Remittances, Growth and Convergence in Mexico: A Spatial Econometric Approach^

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ABSTRACT

Mexico has experienced during the last ten years an explosive growth in the inflow of remittances, making them an important source of external funds with a magnitude similar to the foreign direct investment that the country receives. Using spatial and non-parametric techniques, the study shows that the relationship between remittances and GDP per capita exhibits strong regional polarization dynamics. To evaluate whether this regional stylized fact is significant on economic growth, this research relies on a spatial panel data approach to analyze the effects of remittances through the implementation of a model of regional convergence at the state level. The results show that remittances can affect positively the dynamics of regional conditional convergence only if regional heterogeneity is considered, and this situation is better captured with a spatial econometric model framework that incorporates fixed effects.

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1. Introduction

During the period 2006-2008, the annual flow of remittances to Mexico was in the range of 25 and 26 billions of dollars. From a global perspective, Mexico is the third world largest country in receiving external savings in the form of remittances only behind China and India. For an average developing country these figures well could represent an important inflow of resources to boost growth. In the case of Mexico, it is conventional wisdom among analysts to assume that growth depends importantly on the dollars that Mexican migrants, who are essentially concentrated in USA, sent back to their families .

Nevertheless, it is important to contextualize the phenomenon in terms of the size of the economy. For the case of Mexico, remittances represent no more of 3% of its GDP; in contrast, countries like El Salvador, Honduras y Guyana, remittances can reach more than 20% of their GDP (Fajnzylber and Lopez, 2008). In terms of the other external inflows of the Mexican economy, the levels of remittances are similar to the figures of Foreing Direct Investment (FDI averaged 23 billions dollars in the period 2006-2008), but they are quite small if compared to the manufactory exports during the same period (averaged 218 billions 2006-2008). Then, what is the real impact of remittances on the Mexican economy?

It exists an extensive literature for the Mexican case that has investigated whether remittances stimulates economic activity. Inspired by the methodology of the classical work of Adelman-Taylor-Vogel (1986) that proposes a SAM´s approach to analyze the economic impacts of remittances in Mexican rural communities, we find an important body of essays that favor a hypothesis in where remittances have at macro level positive multiplicative effects on income, employment and investment (Adelman-Taylor 1988, Durand-Parrado-Massey 1996, Zarate 2005). Also on this optimistic side, we can find several studies of the New Economics of Labour Migration that analyzed at micro level the positive effects of migrant remittances to reduce income inequality (Stark-Taylor-Yitzhaki, McKenzie y Rapoport 2007).

Nevertheless, this optimistic perspective of the benefits of remittances on economic activities is not completely clear when addressed by an econometric growth framework. In one of the few works for the Mexican economy, Mendoza-Calderon (2006) considers a conditional convergence model to analyze the effects of remittances on growth of the GDP per capita at state level during the period1995-2003, but they do not find any significant effect of the remittances variable. Similar results were found by Valdivia-Lozano (2009) with more recent data and robust econometric approaches. They tested whether these effects were dependent on the econometric technique used. Effects of remittances on growth were neither present with a fixed-effects panel data approach of the convergence growth model, or a spatial-lag version.

The real impact of remittances on growth must lies –as Taylor has suggested (1999) somewhere in between the optimistic side and the pessimistic side. This paper postulates that this situation well could be conditioning by a spatial dimension of the remittances.

Some studies for the Mexican case run along this proposition; for example, Richard Jones (1998) has postulated that the impact of remittances is not homogeneous and it depends on the regional scale and the migration phase.

Specifically, in this paper we explore through spatial econometric models for panel data whether the real impacts of remittances on growth are conditioned by spatial heterogeneity. The rest of the paper is structured as follows: in section 2, we present the spatial stylized facts about the relationship between remittances and regional GDP in Mexico at state level; in section 3, a brief review of the empirical econometric literature on the issues is presented, and also a methodological discussion of the spatial econometric models used in this paper; in section 4, we present the results of the spatial econometric models; and we conclude with a section of final remarks.

2. Exploratory spatial analysis of the relationship between remittances and regional GDP

These results however are not reflecting clearly the nature of the regional component of the relationship between remittances and growth in Mexico. Mexico has 32 Federal States and the contribution of each State´s remittances to its GDP is very unequal across the country; while States like Michoacan, Zacatecas, Oaxaca and Guerrero receive remittances than go beyond to 10% of their state GDP (2006), other states like Nuevo León, Baja California Sur and the Federal District (Mexico City) receive remittances equivalent or below to 1% of their state GDP. In table 1, we present some indicators of the proportion of the state´s remittances with respect to its GDP (REM/GDP) in the years with available information.

Table 1. Descriptive data and distributions of remittances in Mexico at sate level

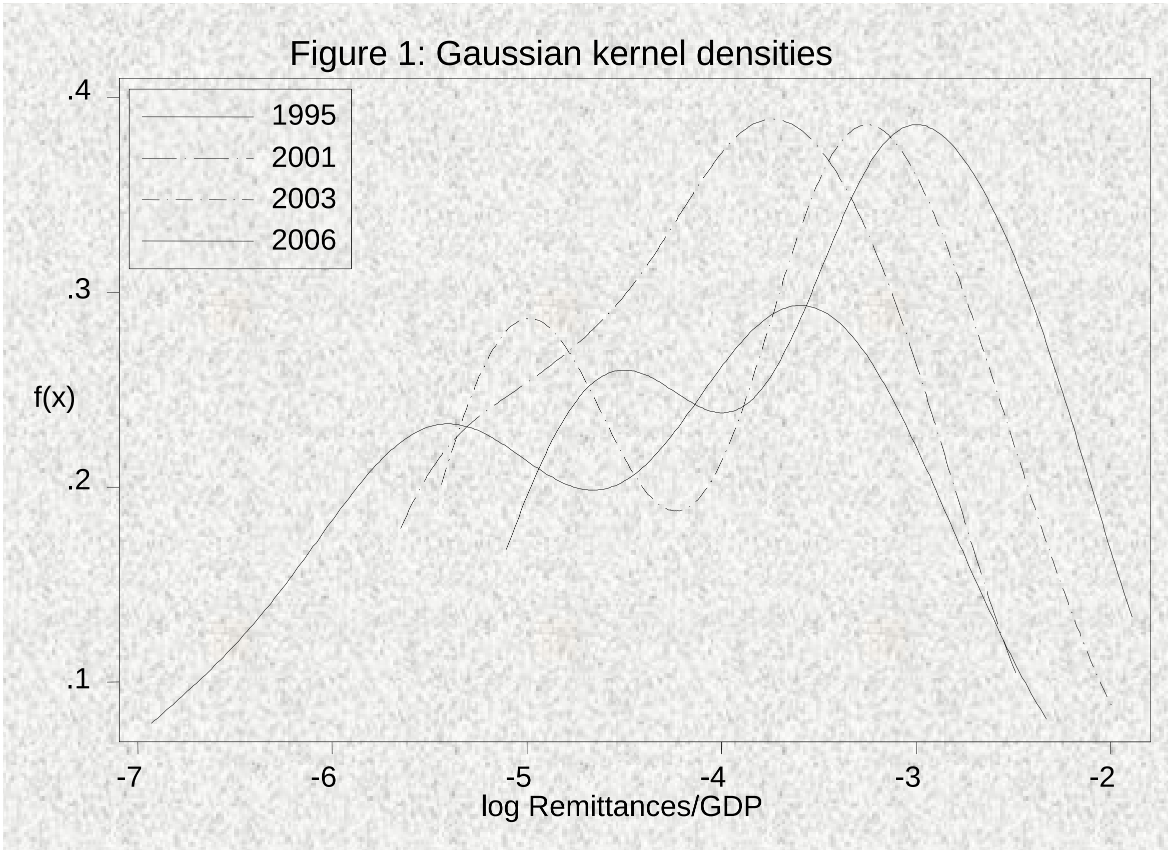
year	Millions of dollars (country)
1995	3,673
2001	8,895
2003	15,041
2004	18,331
2005	21,689
2006	25,567

year	Obs. States	Average	standard deviation	Normality test: Chi2	Normality test: Prob > chi2	Kernel gaussiana: Bandwidth (H)	Mode 1	Mode 2	Mode3
Remittances / GDP									
1995	32	0.0201525	0.0210378	16.21	0.0003	0.0095	0.0066	0.0971	
2001	32	0.0228594	0.0188165	10.28	0.0059	0.0082	0.0115	0.0831	
2003	32	0.0334987	0.0299594	13.08	0.0014	0.0116	0.0114	0.0661	0.1373
2004	32	0.0383241	0.0348743	15.28	0.0005	0.0133	0.0130	0.1641	
2005	32	0.0417688	0.0355858	13.01	0.0015	0.0160	0.0214	0.1648	
2006	32	0.0446028	0.0363335	6.69	0.0352	0.0164	0.0210	0.1469	
Log (Rem / GDP)									
1995	32	-4.524424	1.252392	3.78	0.1514	0.5636	-5.4218	-3.6070	
2001	32	-4.128433	0.896874	3.22	0.2000	0.4036	-3.7454		
2003	32	-3.825340	1.004703	7.45	0.0241	0.4521	-5.0002	-3.2642	
2004	32	-3.697511	1.014750	6.18	0.0455	0.4566	-4.8674	-3.1323	
2005	32	-3.558797	0.950028	4.08	0.1298	0.4275	-4.5999	-3.0694	
2006	32	-3.484506	0.942042	5.18	0.0750	0.4239	-4.5018	-3.0012	
Rem / Population (pesos 1993)									
1995	32	189.1412	167.4184	8.50	0.0143	75.3383	72.3248		
2001	32	251.8719	152.1663	6.49	0.0391	68.3156	158.4922	700.9180	
2003	32	362.8706	250.0348	9.80	0.0075	112.5157	180.0251	1188.1658	
2004	32	430.3491	303.4962	12.84	0.0016	136.5733	223.9802	1491.3805	
2005	32	476.3975	295.7716	11.37	0.0034	133.0972	316.7713	1493.3506	
2006	32	527.8444	309.7577	4.75	0.0930	139.3910	312.2358	1393.9100	

Source: own elaboration with Banco de Mexico data

The main result of the table 1 is that the explosive growth of remittances in the country in the period 1995-2006 (see top of the table) does not come along with a more equal distribution at state level of the REM/GDP and log(REM/GDP) variables. For example, note that the behavior of the standard deviation of log(REM/PIB) from 1995 does not show an important decrease as one will expect under a scenario of **sigma convergence** in the variable. A join kurtosis/skewness test for normality (see D'Agostino *et al*, 1990) in the data (see columns 5 and 6 of table 1) suggest that the data, even with log transformation, are not close from being normally distributed. To evaluate these implications, the kernel gaussian densities were calculated using a different "optimal" bandwidth (column 8) for each year; once the densities were calculated, the modes of the distribution were identified (see column 8 and 9).[1] The results indicate that there are at least two modes in the densities calculated for all the years considered. To have a visual evaluation of this situation, in figure 1 we showed the kernel densities for the log(REM/PIB) in each of the years under study.

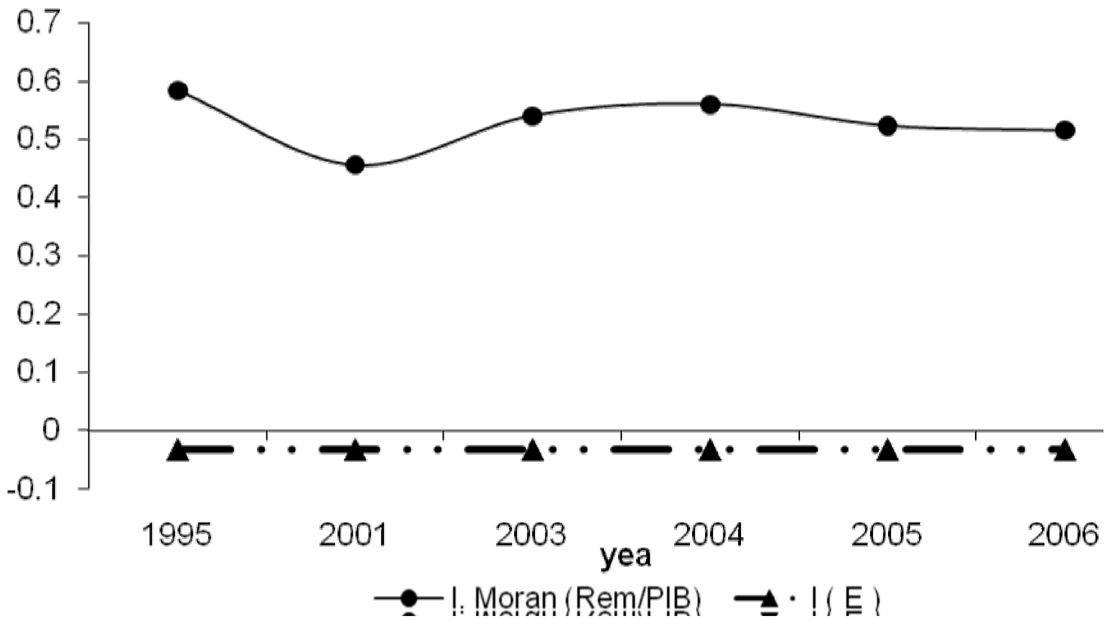
[1] The procedure was executed in STATA using the command "wardpend" developed by Salgado *et al* (1997).



The figure 1 depicts clearly two clubs of convergence which remain strongly along the period considered. Further empirical analysis is required not only to evaluate the dynamic process of the densities estimated (i.e. *sthocastic kernels*) but also to address a statiscal criteria to infer about the multimodality of the densities. Nevertheless, this first nonparameteric approximation is very suggestive in indicating that the relationship between remittances and regional GDP depicts symptoms of polarization. It seems, giving the data of table 1, that a group of states is converging to a percentage of 15% (proportion of remittances with respect to the GDP) and other group is converging to 2%.

Now, it would important to evaluate whether this presumably polarization in the log (REM/GDP) at state level also has spatial connotations. In order to have an approximation to such possibility, we calculated the Moran´s Index of the log(REM/GDP) for all the years under study using a criterion of contiguity of first order to construct the spatial weight matrix (*W*). The results are displayed in the following figure 2:

Figure 2: Moran Index log(REM/GDP),



All the indexes are statically significant with p values practically zero (calculated under a permutation test). The index Moran maintains during the all period a high value around 0.5. If compared the Moran of the log (REM/GDP) to other variables, the spatial autocorrelation of the log (REM/GDP) is sensible higher than the observed in the Moran of the GDP per capita or the Moran of the log(FDI/GDP). Now, an important element to consider is the specific spatial clusters associated to the global spatial autoccorrelation of the variable. Map 1 and Map 2 display for the years1995 and 2006 respectively, the Local Indicators of Spatial Autoccorelation calculated under the methodological lines of Anselin (1995).

Map 1: LISA for the log REM/GDP (1995)

Map 2: LISA for the log REM/GDP (2006)

Observe in the maps that in both years there are two clear agglomerations indicating local spatial autocorrelation of the log (REM/GDP), one of them with Low-Low LISA´s and the other with High-High. In the year 1995, the spot High-High (see dark gray in the map) corresponds to the traditional migration region in Mexico widely discussed by migration experts as Durand (2005). But note in the Map 2 that the High-High cluster moves to the south of the country in 2006. This displacement of the cluster High-High has important implications if the economic regional growth is incorporated in the analysis: it happens that the High-High spot has moved toward the less economic dynamic region of the country. This element is better captured in the following Map 3 that depicts the LISA of the log (REM/GDP) growth between 1995 and 2006.

Map 3: LISA for the log REM/GDP growth (1995-2006)

Now, in the map 3 the cluster Low-Low (see light gray in the map) is located in the center occident of the country that corresponds to the traditional migration region, while the High-High cluster - which experiments the higher rates in growth in the log (REM/GDP), is clearly positioned in those states that have had the lower economic growth rates in the country in such period. This situation can be considered as a *spatial stylized fact* that remit us to consider the hypothesis that remittances could be acting in a countercyclical way, in order to compensate the low levels of effective demand in the poor regions of the country.

So far, it has been shown that there is a spatial dimension of the regional inequality of the log (REM/GDP) at state level in Mexico. In the following sections, we will address, under a spatial econometric setting, whether the remittances variable contributes to explain the variations in the growth of the regional GDP per capita. But before going to the next secction, it is important to mention that standard econometric approaches that implements growth models *a la* Barro do not reveal that remittances contribute to explain regional growth in Mexico. We consider that the reason for that is that there is an important component of spatial heterogeneity in the relationship between growth and remittances that must be analyzed carefully along the new available spatial econometric techniques that have been developed recently, mainly through the spatial panel models.

3. Growth models and spatial econometric techniques

3.1 Brief review of the empirical econometric literature

The regional econometric approach to study remittances and growth is relatively recent and, it has been focused on country data. The econometric approach is based essentially on a neoclassical growth model *a la* Barro and Sala-i-Martin (1992) that examines regional convergence-divergence processes (see technical details ahead). Among these first studies, we mention the work of Chami *et al* (2005) who analyze panel data from 113 countries and find a negative impact of remittances on growth. But in most of the empirical studies prevail an "optimistic view" about the role of remittances. For example, Giuliano and Ruiz-Arranz (2006) show that remittances impact positively on the economic growth of developing economies. Recently, Pradhan et al (2008) with a sample of 39 developing countries also find that remittances have a positive impact on economic growth. In the same way, Ziesemer (2006) argues that remittances have positive effects on growth because it promotes investment in physical and human capital. Likewise, Acosta *et al.* (2008) consider Lationamerican economies and also find that remittances contributes to economic growth and reduce inequality and poverty in the region.

In general, the later econometric studies rely on both fixed and random effects approaches. In these models, "regional heterogeneity" is considered through taking into account possible country-specific factors that affect growth (i.e. the models incorporate different regional constants in the econometric specification). But, it is clear that these econometric approaches do not consider spatial interaction among regions as another mean to understand "regional heterogeneity". To our knowledge, spillovers among regions have not been treated yet in the empirical econometric literature that studies the relationship between growth and remittances. At least for the Mexican case, there are good reasons (see section II) to think that there is a strong spatial dependence in the relationship between remittances and regional GDP, which suggest that spatial heterogeneity might be also explored with spatial econometric approaches.

3.b Econometric models

In the literature on regional and conditional convergence growth models, the methodological discussion has been focused 1) on the use of cross section models in order to test absolute convergence and conditional, 2) on panel data models to test conditional convergence with supposed heterogeneity and 3) recently on spatial conditional convergence with cross section and panel data. These latter methods are based on spatial econometrics, in which the effects of spatial interdependence and heterogeneity can be obtained in a multidirectional approach between regions. This section deals with presenting the essential of these econometrics techniques because they can be used to study the relationship between remittances and growth.

Model of cross section

Different researches about remittances and regional growth in Mexico have used the cross section traditional methodology to estimate absolute and conditional convergence models.

The general model used related the average growth in the analyses period of regional per capita GDP ($\boldsymbol{g_{i,T}}$) measured as $\boldsymbol{Ln}(\mathbf{y_{i,T}}/\ \mathbf{y_{i,0}})/\mathrm{T}$, with the GDP logarithm in the initial period ($\boldsymbol{y_0}$), the remittances logarithm as GDP proportion (***Rem***) and others relevant variables (***X***), for all *i* regions.

$$[1] \qquad \boldsymbol{g_{i,T}} = \beta \boldsymbol{y_{i,0}} + \theta \boldsymbol{Rem_{i,0}} + \alpha \boldsymbol{X_{i,0}} + \mu + \boldsymbol{\varepsilon_i}$$

The analytical implication of the last model, when it is estimated just $\boldsymbol{y_0}$ and it is found the β parameter is negative and significant; this is the existence of *absolute convergence*. As the model is cross section it means that all regional economies are going to the same equilibrium value. The absolute convergence model has been very criticized because at suppose that the economies are homogeny and they go away of the equilibrium in a temporal way.

The model has other analytical implications when exogenous variables are included, control or conditional variables, at the same time as $\boldsymbol{y_0}$ is considered, as ***Rem*** and ***X*** variables, that collect heterogeneity between regions under the supposed existence of initial conditions in the process of regional growth. For the phenomenon of remittances, when the θ parameter is positive at the same time β parameter is negative this implies that the remittances would explain regional growth in a *convergence conditional* process and that each regional economy is reaching its own stationary state as determined by the level of remittances. In other words, higher levels of remittances as a portion of GDP will be producing an accelerated GDP growth per capita in small economies, in such a way that on the long run these can reach the level of economies with a higher GDP per capita with a proportion of remittances to GDP relatively lower. As mentioned somewhere above studies carried out by Mendoza. J. and Calderon, C. (2006) which have used a *conditional convergence* model with cross section data have found little or no evidence that remittances explain regional growth in Mexico.

Panel data models

An alternative econometric approach to model the relationship between remittances and regional growth is the panel data models. With this kind of models not only we have an advantage in increasing the degrees of freedom but also it introduces regional heterogeneity through a simple assumption that considers a different constant for each region (μ_i). In that way, the conditional convergence model with panel data incorporates heterogeneity in two way: different constants and conditional exogenous variables ***Rem*** y ***X***. Therefore, the impact of remittances on regional growth ($\boldsymbol{g_{i,t}} = \boldsymbol{Ln}(\mathbf{y_{i,t}}/\mathbf{y_{i,t-1}})$) must be seen as a permanent process time that does not depend on initial conditions or average behavior during specific periods.

[2] $$\boldsymbol{g_{i,t}} = \beta \boldsymbol{y_{i,t}} + \theta \boldsymbol{Rem_{i,t}} + \alpha \boldsymbol{X_{i,t}} + \mu_i + \boldsymbol{\varepsilon_{i,t}}$$

In *conditional convergence* models with panel data, different regional constants (μ_i) can be estimated using fixed and random effect methods. In the first case it is obtained through the differences in averages, while in the random case two parts are supposed, one is the constant average and the second is a random component which is supposed and distributed as normal and it is independent with respect to ε_{it}. The decision of estimating the model as fixed or random effect model is solved with Hausman's hypothesis.

With the panel data models it would be expected that under conditional convergence and heterogeneity condition hypotheses with fixed or random effects, remittances as a portion of GDP have a positive effect on regional growth. On these terms, what is expected is to find that β be negative, θ positive and μ_i different for each region. The panel data model would give similar results to those of a cross section if the restriction imposed is that there is one single constant instead of individual constants; $\mu_1 = \mu_2 = ... = \mu_i = \mu$.

In studies for the Mexican case the possible existence of a relation between remittances and regional convergence has not been tested, under the hypotheses of regional conditional convergence and heterogeneity using the panel data model.

Interdependence and spatial heterogeneity

The spatial interaction models proposed by Anselin (1988) can be used to try and test if remittances have a spatial impact on regional growth explanations. In general, these models establish that processes at territorial level have a content of spatial dependency, which can condition the way in which the relationship between exogenous variables and the phenomenon to be explained can be obtained. The first spatial models that were proposed were derived from cross section models with two general formats: 1) spatial delay model; and 2) spatial error model

Cross section model and spatial interdependence

The spatial autoregressive models is expressed as

[3a] $$\boldsymbol{g}_{i,T} = \rho W \boldsymbol{g}_{i,T} + \beta \boldsymbol{y}_{i,0} + \theta \boldsymbol{Rem}_{i,0} + \alpha \boldsymbol{X}_{i,0} + \mu + \boldsymbol{\varepsilon}_i$$

Where ρ is the lag spatial coefficient and W is the spatial interaction matrix or spatial weight, which can specify by geographic criterion of weight and distance (Anselin, 1988). The W matrix is $\boldsymbol{N \times N}$ size, positive where the columns and rows correspond to the cross section observances. The $w_{i,j}$ matrix elements express the interaction between i region, in the matrix row, with the j region, in the matrix column, if there is in more than one region it could be considerate as one multiple interrelation and multidirectional. To computational and analytic ways, it works with standard matrix elements what means that the sum by column of each row is equal to unit, $\boldsymbol{w}_{i,j}^{s} = \boldsymbol{w}_{i,j} / \sum_j \boldsymbol{w}_{i,j}$

The spatial autoregressive models could be written in reduced way or spatial multiplicator (Anselin, 1999) with the purpose of count the impacts or stabilize the endogenity of the model and for that the application of a different method of estimation to the OLS.

[3b] $$\boldsymbol{g}_{i,T} = (I - \rho W)^{-1}(\beta \boldsymbol{y}_{i,0} + \theta \boldsymbol{Rem}_{i,0} + \alpha \boldsymbol{X}_{i,0} + \mu + \boldsymbol{\varepsilon}_i)$$

Adding the spatial lag, the regional growth become to a endogenous process in the point of view of the space, which cause that OLS estimation method was biased and inconsistent because of the spatial process simultaneity (Anselin, 1988). In add, with the reduced form or spatial multiplier infer that the lag model should achieve with stationarity conditions which required that $1/\omega_{min} < \rho < 1/\omega_{max}$ where ω_{min} y ω_{max} are the smaller and bigger W matrix characteristic roots respectively (Elhorst, 2009).

By other way, the spatial multiplier shows in the analytical point of view that the remittances could influence in the spatial regional growth by the *conditional convergence,* if the θ parameter is positive, β is negative and if ρ is significant and numerically is in between -1 and 1.

The other choice consists in incorporate the spatial interdependency through the equation error, which is known as spatial error models:

[4a] $$g_{i,T} = \beta y_{i,0} + \theta Rem_{i,0} + \alpha X_{i,0} + \mu + \varepsilon_i$$

y $\varepsilon_i = \lambda W \varepsilon_i + u_i$

The reduced form or spatial multiplier could be written in two equivalent ways: 1) the first is obtain when the second part of the equation is resolved and substitute in the first one, where $\varepsilon_i = (I - \lambda W)^{-1} u_i$, and 2) to get ε_i from the first equation and substitute in both sides of the second equation.

[4b] $$g_{i,T} = \beta y_{i,0} + \theta Rem_{i,0} + \alpha X_{i,0} + \mu + (I - \lambda W)^{-1} u_i$$

o

$$g_{i,T} = \lambda W g_{i,T} + \beta y_{i,0} + \theta Rem_{i,0} + \alpha X_{i,0} + \mu + \lambda W \beta y_{i,0} + \theta \lambda W Rem_{i,0} + \alpha \lambda W X_{i,0} + \lambda W \mu + u_i$$

The second specification could be estimated within *Durbin Espacial* model approach or *Factor Común* model´s, where is estimated the model without restrictions into the parameters and analyze subsequently if it can be simplify (Elhorst, 2009).

As in the spatial lag model case, the condition of stationarity are achieved when $1/\omega_{min} < \lambda < 1/\omega_{max}$.

Since analytical point of view into the model is showed that the remittances could influence in the spatial regional growth determinate by the *conditional convergence,* if the θ parameter is positive, β parameter in negative and if λ is significant and numerically in between -1 and 1.

Panel-Spatial model, spatial interdependence and heterogeneity

The Anselin, LeGallo y Jayet (2005) y Elhorst (2009) proposal to incorporate at same time *interdependency and spatial heterogeneity,* is based in apply panel data models with lag or spatial error and fixed or random effect.

The spatial-panel data with spatial lag with fixed or random effects could be written as

[5] $$g_{i,t} = \rho(I_T \otimes W_N)g_{i,t} + \beta y_{i,t} + \theta Rem_{i,t} + \alpha X_{i,t} + \mu_i + \varepsilon_{i,t}$$

The model in a reduced form or spatial multiplier is written as

[5b] $$g_{i,t} = \left(I - \rho(I_T \otimes W_N)\right)^{-1}(\beta y_{i,t} + \theta Rem_{i,t} + \alpha X_{i,t} + \mu_i + \varepsilon_{i,t})$$

As in the spatial lag model with cross sections information, it could be achieved that ρ is between -1 and 1 what for the model achieve with be stationary. Whereas since analytical point of view is waited that the remittances have an important conditional impact over the regional growth since the point of interdependence and spatial heterogeneity, if θ parameter is positive, β parameter is negative, exist fixed and random effects (μ_i), ρ is significant and numerically its value is between -1 and 1.

4. Econometric results of the models[2]

In this section, we present the estimation results of the traditional panel econometric models (fixed effects and random effects) and those of the spatial panel econometric models. The period of time considered is 2001-2006.

The spatial weight matrix (W)

Three types of spatial weight matrix were considered for the econometric estimations: a) a row standardized contiguity matrix of first order (called **Queen1a(1y 0)**); b) a row standardized contiguity matrix of first order, weighted by the real road distance between pairs of capital cities of the states (called **Queen1b(1/d)**); and c) a distance decay matrix (wij= 1/dij) that uses real road distance between pairs of capital cities of the states (called **Dist.Carr. (1/d)).**

Spatial tests of the panel data models without spatial effects

In table 3, the OLS pooled estimation (see equation [2] with $\mu_{i=0}$) and the fixed effects (see equation [2]) estimation are presented, jointly with the Lagrange Multiplier tests for spatial lag and spatial error dependence in pooled models (see technical details in Anselin-

[2] All estimations were calculated in Matlab using Paul Elhorst´s routines (see http://www.regroningen.nl/elhorst).

LeGallo-Jayet). Two model specifications are presented in table 3, in the first the convergence growth model includes only the log (REM/GDP) [see 2nd and 3rd columns], and the second specification adds the log of the average years of schooling [see 4th and 5th columns].

Table 3: GDP per capita regional growth model

Pooled data 2001-2006, 32 states

	Remittances/GDP		**Remittances/GDP and average year of scholing**	
Independent variable	Pooled OLS	Fixed effects	Pooled OLS	fixed effects
Intercept	4.660		4.692	
	(0.000)		(0.000)	
Log GDP per capita	-0.002	-0.557	-0.027	-0.558
	(0.841)	(0.000)	(0.084)	(0.000)
Log Remittances / GDP	0.005	0.059	0.006	0.039
	(0.323)	(0.000)	(0.250)	(0.009)
Log average years of schooling			0.114	0.234
			(0.014)	(0.045)
R^2_{Ajustada}	0.004	0.340	0.030	0.351
Tests for spatial dependence				
1. W = Queen1a (1 y 0)				
Lagrange Multiplier (lag)	7.25 0.01	2.96 0.09	5.99 0.01	3.01 0.08
Robust LM (lag)	1.86 0.17	2.14 0.14	3.07 0.08	0.61 0.44
Lagrange Multiplier (error)	6.78 0.01	7.53 0.01	2.09 0.03	5.61 0.02
Robust LM (error)	1.39 0.24	6.71 0.01	5.01 0.15	3.21 0.07
2. W = Queen1b (1/d)				
Lagrange Multiplier (lag)	4.45 0.04	1.38 0.24	3.48 0.06	1.33 0.25
Robust LM (lag)	1.25 0.26	1.87 0.17	1.20 0.27	0.76 0.38
Lagrange Multiplier (error)	4.19 0.04	4.20 0.04	2.99 0.08	3.02 0.08
Robust LM (error)	0.98 0.32	4.68 0.03	0.72 0.40	2.43 0.12
3. W = Dist Carr (1/d)				
Lagrange Multiplier (lag)	8.82 0.00	1.60 0.21	5.76 0.02	1.20 0.27
Robust LM (lag)	24.41 0.00	3.89 0.05	18.58 0.00	3.53 0.06
Lagrange Multiplier (error)	7.50 0.01	7.94 0.01	3.64 0.06	5.34 0.02
Robust LM (error)	23.10 0.00	10.24 0.00	16.46 0.00	7.67 0.01

Notes: The dependent variable is Δ log gdp (log differenced of real GDP per capita). t-probability are given in parentheses.

The results show that the OLS pooled model produce neither convergence of the GDP per capita nor significant effect of the log (REM/GDP) variable. But, if the regional heterogeneity assumption is considered through the fixed effects models, it is found not only that there is convergence but also that remittances contribute positively to that process. And these results are not modified when the education variable is included in the model (but note that the explanatory power of the education variable is greater than the remittances).

Test for spatial dependence are presented in the second part of the table for each of the spatial weight matrix considered. In general, the main result of the tests is that, regardless of the type of weight matrix used, there is some evidence that the fixed effect estimation requires to be corrected by considering a spatial error model as alternative.

Spatial panel data model (spatial lag and spatial error model) with random effects

The first spatial alternative to the fixed effects model presented above is the spatial panel model with random effects (see equation [5]). In tables 4 and 5 are presented the results of the estimations (in table 5, the specification also includes the log of the years of schooling). First, note that the spatial panel model with random effects has a poor explanatory power if compared with the traditional fixed effect estimation: the adjusted R2 in all models lies between 0.01 and 0.05. Secondly, the variable of remittances is not statically different to zero, therefore it is not contributing to growth in any of the considered models. Thirdly, under this setting, only the variable of education is statistically significant (see table 5) and it affects positively on the process of conditional convergence.

Spatial panel data model (spatial lag and spatial error model) with fixed effects

The second spatial alternative to the fixed effect model (see table 3) is the spatial panel data model with fixed effects (see equation [5]). As in the later case, the results are presented in tables 4 and 5. Firstly, note that these models have considerable stronger explanatory power than the spatial panel data model with random effects: the adjusted R^2 in all models lies between 0.34 and 0.35. Second, the variable of remittances is positive and statistically significant when it is the only variable that condition the process of growth; in this case, all the specifications (independently of the weight matrix) produce conditional convergence, but note that the spatial lag variable of the GDP per capita growth is not significant (rho is zero) but the spatial error term. Thirdly, these results do not change drastically if the specification includes the education variable, the only difference is that the spatial error term is only significant when the spatial weight matrix used is either the row standardized contiguity matrix or the distance decay matrix that uses real road distance between pairs of capital cities of the states.

Table 4: GDP per capital regional growth models, spatial lag and error model

Pooled data 2001-2006, 32 states

Spatial lag model		**Spatial Weight**	
Independet variable: Remittances/GDP	1. W = Queen1a (1 y 0)	2. W = Queen1b (1/d)	3. W = Dist Carr (1/d)
Pool: spatial fixed effects			
Spatial Lag Crecimiento GDP per capita (ρ)	0.125	0.080	0.197
	(0.115)	(0.291)	(0.154)
Intercep			
Log GDP per capita	-0.552	-0.554	-0.558
	(0.000)	(0.000)	(0.000)
Log Remittances / GDP	0.053	0.055	0.049
	(0.000)	(0.000)	(0.000)
R^2_{Ajustada}	0.333	0.338	0.330
Pool: spatial random effects			
Spatial Lag Crecimiento GDP per capita (ρ)	0.214	0.163	0.354
	(0.015)	(0.054)	(0.023)
Intercep	3.710	3.940	3.081
	(0.000)	(0.000)	(0.000)
Log GDP per capita	-0.007	-0.006	-0.009
	(0.563)	(0.604)	(0.461)
Log Remittances / GDP	0.003	0.003	0.002
	(0.593)	(0.530)	(0.704)
R^2_{Ajustada}	0.014	0.014	0.014

Spatial error model		**Spatial Weight**	
Independet variable: Remittances/GDP	1. W = Queen1a (1 y 0)	2. W = Queen1b (1/d)	3. W = Dist Carr (1/d)
Pool: spatial fixed effects			
Spatial Error (λ)	0.223	0.163	0.462
	(0.011)	(0.054)	(0.001)
Intercep			
Log GDP per capita	-0.589	-0.581	-0.619
	(0.000)	(0.000)	(0.000)
Log Remittances / GDP	0.055	0.056	0.039
	(0.000)	(0.000)	(0.014)
R^2_{Ajustada}	0.342	0.343	0.328
Pool: spatial random effects			
Spatial Error (λ)	0.223	0.179	0.415
	(0.010)	(0.025)	(0.002)
Intercep	4.732	4.781	4.821
	(0.000)	(0.000)	(0.000)
Log GDP per capita	-0.011	-0.016	-0.021
	(0.369)	(0.245)	(0.124)
Log Remittances / GDP	0.002	0.000	-0.003
	(0.754)	(0.990)	(0.568)
R^2_{Ajustada}	0.012	0.009	0.004

Notes: The dependent variable is Δ log gdp (log differenced of real GDP per capita). t-probability are given in parentheses.

Table 5: GDP per capital regional growth models, spatial lag and error model

Pooled data 2001-2006, 32 states

Spatial lag model	**Spatial Weight**		
Independet variable: Remittances/GDP and average year of scholing	1. W = Queen1a (1 y 0)	2. W = Queen1b (1/d)	3. W = Dist Carr (1/d)
Pool: spatial fixed effects			
Spatial Lag Crecimiento GDP per capita (ρ)	0.124	0.081	0.162
	(0.120)	(0.287)	(0.264)
Intercep			
Log GDP per capita	-0.552	-0.555	-0.559
	(0.000)	(0.000)	(0.000)
Log Remittances / GDP	0.033	0.035	0.032
	(0.025)	(0.018)	(0.039)
Log average year of scholing	0.231	0.230	0.221
	0.043	0.045	0.054
$R^2_{Ajustada}$	0.351	0.353	0.349
Pool: spatial random effects			
Spatial Lag Crecimiento GDP per capita (ρ)	0.196	0.146	0.309
	(0.027)	(0.084)	(0.055)
Intercep	3.818	4.045	3.309
	(0.000)	(0.000)	(0.000)
Log GDP per capita	-0.029	-0.029	-0.029
	(0.059)	(0.061)	(0.058)
Log Remittances / GDP	0.004	0.004	0.003
	(0.474)	(0.417)	(0.554)
Log average year of scholing	0.103	0.106	0.097
	(0.022)	(0.019)	(0.032)
$R^2_{Ajustada}$	0.050	0.047	0.053

Spatial error model	**Spatial Weight**		
Independet variable: Remittances/GDP and average year of scholing	1. W = Queen1a (1 y 0)	2. W = Queen1b (1/d)	3. W = Dist Carr (1/d)
Pool: spatial fixed effects			
Spatial Error (λ)	0.191	0.135	0.361
	(0.033)	(0.115)	(0.019)
Intercep			
Log GDP per capita	-0.580	-0.573	-0.602
	(0.000)	(0.000)	(0.000)
Log Remittances / GDP	0.041	0.040	0.035
	(0.007)	(0.009)	(0.036)
Log average year of scholing	0.186	0.206	0.173
	(0.112)	(0.078)	(0.162)
$R^2_{Ajustada}$	0.356	0.357	0.352
Pool: spatial random effects			
Spatial Error (λ)	0.182	0.124	0.307
	(0.040)	(0.129)	(0.054)
Intercep	4.745	4.806	4.792
	(0.000)	(0.000)	(0.000)
Log GDP per capita	-0.032	-0.042	-0.037
	(0.038)	(0.014)	(0.022)
Log Remittances / GDP	0.003	0.003	0.001
	(0.548)	(0.617)	(0.897)
Log average year of scholing	0.107	0.128	0.104
	(0.026)	(0.008)	(0.030)
$R^2_{Ajustada}$	0.043	0.042	0.039

Notes: The dependent variable is Δ log gdp (log differenced of real GDP per capita). t-probability are given in parentheses.

The main analytical implications of these results is that remittances can affect positively the dynamics of regional conditional convergence only if it is considered both spatial dependence and spatial heterogeneity into a spatial model framework with fixed effects. In this case, it is interesting to see that in addition to the standard criteria of contiguity in the spatial interaction specification, a spatial weight matrix that implements a distance decay function (measured by real roads) seems to play also an important role to model spatial heterogeneity.

5. Final remarks

In this paper we investigate whether remittances are contributing to the regional economic growth in Mexico. The study shows that there is a strong spatial dependence in the behavior of the ratio Remittances/GDP at state level. And its evolution during the last years seems to be countercyclical with respect to the regional economic growth of the country; that is, the spatial agglomeration that reflects above average growth rates of the ratio REM/GDP is associated spatially with the less dynamic economic regions (mainly the south of the country). This spatial stylized fact might be conditioning the dynamics of regional convergence-divergence process. Nevertheless, standard econometric approaches that do not consider regional heterogeneity are not revealing any real impact of remittances on growth. Only when a spatial panel model with fixed effects is considered, the effect of remittances on growth is revealed; this situation indicates us that the relationship between growth and remittances must be addressed under a framework that takes spatial heterogeneity into account seriously .

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