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A Spatial Analysis of Regional Economic Growth in MENA Countries

Marouane Alaya

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Marouane Alaya[1]

[1] Email: marwen2004@yahoo.fr. Portland Academic School.

I. Introduction

Despite the vast literature concerning the factors boosting the economic growth, there is still room for improvements both in terms of theoretical extensions, data collection and methodological advancements. In fact, there is a plethora of empirical researches on factors explaining the economic growth, but the treatment of the subject is generally done in an atomistic way with little attention to countries interaction. The third country effect has been by far despite the growing interest for what we call the neighboring effect. According to Montouri (1999, p. 144), "The role of spatial effects in regional studies has been virtually ignored".

Definitely, the economic growth in one country will not depend exclusively of the conditions of that country but also will be influenced by those prevailing in a third country. Space, in fact, is not composed of units isolated from each other. What happens in each of them can influence others: there is spatial interaction, (Jayet, 1993).

The importance of intraregional (the neighboring effects) and interregional geographical interferences in the context of economic growth in MENA region will be the aim of this study. The idea is to detect the spillovers effects between MENA countries and those coming from other regions by running a spatial analysis. Spatial econometric models of interdependence apprehend well the complexity of processes by focusing on spatial and space-time interactions. They are not limited to find proof but give answers to how and why these interactions took place. Indeed, the spatial econometric models will highlight the nature of spillovers effects in term of economic growth (positive or negative); the direct and indirect channels through which the spillovers effects manifest and the intensity of the spillovers effects from the MENA neighboring countries and those coming from other regions. We build our spatial analysis by focusing on global spatial correlation as well as local correlation by using different spatial techniques (on a panel of 73 countries from Asia, Europe and the MENA region. Broadly, speaking the results show that MENA countries seem to be disconnected from Asia and Europe and falling behind in term of clustering in the process of economic growth. To the best of our knowledge this the first study to deal with the spatial correlation issue in the context of MENA region.

II. The Spatial Econometric: A promising framework for the study of Economic Growth in Regional perspective

Given the importance geographical interferences in the context of economic growth in MENA region, it is surprising that this crucial aspect was ignored by empirical works. Neglecting a key determinant of growth (the neighboring effect) will be probably felt in econometric results[2]. In fact, if the existence of spatial autocorrelation is proved, the OLS econometric regressions will lead to biased results (Anselin, 1988) and then will affect the accuracy of the related economic policy. Accordingly, the neighboring effects in MENA region as well as those emanating from other regions should be considered. This is an important feature that should be added to the economic growth paradigm. The economic world is widely open and dynamic and what occurs in one country or region will be spread to others especially those in immediate proximity. "Space, in fact, is not composed of units isolated from each other. What happens in each of them can influence others: there is spatial interaction", (Jayet, 1993, p.7). Hence, the MENA growth literature and empirical studies should seriously take into account the neglected spatial effect.

The studies of spatial interdependence in the empirical growth dates to the last decade with the pioneer work of Fingleton and McCombie (1998), López-Bazo et al. (1999) and Fingleton (1999). The aforementioned papers should be considered as a step forward to deal with the regional aspect of economic growth that has been neglected. Nevertheless, the authors have adopted an ad hoc spatial model disconnected from the theorical corpus. In other words, the aim was to prove mechanically the existence of spatial externalities in the empirical economic growth exercise. The following works have tried to overcome this issue by implementing and accommodating the spatial dependence to the classical and neoclassical models and endogenous growth theory (see for example Bivand and Brundstad 2006) . Hence, Spatial econometric models especially spatial lag model and spatial error model were performed under the hypothesis of the new generation of economic growth theory as well as those proposed by new economic geography models à la Fujita et al. 1999). Spatial econometric models (spatial lag model and

[2] Spatial econometric models (spatial lag model and spatial error model) deal with the unobserved determinants of inward FDI that would be otherwise be caught by the error term in OLS regression.

spatial error model) deal with the unobserved determinants of inward FDI that would be otherwise be caught by the error term in OLS regression. In the spirit of spatial hypothesis, the growth in each county is not associated with its own initial GDP per capita and its idiosyncratic factors (as suggested by the traditional theory) but is affected by the factors prevailing in the other countries especially those in immediate proximity. Indeed, the spatial impact from other regions declines with distance. A remote country is supposed to have a less significant effect than a close one. "Everything is related to everything else, but near things are more related than distant things", (Tobler 1970, p. 236)[3]. The same logic applies to chocs within the region and those coming from others. This is well apprehended by the famous weight matrix W.

It is worthwhile to note that most of spatial empirical growth works have emphasized on the spatial error models (SEM) to deal with the regional interdependence. "What is more surprising is that the empirical evidence on the preferred spatial specification is mixed, and seems to depend on the set of regions, time period, specification, etc" (Fingleton and López-Bazo, 2006, p.179). According to the authors most of the studies supported the spatial error model against the spatial lag regression. In other words, they put forward the nuisance spatial dependence (the random shocks) to explain the presence of regional spillovers. "However, the presence of residual spatial dependence, and its modelling as a spatial error model, may reflect a more insidious cause. It may be that it is a manifestation of the omission of one or more spatially autocorrelated variables", (Fingleton and López-Bazo, 2006, p.182). Also, the authors underline that spatial error models in previous studies didn't include additional variables in the estimated equation leading to inaccurate results since the simple spatial error equations are unlikely to catch all the causes behind regional spillovers. The authors advocate in favor of unconstrained models (spatial lag and spatial Durbin models) conditioning variables excluded by the constrained error models. Hence, the preference is for these models being able to capture the of regional spillovers through physical channels (substantive spatial dependence) versus the spatial error models explaining these spillovers by the only random shocks. The former attempt to

[3] Tobler, W. (1979). "Cellular Geography." In *Philo.oph"* in Geograph", edited by S. Gale and G. Olsson, pp. 579-86. Dordrecht: Reidel. Cited in (Anselin, 1988, p.8)

explain the causes of spillovers and the later simple treat the neighboring effects as nuisance variables.

Blongein et al. (2007) focus exclusively on spatial lag model. The reason behind is that unlike the spatial error model (which the main contribution is to improve standard errors where estimation errors are spatially dependent), the spatial lag model allow the regional effect to manifest through the spatially lag dependent variable $\rho.W.y$ included in the right hand side of the regression equation. Indeed, the estimated ''spatial lag'' coefficient (the famous ρ) capture the simultaneous correlation between one country economic growth and other neighbor countries economic growth[4]. The Spatial Durbin Model (SDM) allow to identify the effects from the other neighboring conditioning variables i.e. the main spillover channels coming from a third country.

III.2. The Spatial Analysis

III.2.1. The Weighted Spatial Matrix: A Prerequisite for the Spatial Analysis

The weighted spatial matrix W brings out the potential of interaction (between observations of each host countries pairs i,j of a given region. It is worthwhile to note that since each observation is weighted by the distance or proximity (contiguity for example); the potential of interaction increases with geographically proximate countries and decreases with remoteness ones. There is a wide range of techniques to specify the structure of the spatial weight matrix[5]. This latter can be for example weighted by contiguity: (i,j) locations interact when they are contigus i.e sharing a common border. Then we obtain a binary matrix with value 0 and 1. Another alternative is to use a band distance weight (i,j locations interact when being within a critical distance band).

The scalar $\rho W_y Gr_{i,t}$ records the economic growth in year t $\{t \epsilon [1996, 2014]\}$ } of 73 countries from Europe, Asia, and Middle East and North Africa weighted by the bilateral

[4] If there is no spatial dependence, and economic growth in a host country does not depend on neighboring growth values, the parameter ρ accounting for spatial autocorrelation of growth will be equal to zero. Econometrically speaking this consists to accept the null hypothesis: $\rho = 0$.

[5] It is recommended to use a variety of weighted spatial matrix W in the estimation process because results may be very sensitive to the structure of matrix W.

distance between country i and country j where $i, j = \{1,2, \dots \dots .73\} \forall\, i \neq j$. The parameter ρ will be estimated and in case of rejection of the null $\rho = 0$, the spatial autocorrelation or dependence will be proved. It is worthwhile to point out that the square matrix W will be composed by a block of diagonal matrix of dimension $73 \times 73\, \{(n \times n)\}$ with each block apprehend a single year's observations for any year t, $t \epsilon\, [1996, 2014]$. Formally for any year t between 1996 and 2014 the matrix W_t can be represented as following:

$$\begin{bmatrix} 0 & W_t(d_{i,j}) & W_t(d_{i,n}) \\ W_t(d_{j,i}) & 0 & W_t(d_{j,n}) \\ W_t(d_{n,i}) & W_t(d_{n,j}) & 0 \end{bmatrix}$$

The cells $W_t(d_{i,j})$ show that for any couple of hot countries the weight will decrease with the distance. Geographically proximate countries will be attributed a higher weight and vice versa. Accordingly, the spillovers effect (positive or negative) will go down with remote countries and close countries are likely to exercise a higher impact. "Everything is related to everything else, but near things are more related than distant things", (Tobler 1970, p. 236)[6].

In our work the spatial weight matrix is a diagonal matrix accounting 146 matrices of dimension 73×73 in the main diagonal. The other matrices are zero-matrices of dimension 73×73. W is row standardized i.e. the sum of each row is equal to unity.

The establishing of the spatial weight matrix is rather intuitive. Moreover, the existence of a rich variety of methods to build such matrix makes the choice of the adequate way quite arbitrary. To overcome this difficulty, we compute in a first time a Moran's I spatial correlogram to decide about the appropriate distance band to choose for the implementation of the spatial white matrix. To do this we run the command *spatcorr* based on cumulative distance bands. For each distance band, the Z-value of the null hypothesis of global spatial independence is provided which is very useful for the choice of the appropriate distance band. Hence, to refine the choice of the distance band we rely on the statistics exposed in the Table.1 below.

[6] Tobler, W. (1979). "Cellular Geography." In *Philo.oph"* in Geograph", edited by S. Gale and G. Olsson, pp. 579-86. Dordrecht: Reidel. Cited in (Anselin, 1988, p.8)

Table. 1: Moran's I spatial correlogram of economic growth[7]

(sample: 77 countries)

Distance bands	I	E(I)	sd(I)	z	p-value*
(0-10]	0.273	-0.014	0.086	3.323	0.000
(10-20]	0.334	-0.014	0.06	5.811	0.000
(20-30]	0.216	-0.014	0.053	4.36	0.000
(30-40]	0.109	-0.014	0.058	2.131	0.017
(40-50]	-0.014	-0.014	0.058	-0.004	0.498

*1-tail test

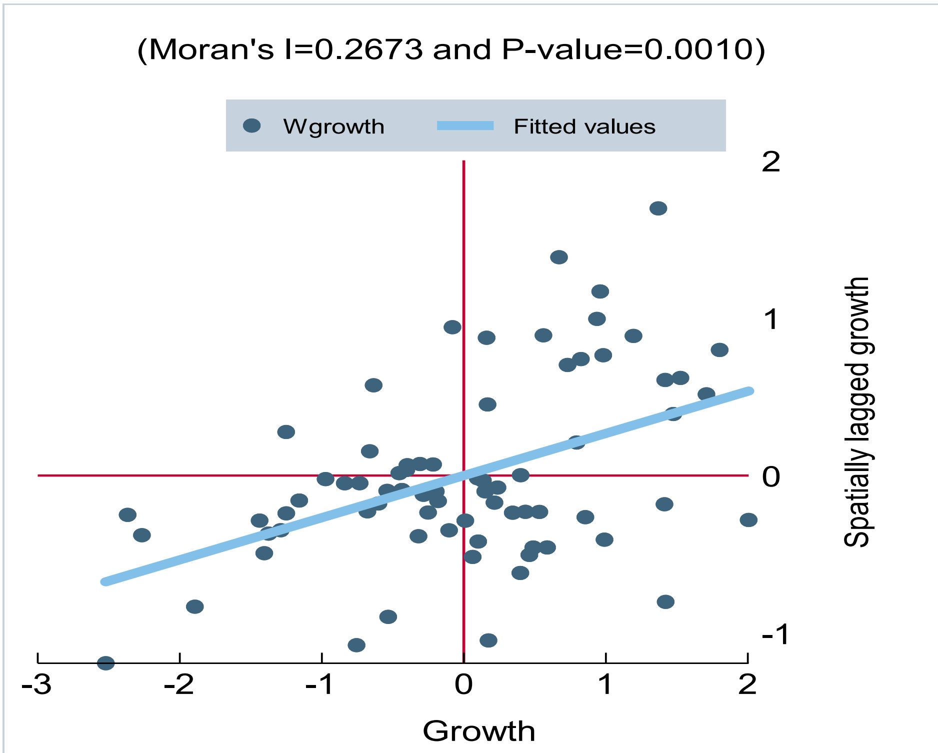
We select the Euclidean distance band of [10-20] (equivalent to a band expressed in Km of [960-1920]). In fact, if we combine the results of the statistic Z and its P-value provided by Moran test, it will be suitable to choose the band distance of [10-20]. In other words, to be considered as neighbors, the distance $d_{i,j}$ between a couple of countries i and j $\forall i \neq j$ used in the definition of the weight spatial matrix should not exceed the threshold distance of 1920 km. For each $d_{i,j}$ $\forall i \neq j \epsilon [10-20]$ i and j are considered as neighbors otherwise the country i *and* j will not considered as neighbors and will not be weighted, *i.e.* will be attributed a value of zero in the spatial weight matrix .

III.2.2. A Diagnostic of the Spatial Interdependence

The Moran Index is very useful to have a first insight about the existence and the nature of economic growth spatial autocorrelation between the countries included in the sample. According to the positive Moran's Index values and the scatter plot (see Fig.1) we can emphasize a positive relationship of economic growth within the sample countries (the Moran index has a statistically significant positive value and the slope of line fitting the scatter is also positive). Anselin (1988) advocates that when Moran's I is positive and significant this indicate the presence of clusters of like values.

[7] We use three alternative economic growth measures to compute the Moran's I statistic (growth of GDP/capita, growth of GDP and the logarithm of average annual growth rate per capita during the period 1996-2014). The results are similar and seems to be insensitive to the choice of the growth indicator.

Fig.2: Moran's scatter plot – Growth of GDP/Capita



Source: Author calculation

The Moran's I index is very useful since will bring us an idea of the nature and magnitude of the global autocorrelation. The benefits of global spatial autocorrelation are palpable when spatial units i.e. observations exanimated are homogenous or at least relatively homogenous. Unfortunately, this is generally unusual, and studies are often constrained by heterogeneity issue making rough the results interpretation. In that case, it is interesting to look for local clusters of low or high values. The local clusters or concentration can be interpreted as specific behaviors or isolated spatial idiosyncrasies. In our case, since we deal with economic growth, the clusters could be viewed as convergence clubs sharing similar growth path or process. Hence, to deepen the analysis, we calculate the local Moran's Index growth (see Table.2) values related to each country to have an idea about the connected ones and the kind (positive or negative) of spillovers effect (if any). According to the results of the local Moran's Index displayed in the Table.2, the European and Asian countries are spatially and positively correlated, and the MENA countries are falling behind (only Kuwait has a weak significant positive Moran's Index)[8]. It seems that the European and Asian countries are probably clustered in term of economic growth.

Table.2: Local Moran's I values

Region	Country	Ii	z	p-value*
Europe	Albania	0.289	1.556	0.060*
	Austria	0.311	1.469	0.071*
	Bulgaria	0.342	1.716	0.043**
	Croatia	0.39	1.881	0.030**
	Cyprus	0.589	2.691	0.004***
	Denmark	0.315	1.632	0.051**
	Finland	1.055	5.022	0.000***
	France	0.387	2.076	0.019***
	Germany	0.272	1.379	0.084*
	Greece	0.535	2.739	0.003***
	Italy	0.651	2.966	0.002**
	Latvia	0.251	1.417	0.078*
	Serbia	1.01	4.933	0.000***
	Ukraine	2.231	11.995	0.000***
	Negative Moran'I value:			
	Ireland	-0.653	-2.154	0.016***
	Malta	-0.797	-4.146	0.000***
	Moldova	-0.296	-1.512	0.065*
Asia	Bangladesh	0.82	2.322	0.010***
	Cambodia	1.261	2.906	0.002***
	China	0.783	1.402	0.081*
	India	1.497	3.122	0.001***
	Lao PDR	1.1	2.574	0.005***
	Malaysia	0.655	1.537	0.062*
	Mongolia	2.458	2.527	0.006***
	Myanmar	1.516	3.834	0.000***
	Nepal	1.185	2.467	0.007***
	Philippines	0.792	1.628	0.052**
	Viet Nam	1.225	2.517	0.006***
MENA 17	Kuwait	0.492	1.416	0.078*

Source: Author calculation

[8] For sake of brevity and space the remaining countries with no significant Moran's I values haven't been retained in the table.

The beauty of local spatial autocorrelation is to check whether, for a given observation i (let say the growth rate of a given country at time t), is surrounded by similar observations of other countries, or if it is (in the opposite case) is being surrounded by a very dissimilar observations. Explicitly, it's about to know if a value of the observation i is positively (resemblance) or negatively connected (dissimilarity) with neighboring observations. Moreover, local measurement allows us to detect outliers (atypical localisations) which is not the case with global autocorrelation measure. Therefore, with global autocorrelation investigation we will be able to learn more about the patterns of the clustering of high or low values. This is commonly known as hot spots (high values) and cold spots (low values). In fact, the Moran scatter plot can be divided into four quadrants each of them describes a kind of spatial correlation. For example, in the High-High quadrant (North-East) are displayed the weighted values of economic growth (the spatially lagged variable: W_{Growth}), whish is high and at the same time surrounded by observations of high value of the "raw" growth observation of neighboring countries. The low-low (South-West) quadrant is the opposite case: W_{Growth} is linked to low values of the neighboring countries. In the High-low (South-East) quadrant the high values of W_{Growth} coexist with low values of neighboring countries. In the opposite side the Low-High (North-West) quadrant displays the case where the spatially lagged variable W_{Growth} is surrounded by high values of neighboring countries. Accordingly, the sample countries in our studies can be classified in the cited four categories.

The Lisa cluster map (see Table 3) show that the hot spot (High-High) is composed by 13 Asian countries. In other side, the cold spot is mostly composed by 23 European countries and two countries from the MENA region namely Lebanon and Tunisia. The high low cluster is formed by 6 European countries and one country from Asia (Georgia). Two countries (Thailand and Honk Kong) are clustered in Low-High categories. For the remaining 26 countries (among them 15 countries from MENA) the spatial correlation is not significant. Henceforth, it seems that the European and Asian can be considered as belonging into two kind of convergence club. MENA countries seem to be spatially disconnected except for Lebanon and Tunisia.

Table. 3: Countries classification by Lisa cluster criteria

High-High	Low-Low	High-Low	Low-High
Bangladesh	Albania	Hungary	Hong Kong
Cambodia	Austria	Luxembourg	Thailand
India	Bulgaria	Macedonia	
Indonesia	Croatia	Malta	
Kazakhstan	Czech Rep.	Moldova	
Lao PDR	Denmark	Romania	
Malaysia	Estonia	Georgia	
Myanmar	Finland		
Nepal	France		
Philippines	Germany		
Sri Lanka	Greece		
Uzbekistan	Italy		
Viet Nam	Latvia		
	Netherlands		
	Norway		
	Poland		
	Serbia		
	Slovakia		
	Slovenia		
	Sweden		
	Switzerland		
	Ukraine		
	United Kingdom		
	Lebanon		
	Tunisia		

Source: Author calculation

IV. Estimation Results

To run the spatial regression models, we follow Tian et al. (2010) who have accommodated Cobb-Douglas function for spatial dependence. For the authors and in line with Marshallian literature (where two kinds of externalities are identified namely technological and pecuniary externalities) the main source of spatial effects is coming from externalities through regional interaction in term of knowledge spillovers, factor mobility and trade. Tian et al. (2010) emphasis on technological externalities supposed to be generated by the accumulation of physical capital and externalities.

The Cobb-Douglas à la Solow equation proposed by the authors is a classical constant return to scale function taking the following form:

$$y_i(t) = A_i\,(t)K_i^{\propto}(t)L_i^{1-\propto}(t), 0 <\propto< 1 \qquad (1)$$

Where $y_i(t), A_i\,(t), K_i(t)\ and\ L_i(t)$ represent respectively the output, aggregated level of technology, capital and labor, in region i and time t while $\propto$ is a parameter representing the capital elasticity. Moreover, Tian et al. (2010) rely on Ertur and Koch (2007) technology spillover function and consider that the steady growth rate of a region will be endogenously established by the interaction with other regions in term of spatial technology externalities. After resolving the system and making multiple algebraic transformation, Tian et al. (2010) obtain the following basic constrained spatial Durbin model[9]:

$$g_T = \beta_0 + \beta_1 Y_0 + \beta_2 S + \beta_3 NGD + \theta_2 WS + \theta_3 WNGD + \rho W g_T + \varepsilon \qquad (2)$$

Where g_T, Y_0, S, NGD are variables (in logarithm) that describe respectively the growth rate of per capita GDP, the initial per capita GDP , the physical capital accumulation, and the sum of population growth rate (n), technology growth rate[10] (δ) and capita depreciation rate (δ) [$NGD = \ (n + g + \delta)$]. The spatially lagged variables are proceeded by the weighted matrix W. Two parameter restrictions have been imposed by the authors. The first constraint is in line with Solow growth literature the coefficient β_2 and $\beta_3$are equal in magnitude and opposite in sign ($\beta_2 = -\ \beta_3$) and the constraint has been imposed to $\theta_2$and θ_3 ($\theta_2 = -\theta_3$). The second constraint is that in case of the absence physical externalities the spatial autoregressive error model (SEM) is favored. To test the presence physical capital externalities the authors run LR common factor test (LRCOM) on the unconstrained spatial Durbin Model (SDM) against spatial error model (constrained spatial Durbin model). When LRCOM test for the null hypothesis is rejected, there is enough proof of significant physical capital externalities in the economic growth process. Finally, the authors augmented the Solow model by adding some control variables.

[9] For sake of brevity the mathematical algorithm is not replicated in this paper. For more details see Tian et al. (2010).
[10] δ reflects the advancement of knowledge and is assumed to be exogenous and not country specific.

To estimate the determinants of economic growth we use a dataset of 73 countries from Europe (33 countries), Asia (23 countries) and the Middle east and North countries (17 countries) between 1996 and 2014. The period and countries were selected to supply both balanced panel data and a large sample size dataset to adequately run spatial regressions. Data are collected from the Penn World Table database (PWT 9.1) from the University of California and the University of Groningen, The World Bank (World Development Indicators and The Worldwide Governance Indicator), and the UNCTAD.

First, we run a Solow model by ordinary least square (OLS) before performing spatial regression on the basic and augmented form of Solow equation. In the first model [equation (3)] we run the growth of GDP per capita dependent variable $G_r = \frac{Y_T - Y_0}{T}$ on the initial per capita GDP (lngdpcapita) (per capita GDP of the year 1996), the capital stock (lnck) (proxy of physical capital accumulation), and the sum of population growth, technology growth rate and capital depreciation rate (lnngd) [11](all the variables are in logarithm).

$Gr_{i,t} = \beta_0 + \beta_i X_{i,j} + \epsilon_{i,t}$ where is the vector of explanatory variables (3)

We start by running the model by OLS on the panel of 73 countries over the period 1996-2014. The restriction that the coefficient on the capital accumulation (lnck) and the explanatory variable (lngd) are equal in magnitude and opposite are tested but the Wald test fail reject the null hypothesis (see Table 4) thereafter restriction has been relaxed.

[11] $g + \delta$ is supposed to be equal to 0.05.

Table. 4: Determinants of economic growth (GLS regressions)

Period: 1996-2014, Sample: 73

Gr	Coef.	z	P>z
lninitial	-0.012***	-4.62	0.000
lnck	0.021***	11.81	0.000
lnngd	0.046***	3.51	0.000
_cons	-0.042	-1.05	0.293

R-sq=0.63, Wald chi2(3)=168.68, Number of obs= 1387, T=19, number of groups=73. lnck + lnngd = 0 chi2(1) *** = 26.64 , Prob > chi2 = 0.0000, The standard errors of the regression coefficients have been derived using White consistent cross-section standard errors & covariance. ***, **,* represent respectively statistical significance at 1, 5 and 10% level.

The econometric results show that all the explanatory variables are significant at a statistical level of 1%. The initial per capita GDP and the accumulation of capital have the expected sign. The negative sign of initial per capita GDP is in line with economic growth literature and decreasing return of capital: economies' per capita incomes will tend to grow at faster rates than richer economies. We note also that the variable lngd display an expected positive sign.

To test the spatial dependence, we run three alternative models [the spatial lag model (SAM), the spatial error model (SEM) and the spatial Durbin Model (SDM)] on the basic and augmented version of Solow's model (see Table 5) and test via LR common factor test the unconstrained spatial Durbin Model (SDM) against spatial error model (constrained spatial Durbin model).

The results of the LR common factor test show that the spatial Durbin Model can not be considered as nested in the spatial error model. The likelihood-ratio test statistic is highly significant (LR chi2(1) = 191.37 and Prob > chi2 = 0.0000) indicating that spatial error model should not be favored against the spatial Durbin Model. Consequently, the idea of physical capital externalities is plausible.

The estimation results of the three alternative spatial models confirm the hypothesis of positive geographical dependence or the geographical diffusion of spillovers as the three spatial variables (rho for SAR and SDM and Lambda for SEM) of the three models are significant at 1% and have a positive sign. In addition, the presence physical capital externalities hypothesis is proved since the spatially lag variable of the accumulation of capital in the SDM model is positively significant. Hence, the economic growth in a given country is not only impacted by its own capital accumulation process but depends positively by the capital accumulation in the neighboring countries.

Table.5: Maximum Likelihood regressions: Spatial Lag Model, Spatial Error Model and Spatial Durbin Model
Period: 1996-2014, Sample: 73

	SAR					**SEM**			**SDM**		
gr	Coef.	z	P>z	gr	Coef.	z	P>z	gr	Coef.	z	P>z
Main				Main				**Main**			
lninitial	-0.008	-3.880	0.000	lninitial	-0.008	-3.830	0.000	lninitial	-0.009	-4.1	0.000
lnck	0.009	2.950	0.003	lnck	0.006	1.370	0.171	lnck	0.007	2.1	0.036
lnngd	0.025	2.530	0.011	lnngd	0.025	3.000	0.003	lnngd	0.025	2.68	0.007
_cons	-0.001	-0.020	0.988	_cons	0.072	1.630	0.102	_cons	-0.113	-1.86	0.063
Spatial				Spatial				Wx			
rho	0.758	13.530	0.000	lambda	0.888	29.270	0.000	lninitial	0.004	1.4	0.161
								lnck	0.007	2.29	0.022
Variance				Variance				lnngd	-0.016	-0.86	0.390
lgt_theta	-1.976	-8.190	0.000	ln_phi	0.590	0.970	0.332				
sigma2_e	0.00012	8.190	0.000	sigma2_e	0.00012	8.340	0.000	Spatial			
R-sq:	within	0.790		R-sq:	within	0.540		rho	0.702	13.92	0.000
	between	0.00030			between	0.004					
	overall	0.130			overall	0.070		Variance			
N. of obs	1387							lgt_theta	- 1.856783	-9.34	0.000
N. of groups	73							sigma2_e	0.000117	8.3	0.000
T=19								R-sq:	within	0.79	
T: panel length									between	0.0004	
									overall	0.23	

To extend the analysis we augment the benchmark model (see Table 6 by adding control variables[12] (the human capital (*KH*), the stock of FDI (*fdistock*), exports (*export*) of goods and services and a proxy of governance (gover) obtained by the average of five governance indicators[13]). The results show that the three models are in some extent robust to the addition of control variables. Except the variable *lnck* has become insignificant probably due to multicollinearity problems and by the way this is among the major weakness of spatial Durbin model. In fact, the explanatory variables are included twice in the SDM in their original form (the direct effect) as well as in the form of spatially lagged form (the indirect effect) which could increase the risk of multicollinearity problem. In addition, we observe that the spatially lagged FDI variable (W_lnfdistock) show a positive and significant sign leading to think about complementarity effect of the FDI stock in the sample countries.

[12] Except the variable governance all the other control variables are in logarithm.
[13] Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.

Table.6: Maximum Likelihood Spatial Regressions (SAR, SEM and SDM) with control variable, Period: 1996-2014, Sample: 73

SAR				**SEM**				**SDM**			
Gr	Coef.	z	P>z	Gr	Coef.	z	P>z	Gr	Coef.	z	P>z
Main				**Main**				**Main**			
lninitial	-0.023	-12.14	0.000	lninitial	-0.022	-11.41	0.00	lninitial	-0.023	-11.75	0.000
lnck	0.002	2.26	0.024	lnck	0.0033	2.26	0.02	lnck	0.001	1.26	0.209
lnngd	0.014	4.52	0.000	lnngd	0.016	5.37	0.00	lnngd	0.016	4.93	0.000
lnkhwdi	0.023	8.88	0.000	lnkhwdi	0.025	9.33	0.00	lnkhwdi	0.024	8.58	0.000
lnfdistock	0.002	4.49	0.000	lnfdistock	0.0024	3.62	0.00	lnfdistock	0.001	2.4	0.017
lnexport	0.009	12.68	0.000	lnexport	0.007	10.33	0.00	lnexport	0.009	11.59	0.000
gover	0.011	6.63	0.000	gover	0.009	5.79	0.00	gover	0.011	6.56	0.000
_cons	-0.150	-6.7	0.000	_cons	-0.12	-3.81	0.00	_cons	-0.256	-5.85	0.000
Spatial				**Spatial**				**Wx**			
rho	0.55273	22.54	0.000	**lambda**	0.84	38.56	0.00	Wx_lninitial	0.009	2.25	0.024
								Wx lnck	-0.001	-0.6	0.551
Variance				Variance				Wx lnngd	-0.021	-2.82	0.005
lgt_theta	-2.2169	-18.78	0.000	ln_phi	1.586	4.9	0.00	Wx lnkhwdi	-0.005	-0.97	0.332
sigma2_e	0.00009	25.47	0.000	sigma2_e	0.000094	24.77	0.00	Wx_lnfdistock	0.004	3.43	0.001
R-sq:	within	0.85		R-sq:	Within	0.80		Wx nexport	0.001	0.83	0.404
	between	0.01			Between	0.05		Wx gover	-0.015	-3.04	0.002
	overall	0.34			Overall	0.22					
								Spatial			
								rho	0.518	15.38	0.000
								Variance			
								lgt_theta	-2.0764	-16.11	0.000
								sigma2_e	9.02E-05	25.05	0.000
								R-sq:	within	0.85	
									between	0.03	
									overall	0.42	

In a last step we split the panel in three regional groups (Europe, Asia and MENA) and we run the model with control variables to conduct a comparative analysis between the three regions and to show if the results display specific features in term of spatial correlation in the process of economic growth (see Table 7, 8 and 9 in appendix). Broadly, speaking we can say that in the case of MENA region the spatial correlation is only confirmed by the SAR model contrary to Asia and Europe where the coefficients of the spatially lagged variable are still strongly significant. This is match well with the results found in this study in term local spatial correlations. MENA countries seems to be disconnected or out of clustering process within the MENA region and with other regions namely Asia and Europe.

V. Conclusion

In this study we focus on the intraregional and interregional spatial correlation in term of economic growth a panel of 73 countries from Asia, Europe and MENA region. We investigate the global spatial correlation and local spatial dependence. We have tried to overcome the classical ad hoc approach usually linked to spatial regression and considered in sometimes as a pure mechanic approach. Indeed, we have accommodated the Solow's model to the context of MENA region. The results are somewhat disappointing for the MENA region as we didn't find robust results to confirm a strong connection with the other regions. Especially, this is true at a local level (local spatial correlation) where the MENA countries seem to be disconnected from the growth clustering process within the MENA region as well as with other regions. In other words, MENA countries are falling behind the European and Asian countries convergence clubs. The economic world is becoming very competitive and the regional spillover (random and physical) widespread with an impressive speed. Geographical proximity does not necessary guarantee the whole benefit from the spread of externalities. Economic and political proximity count more. MENA countries have never benefited from a holy and conducive business and political climate. The risk of falling behind exist and will continue to threat the prosperity of the region if honest and courageous reforms are not being conducted soon.

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Appendix

Data source

Indicators	Sources
Stock of Foreign direct investment in millions of current US $	United Nations Conference on Trade and Development, UNCTAD Statistics database online, 2019. http://unctadstat.unctad.org
Population growth (annual %) GDP per capita (current US$) GDP per capita growth (annual %)	World Bank, World Development Indicators Database online, 2019. http://data.worldbank.org/indicator
Average depreciation rate of the capital stock Capital stock at current PPPs (in mil. 2011US$)	Penn World Tables PWT Version 9.0 The University of California and The University of Groningen. Database online, 2016. http://cid.econ.ucdavis.edu/pwt.html
Distance (Km) between capital cities Latitude and Longitude (in degree)	CEPII- Database http://www.cepii.fr/
The Worldwide Governance Indicators (WGI) project	Daniel Kaufmann, Natural Resource Governance Institute (NRGI) and Brookings Institution and Aart Kraay, World Bank Development Research Group. https://info.worldbank.org/governance/wgi/

Table.7: Maximum Likelihood Spatial Regressions (SAR, SEM and SDM) with control variable in MENA Region, Period: 1996-2014, Sample: 17

SAR				SEM				SDM			
gr	Coef.	z	P>z	gr	Coef.	z	P>z	gr	Coef.	z	P>z
Main				Main				Main			
lninitial	-0.019	-3.120	0.002	lninitial	-0.021	-2.800	0.005	lninitial	-0.017	-3.610	0.000
lnck	0.008	2.000	0.045	lnck	0.010	3.080	0.002	lnck	0.006	4.230	0.000
lnngd	0.003	0.370	0.714	lnngd	0.001	0.150	0.882	lnngd	0.004	1.130	0.258
lnkhwdi	0.029	2.770	0.006	lnkhwdi	0.030	3.130	0.002	lnkhwdi	0.026	5.310	0.000
lnfdistock	-0.002	-0.840	0.403	lnfdistock	0.000	-0.120	0.901	lnfdistock	-0.003	-2.690	0.007
lnexport	0.016	4.120	0.000	lnexport	0.018	4.850	0.000	lnexport	0.013	6.730	0.000
gover	-0.005	-0.660	0.512	gover	-0.007	-1.010	0.313	gover	-0.003	-0.830	0.404
_cons	-0.399	-5.350	0.000	_cons	-0.490	-6.440	0.000	_cons	-0.360	-3.000	0.003
Spatial				Spatial				Wx			
rho	0.212	2.440	0.015	lambda	-0.114	-0.750	0.454	lninitial	-0.006	-0.610	0.540
								lnck	0.005	2.390	0.017
Variance				Variance				lnngd	0.011	1.100	0.272
lgt_theta	-2.745	-17.200	0.000	ln_phi	3.037	10.750	0.000	lnkhwdi	0.002	0.320	0.746
sigma2_e	0.000	4.980	0.000	sigma2_e	0.000	5.510	0.000	lnfdistock	0.008	3.670	0.000
								lnexport	0.000	-0.080	0.939
R-sq:	within	0.890		R-sq:	within			gover	-0.008	-1.560	0.119
	between	0.036			between						
	overall	0.317			overall			Spatial			
								rho	-0.087	-1.070	0.284
								Variance			
								lgt_theta	-2.483	-11.000	0.000
								sigma2_e	0.000	12.210	0.000
								R-sq:	within	0.899	
									between	0.045	
									overall	0.447	

Table.8: Maximum Likelihood Spatial Regressions (SAR, SEM and SDM) with control variable in Asia, Period: 1996-2014, Sample: 23

	SAR				SEM				SDM		
Gr	Coef	z	P>z	Gr	Coef.	z	P>z	Gr	Coef.	z	P>z
Main				**Main**				**Main**			
lninitial	-0.028	0.006	-4.750	lninitial	-0.038	-3.970	0.000	lninitial	-0.025	-3.66	0.000
lnck	0.017	0.002	8.350	lnck	0.025	3.540	0.000	lnck	0.019	7.36	0.000
lnngd	0.052	0.006	8.210	lnngd	0.032	1.120	0.263	lnngd	0.054	8.33	0.000
lnkhwdi	0.004	0.005	0.770	lnkhwdi	0.003	0.290	0.770	lnkhwdi	0.005	0.98	0.325
lnfdistock	0.003	0.001	2.980	lnfdistock	0.009	1.720	0.085	lnfdistock	0.001	1.15	0.251
lnexport	0.006	0.001	6.000	lnexport	0.006	1.660	0.097	lnexport	0.005	5.26	0.000
gover	-0.001	0.003	-0.230	gover	-0.008	-1.030	0.303	gover	0.001	0.23	0.816
_cons	-0.084	0.045	-1.850	_cons	-0.214	-2.440	0.015	_cons	0.025	0.36	0.716
Spatial				**Spatial**				**Wx**			
rho	0.456	0.033	13.790	**lambda**	0.496	2.330	0.020	W_lninitial	-0.016	-1.64	0.102
								W_lnck	0.005	1.39	0.165
Variance				Variance				W_lnngd	0.016	1.87	0.062
lgt_theta	-2.767	0.181	- 15.270	ln_phi	3.323	7.950	0.000	W_lnkhwdi	-0.001	-0.16	0.874
sigma2_e	0.000	0.000	14.200	sigma2_e	0.000	4.740	0.000	W_lnfdistock	0.002	1.1	0.272
R-sq:	within	0.878		R-sq:	within	0.849		W_lnexport	-0.001	-0.88	0.378
	between	0.041			between	0.049		W_gover	0.018	3.43	0.001
	overall	0.327			overall	0.165					
								Spatial			
								rho	0.38228	8.4	0.000
								Variance			
								lgt_theta	-2.78	-13.53	0.000
								sigma2_e	0.00	13.8	0.000
								R-sq:	within	0.8814	
									between	0.0211	
									overall	0.3034	

Table.9: Maximum Likelihood Spatial Regressions (SAR, SEM and SDM) with control variable in Asia, Period: 1996-2014, Sample: 23

Europe				SEM				SDM HR			
Gr	Coef.	z	P>z	Gr	Coef.	z	P>z	Gr	Coef.	z	P>z
Main				**Main**				**Main**			
lninitial	-0.042	-9.600	0.000	lninitial	-0.047	-7.030	0.000	lninitial	-0.046	-8.910	0.000
lnck	-0.006	-3.810	0.000	lnck	-0.003	-0.350	0.728	lnck	-0.003	-1.820	0.069
lnngd	0.007	1.350	0.176	lnngd	0.005	0.490	0.624	lnngd	0.009	1.690	0.090
lnkhwdi	0.011	2.490	0.013	lnkhwdi	0.009	1.100	0.271	lnkhwdi	0.012	2.610	0.009
lnfdistock	0.003	5.110	0.000	lnfdistock	0.004	2.240	0.025	lnfdistock	0.004	6.940	0.000
lnexport	0.032	22.980	0.000	lnexport	0.034	7.880	0.000	lnexport	0.033	23.560	0.000
gover	0.005	2.630	0.008	gover	0.003	0.490	0.624	gover	0.003	1.320	0.187
_cons	-0.359	-7.480	0.000	_cons	-0.430	-5.380	0.000	_cons	-0.052	-0.350	0.723
Spatial				**Spatial**				**Wx**			
rho	0.192	5.210	0.000	**lambda**	0.473	5.190	0.000	Wx_lninitial	-0.010	-0.720	0.474
								Wx_lnck	-0.004	-1.180	0.238
Variance				Variance				Wx_lnkhwdi	-0.041	-2.830	0.005
lgt_theta	-3.055	-20.180	0.000	ln_phi	3.834	9.710	0.000	Wx_lnfdistock	-0.004	-3.430	0.001
sigma2_e	0.000	17.130	0.000	sigma2_e	0.000	5.180	0.000	Wx_lnexport	0.000	0.080	0.937
								Wx_gover	0.001	0.090	0.930
R-sq:	within							**Spatial**			
	between			R-sq:	within			**rho**	0.310	4.170	0.000
	overall				between			Variance			
					overall			lgt_theta	-3.273	- 21.460	0.000
								sigma2_e	0.000	17.020	0.000
								R-sq:	within		
									between		
									overall		