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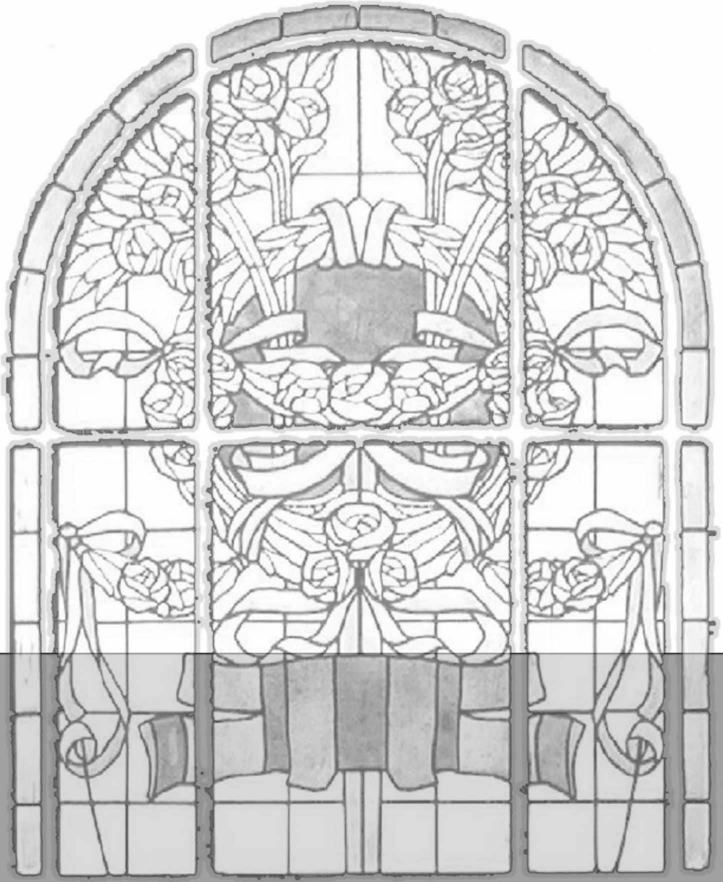

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MEASURING THE EFFECTS OF EUROPEAN REGIONAL POLICY ON ECONOMIC GROWTH: A REGRESSION DISCONTINUITY APPROACH

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Unità di Valutazione degli Investimenti Pubblici

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Measuring the effects of European Regional Policy on economic growth: a regression discontinuity approach

Abstract

Given the increasing share of the EU budget devoted to Regional policy, several studies have tried to identify the impact of Structural funds on economic growth and convergence. However, so far no consensus has been reached on the policy effectiveness, due to both limitations in data availability and comparability at regional level, and the difficulties in isolating the impact of the policy from the confounding effect of other factors. The purpose of this paper is to assess the impact of EU Regional policy, using a non-experimental comparison group design - the regression discontinuity design (henceforth RDD). The study compares the economic scenario arising under policy interventions with a 'counterfactual' situation - what would have happened if the policies were not implemented. To this end, we properly build up an economic and financial regional data set for the period 1994-2006, fully coherent and comparable at the European level. The sharp RDD exploits the allocation rule of regional EU transfers: regions with a per capita GDP level below 75 percent of the EU average qualify for Objective 1 funds. Our findings show a positive, but moderate, effect of Regional policy on economic growth.

L'impatto della Politica regionale sulla crescita delle regioni europee: un approccio basato sul *Regression Discontinuity Design*

Sommario

La Politica regionale europea ha assunto un peso rilevante e crescente nel bilancio comunitario. La valutazione dei suoi effetti sulla crescita e sulla convergenza delle regioni europee è stata oggetto di numerosi studi. Tuttavia, ad oggi le indagini empiriche sull'efficacia della politica non hanno prodotto conclusioni unanimi, a causa sia della limitata disponibilità e comparabilità internazionale di statistiche a livello territoriale, sia della difficoltà di isolare l'impatto della politica da quello di altri fattori che influenzano la crescita. Lo scopo di questo studio è di valutare gli effetti della Politica regionale europea mediante un approccio di inferenza causale denominato *Regression Discontinuity Design* (RDD). Lo studio confronta lo scenario economico che si presenta a seguito di interventi di *policy* con uno scenario "controfattuale" che stima quello che sarebbe successo in assenza di tali interventi. A tale scopo, è stato costruito un nuovo *data set* che raccoglie informazioni finanziarie ed economiche a livello regionale, per il periodo 1994-2006, coerenti e comparabili in ambito europeo. L'approccio RDD (nella versione "*sharp*") sfrutta le regole di assegnazione dei fondi europei, le quali prevedono che siano ammissibili al finanziamento dei Fondi Strutturali nell'ambito dell'Obiettivo 1 solo le regioni con un Prodotto Interno Lordo (PIL) pro capite inferiore al 75 per cento della media comunitaria. I risultati dell'analisi segnalano come vi sia un positivo, anche se moderato, effetto della Politica regionale europea sulla crescita delle regioni.

Study promoted by the Ministry for Economic Development (Department for Development and Economic Cohesion) and coordinated by Professor Guido Pellegrini from "La Sapienza" University of Rome.

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CONTENTS

I. Introduction

The aim of this paper is to assess the effectiveness of EU Regional policy, using a reliable and comparable dataset and a non-experimental comparison group design - the regression discontinuity design (henceforth RDD) - to evaluate the causal effects of the policy on regional economic growth.

Regional policy - or Cohesion policy - is one of the key axes of EU integration, together with single market and monetary union. Its objectives are anchored in Article 174 of the Treaty on the Functioning of the European Union (ex Article 158 TEC)[1], which states that: "In order to promote its overall harmonious development, the Union shall develop and pursue its actions leading to the strengthening of its economic, social and territorial cohesion. In particular, the Union shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions."

In the period 2007-2013, a relevant share of the EU budget – around 36 percent (€347 billion) – is intended for this purpose. The majority of this funding targets the most disadvantaged European regions, identified on the basis of EU statistical indicators and criteria. Although low as a percentage of total EU GNI (0,38 percent), still Cohesion policy represents an important share of resources devoted to public investment policies in the least prosperous regions and Member States of the Union[2].

Given the increasing share of the EU budget devoted to Regional policy since the mid-1970s[3], numerous studies have tried to shed light on the policy's contribution to economic growth and convergence. However, after more than thirty years of policy intervention, empirical evidence remains mixed and contradictory. No consensus exists on the effectiveness of Cohesion policy.

While some econometric analyses suggest that Regional policy has a significant positive impact on growth and convergence (de la Fuente and Vives, 1995; Cappelen et al., 2003; Beugelsdijk and Eijffinger, 2005; Mohl and Hagen, 2010), others find only conditionally

[1] The Treaty of Lisbon amends the EU's two core treaties, the Treaty on European Union and the Treaty establishing the European Community (TEC). The latter is renamed the Treaty on the Functioning of the European Union.

[2] In the period 2000-2006, Regional policy commitments amounted, on average, to an estimated 60 per cent of total public capital expenditure in Portugal, 48 per cent in Greece and 24 per cent in Spain. See European Commission (2007).

[3] Since the establishment of the European Regional Development Fund (ERDF) in 1975, financial resources for Cohesion policy have progressively increased, from a mere 5 per cent of the total Community budget (1.3 billions European Unit of Account) to around 36 per cent over the present 2007-2013 period. See Manzella and Mendez (2009).

positive effects (e.g., depending on the quality of institutions, see, inter alia, Ederveen et al. 2006). Finally, a large number of studies estimate the impact as not statistically significant or even negative (Fagerberg and Verspagen, 1996; Boldrin and Canova, 2001; Dall'erba and Le Gallo, 2008).

This mixed evidence is due not only to limitations in data availability and comparability at regional level, but also (and mainly) to the difficulties faced when isolating the impact of Regional policy from the confounding effects induced by other factors.

Close in spirit to this mentioned literature, and in order to overcome the above referred difficulties, we depart from it as we identify Regional policy effects on the basis of the so-called Regression Discontinuity Design (RDD). This method, rarely used in the evaluation of Cohesion policy programmes, compares the economic scenario arising under policy interventions with a 'counterfactual' situation - what would have happened if the policies were not implemented. In this context we exploit the allocation rule of regional EU transfers: regions with a per capita GDP level below 75 percent of the EU average qualify for Objective 1 funds. We claim that not eligible regions with a per capita GDP just above to the threshold of 75 percent (who did not receive the transfers) are a very good comparison group to those just below the threshold (who did receive the transfers). In the field of regional policies, an explicit counterfactual approach has been used, to the best of our knowledge, only in two recent papers. Hagen and Mohl (2008) apply the method of "generalized propensity score" to indicate that Structural funds payments have a positive, but not statistically significant impact on EU regions' growth rates. Becker et al. (2008), inferred causal effects of Objective 1 interventions on EU regions using a RDD based on a parametric approach exploiting panel data at NUTS 3 level. They find positive growth effects of Structural Funds in the recipient regions.

From a methodological view point, we fully exploit the potential of the RDD: the impact of Regional policy is evaluated using both non parametric and parametric approaches, thereby getting robust results. Further, from an empirical view point, we define a reliable data set for EU-15 regions at level 2 of the NUTS 2003 Nomenclature which, to the best of our knowledge, is innovative for this scope. Indeed, in order to overcome limitations in data availability and comparability at regional level, we collect data from EU Commission on the main variables under study - regional GDP per head in PPS for the years 1988-1990 and GDP per capita average annual growth rate for the years 1995-2006. Data on Structural Funds certified expenditure for the years 1994-2006 are provided by the

European Commission (DG Regional Policy) and the Italian Ministry of Economic Development. Regions are selected in order to have the treated and not treated groups comparable and clearly differentiated. This leads to a sharp RDD.

Although a priori the RDD allows to isolate the Regional policy impact, the analysis is still complex, for several reasons. Not only the limited number of observations, but also the high variability of regional growth with respect to the initial level of GDP per capita can strongly affect the statistical precision of estimates. In order to assess the robustness of our results in the paper we perform different analyses, using several parametric and non parametric estimators, and modifying a number of key characteristics (e.g. specification, sample, bandwidth, kernel function). Moreover, we provide different tests as suggested by Lee and Lemieux (2009) and Imbens and Lemieux (2008b).

Quite interestingly, we find that EU Regional Policy in Objective 1 regions has a positive and significant impact on growth. The comparison between regions' performance points to an annual GDP per capita growth difference of 0.6-0.9 percentage points in favour of Objective 1 regions, over the period 1995-2006. These results are robust to different methods and specifications.

The paper is structured as follows. Section 2 summarises the literature and available empirical evidence on the effects of Regional policy. Section 3 describes the institutional design of EU Regional policy. The evaluation method is discussed in Section 4, followed by a presentation of the database in Section 5. The results of the empirical analysis are presented in section 6, while section 7 assesses the robustness of the results. Finally, we briefly conclude and define some path for future research.

II. Literature review

Since the establishment of the European Regional Development Fund (ERDF) in 1975, the reduction of regional disparities - the Treaty general mission - has often been measured in terms of GDP per head. Convergence in GDP per head has become a major aspect in assessing the effectiveness of EU Regional policy, disregarding the more general goal of the Treaty "to promote overall harmonious development" (Article 174)[4]. The limits of this perspective is that it may not be capturing the different dimensions of well-being, providing a distorted view of regional disparities in terms of people's quality of life[5]. However, GDP or GDP per capita measures continue to provide relevant information in monitoring economic activity, particularly at territorial level where limitations in the cross-country comparability of statistics affect the analysis among regions.

Considering the available empirical evidence on the effectiveness of Regional policy, results are not unanimous, heavily depending on model specification, statistical methodologies and observations (such as geographical areas and reference period). In particular, analyses based on econometric studies do not provide a consistent picture on the effects of Cohesion policy. We can classify econometric analyses in three groups depending on their results: a first group of studies finding a positive impact of Cohesion policy on growth and convergence, a second group finding mix results, and a third group according to which the effects of Regional policy are not significant or even negative.

Among the first group of studies, de la Fuente and Vives (1995) estimate a growth model that includes public and human capital. Using Spanish regional data for the 1980-90, they show that the potential impact of public investment in infrastructure and education on productivity growth is considerable. Hence, supply-side Regional policies have significant effects on income growth and convergence, their impact on regional disparities depending on the overall amount of resources devoted to them. Cappelen et al. (2003), using a pooled cross-country time series dataset for the period 1980-1997, show that Cohesion policy has a significant and positive impact on the growth performance of European regions. However, they also stress that the economic impact is stronger in more developed environments, suggesting the need to accompany regional support with national policies that facilitate structural change and increase R&D capabilities in poorer regions. In a study by Beugelsdijk and Eijffinger (2005), using a

[4] See Monfort (2009).

[5] On the limits of GDP as an indicator of economic performance and social progress see the recent report by Stiglitz, Sen and Fitoussi (2009).

panel regression of the EU-15 countries for the period 1995-2001, a positive relationship between (lagged) Structural Funds expenditure and GDP growth at the national level is found[6]. Finally, Mohl, and Hagen (2010), on the basis of a dataset of 126 NUTS-1/NUTS-2 regions and using various panel data approaches controlling for heteroscedasticity, serial and spatial correlation as well as for endogeneity, confirm that Objective 1 payments do sustain regional economic growth.

Other econometric studies find only conditional effectiveness of Regional policy or mixed evidence. Ederveen et al. (2002), observing EU-12 countries in the period 1960-1995 find that Cohesion policy fosters economic growth in lagging Member States conditional on the openness of the economy. At the regional level, for a sample of 183 NUTS-2 regions between 1981 and 1996, the estimated impact of cohesion policy on economic growth is positive and significant when region-specific steady states are allowed for (so that differences will persist in the long-run). Ederveen et al. (2006), using a dynamic panel specification with data on 13 EU countries covering seven five-year periods from 1960–1965 through 1990–1995, assess the effectiveness of Structural Funds and whether this is conditioned by the "quality of institutions" proxied by quantitative measures of corruption, inflation or openness to trade. They show that when institutional quality is explicitly taken into account, the impact of Structural Funds on regional growth is positive and significant: economies with good institutional quality benefit from the EU funds. Analogously, Bähr (2008), using panel data for a sample of 13 EU Member States from 1975-1995, shows that increasing sub-national autonomy has a significantly positive impact on the effectiveness of EU regional support.

Finally, a further strand of econometric evaluations tends to be quite pessimistic. Fagerberg and Verspagen (1996), for example, do not find any significant impact of the Funds in their convergence regressions. The same result holds for Boldrin and Canova (2001): analysing different measures of dispersion at the regional level for a set of 185 NUTS 2 regions over the period 1980–1996, they do not find convergence of regional per capita income levels. Not even signs of accelerating growth rates in recipient regions appear. Thus, they reject the hypothesis of a positive impact of Structural Funds on

[6] A positive impact of Regional policy is also found in the literature based on macroeconomic simulation models, initiated by the so-called HERMES model in the 1990s (for Ireland see, Bradley et al., 1992), developed for Ireland, Spain, Greece and Portugal by its successor HERMIN (see among many others: Bradley et al., 1995; Fitz Gerald, 2004; Bradley, 2006) and QUEST models (see for example, for the programming period 2007-2013, in't Veld, 2007). However, estimates of the policy impact of Regional policy, which are often positive, are strongly dependent on the specific assumptions underlying the models.

economic growth. Dall'erba and Le Gallo (2008), evaluate the impact of structural funds on the convergence process of 145 European regions over the 1989-1999 period, paying attention to both the presence of spillover effects among regions and the potential risk of endogeneity of the funds. The results do not suggest a significant impact of structural funds on regional convergence. Simulations show how investments targeted to the peripheral regions never spill over to their neighbours. Hagen and Mohl (2008) apply the method of "generalized propensity score" using a panel data set of 122 NUTS-1 and NUTS-2 European regions for the time period 1995-2005 and find that Structural Funds payments have a positive, but not statistically significant, impact on the regions' three-year growth rates.

Overall, the empirical literature remains inconclusive concerning the impact of Cohesion policy on economic growth. Results strongly depend on the model specification adopted and on the dataset used (period under study and number of countries/regions considered). Moreover, limitations in data availability and comparability (in particular on regional trends and policies) have prevented the use of the recent methods of policy evaluation. Taking seriously the problem of causality in the analysis of regional policy, we build up a reliable and comparable dataset, that allow us to exploit a non-experimental design to evaluate the causal effects of the policy on regional economic growth.

III. EU Regional policy

Regional policy (or Cohesion policy in the EU jargon) represents more than one-third of the total European budget; Structural and Cohesion funds are the second largest item after the spending on agricultural policies.

Regional policy aims at promoting the conditions for sustained growth in the European area, by helping weaker economies to fill the gap with the rest of the EU. Developing infrastructure network, supporting enterprises, investing in education, research and innovation activities as well as in environmental protection programmes, are all examples of regional policy initiatives[7].

At territorial level, policy intensity varies both in terms of goals and funds addressed to different areas[8]. This diversity is reflected in the definition of the priority Objectives of the policy which allows to identify both the scope of interventions and the territorial eligibility of each European region.

The bulk of EU Regional Policy concerns the so-called Objective 1 (called, in the current programming period 2007-2103, Convergence Objective). It aims at fostering growth of the least-developed regions, defined as NUTS-2 regions with GDP per head in Purchasing Power Standards (PPS) below 75 percent of the EU average. More than two-thirds of Structural Funds appropriations are allocated to less prosperous regions.

Different territorial Objectives (i.e. Objectives 2 and 3 - now merged in the Regional Competitiveness and Employment Objective) correspond to different concentration of funds, meaning a different amount of per capita Cohesion policy payments by region. Even though Cohesion policy has always aimed at solving different problems of economic decline in specific areas (areas with industrial decline, areas combating long-term

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7 A significant shift in investment priorities has been made with the 2007-2013 programming period. A quarter of resources are in fact now earmarked for research and innovation and about 30 per cent for environmental infrastructure and measures combating climate change.

8 Cohesion Policy includes different financial instruments that allow to fulfil the territorial Objectives defined in the Regulations. Two main financial instruments fall under the Structural Funds. The first is the European Regional Development Fund (ERDF), which supports programmes for infrastructure development, job-creating investment, research, innovation as well as environmental protection activities. The second, the European Social Fund (ESF), is aimed at increasing the adaptability of workers and enterprises, enhancing the access to employment as well as the participation in the labour market, thus reinforcing social inclusion. In the previous programming periods, Structural Funds also included the European Agricultural Guidance and Guarantee Fund (EAGGF) and the Financial Instrument for Fisheries Guidance (FIFG). An important financial instrument, the Cohesion Fund, goes in favour of Member States with a gross national income below 90 per cent of the EU average to finance environmental and large-scale infrastructure projects.

unemployment, facing rural underdevelopment, or suffering problem of urbanization, etc.), still supporting the least developed regions represents its major priority. The definition of "least developed regions" through the adoption of the "75 percent" rule has been kept unchanged during the different programming periods. Regions that have complied with this rule have been eligible to receive most of the payment.

However, the procedure of funds allocation has not always been automatically determined and transparent. This is due to the political negotiations among Member States that have often influenced the planning of the EU budget. Consequently, in the past programming periods a number of Member States have been entitled to receive assistance within the "Objective 1" framework, even if some regions were not fully in compliance with the criterion set in the regulation.

IV. Evaluating the impact of EU Regional policy using a regression discontinuity design

The key issue when evaluating public policies is to identify their impact by separating the effect of other factors influencing the outcome under analysis. The Regression Discontinuity Design (RDD), introduced by Thistlethwaite and Campbell (1960), well fits this aim. Traditionally, it develops as a non-experimental comparison group strategy where participants are assigned to a programme, or "treatment", by whether an observed "forcing variable" is below (or exceeds) a known cutoff point. The rationale is that units just above (below) the cutoff point (who do not receive the treatment) represent good comparisons to those just below (above) the cutoff (who receive the treatment). Any discontinuity in the conditional expectation of the outcome at the cutoff point can be interpreted as evidence of a causal effect of the treatment.

It is worth stressing that in the RDD the discontinuity in the treatment assignment mechanism is solely based on the assignment rule (i.e. the relation between the forcing variable and the cutoff point); accordingly, close to the cutoff, one can easily put apart the confounding factors by comparing the units belonging to the treated and non-treated groups.[9] Also, while it only identifies treatment effects taking place locally at the cutoff point, its rationale can be extended to each unit having a positive probability to be located near the cutoff point (Lee, 2008). Accordingly, from a methodological view point, inferences which are drawn from a well-implemented RDD are comparable, in terms of internal validity, to the findings obtained from randomized experiments, such as matching on observables, difference-in-differences and instrumental variables. Finally, it bypasses many of the questions related to model specification, both the problem of variables identification and the one related to their functional form (Hahn et al., 2001).

The RDD approach is used here for estimating the effects of Regional policy on economic growth in EU[10]. In our analysis, units are represented by EU-15 regions: regions whose per capita GDP is less than 75 percent of the EU average (and thus receiving Objective 1 funds) are compared with those above the 75 percent threshold (and, accordingly, not eligible for funding); the forcing variable is regional GDP per capita, the cutoff point is the 75 percent threshold and the treatment is EU Objective 1

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[9] More precisely, Lee (2008) shows that the RDD is equivalent to a local random assignment around the cutoff.

[10] See Lee and Lemieux (2009) for a survey on the RDD and its main applications in economics.

funds. Let us remark here that, in line with the basic idea of RDD[11], receiving the treatment (i.e. receiving Objective 1 funds) is assumed to only depend on whether in region *i* the level X_i of GDP per capita is below the fixed threshold *c* (75 percent of the EU average). This is a case of "sharp design", as the treatment (receiving a relevant amount of EU funds) only depends on the level of X_i. Let $Y_i(1)$ and $Y_i(0)$ denote the potential outcomes of region *i*, where $Y_i(1)$ is GDP per capita growth of Objective 1 region (i.e. receiving Structural Funds) and $Y_i(0)$ is the economic growth of non Objective 1 regions.

In the case of sharp RDD, the average causal effect of the treatment at the discontinuity point writes as (Imbens e Lemieux, 2008b):

$$\tau_{SRD} = E[Y_i(1) - Y_i(0) \mid X_i = c] \quad (1)$$

The rationale in the paper is that the average outcome for regions just above the cutoff point can represent a valid counterfactual for those just below the 75 percent threshold. Comparing GDP per capita growth of regions receiving EU funds with that of non-beneficiaries at the cutoff point, allow us to control for confounding factors and identify the average policy effect locally at the threshold.

In our analysis, the RDD suffers two main disadvantages. First, the low number of observations close to the threshold determines a trade-off between the size of the interval in the neighbourhood of the cutoff point and the accuracy of statistical estimates. Second, regional growth presents a high variability with respect to the initial level of GDP per capita, due to numerous factors influencing the outcome[12]. In this case, the limited number of observations close to the cutoff value might identify a group of regions with features that differ markedly from those of non beneficiaries, hindering the accuracy of estimates.

In the light of the above pitfalls, inference is rather complex. Accordingly, our empirical analysis - based on a standard convergence equation *à la* Barro - develops along several lines: parametric and non parametric estimators are adopted and several different characteristics evaluated (e.g. specification, sample, bandwidth, kernel function). We use the OLS estimator with robust standard errors in parametric regressions, as suggested

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[11] We refer the interested reader to Imbens and Lemieux (2008a, 2008b) for details.

[12] Considering running an OLS regression on a constant, the initial level of per capita GDP and a dummy for the treatment: it will explain 13 percent of the outcome.

by Imbens e Lemieux (2008b), and local linear regressions with standard errors computed with the bootstrap method in non parametric analyses. Moreover, in line with Lee and Lemieux (2009) and Imbens and Lemieux (2008b), we test the existence of:

- a discontinuity in the density function of X at X = c, which could signal the existence of manipulations in the forcing variable (the level of per capita GDP) by the regions;
- other discontinuities in the forcing variables, which will make weaker the assumption that the discontinuity of the outcome at X = c is only an effect of the treatment;
- variables with a discontinuity at X = c not affected by the treatment, which could determine the discontinuity of the outcome at X = c.

V. Data

The spatial grid used in this paper is defined by the EU-15 regions at level 2 of the NUTS 2003 Nomenclature. NUTS-2 regions receiving Objective 1 support (defined as "treated regions") are those with GDP per head below 75 percent of the EU average at the time eligibility for funding was determined. For the programming period 1994-1999 the EU Commission computed the eligibility threshold of per capita GDP in PPS on the basis of the figures for the years 1988-90.

Regional eligibility is based on territorial data at NUTS 2 level produced by the Commission. This suggest to use the same data, computed by EU Commission/Eurostat, in our analysis: regional GDP per head in PPS for the years 1988-1990 (ESA79) and GDP per capita average annual growth rate for the years 1995-2006[13]. In order to calculate the regional GDP per capita average growth rate we use Eurostat data for the years 2000-2006 and DG Regional Policy estimates for the period 1995-2000. Data on Regional policy certified expenditure for the years 1994-2006 are provided by DG Regional Policy and the Italian Ministry of Economic Development.

The NUTS 2003 Nomenclature includes 213 NUTS 2 regions for the EU-15: 61 of them are classified as Objective 1 regions in the programming period 1994-1999, while the remaining 152 as non-Objective 1 regions (regions not eligible for Objective 1 funds in the programming 1994-1999).

From the initial group of Objective 1 regions we decide to exclude 4 NUTS 2 regions, whose level of GDP per capita in the period 1988-1990 was above 75 percent of the Community average, but were included in Objective 1 for "political reasons": Prov. Hainaut (BE), Corse (FR), Molise (IT), Lisboa (PT). The remaining 57 regions were eligible for Objective 1 funds also in the following 2000-2006 programming period. Therefore our analysis considers the effect of Regional policy on the whole period 1994-2006.

In order to have a comparable control group we decide to eliminate, from the non-Objective 1 group, 10 NUTS-2 regions that received Structural funds in the period 2000-2006:

- we exclude 5 regions that were not Objective 1 in the period 1994-1999, but turned out to be eligible for Objective 1 funds in the period 2000-2006. These

[13] It is not easy to find comparable regional statistics with respect to the real GDP growth rate. As a matter of fact, even though regional economic statistics have recently been improved, data on regional GDP in volume are not available in a unique and comparable source.

are: Burgenland (AT), Itä-Suomi (FI), South Yorkshire (UK), Cornwall and Isles of Scilly (UK), West Wales and The Valleys (UK).

- analogously, we eliminate 5 regions that were not Objective 1 in the period 1994-1999, but were partially Objective 1 in the period 2000-2006: Länsi-Suomi (FI), Pohjois-Suomi (FI), Norra Mellansverige (SE), Mellersta Norrland (SE), Övre Norrland (SE).

A central point in the analysis is related to the per capita intensity of policy interventions in the different regions. We observe that Cohesion policy expenditure is not limited to Objective 1 regions. Currently, also regions interested by other Objectives or Community initiatives receive a non negligible amount of resources. Thus, the analysis is based on the differences in economic growth between "hard financed" regions (Objective 1 status) and "soft-financed" regions (non-Objective 1).

Considering the different sources of financing (Structural funds, Cohesion fund, National and Private resources) in the two programming periods, 1994-1999 and 2000-2006, we identify a threshold of per capita expenditure, between Objective 1 and non-Objective 1 regions, equal to 1960 euro per head approximately[14]. We exclude therefore 9 non-Objective 1 regions with a per capita expenditure higher than the threshold. This is true for most Spanish non-Objective 1 regions benefiting from the Cohesion fund (Pais Vasco, Comunidad Foral de Navarra, La Rioja, Aragón, Comunidad de Madrid, Cataluña, Illes Balears) and also for 2 Finnish regions in receipt of other programmes funding (Etelä-Suomi, Åland).

Therefore, at the end of this process, we compile data on 190 NUTS-2 regions of the EU-15: 57 of them are classified as Objective 1 regions (i.e. regions eligible for Objective 1 funds in both programming period 1994-1999 and 2000-2006, defined as "treated regions"), while 133 as non-Objective 1 (i.e. they do not receive a relevant amount of Structural funds in the period 1994-2006).

The results of our data processing are presented in Figure V.1, where the treated and not treated groups are clearly differentiated. The data allow us to carry out a sharp RDD.

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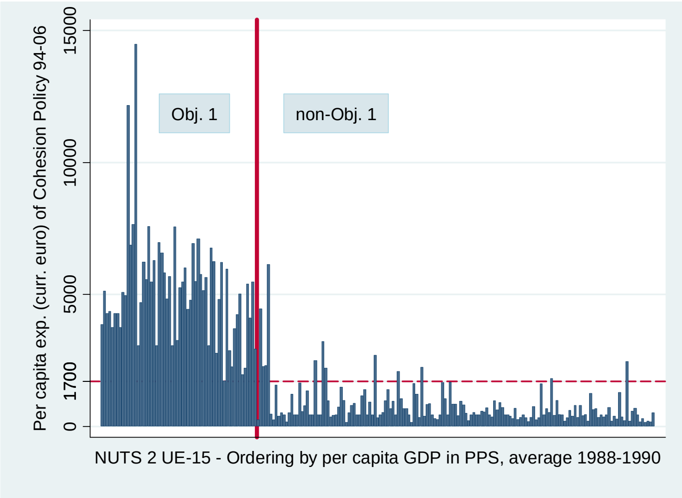
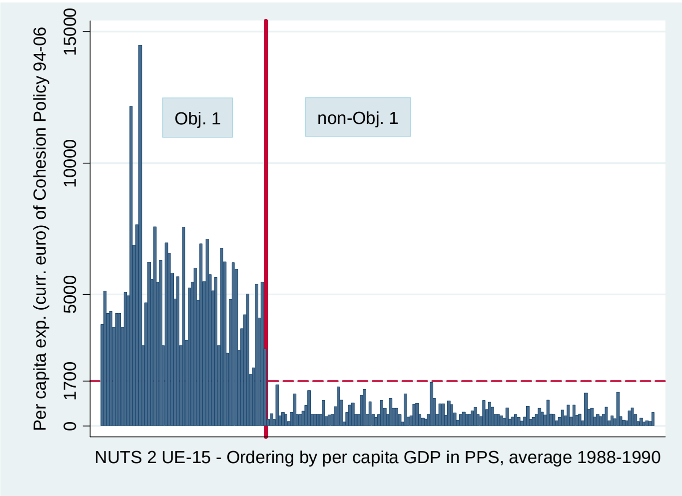
[14] It corresponds to the minimum amount of per capita expenditure in Objective 1 regions.

Figure V.1 Cohesion policy per capita certified expenditure (1994-2006)

a. Complete NUTS 2 Nomenclature (213 regions)



b. NUTS 2 for RDD (190 regions)



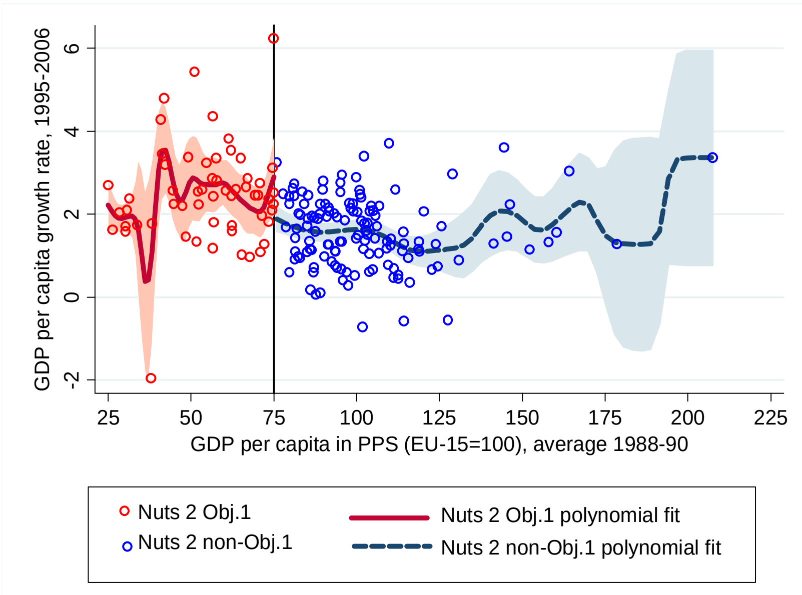
Source: Own computations based on DG Regional Policy data

VI. Results

We first present graphical evidence[15]. A simple way to evaluate the effect of the EU Regional policy on economic growth is to plot the relation between the outcome variable (GDP per capita growth rate) and the forcing variable (the level of GDP per capita) by regions, on either sides of the cutoff point. If there is no visual evidence of a discontinuity in the graph, it is unlikely more sophisticated regression methods will yield a significant policy effect (Lee and Lemieux, 2009). Figure VI.1 plots the annual average per capita GDP growth rate in the period 1995-2006 by region, against the level of GDP per capita (in PPS), average 1988-1990, standardised with respect to the EU-15 mean value (equal to 100). The cutoff line sharply distinguishes between treated (Objective 1) and not treated (non-Objective 1) regions. The figure superimposes the fit of a non parametric flexible polynomial regression model, together with 95 percent confidence bands.

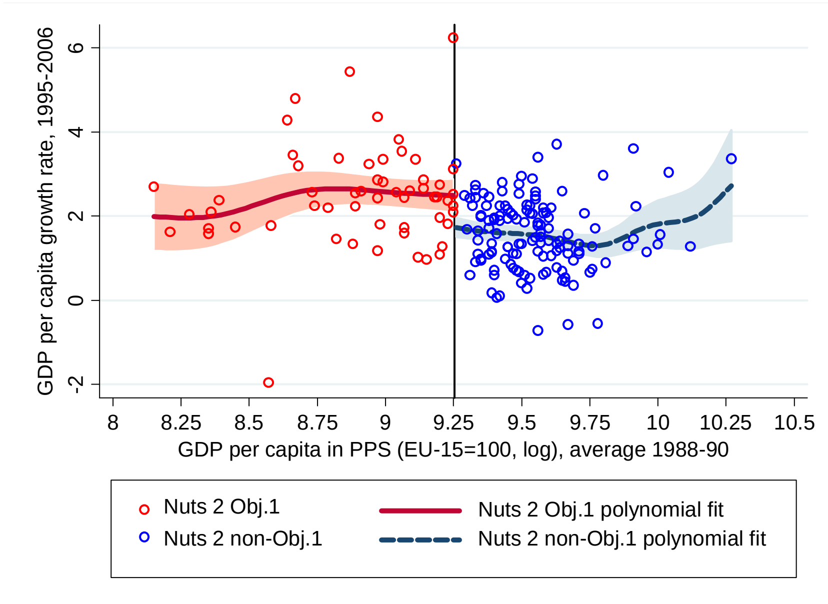
Figure VI.1 A comparison of the growth rates of Objective 1 and other EU-15 regions, 1995-2006

a. Level in PPS



[15] Tables and figures presented are our data processing on Eurostat and DG Regional Policy data.

b. Level in PPS (log)



Source: Own computations based on Eurostat and DG Regional Policy data

On average, Objective 1 regions present higher growth rates than other EU-15 regions (Figure VI.1). A naïve estimator (the difference of the annual average growth rate between treated and not treated regions) indicates that in the period 1995-2006 the annual per capita growth rate is 0.83 percentage point higher in Objective 1 regions (the estimated standard error is 0.18). The existence of a clear but modest discontinuity at the cutoff point is supported by the graph. The non parametric regression line shows a small negative jump moving from Objective 1 regions to the non-Objective 1 regions. The jump is more evident when using a logarithmic scale. Finally, the figure indicates that the relation between the outcome and the forcing variable is weak, and a simple horizontal line parallel to the x-axis can adequately approximate it. The descriptive evidence, using a graphical representation, suggests that there are discontinuities in GDP growth between treated and not treated regions, but the effects are moderate, and thus not easy to detect.

The parametric approach to the estimation of the treatment effect in the RDD contest has been criticised because the consequences of using an incorrect functional form are, in this case, quite serious. The mis-specification of the functional form can determine a bias in the treatment effect (Lee and Lemieux, 2009). A paper by Hahn et al. (2001) proposes the use of a nonparametric regression method. The standard approach is to use a local linear regression, which minimises bias (Fan and Gijbels, 1996).

There are two key issues in implementing a RDD by a local linear regression: the choice of the kernel and the choice of the bandwidth.

Different kinds of kernel are available. The use of a rectangular kernel amounts to estimating a standard regression over a window given by the bandwidth on both sides of the cutoff point. However, while other kernels (Gaussian, Epanechnikov, triangular etc.) could also be used, Lee and Lemieux (2009) argue that the choice of kernel typically has little impact in practice (see also Imbens and Lemieux, 2008b). The above statement still holds in our case. We present our results using three different kernel (Gaussian, Epanechnikov, rectangular).

A very delicate issue of our analysis is the right choice of the bandwidth. In a non-parametric RDD estimation it involves finding an optimal balance between precision (more observations are available to estimate the regression) and bias (larger the bandwidth, wider the differences between treated and non treated regions). Smaller bandwidths are feasible if the number of observations is reasonably high. There are several rule-of-thumb bandwidth choosers, but none is completely reliable. A recent contribution of Imbens and Kalyanaraman (2009) presents a data-dependent method for choosing an asymptotically optimal bandwidth in the case of a RDD.

Imbens and Kalyanaraman (2009) define an optimal, data dependent, bandwidth choice rule integrating a modified Silverman bandwidth rule:

$$\tilde{h}_{opt} = C_k \left(\frac{2\hat{\sigma}^2(c)/\hat{f}(c)}{\left(\hat{m}_+^{(2)}(c) - \hat{m}_-^{(2)}(c)\right)^2 + \left(\hat{r}_+ + \hat{r}_-\right)} \right)^{1/5} N^{-1/5} \qquad (2)$$

where:

$\hat{\sigma}^2(c)$ is the conditional variance,

$\hat{f}(c)$ is the estimation of density at cutoff point,

C_k is a constant that depends by the used kernel,

N is the number of observations,

$\hat{m}_+^{(2)}(c)$ and $\hat{m}_-^{(2)}(c)$ are the second derivates obtained fitting the observations in (c) with $X_i \in [c, c+h]$,

$\hat{r}_+$ and $\hat{r}_-$ are regularisation terms.

However, different bandwidth choices are likely to produce different estimates. We present five estimates as an informal sensitivity test: one using Imbens and Kalyanaraman formula (the preferred bandwidth), and others increasing or reducing the preferred bandwidth. Standard errors are estimated by a bootstrap procedure. The results are presented in Table VI.1.

Table VI.1 Non parametric estimates using different bandwidths and kernel types (estimation of the differences between non treated and treated regions. One-side local linear regressions at cutoff are estimated)

Bandwidth	Epanechnikov kernel	Gaussian kernel	Rectangle Kernel
15	-0.571	-0.538	-0.251
	(0.401)	(0.506)	(0.597)
20	-0.602	-0.612	-0.297
	(364) *	(0.439)	(0.507)
21.3 (opt. bw)	-0.638	-0.628	-0.392
	(0.311) **	(0.272) **	(0.370)
30	-0.719	-0.717	-0.619
	(0.284) **	(0.392) **	(0.352) *
45	-0.886	-0.838	-0.720
	(0.275) ***	(0.375) ***	(0.300) **

Notes: Bootstrapped standard errors in brackets. *, **, *** = significant at 10 percent, 5 percent, 1 percent level, respectively. Bandwidth is measured in PPS (EU-15=100), average 1988-1990

Using the Epanechnikov or the Gaussian kernel and the optimal bandwidth, the effect of EU Regional policy is positive, statistically significant and equal on average to 0.6 percentage points every year. The estimate is 25 percent lower than the naïve estimator. Using rectangular kernel and the same bandwidth the estimate is around 0.4 and not statistically significant, but, if we increase the bandwidth of around 50 percent, the effect is equal to 0.6 again and significant at 10 percent. The wider the bandwidth, the stronger the discontinuity. The reason is clearly exposed in Figures A.1a, A.1b and A.1c in the Appendix: the wider the bandwidth, the higher the smoothness, the lower the impact of some erratic observations close to the cutoff line. In this case the rectangular kernel needs a larger window for smoothing these observations.

In case of the RD design, valid parametric inference requires a correct specification of the functional form. A more flexible specification involves introducing polynomials in the forcing variable as regressors. The parametric approach can integrate the non parametric one, both assessing the robustness of the RDD estimates of the treatment effect. Lee and Lemieux (2009) argue that, in case of polynomial regressions, the equivalent to bandwidth choice in the non parametric regression is the choice of the order of polynomial regressions. Therefore, it is useful to analyse several specifications to see to what extent results are sensitive to the order of the polynomial. The choice of the order of the polynomial can be assessed using some goodness of fit criteria, like the well known Akaike information criterion (AIC) of model selection or the Bayesian information criterion (BIC), where the penalty for additional parameters is stronger than that of the AIC. The adoption of these criteria corresponds to use a generalized cross-validation procedure.

Table VI.2 Parametric estimates using different polynomial fit. Dependent variable: per capita GDP average annual growth rate, period 1995-2006. X=GDP per capita in PPS (EU-15=100, average 1988-1990)

	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8
	dependent variable: GDP growth rate							
Constant	1.358	1.571	1.504	1.773	4.971	5.365	6.391	6.609
	(3.33)**	(21.18)**	(3.34)**	(1.95)	(4.31)**	(4.73)**	(1.38)	(1.42)
X	0.002		0.001	-0.006	-0.059	-0.066	-0.091	-0.097
	(0.52)		(0.15)	(0.37)	(3.16)**	(3.60)**	(0.81)	(0.86)
X^2				0.000	0.000	0.000	0.000	0.001
				(0.52)	(3.46)**	(3.96)**	(0.55)	(0.6)
X^3							0.000	0.000
							(0.24)	(0.3)
Treatment Dummy	1	0.902	0.475	0.901	-2.393	-5.371	-6.339	-10.964
	(4.08)**	(5.14)**	(0.61)	(2.97)**	(1.94)	(2.77)**	(1.34)	(1.13)
Treat. Dummy* X			0.008		0.043	0.158	0.18	0.475
			(0.71)		(2.55)*	(2.18)*	(1.49)	(0.82)
Treat. Dummmy* X^2						-0.001	-0.001	-0.007
						(1.47)	(1.31)	(0.61)
Treat. Dummy* X^3								0.000
								(0.5)
Observations	190	190	190	190	190	190	190	190
R-squared	0.16	0.15	0.16	0.16	0.18	0.20	0.20	0.20
RMSE	0.974	0.972	0.974	0.975	0.962	0.957	0.960	0.961
AIC	532.1	530.4	533.3	533.7	529.4	528.5	530.4	531.8
BIC	541.8	536.9	546.3	546.7	545.7	547.9	553.2	557.8

Notes: Robust standard errors in brackets. * significant at 5 percent level; ** significant at 1 percent level

The results of OLS estimates with heteroskedasticity-robust standard errors on the full sample, adding different polynomials, are presented in Table VI.2. The BIC criterion chooses the simplest specification, just a comparison of annual average growth rate on the two sides of the cutoff point. The effect is positive, statistically significant, equal to 0.9 percentage point per year, higher than in the non parametric estimation. The AIC criterion chooses a specification with a linear and a quadratic term, and the jump is again statistically significant.

In the spirit of the RDD we also estimate the treatment effect in a restricted sample around the cutoff point. We exclude the lower quarter (in term of initial level of per capita GDP) for the treated regions and the higher quarter for the non treated regions.

Our sample is thus reduced from 190 to 143 regions. In this case, both the criteria choose the simplest specification (Table VI.3). The treatment effect is positive, statistically significant and equal to 0.9 percentage point per year.

Table VI.3 **Parametric estimates using different polynomial fit: restricted sample. Dependent variable: per capita GDP average annual growth rate, period 1995-2006. X=GDP per capita in PPS (EU-15=100, average 1988-1990)**

	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8
	dependent variable: GDP growth rate							
Constant	2.121	1.645	2.11	2.757	12.483	15.552	38.84	169.706
	(2.56)*	(20.42)**	(2.40)*	(1.14)	(1.37)	(1.52)	(0.39)	(1.74)
X	-0.005		-0.005	-0.021	-0.229	-0.295	-1.049	-5.286
	(0.57)		(0.53)	(0.39)	(1.17)	(1.33)	(0.33)	(1.66)
X^2				0.000	0.001	0.002	0.010	0.055
				(0.31)	(1.14)	(1.31)	(0.28)	(1.6)
X^3							0.000	0.000
							(0.23)	(1.53)
Treatment Dummy	0.741	0.903	0.768	0.706	-5.233	-11.268	-28.511	-262.436
	(2.13)*	(4.99)**	(0.52)	(1.77)	(0.92)	(0.9)	(0.38)	(2.37)*
Treat. Dummy* X			0		0.077	0.242	0.687	10.201
			(0.02)		(1.02)	(0.73)	(0.35)	(2.43)*
Treat. Dummy* X^2						-0.001	-0.004	-0.138
						(0.49)	(0.31)	(2.38)*
Treat. Dummy* X^3								0.001
								(2.23)*
Observations	143	143	143	143	143	143	143	143
R-squared	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.23
RMSE	0.892	0.890	0.896	0.895	0.894	0.896	0.899	0.881
AIC	376.2	374.6	378.2	378.1	378.7	380.4	382.3	377.4
BIC	385.1	380.5	390.1	389.9	393.5	398.2	403.1	401.1

Notes: Robust standard errors in brackets. * significant at 5 percent; ** significant at 1 percent level

The results are similar if the model is specified in log, closer to a standard convergence equation *à la* Barro (see Table A.2 for the full sample and Table A.3 for the restricted sample in the Appendix).

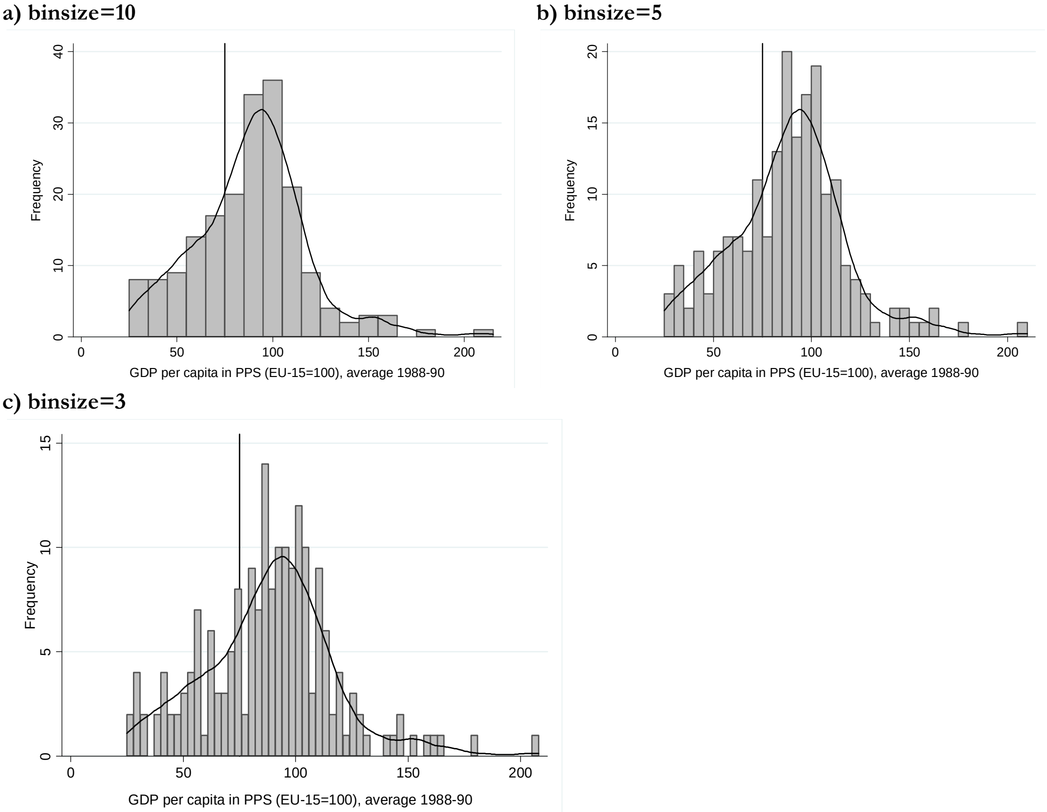
VII. Robustness checks

Following Imbens and Lemieux (2009), we assess the robustness of our results employing several specification tests. Precisely:

- we test for possible discontinuities in the conditional density of the forcing variable (the level of per capita GDP);
- we look whether the outcome (the regional annual growth rate) is discontinuous not only at the cutoff but also at other values of the forcing variable;
- we look at possible jumps in other exogenous covariates at the cutoff point;
- we consider the presence of a spatial correlation in regional growth rates.

Testing for discontinuities in the conditional density of the forcing variable is related to the possibility of manipulating the forcing variable. If regions can manipulate the forcing variable in order to obtain desirable treatment assignments (that is, in our case, they have a great deal of control on per capita GDP data in order to obtain estimates lower than the true values), one would certainly expect regions on one side of the cutoff to be systematically different from those on the other side. However, Lee (2008) shows that if there isn't full control over the forcing variable, variation in treatment status will be randomized in a neighbourhood of the cutoff. In this case, the RDD can be considered being "as good as" a local randomly assignment. Here, the selection process leads to a high degree of uncertainty over the assignment results. The cutoff point is fixed as 75 percent of average per capita GDP in the EU-15, and thus is known only after data referring to all regions is available. Moreover, Eurostat has a strict control over the procedure estimating regional accounts. The evidence of a jump in the conditional density of the forcing variable can be a test of the scarce control over the forcing variable, as suggested in McCrary (2008): if there is some degree of sorting of the regions around the threshold, the appropriateness of the RDD in this contest is dubious. In Figure VII.1, we present histograms of the distribution of GDP per capita in PPS, average 1988-1990, using different bin sizes. Reducing the bin size, a moderate evidence of some differences around the cutoff point appears. However, from a deeper analysis it emerges that only for two treated regions the level of GDP per capita was above the threshold in the years just before 1988 and then again in the years following the eligibility period (1988-1990): Northern Ireland and Flevoland. For Merseyside, the level of GDP per capita was above the threshold in the years before 1988, but below the threshold in the following period.

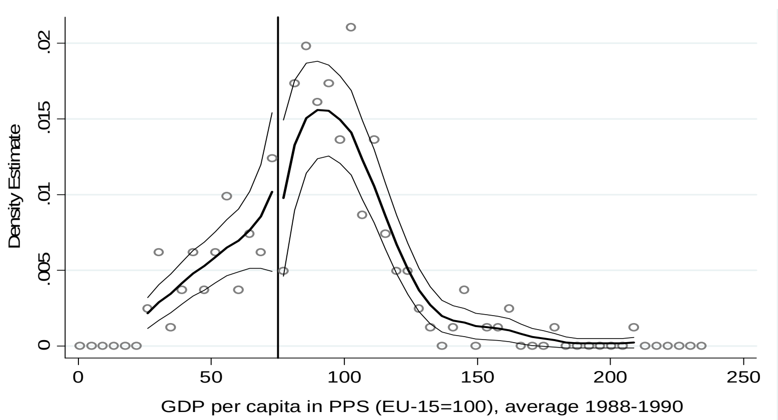
Figure VII.1 Distribution of GDP per capita in PPS, average 1988-1990



Source: Own computations based on Eurostat data

A more formal test of manipulation related to continuity of the forcing variable density function is presented by McCrary (2008). In line with this work, a kernel estimate of the density function of regional GDP per capita with 95 percent confidence bands is shown in Figure VII.2. The weak discontinuity around the cutoff point is not statistically significant.

Figure VII.2 Estimated density of the forcing variable at the cutoff (per capita GDP, average 1988-1990)



Source: Own computations based on Eurostat data

Another robustness test verifies that there are no extra jumps in the levels of the outcome where no hypothesized cutoff exists. The approach used here consists of testing for a zero effect in different points of the forcing variables.

Table VII.1 Test of different cutoff points of the forcing variables

cutoff point	Epanechnikov kernel	Gaussian kernel
50	0.196	0.109
	(-0.557)	(0.560)
55	-0.197	-0.250
	(-0.520)	(0.517)
60	-0.376	-0.353
	(0.369)	(0.403)
65	-0.550	-0.462
	(-0.355)	(0.336)
70	-0.404	-0.296
	(-0.389)	(0.340)
75	-0.638	-0.628
	(0.387)**	(0.306)**
80	-0.577	-0.6407041
	(0.296)*	(0.294)**
85	-0.293	-0.378
	(0.261)	(-0.239)
90	0.202	0.152
	(0.244)	(0.204)
95	0.470	0.413
	(0.216)*	(0.243)*
100	0.306	0.274
	(0.244)	(0.228)

Notes: Bootstrapped standard errors in brackets. Bandwidth =30, 100 replication; *, **, ***: significant at 10 percent, 5 percent, 1 percent level, respectively

We test this effect using different kernels and bandwidth. In Table VII.1 the results obtained with a bandwidth equal to 30 are presented. Some discontinuities only emerge in the neighbourhood of the values from 75 to 80, however close to the hypothesized cutoff.

In light of the assumptions underlying the RDD, we need to verify that there are no jumps at the cutoff point in variables that should not be affected by the treatment. The absence of discontinuities close to the threshold seems to be in line with a causality relation between the jump in the outcome variable and the treatment. We look at possible jumps in the values of some demographic and labour market covariates at the cutoff point using the non parametric local linear regression and three different kernel (Gaussian, Epanechnikov, rectangular). Some of the results are presented in Table VII.2.

Table VII.2 Non-parametric estimates using other covariates (one-side local linear regressions at the cutoff)

Covariates	Epanechnikov kernel	Gaussian kernel	Rectangle kernel
Population (1990)	486 (342)	475 (362)	575 (508)
Population density (1990)	.055 (.207)	.048 (.170)	-.020 (.241)
Employment (1995)	124 (198)	113 (213)	129 (227)
Employment rate (1995)	.026 (.030)	.024 (.025)	.0133 (.039)
Share of agricultural employment (1995)	.059 (019)***	.058 (.016)***	.046 (.018)***
Share of population over 65 years (1990)	.084 (.011)***	.084 (.011)***	.073 (.016)***

Notes: Bootstrapped standard errors in brackets. Bandwidth=30. *, **, ***:significant at 10 percent, 5 percent, 1 percent level, respectively

Overall we do not detect a statistically significant jump. Exceptions are the share of agricultural employment and the share of population over 65 years. However, although it is rather difficult to rationalize such discontinuities, a parametric estimation of the treatment effect including these variables in the model confirms the results presented before.

Finally, we test that spatial correlation does not affect the results. The residuals of the parametric model show a clear correlation across neighbours. We can capture this spatial correlation by a spatial error model (Table VII.3) and a spatial lag model (Table VII.4). Even if the selected specification (using the AIC and BIC criteria) is different between the two models, the estimates confirm our previous results.

Table VII.3 Parametric estimates using different polynomial fit. Dependent variable: per capita GDP average annual growth rate, period 1995-2006. Spatial model estimates. X=GDP per capita in PPS (EU-15=100, average 1988-1990)

	Eq. 1 (lin. reg.)	Eq. 2 (spat. error)	Eq. 3 (spat. lag)	Eq. 4 (spat. error)	Eq. 5 (spat. error)	Eq. 6 (spat. error)	Eq. 7 (spat. error)	Eq. 8 (spat. error)	Eq. 9 (spat. error)	Eq. 10 (spat. error)
	dependent variable: GDP growth rate									
Constant	1.361	1.367	0.347	1.595	1.169	3.131	3.434	3.575	6.829	6.765
	(3.40)**	(3.75)**	(0.95)	(9.80)**	(3.10)**	(4.27)**	(2.92)**	(3.02)**	(1.52)	(1.50)
X	0.002	0.002	0.002		0.004	-0.029	-0.034	-0.037	-0.118	-0.117
	(0.52)	(0.62)	(0.63)		(1.15)	(2.43)*	(1.79)	(1.91)	(1.09)	(1.07)
X^2						0.000	0.000	0.000	0.001	0.001
						(2.87)**	(2.17)*	(2.29)*	(0.96)	(0.95)
X^3									-0.000	-0.000
									(0.79)	(0.78)
Treatment Dummy	1.094	0.975	0.611	0.872	2.055	0.499	0.138	-1.202	-4.275	-2.378
	(4.22)**	(3.57)**	(3.17)**	(3.84)**	(2.67)**	(1.66)	(0.11)	(0.61)	(0.95)	(0.39)
Treat. Dum.* X					-0.018		0.005	0.057	0.126	0.004
					(1.50)		(0.27)	(0.80)	(1.10)	(0.01)
Treat. Dum.* X^2								0.000	-0.001	0.002
								(0.68)	(1.01)	(0.28)
Treat. Dum.* X^3										0.000
										(0.43)
λ (spat. error) or ϱ (spat. lag)	-	0.6299	0.6193	0.6298	0.6653	0.6632	0.6582	0.6548	0.6579	0.6591
λ or ϱ z-statistic	-	(7.67)**	(7.56)**	(7.61)**	(8.10)**	(8.45)**	(7.68)**	(7.65)**	(7.73)**	(7.82)**
Obs	177	177	177	177	177	177	177	177	177	177
ll(null)	-250.6	-232.1	-232.1	-232.3	-231.6	-231.7	-227.7	-227.2	-227.2	-226.8
ll(model)	-232.1	-203.5	-203.2	-203.8	-201.9	-200.0	-200.0	-199.6	-199.2	-199.2
df	3	5	5	4	6	6	7	8	9	10
AIC	470.2	417.0	416.4	415.6	415.8	412.1	413.9	415.2	416.5	418.4
BIC	479.7	432.9	432.3	428.3	434.9	431.1	436.2	440.6	445.1	450.1

Notes: In brackets: 1) robust standard errors for regression coefficients; 2) z-statistic for λ or ϱ coefficients. * significant at 5 percent; ** significant at 1 percent

Table VII.4 Parametric estimates using different polynomial fit. Dependent variable: per capita GDP average annual growth rate period 1995-2006. Spatial model estimates. Restricted sample. X=GDP per capita in PPS (EU-15=100, average 1988-1990)

	Eq. 1 (lin. reg.)	Eq. 2 (spat. lag)	Eq. 3 (spat. lag)	Eq. (spat. lag)	Eq. 5 (spat. lag)	Eq. 6 (spat. lag)	Eq. 7 (spat. lag)	Eq. 8 (spat. lag)	Eq. 9 (spat. lag)
	dependent variable: GDP growth rate								
Constant	2.209	0.684	0.507	0.451	2.895	13.06	12.413	97.255	125.841
	(2.48)*	(0.92)	(3.70)**	(0.58)	(1.11)	(1.66)	(1.47)	(1.18)	(1.50)
X	-0.006	-0.002		0.001	-0.054	-0.271	-0.257	-3.004	-3.929
	(0.63)	(0.25)		(0.07)	(0.94)	(1.61)	(1.42)	(1.13)	(1.45)
X^2					0.000	0.001	0.001	0.031	0.041
					(0.95)	(1.62)	(1.43)	(1.09)	(1.40)
X^3								-0.000	-0.000
								(1.04)	(1.35)
Treatment Dummy	0.872	0.338	0.395	1.106	0.179	-5.807	-3.353	-63.163	-182.898
	(2.36)*	(1.44)	(2.72)**	(0.78)	(0.60)	(1.31)	(0.26)	(1.08)	(1.59)
Treat. Dum.* X				-0.011		0.077	0.005	1.530	6.908
				(0.55)		(1.36)	(0.01)	(1.02)	(1.48)
Treat. Dum.* X^2							0.001	-0.009	-0.091
							(0.20)	(0.95)	(1.36)
Treat. Dum.* X^3									0.000
									(1.26)
ρ (spat. lag)	-	0.6776	0.6786	0.6798	0.6805	0.6764	0.6749	0.6739	0.6705
ρ robust std err.	-	(9.04)**	(9.22)**	(9.06)**	(9.09)**	(9.19)**	(9.50)**	(9.45)**	(9.60)**
Obs	133	133	133	133	133	133	133	133	133
ll(null)	-188.6	-172.7	-173.0	-172.7	-172.4	-171.0	-170.5	-169.8	-168.7
ll(model)	-172.7	-141.3	-141.3	-141.0	-140.5	-139.3	-139.3	-138.6	-137.7
df	3	5	4	6	6	7	8	9	10
AIC	351.4	292.5	290.6	294.0	293.0	292.7	294.6	295.2	295.4
BIC	360.1	307.0	302.2	311.4	310.4	312.9	317.7	321.2	324.3

Notes: In brackets: 1) robust standard errors for regression coefficients; 2) z-statistic for ρ coefficients. * significant at 5 percent level; ** significant at 1 percent

VIII. Conclusions

In this paper we evaluate the impact of European Regional policy on economic growth using a non-experimental comparison group design - the regression discontinuity design. To this end, we properly construct an economic and financial regional dataset and evaluate the casual effects of Regional policy on the basis of both non parametric and parametric approaches.

Our findings show a positive, but moderate, policy effect on regional growth. Per capita GDP of the "treated" regions (Objective 1 regions) grows, on an yearly average in the period 1995-2006, 0.8 percentage points more than that of the non-treated regions. The policy effect is found to be equal to 0.6 percentage point when it is measured within a non parametric model, while it turns out to be equal 0.8-0.9 percentage point when it is measured within a parametric model. Different weights given to the observations closer to the cutoff point (higher for the non parametric model) can explain the differences between the two approaches. Accordingly, most part of the higher growth of Objective 1 regions in the period considered can be attributed to the impact of Regional policy. The estimates are statistical significant and robust to different model specifications and error spatial correlation.

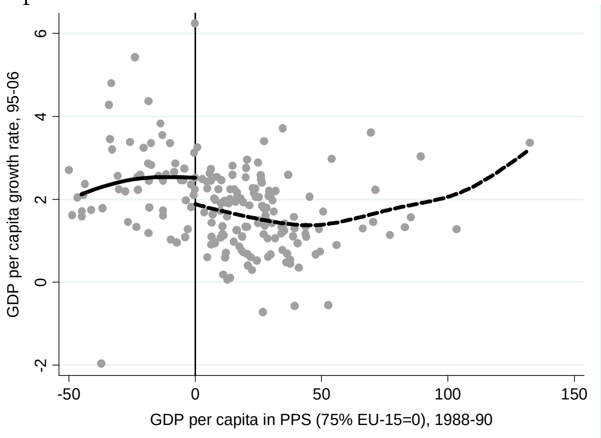
Although in our analysis Regional policy is found to enhance economic growth, still its causal effects are modest, lower than the ones found by Becker and al. (2008).

There is still room for providing further insights into the debate on the effectiveness of Regional policy. For instance, from a methodological perspective, one could allow for several different Regional policy funding supports through a fuzzy RDD rather than a sharp approach. Also, the analysis could be further enriched taking into account the effects of Regional policy in Cohesion Fund countries with respect to other Member States.

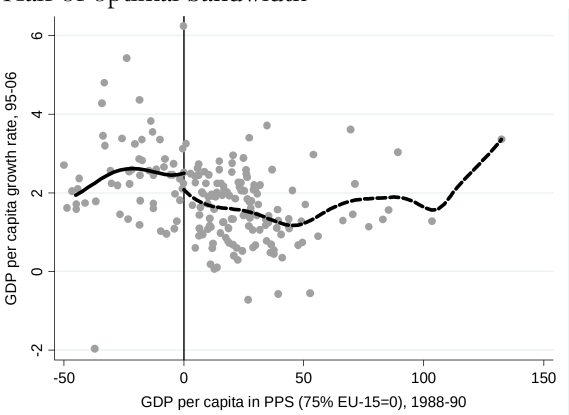
Appendix

Figure A.1 – Further robustness proofs

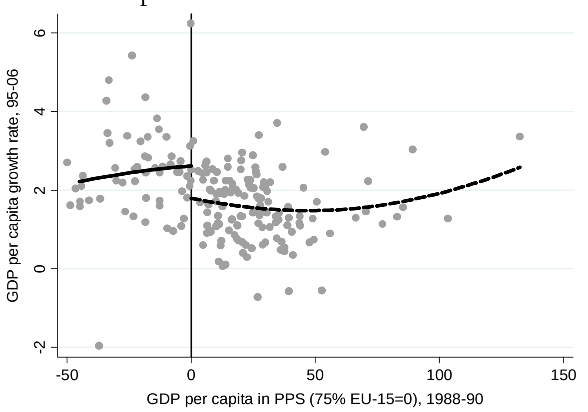
a) Optimal bandwidth



b) Half of optimal bandwidth



c) Double of optimal bandwidth



Source: Own computations based on Eurostat and DG Regional Policy data

Table A.2 Parametric estimates using different polynomial fit. Dependent variable: per capita GDP average annual growth rate, period 1995-2006. X=log of GDP per capita in PPS (average 1988-1990)

	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8
			dependent variable: GDP growth rate					
Constant	-0.576	1.571	2.584	-18.925	90.255	403.611	1,133.00	908.554
	(0.18)	(21.18)**	(0.54)	(0.64)	(0.77)	(3.42)**	(0.26)	(0.24)
X	0.225		-0.106	4.231	-18.27	-83.194	-308.762	-239.123
	(0.66)		(0.21)	(0.65)	(0.75)	(3.41)**	(0.23)	(0.21)
X^2				-0.218	0.94	4.302	27.544	20.345
				(0.61)	(0.74)	(3.41)**	(0.2)	(0.17)
X^3							-0.798	-0.55
							(0.17)	(0.13)
Treatment Dummy	1.048	0.902	-4.617	1.047	-20.009	-524.811	-719.86	0
	(3.92)**	(5.14)**	(0.72)	(3.87)**	(0.87)	(2.96)**	(0.61)	(.)
Treat. Dummy* X			0.612		2.276	110.904	153.087	-86.704
			(0.89)		(0.91)	(2.84)**	(0.6)	(0.68)
Treat. Dum.* X^2						-5.852	-8.133	18.528
						(2.71)**	(0.59)	(0.67)
Treat. Dum.* X^3								-0.989
								(0.66)
Observations	190	190	190	190	190	190	190	190
R-squared	0.16	0.15	0.16	0.16	0.16	0.19	0.2	0.22
RMSE	0.973	0.972	0.973	0.975	0.974	0.957	0.960	0.959
AIC	531.9	530.4	532.9	533.4	534.1	528.6	524.5	530.3
BIC	541.6	536.9	545.9	546.4	550.4	548.0	537.5	553.1

Notes: Robust standard errors in brackets. * significant at 5 percent level; ** significant at 1 percent

Table A.3 Parametric estimates using different polynomial fit: restricted sample. Dependent variable: per capita GDP average annual growth rate period 1995-2005. X=log of GDP per capita in PPS (average 1988-1990)

	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8
			dependent variable: GDP growth rate					
Constant	5.517	1.648	6.391	15.165	208.284	916.299	-25,383.9	504.713
	-0.8	(20.29)**	(0.76)	(0.12)	(0.55)	(1.02)	(1.49)	(1.69)
X	-0.409		-0.501	-2.5	-43.219	-192.868	8,200.62	0
	(0.56)		(0.56)	(0.09)	(0.53)	(1.01)	(1.51)	(.)
X^2				0.113	2.259	10.166	-882.641	-16.808
				(0.08)	(0.53)	(1.01)	(1.53)	(1.68)
X^3							31.652	1.182
							(1.55)	(1.68)
Treatment Dummy	0.728	0.899	0.506	0.729	-1.867	-24.793	38.133	-154.454
	(1.96)	(4.96)**	(0.28)	(1.96)	(0.35)	(0.87)	(0.7)	(2.45)*
Treat. Dummy* X			0.003		0.035	0.63	-1.165	6.89
			(0.12)		(0.47)	(0.84)	(0.76)	(2.33)*
Treat. Dum.* X^2						-0.004	0.009	-0.105
						(0.78)	(0.82)	(2.17)*
Treat. Dum.* X^3								0.001
								(2.04)*
Observations	142	142	142	142	142	142	142	142
R-squared	0.18	0.18	0.18	0.18	0.18	0.19	0.21	0.22
RMSE	0.895	0.893	0.898	0.898	0.900	0.901	0.894	0.885
AIC	374.4	372.8	376.4	376.4	378.0	377.2	376.0	375.0
BIC	383.3	378.7	388.2	388.2	392.8	392.0	393.7	395.7

Notes: Robust standard errors in brackets. * significant at 5 percent level; ** significant at 1 percent

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