CITIES AND REGIONS IN TRANSITION

edited by
Roberta Capello
Andrea Conte

63 Scienze Regionali

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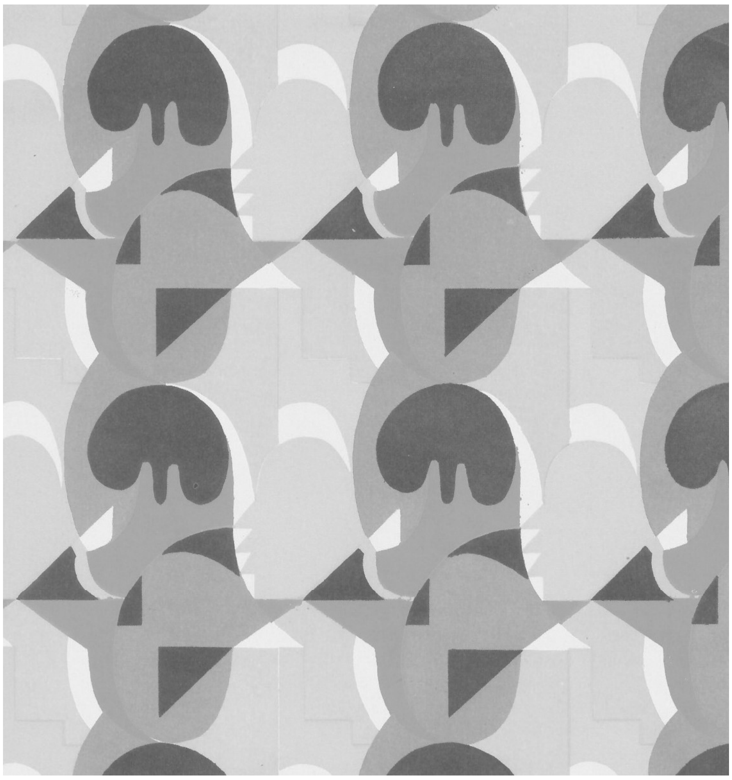

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Do Spatial Spillovers of Regional Policies Aid the Reduction of Regional Inequalities in Europe?

Marusca De Castris, Daniele Di Gennaro°, Guido Pellegrini§*

Abstract

The European cohesion policy promotes the harmonious development of the Union and its regions, fostering inclusive growth and employment in less developed regions, improving people's well-being and reducing regional disparities. However, the effects of the policy are both direct, in the regions where the policy has been addressed, and indirect, in neighboring or economically connected regions through the generation of spillovers. Evaluating the total effects of these policies is therefore complex, as both direct effects and spillovers must be considered. However, spillovers are generally excluded from the classic counterfactual model, which does not allow for interference effects between treated and untreated units of the policy (named SUTVA – Stable Unit Treatment Assumption – assumption). This work aims to overcome this restriction, by implementing a methodology fully coherent with the counterfactual approach but relaxing this assumption. We propose a spatial difference-in-differences model, based on the Spatial Durbin Model (SDM) specification that allows for spillover effects. The paper evaluates the total effects of regional policy of the programming period 2007-2013. Results show positive effects of European regional policy especially in the Eastern regions, where the policy produces high positive externalities, reducing inequalities with the more developed regions.

1. Introduction

The size of regional disparities within Europe is strongly heterogeneous across space. Some regions, such as clusters of Western Europe, tend to be economically developed, while others, such as clusters of Eastern Europe, have traditionally been less developed. Within individual countries, there are also often significant

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disparities between different regions. One major factor contributing to regional disparities is the uneven distribution of economic growth and wealth across the region (Agnew, 2001). This has led to persistent differences in standards of living, levels of education, and access to economic opportunities.

The strategy for reducing regional disparities in Europe is based on the European Union's (EU) regional development policies. European regional policy is the world most important place-based policy, designed to promote economic development and reduce disparities between regions (Ertur *et al*., 2006; Vedrine *et al.,* 2021) within the European Union (EU), redistributing resources and funding from more developed regions to those lagging behind.

The set of policy measures can take many forms, such as infrastructure investment, business support programs, and regional financing instruments. Although there has been a long debate on the effects of European regional policy, from a theoretical as well as empirical viewpoint (e.g., Venables, Duranton, 2019; Ehrlich, Overman, 2020), evaluative studies adopting robust counterfactual methodologies and the dataset shared by the commission clearly show the occurrence of a positive impact on economic development and the reduction of regional disparities, although the size of these impacts is heterogeneous in space and time. There are several papers on this, such as Becker *et al*., (2010); Pellegrini *et al*., (2013), which show that average income and employment grow more in heavily subsidized areas. At the same time, the EU regional policy is heterogeneous, in terms of both the intensity of treatment as well as the combination of the different policy instruments, and the debate on what is the optimal amount and the optimal combination of the different types of programs is still in progress (e.g., Rodríguez-Pose, Garcilazo, 2015; Bachtrögler *et al*., 2019; Di Caro, Fratesi, 2022; Cerqua, Pellegrini, 2022). A new approach, which confirms previous findings, is the one that analyses what happens when regional policy support ends. Cerqua and Pellegrini (2022) investigate what happens when strongly subsidized regions experience a substantial reduction in funding. The results indicate that only regions that experienced a considerable reduction in funding during a recession suffered a negative impact on economic growth. Overall, the regions that left the convergence status appear to have survived this shock relatively well, suggesting a long-term positive impact of the EU regional policy.

In the evaluation of place-based policies, evaluators should keep in mind that one of the founding rationales of such programs very often consists in generating positive externalities, such as a general improvement of the eligible areas' socio-economic situation (Cerqua, Pellegrini, 2014). This is particularly true where less developed regions are grouped into geographic clusters, and therefore the effects of policies are both direct, in the regions beneficiaries of the policy, and indirect, in neighbouring or economically connected regions through the generation of spillovers. Spillovers refer to the effects that a policy or intervention

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has on areas beyond those directly targeted. In the context of European regional policy, spillovers refer to the effects that a policy has on regions beyond those directly receiving support. However, spillover effects on neighboring regions can be positive or negative (De Castris, Pellegrini, 2012), depending on several factors, for instance on the specific measures implemented and the context in which they are implemented. The overall effect of the policy therefore includes the complete set of impacts on the territory, both internal and external to the objective of the policies themselves.

The evaluation of the total effects of regional policies is therefore complex, as it is necessary to consider and estimate the size and sign of spillovers. Considering regional spillovers is important for several reasons. First, spillovers have significant impacts on the development and well-being of neighbouring regions, and it is important to evaluate these impacts to assess the overall effectiveness of a regional policy. Second, spillovers are an important factor in policy design, as policymakers may wish to consider the potential impacts of a policy on neighbouring regions when deciding whether to implement it. Finally, understanding spillovers helps policymakers to identify potential unintended consequences of a policy and eventually to design measures to mitigate negative spillovers.

A further difficulty is that spillovers are generally excluded from the classic counterfactual model by Rubin, which does not allow for interference effects between treated and untreated units of the policy (named SUTVA assumption). In this paper we have chosen to remain within the counterfactual approach, and to estimate the spillovers implementing a methodology fully consistent with this approach. The spillovers considered depend on the spatial distance and are estimated based on a model with a spatial specification of the Spatial Durbin Model (SDM) type. We propose a spatial difference-in-difference (DiD) model, that allows for spillover effects. The total effects are decomposed in direct and indirect effects, following the approach presented in LeSage and Pace (2009) and Arbia *et al*. (2020). The paper evaluates the total effects of regional policy of the programming period 2007-2013 using data at both Nuts-2 and Nuts-3 level. Results show overall positive effects of European regional policy, especially in the Eastern regions, where the policy produces high positive externalities and reduce inequalities with the more developed regions.

Our work contributes to the literature on policy evaluation in the presence of spillovers. The applied econometrics literature has shown that spillovers can lead to biased estimates if they are not properly accounted for. For example, Kalenkoski and Lacombe (2013) demonstrate that analyses of minimum wage changes, like the influential work of Card and Krueger (1994), can suffer from bias when spillovers are ignored, especially when contiguous counties are selected as controls due to spatial heterogeneous trends, as in Dube *et al*. (2010) and Neumark and Kolko (2010).

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Hanson and Rohlin (2013) show how using nearby areas as controls to evaluate policies, as analysed for de-regulation policies for labour in Holmes (1998), banking in Huang (2008), and crime prevention in Blattman *et al*. (2017), can present upward biases when spillovers are negative (see also Cerqua, Pellegrini, 2014). This study contributes to the literature by proposing a spatial region-level regression design to control for spillover effects exploiting geographic proximity. Our analysis provides measures of both the spillover and the direct effect net of the spillover bias, allowing for an assessment of the overall effectiveness of a regional policy.

2. Regional Policy and Spillover Effects

A large body of literature evaluated the effectiveness of Structural Funds to reduce economic and social inequalities. As reported by Ehrlich and Overman (2020), many studies (Becker *et al*., 2010; Mohl, Hagen 2010; Pellegrini *et al*. 2013; Giua, 2017) demonstrate that on average, Cohesion Policies appear to have been effective in reducing disparities. This effect depends on the policy impact on beneficiaries and on indirect effects caused by economic interactions between regions. Indeed, one relevant feature of cohesion policy is that its structural investments can generate substantial spatial spillovers (Di Gennaro, Pellegrini, 2019; Fratesi, 2020; Monfort, Salotti 2021). Spatial spillovers imply that the economic impact of the policy is not confined to the target regions, but spills over to the rest of the EU (Monfort *et al*, 2021).

In the context of regional policy, spillover effects occur because policy implemented in one region has an impact, which can be positive or negative, on the economic or social conditions of neighboring regions. Positive spillover effects can occur when a regional policy leads to economic growth or improved social conditions in the recipient region, which can then spill over to neighboring regions through increased trade or other economic linkages. Negative spillover effects can occur when a regional policy leads to negative economic or social consequences in the recipient region, which can then spill over to neighboring regions. Overall, the size and direction of spillover effects will depend on the specific policy being implemented, the characteristics of the recipient region, and the economic and social linkages between the recipient region and neighbouring regions.

In general, the impact of regional policy on neighbouring regions will depend on a variety of factors, including the specific policies being implemented, the economic, social, and environmental characteristics of the regions involved, and the extent to which the regions are integrated and interconnected (Capello, 2020; Cerqua, Pellegrini, 2020).

Angelucci and Di Maro (2016) identify four types of spillover effects: (1) externalities, where effects operate from the treated subjects to the untreated

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population. An example is an increase in the local demand that spread out in the neighboring regions (2) general equilibrium effects, i.e. effects that an intervention, which targets only part of the local economy, can have on the entire population. An example is an investment policy that affect the price of the investment goods (3) interactions, where the local nontarget population may also be indirectly affected by the treatment through any social and economic interaction with the treated. A classical example is the distribution of classbooks, that can be used also by non-treated individuals and (4) behavioural effects. These spillover effects stem from an intervention that affects the behavioural or social norms within the contexts (say a locality) in which these interactions are relevant.

Among the regional policies, investment subsidies policies have also been particularly studied in its spillover effects. Cerqua and Pellegrini (2017) highlight that investment subsidies policies are a way to trigger endogenous changes and generate a self-sustaining growth. Therefore, business incentives policies are not only expected to improve the economic situation of subsidized firms but also to generate a virtuous circle that will benefit unsubsidized firms. However, business incentives programs can potentially generate also negative spillovers. In the literature, the most quoted negative spillover is arguably the cross-sectional substitution (Cerqua and Pellegrini, 2017). This externality occurs when subsidized firms take some of the investment opportunities that unsubsidized firms would have exploited in the absence of the policy. In presence of cross-sectional substitution, publicly funded investments partially crowd-out private investments making the rationale in favour of business incentives less clear. Thus, the assessment of the net effect of the policy is an empirical problem, to be evaluated by means of suitable econometric analysis.

3. Methodology

An important methodological aspect for policy evaluation analyses concerns the treatment of the presence of interference (spillovers) among units, both treated and untreated. In the Rubin casual model, the SUTVA formalizes the absence of interference among units. This implies that spillover effects are ruled out by this assumption. Cerqua and Pellegrini (2019) highlight that "although many public policies can be credibly evaluated under the SUTVA, this is rarely valid for the evaluation of regional policies, as we should expect them to engender spillover effects". Only in the case of the absence of interference the non-treated subjects, whether people or geographical areas, are valid control samples, or the counterfactual, of what would have happened to the treated without treatment.

However, the Stable Unit Treatment Value Assumption (SUTVA) appears completely unrealistic in many evaluations of regional policies, like the European regional policy, which often have the purpose of generating spillovers between

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treated and untreated units to engender local development. In our case, the possibility of interference is higher, because the target population is a subset of the regional economy, loosely defined as the geographic unit or local institution within which the target population lives and operates (Angelucci, Di Maro, 2016). To design an evaluation strategy that accounts for the presence of spillover effects requires understanding and identification of which untreated units are subject to spillovers. In our paper we assume that the presence of interference depends directly on the geographical distance. This is a common assumption, which constrain the effects of spillover to follow a certain spatial pattern. This approach is at the basis of spatial econometric models (see, among others, Anselin 2003; Arbia, 2014), which use a spatial weight matrix to model the interactions between units.[1] However, identification of spillover effects is closely related to the analytical tools used and in particular to the spatial econometric models identified (Arbia *et al*, 2020; Delgado, Florax, 2015) that justify interference effects with the relationships between regions.

In this paper we apply a methodology useful to identify, estimate and disentangle spatial effects of the policy, both direct and indirect. In a counterfactual framework, we use a modified spatial difference-in-differences estimator (Di Gennaro, Pellegrini, 2016). The idea is to highlight the spatial effects due to the policy treatment and, in overall, to provide unbiased estimates of the effects of the policies. The pillar of the empirical methodology is a spatial autoregressive Durbin model (SDM) combined with a difference-in-differences (DiD) estimator.

In the standard counterfactual approach, under SUTVA and common trend assumptions (Lechner, 2011) a DiD model is applied by using an interaction term between time and treatment indicator whose coefficient describes the difference over time in the outcome variable between the treated and untreated groups.

Let recall the DiD model:

$$Y = \beta_0 + D\beta_1 + t\beta_2 + D't\beta_3 + \varepsilon \qquad [1]$$

Where Y is the n x1 vector of dependent variable, in our paper the growth rate of the outcome variable in the pre-post period treatment, t is the n x1 vector of time dummy variable that assumes value 0 in the pre-treatment time and value 1 in the post-treatment, D is the n x1 vector of treatment dummy variable, and ε is the n x 1 vector of regression disturbance terms.

In presence of interferences, the casual framework changes to consider a different number of potential outcomes, i.e., the effect of the treatment with and without

1. Although the approach to place more weight on closer observations is widely accepted, the true spatial matrix is generally unknown (Halleck-Vega, Elhorst, 2015). Moreover, in some applications even relatively small perturbations in the spatial weights matrix will have salient consequences in the empirical results (Ward, Gleditsch, 2008).

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interactions. We introduce a proximity function based on the state of treatment of the neighbours, imposing the restriction to consider only the first level of proximity.

We consider the spatial econometrics model that contains parameters that allow for the incorporation of spatial dependence among the observations. These parameters include spatial lag and error terms, which capture the relationship between the dependent variable and its neighbours, as well as spatial weights matrices, which specify the strength of the relationship between the observations.

Starting from the founding model by Manski (1993):

$$Y = \rho WY + X\beta + WX\theta + u \qquad [2]$$
$$u = \lambda Wu + \varepsilon$$

where β is the vector of parameters for exogenous explanatory variables in vector X, ρ is the spatial autoregressive parameter for the endogenous interaction effect, θ is the parameter for exogenous interaction effects (of dimension equal to the number of exogenous variables) and λ is the spatial autocorrelation parameter (spatial effect of errors).

Following Elhorst (2010) classification models, we can assume the case $\rho = 0$ that makes explicit the hypothesis that there is no endogenous interaction and so the accent is placed on neighbourhood externalities, i.e., spillover effects. The model under consideration with the restriction is named Spatial Durbin Error Model (SDEM)

$$Y = X\beta + WX\theta + u \qquad [3]$$
$$u = \lambda Wu + \varepsilon$$

the model analyses the relationships between Y and one or more independent variables X, while taking into account the spatial dependence between the units.

In contrast, if we assume that the model is such that $\lambda = 0$,

$$Y = \rho WY + X\beta + WX\theta + \varepsilon \qquad [4]$$

known as the Spatial Durbin Model (SDM), the model assumes that the value of the dependent variable for a given unit is not only influenced by the values of the independent variables for that unit, but also by the values of the dependent variable for neighbouring units.

Moreover, it is important to consider the potential bias induced by the fact that observation units belong to groups, like considering provincial data in analysing public funds provided at regional level. In fact, regardless of the presence of spatial autocorrelation, the independence assumption is usually erroneous when data are extracted from a population with a clustered structure, since this adds a common element to the errors thus inducing correlated errors within the group (Corrado, Fingleton, 2011). We know it is necessary to account for clustering

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either in the error term or in the specification of regressors (Moulton,1986). For example, this can occur when we consider administrative areas, like regions and provinces, where neighboring areas may have greater similarity with respect to the farthest ones. One way to incorporate the group effect is to assess the impact on the singular unit of higher-level variables that measure one or more aspects of the composition of the group. In order to control for structural differences between areas, i.e. clusters characterized by, for example, exceptionally high, or low, economic growth, in our work we model specific dummy variables designed for properly asses unobservable spatial effects that, if not accounted, could produce biased estimation of the impact of the policy considered.

4. Empirical Strategy

We focus on a known "microlevel" difference-in-differences (DiD) model in which the treatment is assigned to a group (Nuts-2 region) and observations are available also for units within groups (Nuts-3 unit) before and after the intervention.

$$\Delta Y_{prt} = \beta_0 + \beta_1 D_r + \beta_2 t + \beta_3 D_r t + \varepsilon_{prt} \qquad [5]$$

where p indexes province, r indexes regions, t indexes time.

ΔY_{prt} is the GDP growth rate, D is a treatment dummy variable, equals to 1 if the region was treated, but declined at Nuts-3 level, t is a time dummy variable, equals to 0 if 2004-2006 and equals to 1 if 2015-2017, ε_{prt} is the random error term. We are in the simplest case, in which there are only two groups, i.e., treated and control, without spillover.

To account for initial differences between regions and spillover effects from neighbouring regions, we modify the model by introducing variables that can control for heterogeneous effects and spatial effects.

Let define:

- a spatial weights matrix W, an $p \times p$ positive symmetric matrix with element w_{ij}, each one is a weight for each pair of locations (i, j). The spatial matrix represents the spatial structure (Kelejian, Prucha, 1998; 2010) of our data where p is the number of Nuts-3 units, equal to 1320;
- an indicator D_j representing the presence of neighbours treated units, given by the spatial lag of the treatment variable at the Nuts-3 level;
- a set of covariates X describing the socioeconomic heterogeneity within regions, by means of the provincial-level variables, which are population growth rate and manufacturing employment growth rate;

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- dummy variables to capture fixed effects: Eu enlargement as 2004 and 2007, capital city, metropolitan areas, pre-treatment clusters of more, resp. less, performing regions.

  Let's get the integrated model:

$$\begin{aligned}\Delta Y_{prt} = {} & \beta_0 + \beta_1 D_r + \beta_2 t + \beta_3 D_r t + \beta_4 D_j D_r \\ & + \beta_5 D_j t + \beta_6 D_j D_r t + \beta_7 \Delta X_{pt} + \beta_8 \mu_p + \varepsilon_{pr}\end{aligned} \qquad [6]$$

Introducing the Spatial Durbin error model, we combine both a spatial autoregressive and a spatial error component as:

$$\begin{aligned}\Delta Y_{pr} = {} & \rho W \Delta Y_{pr} + \beta_0 + \beta_1 D_r + \beta_2 t + \beta_3 D_r t + \beta_4 D_j D_r \\ & + \beta_5 D_j t + \beta_6 D_j D_r t + \beta_7 \Delta X_{pt} + \beta_8 \mu_p + \varepsilon_{pr}\end{aligned} \qquad [7]$$

where the spatial autoregressive parameter, ρ, refers to the endogenous spatial lag while the structure of the error is:

$$u_{pr} = \lambda W u_{pr} + \varepsilon_{pr} \qquad [8]$$

We estimate both the case with $\rho = 0$ (there is no endogenous interaction) and the case with $\lambda=0$ (no spatial dependence between the units).

5. Data

We make use of an integrated dataset, which combines data by different sources, linking, at both Nuts-2 and Nuts-3 level, data on economic and demographic variables.

Data on economic and demographic variables (population growth, manufacturing employment growth) comes from European Regional Database of Cambridge Econometrics that contains annual observations since 1980 at Nuts-3 level, while the GDP growth rate comes from Eurostat Regional Database that contains annual observations at Nuts-3 level.

We consider data for both the pre-treatment and post-treatment periods. The pre-treatment period refers to the years 2004-2006, the treatment period is 2007-2013, and the post-treatment period includes information between 2015 and 2017, also to consider the closing period of the 2007-2013 policy cycle.

Some characteristics of the sample before and after the policy by full sample, Eu15 regions, Eastern Europe Enlargement regions, spatial clusters are described in Tables 1 and 2.

Regional population dynamics is very heterogeneous: population growth rates (Nuts-3) ranging from a minimum value of minus 5 percent to a maximum and positive value of 10 percent. On average, enlargement regions before 2007

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Table 1 – Summary Statistics of Socioeconomic Indicators Considering the Full Sample, Eu15 Regions, Eastern Europe Enlargement Regions and Distinguishing Between Pre- and Post-Treatment Periods

Indicator A: Population Growth Rate (Nuts-3)

Pre-treatment	*Mean*	*SD*	*Min*	*Max*
Full sample	0.00	0.02	-0.05	0.10
EU15 regions	0.01	0.02	-0.05	0.10
Enlargement regions	-0.01	0.01	-0.05	0.03
Post-treatment	*Mean*	*SD*	*Min*	*Max*
Full sample	0.00	0.01	-0.05	0.07
EU15 regions	0.01	0.01	-0.04	0.05
Enlargement regions	-0.01	0.02	-0.05	0.07

Indicator B: Manufacturing Employment Growth Rate (Nuts-3)

Pre-treatment	*Mean*	*SD*	*Min*	*Max*
Full sample	-0.01	0.07	-0.28	0.41
EU15 regions	-0.02	0.06	-0.28	0.34
Enlargement regions	0.02	0.11	-0.28	0.41
Post-treatment	*Mean*	*SD*	*Min*	*Max*
Full sample	0.02	0.07	-0.36	1.14
EU15 regions	0.01	0.06	-0.36	1.14
Enlargement regions	0.04	0.09	-0.36	0.29

Source: Authors' elaboration

Table 2 – Summary Statistics of Outcome Variable in the Pre-treatment Period: GDP Growth Rate (Nuts-3)

Pre-treatment	*Mean*	*SD*	*Min*	*Max*
Full sample	0,055	0,054	-0,237	0,502
EU15 regions	0,048	0,045	-0,237	0,502
Enlargement regions	0,094	0,078	-0,113	0,418
High-High cluster	0,141	0,060	0,070	0,418
Low-Low cluster	0,001	0,033	-0,237	0,035

Source: Authors' elaboration

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register a negative population change of 1 percent. After the policy, while, on average, regional population dynamics remain unchanged, changes are observed in the maximum values, which fall for the full sample and the EU15 countries but rise in the enlargement countries, where a few regions stand out from the average with a growth rate of 7 percent.

Manufacturing employment shows growth trends in all three areas under review, but certainly the enlargement regions, where investment in private and public capital is large, show a higher growth rate.

We define some other dummy variables to distinguish the effect for the new entrant regions (wave of 2004 and 2007), dummies to detect the presence of the capital, the metropolitan areas. In addition, to consider the presence of areas already funded in the previous programming period, i.e., 2000-2006, we control for territories which shifted their treatment status, in particular the ones which switched from beneficiaries to not beneficiaries.

These starting conditions that characterize the regions are introduced in the estimation models, to be consistent with the parallel trend assumption. In our case, the impact of European regional policy, estimated with a selection model on unobservables (DiD), must consider that the new member countries are composed mainly of regions treated with higher growth rates if compared with the rest of the union. This aspect undermines the assumption of common trends and requires an in-depth investigation, based on the presence of cluster of regions with different growth trends.

We test the presence of spatial autocorrelation in the distribution of the outcome variable. The value of Global Moran's I, positive and significant (0.13 with a p-value<0.001), shows that spatial distribution of high values and that of low values in the sample is spatially clustered; it means that high values cluster near other high values and low values cluster near other low values. This assumption is tested by apply a Local Moran's I (Figure 1). Therefore, in the estimation model, the effect due to the presence of hot spots, i.e., high-high value cluster that are composed mainly by treated regions from the enlargement areas has been isolated. At the same time, we highlight cold-spots, i.e., low-low value cluster, characterized by negative, or very low, economic growth. Specific dummies are be added to the model. We built a dataset covering 1310 provinces (Nuts-3) for two periods, for a total number of 2620 observations.

6. Results

We estimate the effect of European regional policy in the pre-treatment and post-treatment period. At the same time, we evaluate the presence of spatial spillover on provincial economic growth in response of regional European policy.

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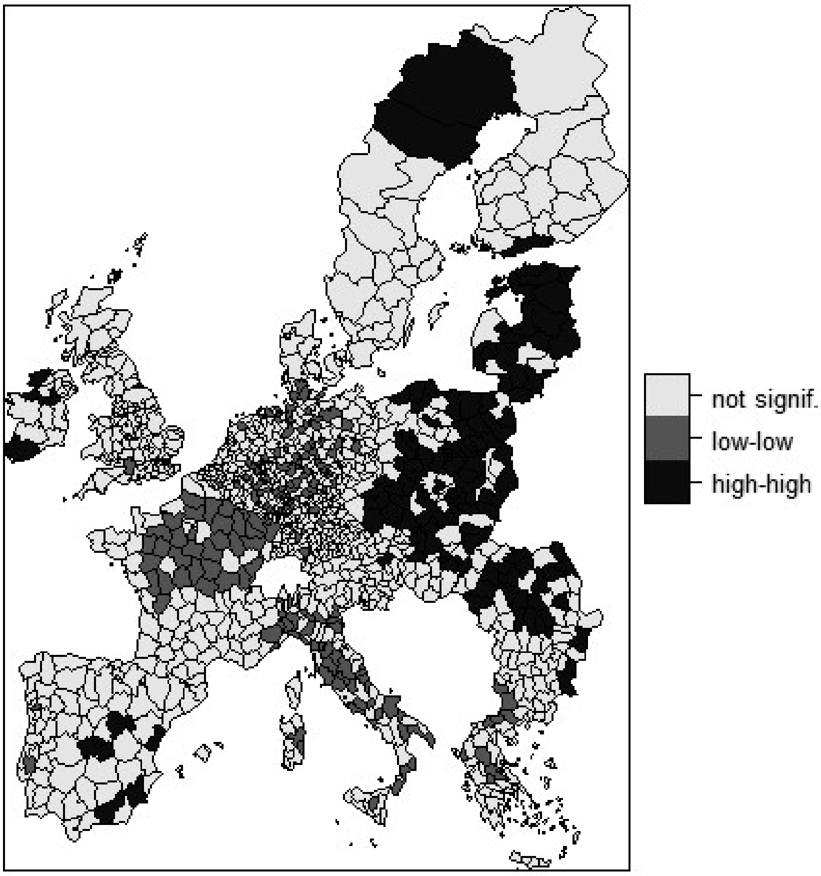
Figure 1 – Identification of Spatial Patterns by Local Moran's I



Source: Authors' elaboration

The total impact of the policy is disentangled in direct and indirect effects, i.e., in response to neighbours' state of treatment.

Table 3 resumes the findings of our analysis. The choice between spatial models is made on the basis of the Lagrange Multiplier tests for spatial dependence (Table 4). The results of the baseline model (1), a *DiD* model controlling for spatial clusters, show a positive and significant average treatment effect of regional policies implemented between 2007-2013 on the outcome measured by the 2015-17 gross domestic product growth rate. Note that the model captures the slowdown in the post-treatment period (negative coefficient of t) with a reduced resilience of the lagging regions (negative coefficient of *D*).

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Table 3 – Direct and Indirect Effects on GDP Growth Rate

	Model 1: DiD	*Model 2: SDiD*	*Model 3: SDiD with Covariates*	*Model 4: SDM DiD*	*Model 5: SDEM DiD*
Constant	0.059***	0.064***	0.058***	0.050***	0.058***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
D	-0.011***	-0.009***	-0.015***	-0.015***	-0.016***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
t	-0.018***	-0.027***	-0.029***	-0.026***	-0.028***
	(0.002)	(0.004)	(0.004)	(0.004)	(0.006)
Dt	0.029***	0.025***	0.021***	0.021***	0.022***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
DjD		-0.020**	-0.022**	-0.023***	-0.020
		(0.009)	(0.009)	(0.009)	(0.014)
Djt		-0.013	-0.015	-0.019	-0.013
		(0.020)	(0.019)	(0.019)	(0.019)
DjDt		0.050**	0.048**	0.048**	0.043
		(0.025)	(0.024)	(0.024)	(0.028)
population growth rate			0.468***	0.455***	0.480***
			(0.062)	(0.062)	(0.063)
manufacturing employment growth rate			0.076***	0.077***	0.071***
			(0.012)	(0.012)	(0.012)
S10			0.003	0.003	0.001
			(0.003)	(0.003)	(0.003)
enlargement 2004 and 2007			0.033***	0.032***	0.035***
			(0.004)	(0.004)	(0.004)

(...continue...)

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(...continue)

	Model 1: DiD	*Model 2: SDiD*	*Model 3: SDiD with Covariates*	*Model 4: SDM DiD*	*Model 5: SDEM DiD*
dummy capital			0.004	0.004	0.003
			(0.004)	(0.004)	(0.004)
dummy metropolitan area			0.005***	0.005***	0.005***
			(0.002)	(0.002)	(0.002)
Pre-treatment positive clusters	0.092***	0.093***	0.069***	0.069***	0.072***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Pre-treatment negative clusters	-0.057***	-0.056***	-0.050***	-0.049***	-0.051***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
rho				0.155***	
				(0.06)	
lambda					0.42***
					(0.07)
Observations	2620	2620	2620	2620	2620
R^2	0.256	0.258	0.317		
Adjusted R^2	0.254	0.256	0.314		
Log Likelihood				4621.87	4635.73
$sigma^2$				0.002	0.002
Akaike Inf. Crit.				-9209.74	-9237.46
Residual Std. Error	0.043 (df = 2614)	0.043 (df = 2611)	0.042 (df = 2605)		
F Statistic	179.724*** (df = 5; 2614)	113.564*** (df = 8; 2611)	86.475*** (df=14;2605)		
Wald Test (df = 1)				6.663***	37.414***
LR Test (df = 1)				5.364**	33.085***

Source: Authors' elaboration.

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Table 4 – Testing Spatial Dependence

Lagrange Multiplier diagnostics	*Statistic*	*Parameter*	*P-value*
LM spatial error	50.65	1	1.1e-12***
LM spatial lag	4.38	1	0.0364*
Robust LM spatial error	61.33	1	4.9e-15***
Robust LM spatial lag	15.06	1	0.0001***

Source: Authors' elaboration.

Model estimates are affected by the spatial dependence of outcome and treatment variables. We consider indirect effects produced by neighbouring regions that may have economic relations with the treated territories. Moreover, European regions are characterized by strong heterogeneity in growth rates, especially within EU15 regions and the newly annexed regions, admitted in 2004 and 2007.

In model 2 we present estimates of spatial DiD model using OLS estimator. The effect is equal to 0.025 while the covariate on spatial clusters shows higher coefficients. In fact, more significant variation is registered regarding the spatial clusters of hot-spots (0.093) and cold-spots (-0.056). This is not surprising, since the hot-spots (brown in fig. 1) represent the lagging regions, where higher growth is expected, and the cold-spots (purple in fig. 1) the more developed regions. Model 3 considers other covariates and, inter alia, a specific dummy for the regions belonging to newly annexed countries (*enlargement*). We find positive effects for the abovementioned regions, suggesting the driving force of cohesion policies leaning toward the convergence process. Considering spatial dependence in the outcome variable and between units, models 4 and 5 confirm our hypothesis of the existence of spatial effects, both direct and indirect. The average treatment effect is positive and equals 0.021, and it represents the direct impact of the policy, i.e., the difference on growth rates between treated and controls.

The indirect treatment effect (ITE) due to the presence of neighbours treated units is captured by the parameter Djt, that is negative and not significant. The indirect treatment effect on the treated (ITET) is measured by considering the interaction between own state of treatment and the one of neighbours, DjDt: the parameter is positive and significant in all the models.

The results suggest that regions cluster on territorial strengths. The spatial lag (rho) indicates that regions are expected to have higher GDP growth rates (Marica *et al*., 2021) if their neighbours have, on average, high GDP growth rates.

Finally, we provide the identification of different impacts in the preferred SDM DiD model (Table 5). Result confirms the presence of significant ITET

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Table 5 – Marginal Effects of the SDM Estimates

	Direct	*Indirect*	*Total*
D	-0.015***	-0.003*	-0.017***
	(0.004)	(0.001)	(0.004)
t	-0.021***	-0.005**	-0.031***
	(0.004)	(0.002)	(0.005)
Dt	0.021***	0.004**	0.025***
	(0.004)	(0.002)	(0.005)
DjD	-0.023***	-0.004	-0.028**
	(0.009)	(0.003)	(0.011)
Djt	-0.019	-0.003	-0.022
	(0.019)	(0.004)	(0.023)
DjDt	0.048**	0.009	0.057**
	(0.024)	(0.006)	(0.029)
population growth rate	0.455***	0.083**	0.538***
	(0.062)	(0.040)	(0.079)
manufacturing employment growth rate	0.077***	0.014**	0.091***
	(0.012)	(0.007)	(0.016)
S10	0.003	0.001	0.003
	(0.003)	(0.001)	(0.003)
enlargement 2004 and 2007	0.032***	0.006**	0.038***
	(0.004)	(0.003)	(0.005)
dummy capital	0.004	0.001	0.005
	(0.004)	(0.001)	(0.005)
dummy metropolitan area	0.005***	0.001*	0.006***
	(0.002)	(0.001)	(0.002)
Pre-treatment positive clusters	0.070***	0.013**	0.082***
	(0.005)	(0.006)	(0.008)
Pre-treatment negative clusters	-0.049***	-0.009**	-0.058***
	(0.005)	(0.004)	(0.005)

Source: Authors' elaboration

even when considered the presence of feedback effects (column indirect). In addition, the total average treatment effect is still positive and significant.

From the models we have decomposed the total effect of the policy in direct and indirect effects, following the approach presented in LeSage and Pace (2009) and

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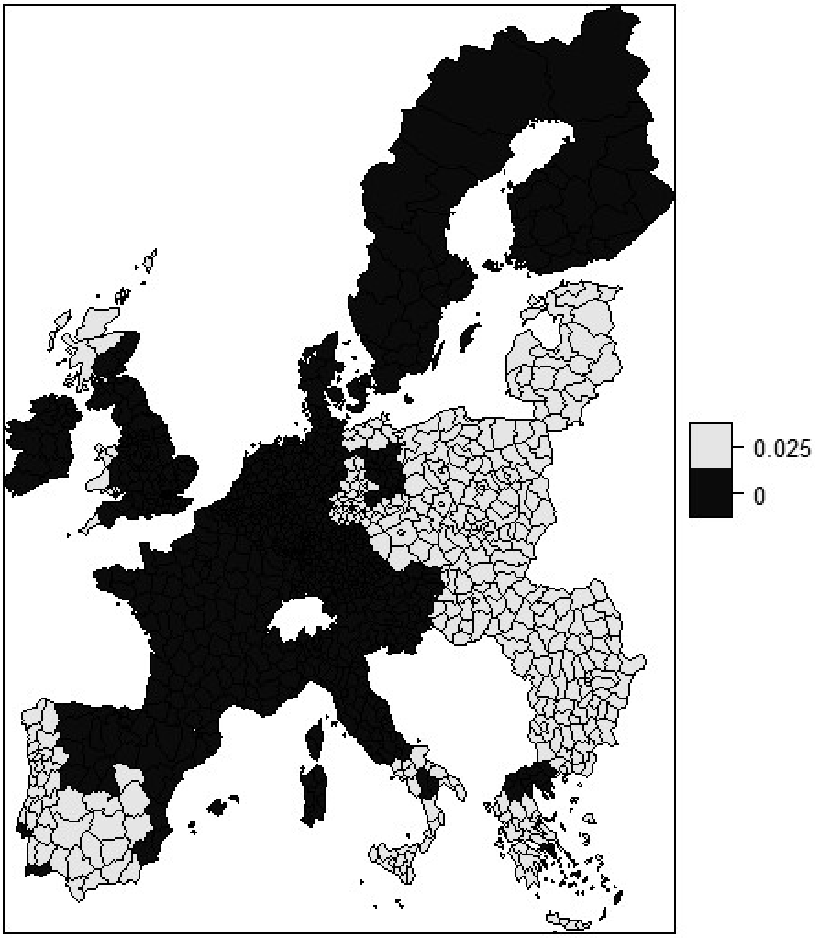
Figure 2 – Direct Effects of the 2007-2013 Cohesion Policy



Source: Authors' elaboration

Arbia *et al*. (2020). Overall, the indirect effects have the same sign as the direct effects, so they boost the output effect of the policy. In other words, Cohesion Policy of the programming cycle 2007-2013 succeeds in generating development processes in neighboring areas by strengthening the final effects expected by policy makers. By examining our preferred specification (the SDM model), Figure 2 shows how European regional policy is located in the weakest areas, where therefore its direct effects appear. More interesting is Figure 3, indicating the location and intensity of the indirect effects. These are generally grouped into geographic clusters. The most significant and largest cluster in terms of impact is represented

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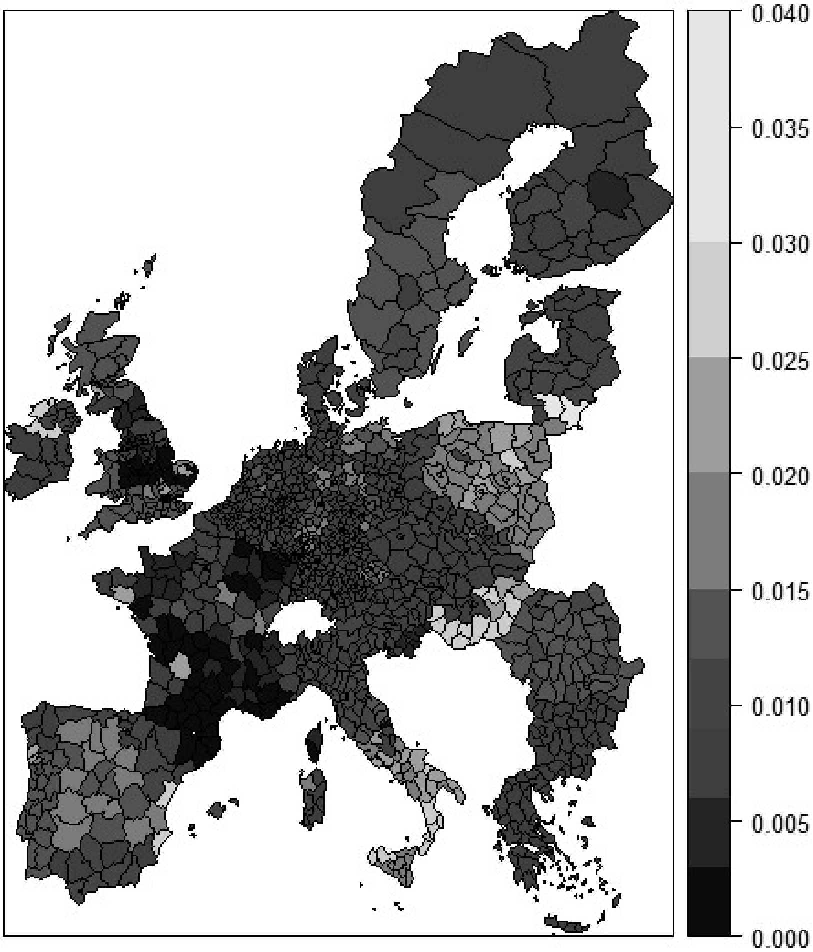
Figure 3 – Indirect Effects of the 2007-2013 Cohesion Policy



Source: Authors' elaboration.

by several regions in the Eastern Europe, including some new entrants. Also note-worthy is the cluster in the South Italy and in Ireland. The total effects, presented in Figure 4, are greater in the areas where the indirect ones are more relevant. Overall, the total effects are larger in areas of the European Eastern regions, where the policy produces high positive externalities, reducing inequalities with the more developed regions. In practice, this has strengthened resilience processes in these areas and thus reduced the gap with the more developed regions.

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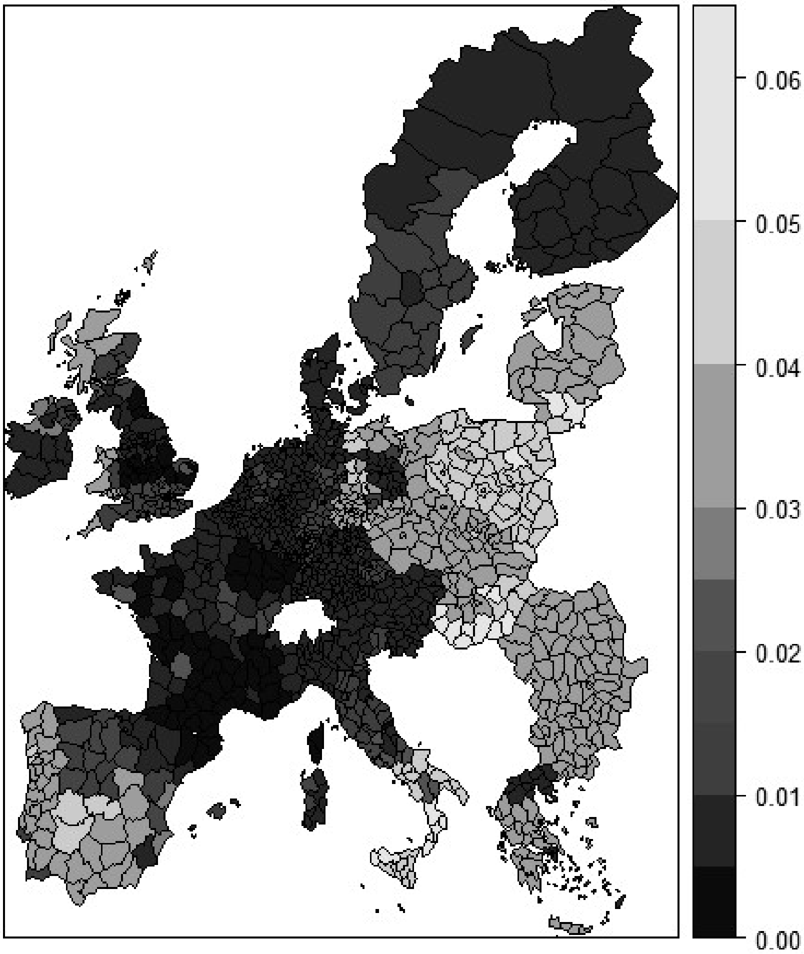
Figure 4 – Total Effects of the 2007-2013 Cohesion Policy



Source: Authors' elaboration

7. Conclusions

The aim of our work is to evaluate the total effects of European regional policy, considering both direct impacts and impacts due to spillovers. Unlike of the recent literature, our study considers the spatial configuration of regions in Europe and evaluate the effect to the clusters that have formed between developed and lagging regions.

This evaluation is based on a newly developed counterfactual approach, which at least partially overcomes the limits of the SUTVA, and consistently estimates

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the spillovers, which are detected based on the spatial distance between areas. The econometric model used is of the DiD type, with a spatial specification considering both the SDM and SDEM approach, clearly confirmed by the data.

The results confirm that the effects of regional policy on growth are positive also in the period considered (2015-2017). Therefore, also in a moment of economic downturn, European regional policy has helped the resilience of the weakest regions, which have been more exposed to the effects of the crisis.

The most innovative aspect of the analysis is the measurement of spillovers, which are positive, statistically significant, and therefore reinforce the impact of the policy. In the preferred SDM specification, about one-sixth of the overall policy effects are due to indirect effects attributable to the detected spatial spillovers. In the absence of an assessment of spillovers, the effects of the policy could not only be biased but also be underestimated.

The results underline how the structure of European regions empirically grouped into clusters, as shown by the analysis using Local Moran's I, interacts with spillovers. Empirically, these spillovers manifest themselves positively especially in the clusters of Eastern Europe, reinforcing the processes of convergence towards the more developed regions. This has therefore strengthened the resilience processes in these areas and contributed to an overall reduction of regional disparities in Europe.

The policy suggestions deriving from these results reaffirm the need to consider the total effects of the policies, including the spillover effects towards neighboring areas, in the evaluation of a place-based policy intervention. On the other hand, this is consistent with the place-based approach of the European policies which stimulate the processes of convergence of the European regions by enhancing the endowments of material, immaterial and human capital in the territory, also overcoming administrative boundaries. These results therefore suggest larger coordination of policies, overcoming administrative boundaries and having as an optimal dimension the geographical clusters of similar areas that are formed in the European space.

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Gli spillovers spaziali delle politiche regionali aiutano a ridurre le disuguaglianze regionali in Europa?

Sommario

La politica di coesione europea promuove lo sviluppo armonioso dell'Unione e delle sue regioni, favorendo la crescita inclusiva e l'occupazione nelle regioni meno sviluppate, migliorando il benessere delle persone e riducendo le disparità regionali. Tuttavia, gli effetti della politica sono sia diretti, nelle regioni in cui la politica viene indirizzata, sia indiretti, attraverso la generazione di effetti di ricaduta nelle regioni vicine o economicamente collegate. La valutazione degli effetti complessivi di queste politiche è quindi complessa, in quanto occorre tenere conto di entrambi gli effetti, diretti e indiretti. Tuttavia,

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gli spillover sono generalmente esclusi dal modello controfattuale classico, che non ammette effetti di interferenza tra le unità trattate e non trattate della politica (ipotesi denominata SUTVA – Stable Unit Treatment Value Assumption). Il presente lavoro mira a superare questa restrizione, implementando una metodologia pienamente coerente con l'approccio controfattuale, che non ammette questa ipotesi. In questo lavoro, viene proposto un modello DID spaziale, basato sulla specificazione Modello Spaziale Durbin (SDM) che consente effetti di spillover. Il saggio valuta gli effetti complessivi della politica regionale del periodo di programmazione 2007-2013. I risultati mostrano effetti positivi della politica regionale europea specialmente nelle regioni dell'Est Europa, dove la politica produce esternalità positive elevate, riducendo le disuguaglianze con le regioni più sviluppate.

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