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Provincial Assessment of Convergence and Migration in Spain

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Abstract

Convergence is a subject of controversy in regional studies, no matter if the analysis is carried out across regions of various countries or regions of the same country. Convergence is quite difficult to assess because it can be unconditional, conditional or club convergence. When referring to the impact of migration, the difficulty arises from the distinction made between net and gross migration, between the homogenous or heterogeneous nature of migrants when talking about their human capital endowment and from the issue of spatial dependence between adjacent regions.

The present study carries out a cross-provincial analysis of GDP evolution in time and the influence exerted by internal migration. For this, I have used panel data covering the period 1998-2008 and, moreover, I have controlled for human capital content of migrants in order to determine if a brain drain or brain gain process took place in Spain. The appropriate model employed to assess beta-convergence is the spatial Durbin model with province- and period-specific effects.

The main results point out at an increasing migration over the years, the existence of both sigma- and beta-convergence, a negative and significant effect of out-migration, significant estimates of spatially lagged GDP growth and GDP level. Unfortunately, because some coefficients returned insignificant values, I cannot pronounce myself in favor of brain drain or brain gain existence.

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1 Introduction

According to Eurostat NUTS 3 level, Spain is divided into *50 provinces,* which closely follow the pattern of the territorial division of the country carried out in 1833. The most populated provinces (in 2009) are Biscay (519.8 inhab./km2), Barcelona (710.1 inhab./km2) and Madrid (795.6 inhab./km2) whereas the least dense are Soria (9.2 inhab./km) and Teruel (9.9 inhab./km). As for the surface, Gipuzkoa and Biscay have only 1,980 and, respectively, 2,217 km2 while Ciudad Real and Caceres and Badajoz have 19,800 the former two and 21,713 km2 the latter one.
The main objectives of this paper are to determine: if there was sigma- and/or beta-convergence in Spain; if migration had any impact on beta-convergence, and in which version; if migrants were mainly homogenous or heterogeneous in their level of skills, i.e. brain drain or brain gain effect; and the magnitude of the Spanish migration flows.
The structure of the article comprises the following sections: section 2 makes a review of the existing literature on regional convergence and its relation with domestic migration, section 3 displays the evolution of internal disparities as regards income, migration and education, section 4 investigates on the nature of sigma- and beta-convergence and other interesting particularities of the beta phenomenon, while section 5 offers some insights on future research. To my knowledge, there is no another study that analyzed convergence and migration using the present methodology and period of time in Spain.

2 Literature Review on Convergence and Migration

2.1 Main theories of economic growth

In the economic growth literature there are two main approaches:

- *exogenous or neoclassical growth theory* (optimistic approach): decreasing disparities in income levels because of diminishing returns to capital and constant returns to scale (Solow, 1956);
- *endogenous or new growth theory* (pessimistic approach): persistent and increasing disparities because of positive returns to scale due to the accumulation of factors (Romer, 1990; Lucas Jr., 1988).

Instead, the *new economic geography*, neither optimistic nor pessimistic, claims that the economic situation of a region depends also on its location and neighbors;

as a consequence, poor regions should be favored if they are surrounded by rich neighbors (Krugman, 1991).
Because the exogenous theory considers closed economies, Arbia et al. (2005) argue that this limitation is too strong for regions within a country where there are small barriers to factor mobility (capital and labor), trade relations and technological diffusion (knowledge spillover). Hence, the convergence rate in the open mobile economy would be higher than in the closed rigid economy[2].

2.2 Convergence: typology and lemmas

From the perspective of the traditional neoclassical growth theory, *convergence takes place when there is a negative relationship between the initial GDP per capita and its growth in time*. Convergence implies a long-run process towards the balancing of per capita national product at different scales (Abramovitz, 1986). Thus, the further a region is from its own steady state the faster this region will grow (Solow, 1956).
According to the vast convergence literature, the evolution of regional income can be appreciated by two main types of convergence (Barro and Sala-i-Martin (from now on, BSiM), 1992; Marques and Soukiazis, 1998):

- *sigma-convergence* (traditional type developed by Baumol, 1986): measures the temporal dispersion of real output across regions using the standard deviation or the coefficient of variation; convergence is when the dispersion falls over time, otherwise there is divergence, and when it shows ups and downs, there is a mix of both[3];
- *beta-convergence* (neoclassical type developed by Barro et al., 1991): measures the relationship between the previous per capita income and current income growth rate using the long-run regression:

$$\frac{\log\left(\frac{gdp_{iT}}{gdp_{it}}\right)}{T} = \alpha - b * \log(gdp_{it}) + \delta * X_{iT} + \varepsilon_{iT} \quad (1)$$

where gdp_{iT} is the per capita income in the final year T, gdp_{it} is the per capita income in the initial year t, T the length of time, α the autonomous or steady-state growth rate (or technological progress rate), b the convergence

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[2] It assumes the introduction of capital, labor and technology measures into the growth equation, but this is quite difficult because of some data unavailability. A proper solution: controlling for spatial dependence.

[3] Quah (1996) says that sigma-convergence has the shortcoming of offering no information about the intra-distributional dynamics of income.

coefficient, X_{iT} a vector of structural exogenous variables influencing income growth, and ε the idiosyncratic error.

The rate or speed of convergence, i.e. beta, is computed as $\beta = -\frac{\ln(1+b*T)}{T}$. *Convergence happens when beta turns positive*, otherwise there is divergence. One can also compute the half life, i.e. the number of years necessary to cover half the distance from the steady state, as $\kappa = -\frac{\ln 2}{\ln(1+b)}$ (Hierro and Maza, 2010). BSiM (1992: 230) estimates β non-linearly because "... *as T tends to infinity, the coefficient* [b] *tends to zero*".

Also, beta-convergence can be:

- *absolute/ unconditional/ strong*: when homogenous regions (in technology, preferences, institutions, language, etc., or in initial conditions) tend to reach the same steady state in time, i.e. beta is obtained without introducing any structural variable X;
- *relative/ conditional/ weak*: when heterogeneous regions (although with similar initial conditions) tend to reach their own steady-state levels, i.e. beta is obtained including some structural variables X[4].

Conditional convergence is more appropriate when using between-country data whereas unconditional convergence is more adequate with within-country data (Sala-I-Martin, 1995). Even so, BSiM (2004) recommend using both types of convergence with regional data.

There is also *conditional sigma-convergence* which takes place when the income distribution shrinks over time after controlling for relevant exogenous variables. This implies a decreasing variance of predicted income (Pfaffermayr, 2007).

While sigma-convergence tests the evolution over time of the distribution of per capita income, beta-convergence tests the mobility of per capita income within the same distribution. Therefore, *beta-convergence is a necessary but not a sufficient condition for sigma-convergence* (stronger)[5]; thus, these two concepts are more complementary than substitutable (Sala-I-Martin, 1995). Or, the "beta" concept examines how fast poor regions become richer and rich regions become poorer; instead, the "sigma" concept examines whether regional incomes become more similar (Magrini, 2007).

Maurer (1995) explains the statistical relation between the two concepts of convergence in six lemmas based on Cauchy-Schwarz inequality:

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[4] Friedman (1992) affirmed that beta-convergence tests may be affected by Galton's fallacy of regression toward the mean. Also, both types may suffer from heterogeneity, endogeneity and measurement problems (Durlauf and Quah, 1999).

[5] Quah (1993) and Friedman (1992) consider sigma-convergence more important.

- σ-convergence implies necessarily β-convergence;
- β-divergence implies necessarily σ-divergence;
- β-convergence syncs with σ-convergence or σ-divergence;
- σ-divergence syncs with β-divergence or β-convergence;
- β-constancy syncs with σ-convergence or σ-constancy;
- σ-constancy syncs with β-convergence or β-constancy.

A third type of convergence is *stochastic convergence* which implies that the long-run forecasts of income differences across regions evolve to 0 (Carlino and Mills, 1996, Bernard and Durlauf, 1996). Also, Baumol (1986) introduced a forth concept, *club convergence* which denotes regions with similar structures and initial conditions that converge to one another in the long run. Moreover, Chatterji (1992) bases this concept on the endogenous growth theory which is in favor of multiple and locally stable steady states. Galor (1996) argue that if heterogeneity is allowed across regions, the Solow-Swan growth model could have multiple steady-state equilibriums and thus club convergence may become a viable possible hypothesis.

Critics of absolute convergence in favor of relative convergence include in the growth regression "control variables" to account for regional heterogeneity, while critics in favor of club convergence use "split variables" to account for initial conditions. Differentiating between relative and club convergence is difficult. *Absolute convergence implies constant α and β and zero δ, relative convergence implies also non-zero δ whereas club convergence implies varying α and β and non-zero δ* (Johnson and Takeyama, 2003). In practice, club convergence is considered mainly when referring to cross-country convergence, while the others are more suitable when testing within-country convergence.

2.3 Convergence and migration

Usually, migrants move from regions with low incomes and high unemployment to regions with higher incomes and better employment opportunities. This contributes to the adjustment to asymmetric shocks. But if labor is rigid, the regional disequilibria will persist unless other mechanisms (such as fiscal) intervene (Fidrmuc, 2004).

Labor mobility is high in the US (Blanchard and Katz, 1992) and low in Europe (Decressin and Fatas, 1995). Moreover, in Central and Eastern Europe, the transition from central planning to market economy caused a series of regional disparities; here, labor mobility is even more crucial to help diminish them (Repkine and Walsh, 1999).

Standard growth models assume that migration adds to convergence and explain its impact on the convergence process like this: is labor goes from capital-poor regions to capital-wealthier regions until wages equalize, all regions will tend to reach their steady-state equilibrium with the same capital-labor ratio and income (Faini, 2003).

Empirical convergence across countries and regions has started with the work of Barro et al. in 1991. Afterwards, an extensive number of studies flourished. The majority of them were based on the neoclassical growth theory. According to this, in time, poorer regions (with a lower capital intensity or ratio capital/labor) catch up richer regions (higher capital intensity) in their GDP/capita level due to decreasing returns to capital. Moreover, allowing for mobility (people/labor) across regions would speed the rate of convergence only if migrants are homogenous in their human capital content. Unless controlling for migration the rate of convergence would be overestimated (BSiM, 2004).

The existing literature predicts that within developed countries, migration is expected to have a rather small impact on convergence (BSiM, 2004), whereas within developing countries its impact is expected to be higher as migrants are in general low skilled and move from poor agricultural regions to wealthier urban ones (Kirdar and Saracoğlu, 2007).

2.4 Net migration or gross migration

In European practice, regions with high wages tend to have high in-migration as well as high out-migration, rather than high in-migration and low out-migration. Similarly, unemployment seems to discourage both in-migration and out-migration, although its significance is, usually, lower than wages´. This is how regional disparities persist, because developed regions display high migration (and persistent high wages and low unemployment) while depressed regions display low migration (and persistent high unemployment and low wages) (Fidrmuc, 2004). This is where the concepts of convergence (diminishing disparities) and divergence (increasing disparities) intervene.

The impact of migration should be assessed considering both net and gross migration. Using gross (arrivals and departures) and net migration (balances) could yield different results because *in- and out-migration may not work symmetrically* in the growth rate equation and, hence, should not be treated as such. It is possible that even when net migration is null, gross migration may conduct to important regional redistributions of human capital and, in turn, regional traits may reflect differently on gross flows. Another way put, a subtle variation in net migration rate can be accompanied by large variations in both in- and out- migration rates. Therefore, *using only net migration instead of both net and gross migration could be misleading*. According to the neoclassical approach, in-migration should negatively impact on convergence while out-migration positively (Østbye and Westerlund, 2007; Etzo, 2008).

2.5 Homogeneous or heterogeneous migrants?

As I have said before, *migration should impact negatively on growth and add to convergence if migrants possess the similar human capital* (i.e. are homogenous) by increasing the capital intensity in regions with net migration outflows and lowering it in regions with net migration inflows. But if migrants do not have the same human capital content, the net effect depends on the following two situations (Østbye and Westerlund, 2007):

- if migration leads to an increase in human capital in the lagging regions and to a decrease in the leading regions or, simpler, lagging regions are favored by migration, we say that the quantity (negative) effect is dominated by the composition (positive) effect, which is called in the literature *brain gain*;
- if migration boosts human capital in the already leading regions and diminishes it in the lagging regions or, simpler, leading regions are the net gainers from migration, we say that the quantity effect is stronger, phenomenon called *brain drain*.

In the case of brain drain migration will impact negatively on economic growth and beta-convergence will decrease, whilst in the case of brain gain migration will impact positively on an increasing beta-convergence.

Therefore, when controlling for the human capital endowment, i.e. taking account of heterogeneity among migrants, migration could act as a favorable or unfavorable tool for income convergence. Østbye and Westerlund (2007) states that *if out-migrants are more skilled than non-migrants this could lead to (negative) out-migration slowing down growth* because the loss in human capital per head may exceed the gain in physical capital per head. Additionally, *if in-migrants are more productive than host inhabitants this could lead to (positive) in-migration raising growth* because the gain in human capital may exceed the loss in physical capital.

But what is the implication of higher skills? According to the exogenous theory, a higher education generates a higher productivity and thus a higher level of output (Etzo, 2008).

2.6 Econometric methods of convergence estimation

In assessing convergence, either across European regions or within-country regions, various researchers employed the following econometric methods of estimation:

- cross-sectional data using OLS or NLS: it is affected by omitted variables and the assumption of regional homogeneous parameters (Arbia et al., 2005);
- panel data with fixed effects (Islam, 1995; Evans, 1997; Etzo, 2008): allow for unobserved regional heterogeneity or time invariant characteristics, present more variability and less collinearity, allow for more degrees of

freedom, provide more efficient estimates and are more informative; such studies found higher beta rates;

- dynamic panel data using GMM in first differences (Caselli et al.,1996; Tondl,2001) to treat endogeneity or system GMM to overcome the problem of weak instruments (Blundell and Bond, 1998);
- cross-sectional spatial data models using OLS or ML: take advantage of the spatial dependence existing between the growth rates of neighboring regions (Rey and Montouri, 1999; Niebuhr, 2001; Carrington, 2002);
- spatial fixed-effects panel data: help separating the spatial heterogeneity (region-specific traits) across regions from spatial dependence (Arbia et al., 2005);
- spatial dynamic panel data (Badinger et al., 2002).

Spatial econometrics is a branch of econometrics which deals with *spatial dependence* and *spatial heterogeneity* in cross-sectional and panel data regression models. The necessity to use spatial econometrics in convergence testing is because regional data cannot be independently generated given similarities among neighboring regions (Arbia et al., 2005). Spatial dependence can be split in nuisance dependence and substantive dependence. The existence of *nuisance (error) dependence* (or spatial autocorrelation) violates the OLS hypothesis of independent residuals thus generating unbiased but inefficient OLS estimates[6]; it is due to poor matching between observations and spatial patterns, to measurement problems or to omitted variables spatially autocorrelated[7]. *Substantive dependence* is due to spatial spillover effects (externalities) across regional boundaries and ignoring it would produce biased estimates (Anselin and Rey, 1991). *Spatial heterogeneity* refers to structural instability, i.e. varying error variances (heteroskedasticity) or variable coefficients[8]. Spatial dependence is more expected in internal regional convergence studies because factors of production are quite mobile across regions of one country (Aldan, 2005). This phenomenon can vanish by introducing regional dummies in OLS estimations (Paas et al., 2006).
The first models largely employed in testing spatial dependence were the *spatial error model* which tests for nuisance dependence, the *spatial lag/autoregressive model* and the *spatial cross-regressive model* both testing for substantive spatial dependence. Later on, some combinations of these models have appeared.

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[6] In the absence of relevant exogenous variables, spatial autocorrelation proxies for these omitted variables taking over their effects.

[7] Also the dependent variable should be spatially autocorrelated.

[8] Spatial heterogeneity is related to the notion of club-convergence. The existence of clubs requires estimating one growth equation per club.

Therefore, today we can estimate the following seven spatial models (Elhorst: 13, 2010b):

a) *Spatial lag model:* $Y = \alpha + \beta X + \rho WY + \varepsilon$
b) *Spatial error model:* $Y = \alpha + \beta X + \lambda Wu + \varepsilon$
c) *Spatial cross-regressive model:* $Y = \alpha + \beta X + \theta WX + \varepsilon$
d) *Spatial Durbin model* (*a*+*c*): $Y = \alpha + \beta X + \rho WY + \theta WX + \varepsilon$
e) *Kelejian-Prucha model (a+b):* $Y = \alpha + \beta X + \rho XY + \lambda Wu + \varepsilon$
f) *Spatial Durbin error model* (*b*+*c*): $Y = \alpha + \beta X + \theta WX + \lambda Wu + \varepsilon$
g) *Manski model* (*a*+*b*+*c*): $Y = \alpha + \beta X + \rho WY + \theta WX + \lambda Wu + \varepsilon$

Rey and Montouri (1999) argue that using such models takes account of the spillover effects of random shocks. A random shock in a particular region does not have an isolate impact but a wider one affecting also the adjacent regions. Thus, we should take into spatial dependence to obtain uncorrelated residuals.

2.7 Within-country beta-convergence: previous empirical results

Rey and Montouri (1999) employed a spatial econometric perspective in analyzing the dynamics of regional income convergence patterns in the US over the period 1929-1994 and using cross-sectional data. Their results revealed the existence of spatial correlation in growth rates. Because regions cannot be treated as “isolated islands” (Quah, 1996), convergence studies should consider the spatial dependence of regional growth, i.e. one region is also dependent of other regions growth due to various interactions (trade, labor markets, information, knowledge, etc.).

Johnson and Takeyama (2003) studied absolute, conditional and club convergence hypotheses in US states in 1950 and 1993. Their results confirmed the existence of both conditional and club convergence, although club convergence seems to have been stronger.

BSiM (2004) estimated convergence in per capita personal income across 48 states of USA over 1920-1990 using cross-sectional data and found significant but different conditional convergence rates for each decade. They used as control variables the population density (and its square value) and the heating degree days. Also, they estimated convergence for Japanese prefectures over 1955-1990 and also found significant but different rates of conditional convergence. The conditioning variables used were the extreme temperature, each prefecture’s own population density and of its neighbors′. They employed a Two-Stage Least Square (2SLS) method of estimation.

Arbia et al. (2005) used spatial fixed-effects panel data in modeling regional convergence and growth within Italian provinces over 1951-2000. The motivation for using both fixed-effects panel data and spatial econometrics is to separate the individual effects of spatial dependence and spatial heterogeneity/omitted variables[9]. When testing for conditional convergence using cross-sectional data they obtained convergence for the whole period and both sub-periods (´51-´70, ´70-´00). When estimating a fixed-effects spatial lag model, all beta coefficients fall although remain robust, adjusted R2 rose, the spatially lagged term of growth rate turned positive and significant, thus confirming the positive effect of technological spillovers, factor mobility and trade on convergence. Afterwards, when estimating a fixed-effects spatial error model, the authors obtained significant spatial autocorrelation coefficients and similar beta coefficients as those obtained using the standard fixed-effects model. Hence, it results that SER was more suitable.

Kirdar and Saracoğlu (2007) analyzed internal convergence across 67 Turkish provinces for the period 1975-2000. They used panel data, employed also 2SLS method and controlled for provincial fixed effects. The variables used were real gross provincial product per capita, net internal migration rates, provincial population densities and state of emergency status. Their results showed a strong negative impact of migration on provincial convergence because of two main reasons: first, most Turkish migrants were low skilled workers leaving rural areas for urban ones and, secondly, migration within Turkey reached high levels.

Østbye and Westerlund (2007) made a convergence analysis across Swedish and Norwegian counties during the period 1980-2000. Apart from the standard variables, real GDP per capita and migration (net and gross), the authors also used: the share of population with a college degree as proxy for the educational attainment, the share of the employed in the working age population as proxy for employment opportunities, the share of real added value from primary production as proxy for different industry structures, climate and population density measures (each different by country) as proxies for regional amenities. The method of estimation employed was the Generalized Method of Moments (GMM). The two researchers employed two versions for each country: without human capital and with human capital. Within each version, migration was first excluded and after included in its both forms (net, and after, in and out) from/in the convergence equation. The results of the most advanced estimation (human capital with net migration) pointed out at migration being an imbalance factor for Norwegian convergence (brain drain) and an equilibrating one for Swedish convergence (brain gain). Moreover, for Norway, net migration turned negative while in- and out-migration acted quite symmetrically although with the correct signs according to the neoclassical theory. For Sweden, net migration turned positive while in- and out-migration also returned opposite signs (this time inconsistent with the neoclassical view).

Etzo (2008) assessed the impact of domestic migration on provincial growth rates for Italy over the interval 1983-2002 (divided in two sub-intervals 1983-1992 (I) and 1993-2002 (II)). After including conditioning variables (to control for

[9] Fixed effects (i.e. regional dummies) control for omitted, time-invariant variables.

different steady states) such as population growth rate and saving rate, and using fixed effects panel data, the author found conditional convergence during the whole period and the two sub-periods. Afterwards, when adding net migration (with 2 lags), the results showed positive and statistically significant coefficients of migration for 1983-2002 and II. Onward, when replacing with gross migration, in-migration did affect income growth negatively during I, whilst out-migration turned negative and statistically significant for the whole period and II. Because both in- and out-migration turned negative and affected growth in the same direction during the first decade, this means that net migration was a bad measure in studying the impact of migration on convergence and that is why proved insignificant earlier. The next step undertaken by Etzo in his analysis was to introduce the human capital stock. The corresponding results (with net migration) indicated: during I, migration had no impact on income growth; only highly educated migrants had a positive and statistically significant influence on growth over II and the whole period, i.e. the composition effect overcame the quantity one (brain drain); the effect of highly educated migrants on convergence was higher than the effect of overall migration. Later, when considering gross migration, it turned out that also in-migrants with medium education did affect directly the growth rate while low-educated in- and out-migrants did affect inversely growth (for the entire period and II). Therefore, Italian regions proved heterogeneous and exhibited only conditional convergence, during II interregional migration flourished in Italy and the latter migrants were relatively more educated.

3 Income, Migration and Education Disparities within Spain

Data. This article uses the following indicators: real GDP per inhabitant[10] (level and growth), net and gross migration rates and the percentage of people with higher education. Data were obtained from the National Statistics Institute of Spain (INE) database. The current research is performed at NUTS 3 level because of its higher relevance and covers the period 1998-2008 (11 years).

Figure 1 displays the provincial maps of Spain of relative values (to national means) of per capita income level, net migration and higher education rate, all as 1998-2008 averages. *23 provinces had above average GDPs, 20 provinces had positive migration balances and also above average higher education rates*. But what are the provinces that recorded at the same time above average GDPs and higher education rates and positive migratory balances? Answer: 6 provinces - Alava, Navarre, Cantabria, La Rioja, Valencia and Tarragona.

[10] Is deflated using the Consumer Price Index (CPI) by province. Real GDPs are in 1998 prices.

Source: Own elaboration based on INE data

Figure 1: Provincial map of real GDP per head, migration balances and higher education rate

Figure 2 represents the yearly evolution of migration, both numbers and rates. Thus, the national averages were *1,357,000 migrants and 31.5‰*, with a breakpoint in 2003 (see the grey color). The lowest values were recorded in 1998 (925,137 persons and 23.21‰) and the highest ones in 2007 (1,785,205 persons and 39.5‰). Notably, from 2002 to 2007, migration values followed an upward trend.

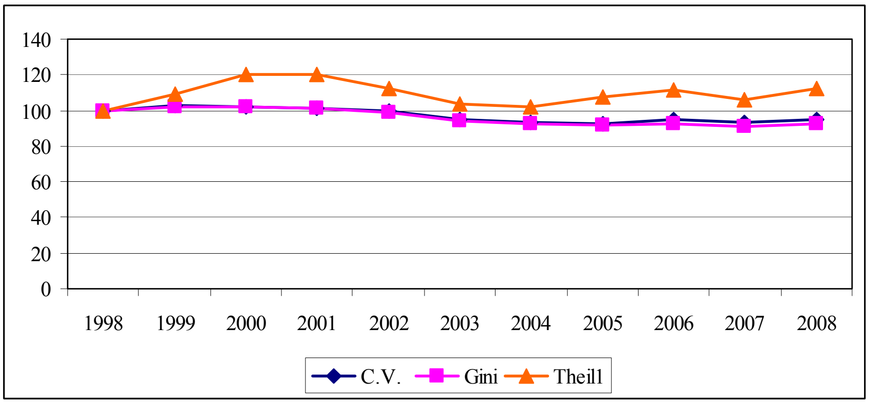
Source: Own elaboration based on INE data

Figure 2: Numbers and rates of internal migrants in Spain, 1998-2008

4 Statistical and Econometric of Spanish Income Convergence

4.1 Sigma-convergence

Figure 3 depicts the evolution of the main inequality indexes, i.e. sigma-convergence trend. The coefficient of variation (CV) and the Gini index both show a slight descending tendency of inequality although with some ups and downs. Instead, the Their index illustrates a more fluctuant evolution in favor of divergence. Despite this last divergent trend, I opt for sigma-convergence because the Gini and CV indexes have a stronger and wider use in assessing inequality in empirical studies. Later, we will see if beta-convergence accompanies or not sigma-convergence.



Source: Own elaboration based on INE data

Figure 3: Inequality indexes (sigma-convergence) for real per capita GDP (1998=100)

4.2 Beta-convergence

In this sub-section, I investigate on conditional beta-convergence and try to identify if a brain drain or brain gain process took place using the variables described in Table 1.

Table 1: Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth rate (log)	500	0.001	0.004	-0.0116, Segovia ´08	0.0112, Zamora 1999
GDP/capita	550	14424.57	3265.65	8337, Caceres 1998	24385, Alava 2007
Net migration rate	550	0.61	4.96	-11.37, Teruel 2007	30.57, Guadalajara 2005
In-migration rate	550	30.72	11.48	11.91, Cordoba 1998	86.56, Guadalajara 2006
Out-migration rate	550	30.10	9.04	13.76, Zaragoza 1998	59.71, Guadalajara 2007
Education rate	550	18.05	5.22	8.25, Zamora 2001	36.82, Guipuzcoa 2008

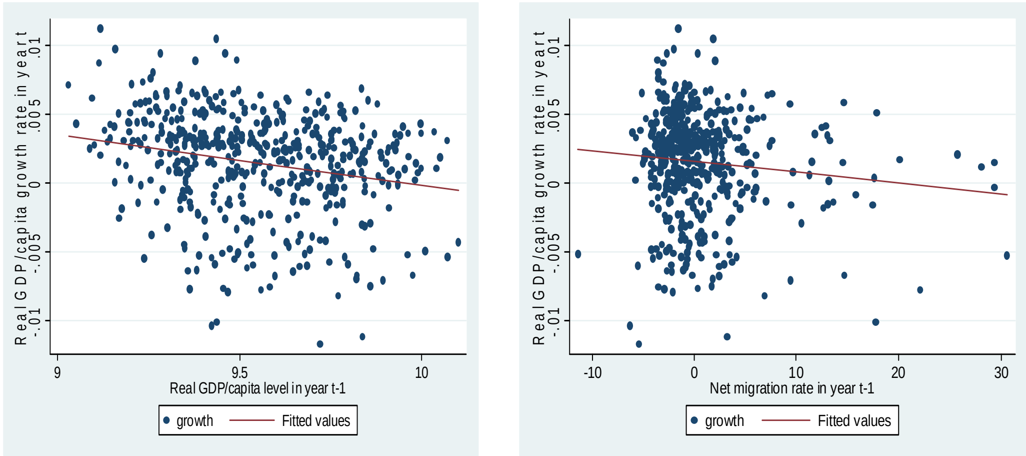
N.B. 1. The statistics were obtained using STATA.
2. The *net migration rate* is computed as the ratio between the difference of in-migrants and out-migrants in/from a province at the end of period t, on one hand, and the province's population at the beginning of period t, on the other hand.

At a first look, it seems that Spain witnessed a beta convergence process (downward regression line of previous GDP level) and that the net migration rate impact negatively on the income convergence (also downward line); see Figure 4. The present analysis is using the following spatial Durbin model with two-way fixed effects performed on panel data according to the methodology proposed by Elhorst (2010):

$$\log Y_{it} = \alpha + \eta_i + \nu_t - b * \log X_{i,t-1} + \rho W * \log Y_{it} + \theta W * \log X_{i,t-1} + \varepsilon_{i,t} \qquad (2)$$

where *Yit* is the growth rate of real GDP per capita in year t, *Xit-1* are the explanatory variables in the previous year t-1, i.e. the level of GDP per capita, the net and gross migration rates, and the higher education rate, α is the autonomous/steady-state growth rate, η_i is the province-specific effect (time invariant), ν_t is the time-specific effect (common to all regions); ρW is the coefficient of the spatially lagged dependent variable; θW are the coefficients of the spatially lagged independent variables; and ε is the idiosyncratic error.
Elhorst (2010a) applies two approaches in order to establish which model best describes the data, spatial Durbin model (SDM), spatial lag model (SAR) or spatial error model (SEM). The first, called the *specific-to-general approach*,

implies the estimation of the non-spatial model and tests it against SAR and/or SEM[11]. The second, the *general-to-specific approach* implies the estimation of SDM if the non-spatial model is to be rejected and tests if this last model can be simplified to SAR or SEM. If both approaches point to the use of SAR or SEM, one should use the right one; but if the non-spatial model is rejected in favor of SAR or SEM while SDM is not, one should use SDM[12].



(a) (b)

Figure 4: Scatterplots of current GDP growth and previous GDP level (a) and net migration (b)

The main drawback of SDM is the need to use long-time data in order to return significant coefficients of the spatially lagged independent variables and, in consequence, significant indirect effects. For this main reason, many researchers propose to use SAR, in spite of returning the same ratio between direct and indirect effects for any explanatory variable of the model.

When using SDM, the direct effects of the covariates are different from their coefficient estimates due to the *feedback effects*, i.e. those influences passing

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[11] The corresponding tests are the classic and robust LM tests which work under the null hypothesis of no spatial lag or no spatial error.

[12] The corresponding tests are the Wald and LR tests, both working under the null hypotheses that SDM should be simplified to SAR or SEM. If both hypotheses are rejected, then one should use SDM. But if one of them cannot be rejected, e.g. SAR, then one should use SAR only if the (robust) LM tests also point to it. Moreover, if the (robust) LM tests point to another model than the Wald/LR tests, then SDM should be applied.

through neighboring provinces and returning to the provinces themselves. These effects are due to the coefficients of the spatially lagged dependent and independent variables. Furthermore, in SDM, the *indirect effects* (set to 0 in the non-spatial model) reflect the impact of a change in the independent variable(s) over the economic growth rate (in my case) of the neighboring provinces. For more details, see Elhorst (2010a and 2010b).
Now, let's observe the results from Tables 2 and 3.

Table 2: Non-spatial model of convergence with two-way fixed effects

	Net migration		Gross migration	
	A: no education	B: education	C: no education	D: education
GDP	-0.0243***	-0.0246***	-0.0336***	-0.0337***
Beta (%)	2.78	2.82	4.09	4.11
NET (%)	-0.002	-0.001	-	-
INM (%)	-	-	0.25	0.23
OUTM (%)	-	-	-1.29***	-1.26***
EDU (%)	-	0.23	-	0.17
Obs. (no)	500	500	500	500
R2	0.66	0.66	0.70	0.70
Log Likelihood	2367	2368.1	2394.3	2395
AIC	-4730	-4730.2	-4782.6	-4782
BIC	-4728.6	-4728.1	-4780.5	-4779.2
LM test SAR	3.96**	3.89**	3.50	3.44
Robust LM test SAR	27.11***	24.96***	1.93	1.66
LM test no SEM	13.60***	13.29***	6.25**	6.01**
Robust LM test SEM	36.75***	34.36***	4.68**	4.23**
LR test - no spatial fixed effects	134.73***	123.98***	186.75***	177.76***
LR test - no time fixed effects	323.49***	324.17***	357.76***	358.75***

N.B. *** Significant at 1% threshold level,
** Significant at 5% threshold level Regressions were carried out in MATLAB.

Table 3: Spatial Durbin model of convergence with two-way fixed effects

	Net migration		Gross migration	
	A: no education	B: education	C: no education	D: Education
GDP	-0.0345***	-0.0348***	-0.0393***	-0.0396***
Beta (%)	4.23	4.28	4.99	5.04
Half-life (years)	19.7	19.6	17.3	17.2
NET (%)	-0.01	-0.01	-	-
INM (%)	-	-	0.11	0.07
OUTM (%)	-	-	-0.94***	-0.90***
EDU (%)	-	0.25	-	0.19
W*GROWTH	0.2599***	0.2551***	0.2106***	0.2040***
W*GDP	0.0314***	0.0309***	0.0230***	0.0221***
W*NET	0.00004	0.00003	-	-
W*INM	-	0.0018	-0.0015	-0.0023
W*OUTM	-	-	-0.0005	-0.0004
W*EDU	-	-	-	0.0038
Direct effects GDP	-0.0330***	-0.0332***	-0.0383***	-0.0388***
Indirect effects GDP	0.0286***	0.0282***	0.0178***	0.0168***
Total effects GDP	-0.0044	-0.0050	-0.0205***	-0.0220***
Direct effects OUTM	-	-	-0.0095***	-0.0091***
Indirect effects OUTM	-	-	-0.0031	-0.0028
Total effects OUTM	-	-	-0.0126**	-0.0119**
Obs. (no)	500	500	500	500
R2	0.69	0.70	0.71	0.72
Log Likelihood	2389.08	2390.48	2407.75	2409.21
AIC	-4768.16	-4766.96	-4801.5	-4800.42
BIC	-4764.67	-4762.07	-4796.61	-4794.13
Wald SAR	45.15***	42.80***	23.51***	25.14***
LR SAR	40.06***	40.61***	23.28***	24.95***
Wald SEM	24.75***	25.98***	16.36***	18.07***

LR SEM	29.07***	29.85***	20.15***	NA
Hausman test	113.71***, 5 df	104.01***, 7 df	28.29***, 7 df	145.96***, 9 df

N.B. ^ Bias-correction; for more, see Lee and Yu (2010) and Elhorst (2010).
*** Significant at 1% threshold level, ** Significant at 5% threshold level
Regressions were carried out in MATLAB.

On going, I will summarize the main results of Tables 2 and 3 obtained using the Matlab software and applications.

1. LR tests from Table 2 for spatial and time fixed effects reject the null hypothesis of insignificance; therefore, this explains the need for employing a two-way fixed effects model. Moreover, the Hausman test (Table 3) confirms the alternative hypothesis of valid fixed effects;
2. When considering net migration, independently of the inclusion or not of the education rate, all (robust) LM tests confirm the validity of both SAR (weaker) and SEM models. Thus, the non-spatial model must be rejected as its estimates are biased. But when considering gross migration, LM tests confirm only the validity of SEM at 5% significance level;
3. Instead, the Wald and LR tests for SAR and SEM from Table 3 (all cases) confirm that the spatial Durbin model cannot be simplified to SAR or SEM, as both hypotheses of SAR and SEM are rejected at 1% significance level;
4. In Table 3, I obtain annual beta rates within the range [4.23-5.04%], irrelevant net and in-migration rates, education rate and also spatially lagged migration and education rates, but important negative out-migration rate and positive spatial lag of GDP/capita growth rate and GDP/capita level;
5. Net migration turns out to be a wrong measure because even though gross migration acts symmetrically, only out-migration has a certain impact on convergence;
6. After introducing the rate of higher education, which turns irrelevant in all cases, beta increases in spite of persistent insignificant net migration. The same happens when replacing net with gross flows.
7. The negative sign of out-migration could be interpreted as follows: because (heterogeneous) out-migrants have been more skilled than non-migrants, the loss in human capital per head has exceeded the gain in physical capital per head, this lowering income growth.
8. Unfortunately, because net migration and education turn to have no impact on economic growth, I cannot pronounce myself in favor of homogeneous migrants (although out-migrants were not) and the existence of a brain drain or brain gain process. These insignificant estimates can be attributed to the short period of analysis which may affect SDM estimations as mentioned by Elhorst (2010a).
9. In the different specifications of SDM, the direct effects of the previous GDP

coefficient are overestimated by: case A, 35.8% from -0.0243% (non-spatial) to - 0.0330% (SDM direct); case B, 34.95% from -0.0246% to -0.0332%; case C, 14% from -0.0336% to -0.0383%; case D, 15.1% from -0.0337% to -0.0388%.

The feedback effects in the case of the GDP variable are very small: 0.0015 (or 4.5%) case A, 0.0016 (4.8%) case B, 0.001 (2.6%) case C, and 0.0008 (2.1%) case D. Ongoing, the indirect effects are: -86.7% (A), -84.9% (B), -46.5% (C), and -43.3% (D) of the direct effects, which represent very high levels. More precisely, if the level of previous GDP of a certain province increases the growth rate of that province will decrease (negative direct effects) while the growth rates of the surrounding provinces will increase (positive indirect effects); the change in these provinces to the change in the province itself is in the ratio of 1 to -2.15 (case C).

10. Similarly, for the gross migration rate, its direct effects are underestimated by: case C, 37.2% from -1.29% (non-spatial) to -0.94% (SDM direct); case D, 40% from -1.26% to -0.90%. The feedback effects are relatively big: 0.9305 (case C) and 0.8909 (case D). The indirect effects of this rate are insignificant, meaning that the change in the previous outgoing rate in a province affects the growth rate of only that province.
11. Taking into account the values of R2 (highest), log-likelihood (highest), Akaike and Bayesian information criteria (smallest), the best specification of the growth model includes gross migration with or without education, i.e. cases C and D.
12. The association between beta-convergence and sigma-convergence validates Maurer's 1st lemma aforementioned.

5 Future Research

In a future article I intend to employ a dynamic spatial panel data model to assess convergence and migration to overcome the possible drawbacks of the static model used here. Also, I plan to perform a convergence analysis through the distribution dynamics approach.

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