering conditional variables does not make a great difference to the impact of initial employment on per capita regional employment growth. The heteroskedastic method ($r = 4$) takes the spatial heterogeneity in observations into account; with this method, estimators are more robust to differences in variances. Calculations of estimators are based on observations weighted by variances.

The results in Table 3 (columns 2 and 4) are extended to include conditional variables. In both cases, results are obtained by implementing the contiguity matrix and the squared inverse distance matrix. The coefficient $\rho$ which measures the scope of externalities is significantly different from zero in all cases. Compared to the first-order autoregressive model [8], the inclusion of conditional variables does not reduce the magnitude of externalities. Considering exogenous variables improves the significant aspect of the externality effect. This shows that there is a stronger spillover effect after the introduction of those variables. The reduction of $\rho$ suggests, in the case of the absolute models in Table 3 (columns 1 and 3), that the lack of a global convergence process between Algerian regions lowers the dependence on the variable per capita industrial employment growth. Our estimation

indicates that, on average, industrial employment growth in regions gains from growth in neighboring regions in the order of 0.43% (in the case of the contiguity matrix) to 0.47% (in the case of the inverse squared distance matrix). It must be noted that the addition of conditional variables does not change the robustness of the estimation of $\rho$.

The degree of concentration of past industrial activity – measured through the ratio of the share of industrial employment in a region to the share of industrial employment at the national level – affects industrial employment growth positively. The coefficient of this variable is significant to an order inferior to 5%. On the contrary, past activity in the hydrocarbon sector and in the construction industry and public works (BP) does not significantly influence per capita regional employment growth. According to these estimations, it seems that benefits from past industrial activity have an impact on regional economic activity. The hydrocarbon sector, so crucial for the Algerian economy, does not seem to have a significant impact on industrial regional growth. The concentration of past activity creates an attractive environment for potential investors. Thus, localization externalities or MAR externalities have a positive impact on per capita regional employment growth. According to our estimation, a rise of 1% in the level of past industrial concentration in a region raises per capita industrial employment growth to an order of 0.32–0.35%.

Variation in population density has a positive coefficient and is statistically significant. Recent studies admit the strength of the link between the density of firms and population density. High spatial density improves the production and transmission of ideas. This creates an environment that stimulates innovation and growth. Jaffe, Trajtenberg, Henderson (1993) find that the distance to the source of ideas influences the communication of new ideas. In the same vein, a high spatial concentration of population and firms facilitates the transmission of those ideas that lead to product and organizational innovations. Rappaport (1999b) and Glaeser (2000) consider the population density as the best indicator of productivity growth and of life quality. According to Rappaport (1999b), the problem is that population density does not allow to distinguish between life quality and productivity growth. In a certain sense, the distinction is less important in a regional analysis since both measures contribute positively to utility (directly for life quality and via high wages for productivity). As life quality is a normal good, that is, its demand increases with income, individuals living in less developed countries give a low value to the attributes of life quality relatively to developed countries.[1]

1 According to Blanchard and Katz (1992), employment increases and decreases at a rate whose value and sign depends on two situations. In employment-attractive regions, employment supply is positive; the labor influx leads to a decrease of wages. That attracts new firms and

The effect of inter-regional mobility and of education is not significant. The variable AEP (share of households connected to the drinking water network) measures the public effort in a region. This variable is significant and has a positive impact on the regional growth of industrial employment.

## 3.4 Spatial Heterogeneity of Regional Employment Growth

Spatial heterogeneity leads to a spatial instability of the parameters in the regression: models are not stationary in space and parameters vary systematically with localization. This instability gives rise to an absence of stability of behavior and economic relationships over space. Functional forms and parameters vary in relation with their localizations and, consequently, are not homogeneous. To adapt spatial dependency and heterogeneity, we introduce a Bayesian spatial autoregressive local estimation (BSALE) approach in eq. [11] that produces estimations for $n$ models according to the following framework:

$$\begin{aligned} U(i)y &= \rho_i U(i)Wy + U(i)X\beta_i + U(i)\varepsilon \\ \mathrm{diag}U(i) &= \left(\left(1 - d_i^j / d_i^m\right)^3\right)^3 I_{\left(d_i^j \prec d_i^m\right)} \\ U(i)\varepsilon &\sim N\left(0, \sigma^2 U(i)V\right) \\ V &= \mathrm{diag}(v_1, v_2, \ldots, v_n) \end{aligned} \qquad [11]$$

With $d_i^j$ the distance between region $i$ and region $j$, $d_i^m$ the distance between the $m$ closest region of region $i$. $U$ is the relative distance weight matrix corresponding to region $i$. When $m \to n, U(i) \to I_n$ and $m$ is chosen so that $\frac{1}{4}n \leq m \leq \frac{3}{4}n$. The results obtained for the parameter $\beta$-convergence are presented in Figure 3.

The results change when one considers differences in a space that presents heterogeneous structures. The lack of convergence that we have found in the global model is not a general situation for all regions considered in our sample. Local convergence appears in three regions located in the East-Center of the country and corresponding to three wilayates: Bordj-Bou-Arreridj, M'Sila and Biskra. These three regions seem to constitute a convergence club in Algeria. A global spatial autoregressive model (SAR) does not display this differentiation

thus sustains employment growth. In regions characterized by highly attractive firms, labor demand is positive and the new firm influx causes a rise in wages. That stimulates labor influx and thus sustains employment growth.

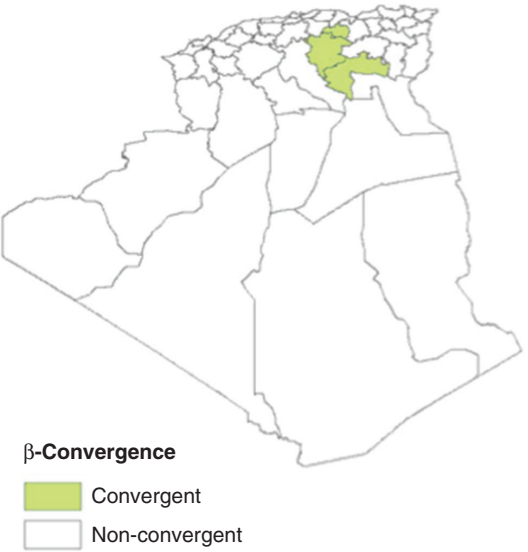


**Figure 3:** Regional convergence in Algeria when spatial heterogeneity is included.

between these three regions and the rest of Algeria's wilayates. The BSALE model provides additional information on local convergence in Algeria's regional industrial employment growth. Results obtained via the BSALE model suggest that regional convergence in Algeria is concentrated in a specific space.

## 4 On Direct and Indirect Effects

An empirical implication of our spatial autoregressive model is that calculation of the effect of explanatory variable $r$ from region $j$ on employment growth in region $I$, $\left(\delta y_i / \delta x_{jr}\right)$ will differ from conventional non-spatial regression models. As mentioned by LeSage and Pace (2009), in models with spatial lags of explanatory or dependent variables, interpretation of parameters becomes richer and more complicated. Spatial regression models expand the information set to include information from neighboring regions/observations. In the previous sections, the standard interpretation of the regression coefficients as partial derivatives does not take into account the possible effect of explanatory variable changes in a given region on other regions through the matrix inverse. As mentioned by Elhorst (2010), two effects can be distinguished when a particular explanatory variable in a particular unit changes: on the one hand, a direct effect when the dependent variable in that unit itself changes and, on the other

hand, an indirect effect when the dependent variable in other units changes. Direct and indirect effects are different because both diagonal and non-diagonal elements of the inverse matrix are different. In the SAR model, in contrary with the spatial durbin model (SDM) model, indirect effects that occur if $\rho \neq 0$ are known as global effects. The geographical scope can be addressed by using the structure of the impact estimates to provide a spatial profile of the direct, indirect and total impacts (cf. Table 4).

The interpretation of our results is derived from Table 3 which is derived from the new estimation method. Table 4 indicates that direct effects are significant whereas indirect and total effects are not significant. At the 5% level, direct effects are significant for all variables of the model. At the 1% level, the variation intervals of coefficient variables "log per capita initial employment" and "industrial concentration index" contain the value 0. In other words, the probability that these parameters are different from 0 is not conclusive.

# 5 Conclusion

The dramatic political events that Algeria experienced in the period often qualified as the "black decade" (1988–1998) made urgent a series of economic reforms. The political troubles were explained by the socioeconomic conditions which were notably characterized by mass unemployment. Indeed, in the 1980s, the failure of Algerian industrial development strategy generated very high industrial unemployment. The Algerian authorities then restructured their economic strategy. They tried to promote private investment and to counterbalance inequalities between regions in order to reduce unemployment. Our analysis of the determinants of industrial employment growth in a framework that includes a spatial dependency effect has led us to the following results which question the efficiency of Algeria's economic policy during the period studied.

We found a substantial spillover effect on growth with different specifications. The specification uniquely based on per capita employment growth (without exogenous control variables) shows a strong spatial dependency between the regions. This specification is in our view crucial since the inclusion of conditional variables in the standard specification does not reduce the spillover effect on the regions. The analysis of the Moran graph confirms that the spatial autocorrelation is obvious. The Moran-*I* test indicates a high significance of spatial dependency. Despite this spatial dependency effect, our results demonstrate that there is no convergence process between the Algerian regions. In

**Table 4:** Direct, indirect and total effects estimates (*W*).

| Variable | Lower 0.1 | Lower 0.5 | Mean | Upper 0.95 | Upper 0.99 | Standard deviation | *p*-Level |
|---|---|---|---|---|---|---|---|
| **Direct effect** | | | | | | | |
| Log per capita initial employment | −0.0691 | 0.0482 | 0.3946 | 0.7491 | 0.8802 | 0.17509778 | 0.028826 |
| Industrial concentration index | −0.0775 | 0.0355 | 0.3450 | 0.6429 | 0.7468 | 0.15420345 | 0.029945 |
| Variation in population density | 0.0187 | 0.0519 | 0.1461 | 0.2339 | 0.2726 | 0.04751461 | 0.003470 |
| Labor mobility | −4.686940 | −4.087117 | −2.504959 | −0.821585 | −0.199658 | 0.82025564 | 0.003679 |
| AEP | −0.405700 | 0.251632 | 2.070150 | 3.784624 | 4.396409 | 0.89536765 | 0.025109 |
| **Indirect effect** | | | | | | | |
| Log per capita initial employment | −0.061715 | 0.001855 | 0.354590 | 1.259877 | 2.174704 | 0.40361327 | 0.384028 |
| Industrial concentration index | −0.059600 | −0.000240 | 0.311745 | 1.110639 | 1.394353 | 0.35503191 | 0.384277 |
| Variation in population density | −0.008443 | 0.007247 | 0.131998 | 0.441946 | 0.753150 | 0.14001542 | 0.350535 |
| Labor mobility | −12.595004 | −7.530483 | −2.252054 | −0.107913 | 0.159354 | 2.38281074 | 0.349329 |
| AEP | −0.351450 | 0.006952 | 1.863127 | 6.496076 | 11.305395 | 2.14666247 | 0.389758 |
| **Total effect** | | | | | | | |
| Log per capita initial employment | −0.122920 | 0.079194 | 0.749214 | 1.896029 | 2.877683 | 0.51756096 | 0.154233 |
| Industrial concentration index | −0.130957 | 0.058030 | 0.656770 | 1.664932 | 2.541014 | 0.45646432 | 0.156691 |
| Variation in population density | 0.029555 | 0.078106 | 0.278138 | 0.651062 | 0.988410 | 0.16915756 | 0.106658 |
| Labor mobility | −16.579669 | −11.06474 | −4.757013 | −1.271947 | −0.324433 | 2.87922713 | 0.105025 |
| AEP | −0.743445 | 0.410892 | 3.933277 | 9.752896 | 14.862138 | 2.719033 | 0.154516 |

other words, "rich" Algerian regions stay rich whereas relatively poor regions stay poor. This also means that a rise in density does not necessarily go along with a process of regions becoming richer over time. Nonetheless, the significance of the spatial dependence coefficient may reveal that there are convergence clubs in Algeria. Indeed, a convergence club gathering the wilayates of Bordj-Bou-Arreridj, M'Sila and Biskra appears when spatial heterogeneity of industrial employment growth is considered.

Given these results, one can conclude that the infrastructure policy that tried to reduce spatial inequalities since 1998 did not have an effect on industrial employment. Growth dynamics in Algeria are not equitably distributed. The decrease of the Gini coefficient of regional public expenditures had no impact on the spatial dispersion of industrial employment growth in Algerian regions. This budgetary effort does not seem to have had the expected results in terms of industrial employment growth. Indeed, the spatial distribution of employment growth in the industrial sector does not mirror the spatial distribution of public investment in infrastructure. In particular, the 2001–2004 economic recovery program (PRSE) did not result in a more balanced regional growth of industrial employment. An industrial strategy should also consider regional realities and the spatial relationships between the wilayates. However, the regional development strategy that is currently under discussion in Algeria (SNAT 2008) does not consider as fundamental the industrial challenges. Only three lines are devoted to industry in the whole report.

Nevertheless, one should admit that, during this period, the national unemployment rate decreased from 27.6% in 1998 to 15.3% in 2005.[2] Our results help to explain this apparent contradiction: a decrease of the unemployment rate at the same time as a decline of the share of the industrial sector in the Algerian GDP. The reduction of Algeria's national unemployment rate is mainly due to an increase of employment in the agriculture and construction and public works sectors. Indeed, between 1994–1999 and 2000–2004, average annual employment growth increased mainly in agriculture and construction and public works, which were among the sectors that benefited most from government investment in the Economic Recovery Program (IMF 2006, 27). Although the share of construction and public works in employment is stable, employment in that sector has grown steadily since 2000, with the increase ranging from 3% in 2001 to 8% in 2004, mainly because of the increase in government capital spending (IMF 2007, 19). Now, our paper demonstrates that the hydrocarbon and the construction and public work sectors do not have externality effects on the dynamics of the local economy, particularly on local industrial employment

2 Source: ONS Data. See also IMF Selected Issues (2007).

growth. This result has two implications. First, the hydrocarbon sector in Algeria does not have an influence on regional growth dynamics. Second, Algeria's economic policy based on a strategy where the authorities developed their public expenditure programs did not benefit the rest of the economy. Algerian public plans had an impact on unemployment, but mainly on informal unemployment through the support of the construction and public work sector, but did not exert positive externalities on industrial employment dynamics. According to the Algerian national bureau, the share of informal employment in total employment increased from 39% in 1997 to 49.1% in 2005 (ONS 1997, 2005). Hence, the destruction of capital that has followed the bankruptcy of state-owned enterprises has not been replaced by private investments in the manufacturing sector despite Algeria's strategy to promote private investment in small and medium enterprises.[3]

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**3** In 2001, a national agency for the development of investment (ANDI) was created. The 01–18 law was promulgated in the same year to support entrepreneurship in small and medium enterprises. Nonetheless, the share of industry in Algerian GDP decreased from 10.6% in 1998 to 5.3% in 2005.

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