

# Going NUTS: The Effect of EU Structural Funds on Regional Performance\*

Sascha O. Becker  
*U Stirling, ifo, CESifo, and IZA*

Peter H. Egger  
*ifo, LMU Munich, Wifo, and CESifo*

Maximilian von Ehrlich  
*LMU Munich*

May 30, 2009

## Abstract

The European Union (EU) provides grants to disadvantaged regions of member states to allow them to catch up with the EU average. Under the Objective 1 scheme, NUTS2 regions with a GDP per capita level below 75% of the EU average qualify for structural funds transfers from the central EU budget. This rule gives rise to a regression-discontinuity design that exploits the discrete jump in the probability of EU transfer receipt at the 75% threshold. We estimate causal effects of Objective 1 treatment on economic growth of regions of the EU by using a host of micro-econometric methods for causal effects analysis. We find positive GDP growth effects of Objective 1 funds, but no employment effects. A back-of-the-envelope calculation suggests that Objective 1 transfers are not only effective, but the associated benefits exceed the costs.

---

\**Acknowledgements:* We thank Serguei Kaniovski and Rafal Raciborski for providing us with data. We are indebted to seminar participants at the Meeting of German Economists Abroad in Bonn, IIPF Maastricht, EEA Milan, the 7th Workshop on Spatial Econometrics and Statistics in Paris, the Scottish Economic Society Conference in Perth, the Universities of Dresden, Osnabrück and Stirling, the Center for Economic Studies, the Ifo Institute for Economic Research, and the Centre for Business Taxation at Oxford University for valuable comments. Von Ehrlich gratefully acknowledges financial support from the German Science Foundation (DFG). Part of the work was undertaken during Egger's stay at the Centre for Business Taxation at Oxford University, and he gratefully acknowledges their hospitality. Egger also acknowledges funding by the Austrian Science Fund through grant # P17713-G05.

*E-mail addresses:* Becker: sascha.becker@stir.ac.uk; Egger: egger@ifo.de; von Ehrlich: vonEhrlich@lmu.de.

**Keywords:** STRUCTURAL FUNDS; REGIONAL GROWTH; REGRESSION-DISCONTINUITY DESIGN; QUASI-RANDOMIZED EXPERIMENT  
**JEL Classification:** C21; O40; H54; R11

# 1 Introduction

Most federations – national or supra-national in scope – rely on a system of fiscal federalism which allows for transfers across jurisdictions. Examples of such national federations are the United States of America or the German States (Länder). An example of a supra-national federation is the European Union (EU). The most important aim of the aforementioned transfers is to establish equalization – at least partially – of fiscal capacity and per-capita income among the participating jurisdictions (see ?). In comparison to other federations, the magnitude of equalization transfers is particularly large within the EU.

The lion’s share of fiscal equalization transfers at the level of the EU is spent under the auspices of the *Structural Funds Programme*. Starting in 1988, this programme distinguishes between transfers under three mutually exclusive schemes: Objective 1, Objective 2, and Objective 3.

The goal of our study is to assess the causal effect of Objective 1 status on per-capita GDP growth of treated regions in the EU, using a host of micro-econometric techniques for program evaluation. Our analysis sheds light on the effectiveness of the Objective 1 scheme (i.e., whether it causes treated regions to grow faster than control regions) and its efficiency (i.e., whether the growth induced justifies the costs incurred).

We confine our analysis to Objective 1 treatment for three reasons. First, Objective 1 funding has the explicit aim of fostering GDP-per-capita growth in regions that are lagging behind the EU average and of promoting aggregate growth in the EU (?). Second, Objective 1 expenditures form the largest part of the overall *Structural Funds Programme* budget. They account for more than two thirds of the programme’s total budget: 70% in the 1988-93 period, 68% in the 1994-99 period and 72% in the 2000-06 period (see ?, p. 154f., and ?, p. 202). Third, the Objective 1 scheme has been largely unchanged over all three programming periods of its existence.<sup>1</sup>

---

<sup>1</sup>Objective 2 covers regions that face socioeconomic problems which are mainly defined by high unemployment rates. More precisely, regions must satisfy three criteria to be eligible for Objective 2 transfers: first, an unemployment rate above the Community average; second, a higher percentage of jobs in the industrial sector than the Community average; and, third, a decline in industrial employment. Objective 3 deals with the promotion of human capital. The main goal is the support of the adaptation and modernization of education, training and employment policies in regions. Objectives 2 and 3 were modified slightly over the programming periods considered here. In 1989-93 and 1994-99 three additional objectives of minor importance existed which were abolished in 2000-06. For the new programming period 2007-13 the three objectives have been renamed Convergence Objective, Regional Competitiveness and Employment Objective, and European Territorial Cooperation Objective.

A region qualifies for Objective 1 transfers if its GDP per capita in purchasing power parity terms (PPP) is less than 75% of the EU average. For the programming periods 1989-93, 1994-99, and 2000-06, the European Commission computed the relevant threshold of GDP per capita in PPP terms based on the figures for the last three years of data available at the time when the Commission's regulations came out.

To further understand the Objective 1 scheme, it is useful to introduce the classification system of regional units in the EU. Eurostat, the statistical office of the European Commission, distinguishes between three sub-national regional aggregates: NUTS1 (large regions with a population of 3-7 million inhabitants); NUTS2 (groups of counties and unitary authorities with a population of 0.8-3 million inhabitants); and NUTS3 regions (counties of 150-800 thousand inhabitants).<sup>2</sup>

With very few exceptions, transfer eligibility is determined at the NUTS2 level and in advance for a whole programming period of several years.<sup>3</sup> For instance, in the 1994-99 programming period, the European Commission provided Objective 1 transfers to 64 out of 215 NUTS2 regions in the EU15 area. A graphical illustration of the regions receiving Objective 1 funds ("treated regions") across the three most recent budgetary periods is provided in Figure 1.

### Figure 1 and Table 1 about here

The amounts that are paid are quite significant for the recipient regions. In the 1994-99 programming period the 64 Objective 1 treated NUTS2 regions received on average transfers in the order of 1.8 percent of their GDP (see European Commission, 1997, 2007; Table 1 provides information for the three most recent programming periods). A number of questions relating to these expenses are of obvious interest

---

<sup>2</sup>NUTS is the acronym for *Nomenclature des Unités Territoriales Statistiques* coined by Eurostat. The highest level of regional aggregation (NUTS1) corresponds to Germany's *Bundesländer*, France's *Zones d'Études et d'Aménagement du Territoire*, the United Kingdom's *Regions of England/Scotland/Wales* or Spain's *Grupos de Comunidades Autónomas*. At the other end of the NUTS classification scheme, NUTS3 regions correspond to *Landkreise* in Germany, to *Départements* in France, to *Unitary Authorities* in the UK or to *Comunidades Autónomas* in Spain.

<sup>3</sup>Owing to their territorial adjacency to Belgium's Objective 1 region Hainaut, the three French préfectures Valenciennes, Douai, and Avesnes (within the NUTS3 region Nord) received Objective 1 status in the 1994-99 programming period even though their NUTS2 mother region Nord-Pas-de-Calais did not qualify. The Austrian region Burgenland as the single Objective 1 region of the 1995 accession countries (Austria, Finland, and Sweden) did only receive Objective 1 funds from 1995 onwards. Similarly, the Objective 1 regions of the 2004 accession countries (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, and Slovenia) did only receive funds from 2004 onwards.

to both policy makers and economists. *To which extent do economic outcomes in the recipient regions actually respond to such re-distributional transfers?* This calls for an evaluation of the overall (causal) impact of transfers. Moreover, one could ask about the efficiency of transfers: *Does the response in economic outcomes in the treated regions justify the size of the programme and, in particular, its costs to the untreated jurisdictions?* Surprisingly little is known to answer these questions.

A small number of previous studies looked into the impact of re-distributional regional policies on economic outcomes (see section 2 for a detailed discussion of the literature). Most of that research focused on the impact of the EU’s *Structural Funds Programme*. Yet, essentially all existing work on that topic uses fairly aggregated regional data at the NUTS1 level. Whereas some papers even used NUTS2-level data, they did not exploit important features of the design of the programme. This might be problematic because, by design of the programme, regions which are eligible for transfer payments under Objective 1 (“poor regions”) differ systematically on average from non-eligible ones (“rich regions”). Furthermore, with regard to transfers under the auspices of the *Structural Funds Programme*, most papers use cross-sectional data. Hence, the level of aggregation, the cross-sectional nature of the data employed, and the type of empirical methods applied in previous work rendered identification of the causal effect of the programme difficult if not impossible.

We compile data on 285 NUTS2 and 1,213 NUTS3 regions in Europe for three programming periods – 1989-93, 1994-99, and 2000-06 – to assess the causal effect of transfers through the EU’s *Structural Funds Programme* on economic outcomes such as average annual growth of GDP per capita and employment growth of treated versus untreated regions. Ideally, in an experimental setting, we would randomly assign regions to a treatment and control group, i.e., give structural funds to some randomly selected regions and compare their economic outcomes to those of randomly selected control regions. While such an ideal experiment is not possible, the EU criteria for assigning Objective 1 status have quasi-experimental features. The 75% threshold at the NUTS2 level gives rise to a regression-discontinuity design (RDD) whereby regions very close to that threshold are likely to be very similar ex ante, but those below the 75% threshold qualify for Objective 1 funds, whereas those above do not. This rule is strictly applied in the vast majority of cases.<sup>4</sup>

We pursue a *sharp* RDD (considering only compliers with the 75% rule) as well as a *fuzzy* RDD (considering compliers and non-compliers with the 75% rule).<sup>5</sup> We analyze causal effects on growth of per-capita GDP at purchasing power parity (PPP) at NUTS2 level for most of the paper, but also at NUTS3 level since part

---

<sup>4</sup>For 628 out of the 674 NUTS2 observations across all periods, Objective 1 status complies with the formal 75%-rule. See below for further details on exceptions from the rule.

<sup>5</sup>Eligibility is synonymous with actual treatment under sharp RDD but not under fuzzy RDD.

of the fuzziness in the design is brought about by exceptions which are made at the more disaggregated NUTS3 level. Similarly, we consider possible effects on employment. Moreover, we consider dose-response function estimates of the amount of Objective transfers at the NUTS3 level for the most middle programme period (1994-99) for which we have data on the actual level of Objective 1 transfers. Finally, we deliver a back-of-the-envelope calculation of the net benefits of the programme.

Overall, we identify positive causal effects of Objective 1 treatment on the growth of per-capita income at PPP with both discrete and continuous treatments. The positive effect is qualitatively robust to estimation methods applied. In the preferred specification and procedure, we estimate a differential impact of Objective 1 programme participation on the growth of GDP per capita at PPP of about 2.0 percentage points within the same programming period. No such effects can be found for employment. A back-of-the envelope calculation suggests that – on average – the funds spent on Objective 1 have a return which is about 1.21 times higher than their costs in terms of GDP. Hence, the programme seems effective *and* generates benefits in the recipient regions which exceed the costs to the EU budget.

The remainder of the paper is organized as follows. The next section provides a discussion of the state of the literature on the evaluation of the EU’s *Structural Funds Programme*. Section 3 presents our data and shows descriptives on treated (i.e., Objective 1) and untreated (i.e., non-Objective 1) NUTS2 and NUTS3 regions. Section 4 summarizes the findings about the (causal) effects of Objective 1 treatment on the growth of GDP per capita when using the aforementioned quasi-experimental design. Section 5 provides sensitivity checks and extensions and delivers a back-of-the-envelope calculation of the effectiveness of the European Union’s Objective 1 Programme and its net benefits based on the preferred estimates of the treatment effect. The last section concludes with a summary of the most important findings.

## **2 Effects of the Structural Funds Programme: state of the debate**

The interest in effects of the EU’s structural policy roots in empirical work on regional growth and convergence. ? started the debate by diagnosing a failure of the EU’s structural policy based on cross-sectional regressions showing that the regional growth and convergence pattern in the EU was not different from the one in other federations which lack such an extensive cohesion programme. Obviously, such a conclusion requires comparability of federations and their regions in all other respects, which is not necessarily the case. However, ? came to similar conclusions when focusing on regional growth within the EU and comparing recipient and

non-recipient regions. Yet, both papers looked at the combined *Structural Funds Programme* and not at the Objective 1 scheme, which primarily aims at closing the gap in per-capita income. Furthermore, they used fairly aggregated NUTS1 and NUTS2 data, since data at the NUTS3 level was not available at the time.

This evidence is different from the findings of ? who identify a positive impact of the *Structural Funds Programme* on industry location and agglomeration at the national level.<sup>6</sup> Similarly, ? and ? took a national perspective and found a positive relationship between *Structural Funds Programme* spending and GDP-per-capita growth (at least, in countries with favorable institutions). At the sub-national (NUTS1 or NUTS2) level, ? as well as ? detect a significant positive impact of structural funds on regional growth while ? do not support this conclusion.

However, as argued in the introduction, there is a number of potential problems with evaluations in earlier work which mostly relates to the limited availability of sufficient data in the cross-sectional as well as the time dimensions, and to the methods applied.<sup>7</sup> With much more data at hand now, we may revisit earlier conclusions and exploit information contained in the design of the programme by means of a regression-discontinuity design.<sup>8</sup>

## 3 Data and descriptive statistics

### 3.1 Data sources

For the empirical analysis, we link data from several sources. Our main outcome variable of interest is average annual growth of GDP per capita at purchasing power parity (PPP) during a programming period. In an extension, we look at average annual employment growth as an alternative outcome. Data for these variables at

---

<sup>6</sup>However, they find that the funds seem to stimulate economic activity counter to the comparative advantage of the recipient countries.

<sup>7</sup>In many of the previous studies, the number of observations and, hence, the number of treated and untreated regions, is so small that it almost precludes the use of modern techniques for program evaluation, such as our regression-discontinuity design.

<sup>8</sup>A related approach of identifying causal effects of regional policy for one selected EU country is conducted in ?. They use micro level data on firms in the United Kingdom (UK) and employ a quasi-experimental framework to identify the causal effects of the UK's *Regional Selective Assistance* programme on firm performance. They generate an instrument for recipient status of state aid by exploiting changes in the area-specific eligibility criteria. The eligibility criteria in the UK are determined by the European Commission's guidelines for regional development policies which also underly the *Structural Funds Programme*. The revision of regional eligibility for structural funds before each programming period also determines the provision of *Regional Selective Assistance* to firms in the UK and may therefore be used as an exogenous instrument. The authors find a significant positive effect of state aid on investment as well as on employment.

the NUTS2 and NUTS3 regional levels are taken from Cambridge Econometrics' Regional Database. Data on Objective 1 treatment in the *Structural Funds Programme* at various levels of regional aggregation were collected from documents of the European Commission concerning structural funds.<sup>9</sup> In one of the sensitivity checks, we exploit information about the amount of funds paid instead of using a binary treatment indicator. The corresponding information has been kindly provided by ESPON (European Spatial Planning Observation Network). However, data on funds paid at the regional level are only available for the programming period 1994-99.<sup>10</sup>

In part of our analysis, we use information on sectoral employment,<sup>11</sup> population, and investment as control variables at the level of NUTS2 and NUTS3 regions from Cambridge Econometrics' Regional Database. Moreover, some of the sensitivity checks involve data on the geographical size and location of regions from the Geographic Information System of the European Commission (GISCO) to guard against a possible bias of the Objective 1 treatment effect associated with spillovers across regional borders. Finally, some of the empirical models in the sensitivity analysis involve a measure of countries' voting power in the EU Council (measured by the  $\nu$  index). Those are taken from  $\nu$  for the years until 2004 (for EU12 and EU15), and from  $\nu$  for the current voting scheme in the EU27 under the rules of the Treaty of Nice.

### 3.2 Descriptive statistics

It is instructive to consider the variation in GDP per capita across NUTS2 jurisdictions in the EU. This is done in Table 2 for the year 1999 (i.e., the year prior to the last available programming period, 2000-06).

**Table 2 about here**

---

<sup>9</sup>For each programming period, eligibility was determined by the European Commission one year in advance of the start of the programming period on the basis of the figures for the last three years of data that were available at the time. Concerning the first programming period 1989-93, see Council Regulation number 2052/88 and – regarding the New German Länder – see Official Journal L 114, 07/05/1991. The NUTS2 regions covered by Objective 1 in 1994-99 are listed in Council Regulation 2081/93 and – regarding the new member states Austria, Finland, and Sweden – in the Official Journal L 001, 01/01/1995. For the last programming period 2000-06, data stem from Council Regulation 502/1999 and – for the new member countries of 2004 – from the Official Journal L 236, 23/09/2003. All the regulations are available on the database for European Law, EUR-Lex.

<sup>10</sup>Data on the amount of funds paid for the period 2000-06 turned out not be comparable with our main data set and therefore could not be used.

<sup>11</sup>Sectoral employment is used to compute sector shares of agriculture and services to establish comparability of recipient and non-recipient regions in the instrumental variables estimation under fuzzy RDD.



The number of countries considered in the table is 25. Between 1986 and 1995, the EU consisted of 12 economies as included in the programming period 1989-93. Countries that joined the EU in 1995 (Austria, Finland, and Sweden) were included in the EU regulations for the programming period 1994-99. Similarly, the *Eastern Enlargement* of the European Union (in 2004) by 10 economies<sup>12</sup> was incorporated in the programming period 2000-06. Table 2 sheds light on the variation of GDP per capita across NUTS2 regions within and within countries and relative to the average GDP of EU25 countries, using data from the year 1999.

We may summarize insights from that exercise as follows. There is considerable variation in GDP per capita both between and within EU countries. The former obviously strongly increased after the EU's enlargement in 2004. Some countries host NUTS2 regions above and below the 75% threshold.

According to the 75%-rule, *all* NUTS2 regions in a country would be eligible for Objective 1 transfers if the maximum GDP per capita across all regions were smaller than 75% of the EU25 average (see the fifth data column of Table 2). Suppose 1999 would have been the decisive year for the determination of Objective 1 eligibility for all regions in the EU25 countries. In this case, the Baltic countries (Estonia, Latvia, and Lithuania) as well as Poland would have been eligible in total.<sup>13</sup> Instead, none of the NUTS2 regions in a country would be eligible for Objective 1 transfers if the minimum GDP per capita in a region were higher than 75% of the EU25 average. This is the case for Luxembourg, Cyprus, and Malta (all of them cases of small countries consisting of only one NUTS2 region) as well as for Belgium, Denmark, Finland, France, Ireland, the Netherlands, and Sweden. However, the actual eligibility criterion applied for the 2000-06 programming period was somewhat different from that: the NUTS2 average GDP per capita over the years 1994-96 relative to the Community average was used for the EU15 countries while the average over the years 1997-99 was applied for the accession countries of 2004.

### **Table 3 about here**

Since a region's initial GDP per capita is the only official criterium for Objective 1 status, Table 3 compares treated and non-treated regions with respect to the difference in their GDP per capita. The prime target of Objective 1 transfers is the reduction of this gap. Not surprisingly, the average difference in per-capita GDP between Objective 1 and non-Objective 1 regions in column 3 increases as further countries join the EU over the course of the three programming periods.

---

<sup>12</sup>Cyprus, Malta, and 8 Central and Eastern European countries: Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia, Slovak Republic.

<sup>13</sup>Of course, actual Objective 1 transfer eligibility of the Baltic countries as well as Poland became only relevant after their EU membership in 2004.

In 1988, for the EU12, the average NUTS2 recipient region had a per-capita GDP that was 63 percent of the average non-recipient region. In 1999, for the EU25, the average recipient region had a per-capita GDP that was 53 percent of the average non-recipient region.

Given the *ex ante* differences between Objective 1 and non-Objective 1 regions, an unconditional comparison of their economic performance seems like comparing apples to oranges. The main problem is that real per-capita GDP determines not only the probability of Objective 1 *treatment* but – according to the convergence hypothesis – also the growth of real per-capita income (the *outcome*). Hence, the challenge is to disentangle the impact of initial levels of real per capita income on growth *per se* from the discontinuity related to and associated with Objective 1 at a level of per-capita income which is less than 75% of the EU average.

### Figure 2 and Table 4 about here

Figure 2 illustrates graphically how the probability of Objective 1 treatment relates to region-specific per-capita GDP at PPP prior to a programming period. There, we plot local polynomial functions of NUTS2-level real per-capita income prior to each programming period against Objective 1 treatment (a binary variable) of NUTS2 regions during that period, one to the left of the 75%-threshold and one to the right of it.

In the upper panel, we enforce a *sharp* regression-discontinuity design (see ?, ?, as well as ?, for a general discussion of RDD). For this, we remove regions where Objective 1 status does not comply with eligibility status: some of these regions got treated even though they were too rich to be eligible and others were not treated even though they were poor enough to be eligible (see Table 4 for the number of regions by programming period and compliance status). With the sharp RDD, all regions below the per-capita income threshold get Objective 1 treatment with probability one and all regions above the threshold get treatment with probability zero so that the local polynomial functions are straight horizontal lines. Across the three programming periods 1989-93, 1994-99, and 2000-06, the number of observations which conform to the sharp RDD is 628 (out of 674) for NUTS2 regions and 3,142 (out of 3,300) for NUTS3 regions. Only about 5% of all regions are thus exceptions from the rule.

The lower panel uses all NUTS2 regions, including exceptions from the 75% rule, which gives rise to a *fuzzy* regression-discontinuity design. The main feature of a fuzzy RDD is that the size of the discontinuity in treatment probability is smaller than unity. As we approach the 75%-threshold from below, some regions that would be formally eligible do not obtain Objective 1 status. Hence, the probability of Objective 1 status is smaller than unity. For instance, the UK did not deliver GDP data

at the NUTS2-level at the time Objective 1 status was determined in the programming period 1989-93. Only ex post, when the data became available, it turned out that some British NUTS2 regions should have been eligible for Objective 1 funds. As we approach the 75%-threshold from above, the probability of Objective 1 status exceeds zero, witnessing cases where governments negotiated exceptions from the 75% rule for regions which were too rich to be formally eligible.

**Figure 3 about here**

To illustrate the effect of the discontinuity in Objective 1 treatment on economic outcome, we plot local polynomial functions of per-capita GDP at PPP prior to each programming period against average annual growth of per-capita GDP at PPP during that period. Identification of a causal effect of Objective 1 treatment on growth by means of RDD requires that there is a discontinuity about the threshold in Figures 2 and 3. The results in the figures are promising in that regard, since the discontinuity in Figures 2 is obvious and the confidence intervals of the local polynomial functions to the right and the left of the 75% per-capita income threshold in Figure 3 are non-overlapping. However, the lower panel of Figure 2 suggests that the design is fuzzy which requires instrumental variable estimation for consistent estimation of the Objective 1 treatment effect (see ? and ?). Accordingly, we proceed with regression analysis in the next section to identify the treatment effect by means of instrumental variables estimation.

Before we proceed to the regression analysis, Table 5 displays descriptive statistics of the variables entering in our regressions.

**Table 5 about here**

## 4 Regression analysis

We seek to estimate the causal effect of Objective 1 status on regional economic performance by means of regression analysis. Below, we will employ regression models for sharp and fuzzy RDD. Let us briefly introduce such models in formal accounts before we discuss the associated results with the data at hand.

### 4.1 The regression-discontinuity design (RDD)

Think of a NUTS2 region A with a GDP per capita of 74.99% and a NUTS2 region B with a GDP per capita of 75.01%, one eligible, one not. These two regions are certainly more comparable than regions far away from the threshold. In our context,

the reason is simply that – on average – regions which are far below the steady state of per-capita income grow faster than regions which are closer to the steady state. The crucial question is whether the discontinuity about the threshold associated with Objective 1 status is discernible from a polynomial function of per-capita income of reasonable order.

In case of a sharp RDD, we could stop at displaying the upper panel of Figure 3. Formally, a sharp RDD with data across regions and periods can be estimated by means of the regression of the following form (see ?):

$$Growth_{it} = \theta + \rho Treat_{it} + \mathbf{x}_{it}\boldsymbol{\pi} + \lambda_i + \mu_{it}, \quad (1)$$

where  $Growth_{it}$  represents average annual growth of region  $i$ 's real per-capita income in PPP during programming period  $t$ ,  $Treat_{it}$  is a binary indicator variable for Objective 1 treatment which is unity in case of treatment of region  $i$  in programming period  $t$  and zero else, and  $\mathbf{x}_{it}$  is a row-vector of control variables. In its purest form,  $\mathbf{x}_{it}$  only consists of  $f(GDP_{it}/capita_{it})$ , a polynomial function of  $p^{th}$  order of per-capita income prior to programming period  $t$  (see above for details on the years which the European Commission considered to determine Objective 1 treatment status based on real per-capita income).<sup>14</sup> Furthermore,  $\theta$  is a constant,  $\rho$  is the average treatment effect of Objective 1 treatment status,  $\boldsymbol{\pi}$  represents a column vector of parameters on  $\mathbf{x}_{it}$ ,  $\lambda_i$  is a region-specific effect that may be random or fixed,<sup>15</sup> and  $\mu_{it}$  is a possibly heteroskedastic disturbance term.

The lower panel of Figure 2 illustrates that, with partial non-compliance, the 75%-rule gives rise to a fuzzy regression-discontinuity design (fuzzy RDD) that requires instrumental variables estimation.

With the fuzzy RDD,  $Treat_{it}$  is not exogenous anymore in (1). Formally,  $Treat_{it}$  in (1) may be instrumented by a first stage regression of the form

$$Treat_{it} = \alpha + \beta Rule_{it} + \mathbf{x}_{it}\boldsymbol{\gamma} + \epsilon_{it} \quad (2)$$

or

$$P(Treat_{it} = 1) = f(\delta + \zeta Rule_{it} + \mathbf{x}_{it}\boldsymbol{\eta} + \nu_{it}) \quad (3)$$

where  $i$  refers to a region and  $t$  to a programming period (1989-93; 1994-99; 2000-06).  $Treat_{it}$  and  $\mathbf{x}_{it}$  are defined as with sharp RDD.  $Rule_{it}$  is a binary indicator variable for Objective 1 eligibility which is unity in case of eligibility of region  $i$

---

<sup>14</sup>The polynomial function is defined as  $f(GDP_{it}/capita_{it}) = \pi_1(GDP_{it}/capita_{it})^1 + \dots + \pi_p(GDP_{it}/capita_{it})^p$ , where  $\pi_1, \dots, \pi_p$  are parameters to be estimated. In our empirical models, we will use fourth-order polynomials so that  $p = 4$ .

<sup>15</sup>With fixed  $\lambda_i$ , we may include region-specific indicator variables or, where more convenient, averages of all right-hand-side variables across the programming periods  $t$  as in ?.

in period  $t$  according to the 75% rule and zero else.  $\alpha$ ,  $\beta$ ,  $\delta$ , and  $\zeta$  are unknown parameters, and  $\boldsymbol{\gamma}$  and  $\boldsymbol{\eta}$  are column vectors of unknown parameters.  $\epsilon_{it}$  and  $\nu_{it}$  are disturbance terms of the two models. While some distributional assumption has to be made for the nonlinear probability model, this is not the case for the linear probability model. However,  $\epsilon_{it}$  will be generally heteroskedastic and we correct for this in estimation of the variance-covariance matrix.

To identify the causal effect of Objective 1 status,  $Treat_{it}$ , on annual growth of real per-capita income of region  $i$  during programming period  $t$ ,  $Growth_{it}$ , we need to instrument  $Treat_{it}$  in the first stage either as in the linear probability model (2) or by  $\hat{P}(Treat_{it} = 1)$  obtained from (3). As long as we control for  $\mathbf{x}_{it}$  in the second stage, either approach represents a just-identified two-stage model.

### Tables 6, 7, and 8 about here

Tables 6 and 7 summarize our findings for six different models each. Three of the six models are estimated by pooled OLS and three of them include fixed effects at the respective regional level (NUTS2 in Table 6 and NUTS3 in Tables 7).<sup>16</sup> For both pooled OLS and fixed effects estimates, there are three models in each table: one which (inappropriately) assumes a sharp RDD with  $Treat_{it}$  exogenous in the second-stage model in (1);<sup>17</sup> one which assumes a linear first stage model with fuzzy RDD; and one which assumes a nonlinear (probit) first stage model with fuzzy RDD.<sup>18</sup> All of the models include a fourth-order polynomial function of real per-capita GDP at the level of the corresponding NUTS2 region in the relevant years prior to programming period  $t$ .<sup>19</sup>

The models in Table 8 do not only include the above-mentioned fourth-order polynomial function in  $\mathbf{x}_{it}$  but also other covariates which vary across programming periods and countries (voting share in the EU Council as measured by the Shapley-Shubik index of the number of votes of a country in the respective programming period) or across programming periods and NUTS3 regions (Employment share in

---

<sup>16</sup>We always cluster standard errors at the level of NUTS2 regions.

<sup>17</sup>As explained above, under the assumption of a sharp RDD, we exclude observations that do not comply with the 75% per-capita income rule. There are 46 NUTS2 observations across the three programming periods which do not comply with the 75% per-capita income rule. Therefore, the number of observations is smaller in the models assuming sharp RDD than in those assuming fuzzy RDD.

<sup>18</sup>With nonlinear first stage models, we generally apply a Mundlak-Chamberlainian approach under fixed effects estimation, since a simple within transformation of the data would be inappropriate (see ?). We estimate the nonlinear probability models for each programming period separately and then include time averages  $\bar{\mathbf{x}}_i$  of the covariates  $\mathbf{x}_{it}$  in the second stage model.

<sup>19</sup>Irrespective of whether we use NUTS2 or NUTS3 data, the polynomial function involves always NUTS2 real per-capita GDP. The reason is that the rule generally applies to NUTS2 regions.

total population; Share of agriculture in total employment; Share of services in total employment; Population growth; Population density). These variables reflect the bargaining power of countries at the level of the European Union as well as structural characteristics, which should be associated with the probability that a NUTS3 regions obtains Objective 1 transfers from the corresponding NUTS2 recipient region. Specifications (5) and (6) in Table 8 not only control for the NUTS3 level covariates but also include country-year dummies. The latter is supposed to capture any country-specific effect that might impact a country’s bargaining power in any of the periods. It is thus even more general than the inclusion of the Shapley-Shubik of voting power in the EU Council which we use in columns (3) and (4). Considering the similar results for linear and nonlinear first stage specifications in Tables 6 and 7 we report only the results for the nonlinear specifications in Table 8.

Tables 6, 7, and 8 can be summarized as follows. First, Objective 1 treatment enters positively and is significantly different from zero in all models estimated. The difference between pooled OLS and fixed effects in the second stage is fairly small. The confidence intervals around the Objective 1 treatment indicators under pooled OLS and fixed effects estimation are overlapping with conventional confidence bands. This indicates that the bias from omitted time-invariant variables is small with the RDD in our application. The difference between the fuzzy RDD models with a linear versus a nonlinear probability model in the first stage is negligible. The relevant results of each of the respective models (1)-(6) in Tables 6 and 7 are not statistically different across tables. Including controls neither affects the significance nor the magnitude of the coefficients substantially. This indicates that the basic assumptions about RDD are met with the data at hand (i.e., it is enough to include a polynomial function  $f(GDP_{it}/capita_{it})$  for consistent estimation of the treatment effect; see ?). The latter is true also irrespective of whether we use NUTS2 controls or NUTS3 controls with outcome at the NUTS3 level. To see this, compare the results from columns (5) and (6) in Table 8 with the corresponding columns in Tables 6 and 7. Overall, we identify a positive effect of Objective 1 treatment that is significantly different from zero and robust in various regards investigated in Tables 6, 7, and 8.

## 5 Sensitivity checks, evaluation, and extensions

Let us use the positive average treatment effects of Objective 1 transfers in models (5) and (6) reported in Tables 6 and 8 as our reference estimates. In this section, we proceed along several lines. First, we check the sensitivity of the estimates with regard to using an alternative approach to estimating binary treatment effects. Second, we check for and possibly avoid a potential bias of cross-border spillovers

from Objective 1 treatment on regions in the control group. Third, we investigate possible effects on employment to shed light on a possible impact on an outcome other than income. Fourth, we assess the effectiveness of the program and the associated net benefits based on the preferred point estimates by means of a back-of-the-envelope calculation. Finally, we exploit information about the extent of Objective 1 transfers in one of the three programming periods and provide dose-response estimates of the role of Objective 1 transfers on per-capita income growth.

**Switching regression estimates of Objective 1 treatment effects** To probe the robustness of our results with respect to the empirical estimation strategy, we may use a switching regression model as described in Wooldridge (2002, Procedure 18.4) instead of RDD.<sup>20</sup> This model starts from the following system of equations:

$$Growth_{1,it} = \mathbf{x}_{it}\boldsymbol{\nu}_1 + \psi_{1,it} \quad (4)$$

$$Growth_{0,it} = \mathbf{x}_{it}\boldsymbol{\nu}_0 + \psi_{0,it} \quad (5)$$

where  $Growth_{1,it}$  is the outcome (average annual growth during programming period  $t$ ) in case of Objective 1 treatment and  $Growth_{0,it}$  is the outcome in case of non-treatment. After stacking the two processes, the outcome  $Growth_{it}$  can be written as

$$Growth_{it} = \rho_0 + (\rho_1 - \rho_0)Treat_{it} + \mathbf{x}_{it}\boldsymbol{\nu} + \chi_{it} \quad (6)$$

with  $\chi_{it} = Treat_{it}\psi_{1,it} + (1 - Treat_{it})\psi_{0,it}$ . If  $E[\chi_{it}] \neq 0$ , as is the case if eligibility and actual treatment do not coincide, an OLS estimate of equation (6) will give a biased estimate of the average treatment effect  $\rho = \rho_1 - \rho_0$ .

### Table 9 about here

One can however compute two (period-specific) selection terms, one for selection into treatment and one for selection into non-treatment, and add those to the outcome equation. Wooldridge (2002, Procedure 18.4) proposes to estimate (period-specific) probits of  $Treat_{it}$  on  $Rule_{it}$  and  $\mathbf{x}_{it}$  as in equation (3) above.<sup>21</sup> One then computes predicted probabilities,  $\hat{\Phi}_{it}(\hat{\delta} + \hat{\zeta}Rule_{it} + \mathbf{x}_{it}\hat{\boldsymbol{\eta}})$ , along with  $\hat{\phi}_{it} = \phi(\hat{\delta} + \hat{\zeta}Rule_{it} + \mathbf{x}_{it}\hat{\boldsymbol{\eta}})$ , where  $\phi$  and  $\Phi$  are the normal density and the normal cumulative distribution function, respectively.

<sup>20</sup>In fact, Wooldridge (2002, Procedure 18.4) describes the cross-sectional case. The extension to the case of panel data is similar to Wooldridge's (1995) panel estimator for the sample selection model.

<sup>21</sup>As in section 4.1, one may apply a Mundlak-Chamberlainian approach as in Wooldridge (1995), i.e., estimate the nonlinear probability models for each programming period separately and then include time averages  $\bar{\mathbf{x}}_i$  of the covariates  $\mathbf{x}_{it}$  in the second stage model in addition to  $\mathbf{x}_{it}$ .

We then run pooled OLS regressions of  $Growth_{it}$  on  $Treat_{it}$ ,  $\mathbf{x}_{it}$ ,  $Treat_{it}(\mathbf{x}_{it} - \bar{\mathbf{x}}_t)$ ,  $Treat_{it}(\hat{\phi}_{it}/\hat{\Phi}_{it})$  and  $(1 - Treat_{it})[\hat{\phi}_{it}/(1 - \hat{\Phi}_{it})]$  and – in the fixed effects version – the Mundlak-Chamberlain terms  $\bar{\mathbf{x}}_i$ .<sup>22</sup>

Table 9 displays the results from this estimation. In columns (1) and (2), results are shown for the sample of NUTS2 regions. The point estimates on the Objective 1 indicator are 0.016 and 0.014, respectively, and are very close to the results in columns (3)-(6) of Table 6. We also obtain estimates for the sample of NUTS3 regions in columns (3) and (4). In the covariate vector  $\mathbf{x}_{it}$  we use the same variables as in columns (3) and (4) of Table 8. Again, the switching regression results are very similar to the fuzzy RDD results.

In summary, the results from the switching regression model are very close to the RDD. This indicates that our results do not depend on the assumptions adopted in RDD as compared to switching regression analysis.

**Avoiding a possible downward bias of the treatment effects from cross-border spillovers** One concern with the estimates in Tables 6, 7 and 8 is that Objective 1 transfers may be used to finance public infrastructure, generating not only local effects on the treated regions but also spillovers to neighboring regions. The latter would violate the so-called *stable unit treatment value assumption* and lead to downward-biased estimates of the average Objective 1 treatment effect, unless spillovers are captured by the polynomial function of NUTS2 per-capita income. The reason is that positive spillovers affect per-capita income growth of untreated (control) neighboring units positively which reduces the difference between growth rates of the treated and the untreated regions.

Provided that the aforementioned spillovers are of medium reach (e.g., do not exceed a distance of 100-200 kilometers), such a bias can be avoided by the following procedure. Let us assume that Objective 1 transfers mainly affect regions within a radius of 100, 150, or 200 kilometers but not more distant ones. We may then exclude all untreated regions that are located within such a radius from any treated region. The corresponding estimates, especially the ones using a radius of 200 kilometers, would then be free of a bias from spillovers.<sup>23</sup>

### Tables 10 and 11 about here

Tables 10 and 11 summarize the results from fixed region effects estimation involving a nonlinear probability model in the first stage. The estimates are obtained

---

<sup>22</sup>We have skipped the arguments of  $\hat{\phi}_{it}$  and  $(1 - \hat{\Phi}_{it})$  for the sake of brevity.

<sup>23</sup>Admittedly, we ignore Objective 1-induced (second or higher order) spillover effects from untreated regions to other untreated regions, but these should be negligible with spillovers of reasonable magnitude.



in the restricted samples excluding untreated observations within the mentioned radius around treated. Obviously, the number of observations declines with a larger radius applied around Objective 1 treated regions. With a radius of 100 kilometers the number of NUTS2 observations drops from 674 in Table 6 to 625 observations in Table 10. With a radius of 200 kilometers, the number of observations drops to 544. Similarly, the number of NUTS3 observations drops from 3,300 in Table 7 to 2,861 in Table 11 with a radius of 100 kilometers and to 2,306 with a radius of 200 kilometers.

A comparison of the results between the fixed effects two-stage least squares estimates with a nonlinear first stage in Tables 6 and 10 suggests that, at the NUTS2 level, the downward bias of the average Objective 1 treatment effect on per-capita income growth due to cross-regional spillovers in Table 6 is quite small: the coefficient estimate for a radius of 200 kilometers in Table 10 amounts to 0.020 which is identical to its benchmark in Table 6. Similar conclusions apply for the case with NUTS3 regions. The corresponding estimate at the NUTS3 level is 0.011 with a radius of 200 kilometers in Table 11 while it was 0.007 in Table 8. We conclude that there are only modest cross-region spillovers.

**Objective 1 treatment effects on regional employment growth** Since a fraction of the funds is used as employment subsidies, there might also be a positive effect of Objective 1 treatment on employment growth. We address this question by means of Tables 12 and 13 which are identical to Tables 6 and 8, except that they use average annual employment growth instead of per-capita income growth during a programming period as the dependent variable.

#### **Tables 12 and 13 about here**

The treatment effect estimates in these tables indicate that significant employment growth effects of Objective 1 can not be identified. This result is obtained irrespective of whether we use outcome at the NUTS2 or the NUTS3 regional level; see the preferred model (6) in Table 12 or models (2), (4), or (6) in Table 13. However, employment growth is not a direct target of Objective 1 transfers at large. Together with the results on per-capita income growth in Tables 6 and 8, our findings indicate that income growth effects must be triggered mainly by investment growth and productivity growth.

**Assessing the net benefits of Objective 1 treatment** With the estimates at hand, we may easily infer whether the use of Objective 1 transfers is justified on average or not, when requiring efficiency within a programming period. In Table

6 the average estimate on the Objective 1 effect across columns (3) through (6) is 0.018. However, there is evidence of moderate cross-regional spillovers so that we refer to the point estimate of 0.020 in column (3) of Table 10 as the preferable estimate. Accordingly, Objective 1 treatment led to an average growth advantage of real GDP per capita of approximately 2.0 percentage points in recipient regions. The level of GDP per capita and GDP (at PPP) in the average treated NUTS2 region and year amounted to 11,074 Euro and 16,000 million Euros, respectively.<sup>24</sup> The average Objective 1 NUTS2 region’s population changed only slightly over the average period with a yearly growth rate of 0.1 percent. Hence, Objective 1 treatment caused absolute GDP to change by about the same rate as per-capita GDP, namely by 2.0% or 320 million Euros (at PPP) per annum in the average treated region and programming period. Aggregating this effect up for all treated regions in the average programming period results in a treatment effect of 23.06 billion Euros (at PPP) per year within the EU as a whole.<sup>25</sup> The total cost of the Objective 1 programme was 18.98 billion Euro (at PPP) per annum in the average programming period (see Table 1). Then, we may conclude that the Objective 1 programme induces a net effect of 4.08 billion Euros (at PPP) per year or 21 percent of the expenses per year in the EU as a whole. In other words, every Euro spent on Objective 1 transfers leads to 1.21 EUR of additional GDP.<sup>26</sup>

**Estimating the effect of marginal changes in Objective 1 transfers: dose-response function estimation** The amount of Objective 1 transfers differs across recipient regions. *Dose-response function* estimation allows us to assess how Objec-

---

<sup>24</sup>Taking GDP and GDP per capita prior to each single programming period, i.e., in 1988 for the EU12 in the first period and 1989 for the German New Länder, 1993 for the EU12 and 1994 for Austria, Finland, and Sweden in the second period, 1999 for the EU15 and 2003 for the new accession countries in the third programming period.

<sup>25</sup>There were 58 treated NUTS2 regions in the first period of which the 11 New Länder regions received funds only for 4 years. In the second period, there were 64 treated NUTS2 regions of which the Austrian NUTS2 region Burgenland received funds only in 5 out of 6 years, and in the third period there were 129 treated NUTS2 regions of which the 67 Objective 1 regions in the new accession countries received funds only from 2004 onwards, that is for 3 rather than 7 years. This makes a total of 1297 region-year observations of Objective 1 treatment or, on average, 72.06 regions per annum receiving treatment over the three periods.

<sup>26</sup>A crucial assumption for this cost assessment is that the associated collection of taxes did not distort economic activity in net paying regions. Moreover, we abstract from administrative costs associated with the collection of these taxes. Hence, we assume that one Euro of Objective 1 transfers is identical to one Euro of costs. However, for a violation of the assumption of non-distortionary taxation, one would have to blame the taxing authorities at the national level rather than the European Commission.

tive 1 regions respond to variations in the *treatment intensity*.<sup>27</sup>

In a final assessment, we consider continuous Objective 1 transfers and estimate their effects on economic growth. Binary indicators of Objective 1 recipient status may conceal varying effects of different magnitudes of EU transfers. We consider Objective 1 funds as a fraction of GDP as the continuous treatment variable. However, there are not enough data points to estimate a dose-response function at the NUTS2 level, and information on continuous transfers at the NUTS3 level of aggregation is only available for the programming period 1994-99. So, unlike with binary Objective 1 transfer recipient status, we have to focus on the analysis at the NUTS3 level but may not entertain the advantages of region-fixed effects estimation.

? derive an extension of the ? propensity-score method to estimate the average local effects of continuous treatments. We discuss this relatively recent method, known as generalized propensity score matching, in Appendix A. The estimates from generalized propensity score matching are typically reported with a so-called dose-response function. In our case, the dose-response function depicts the growth rate over a programming period as a function of EU transfers relative to GDP. Figure 5 plots the dose-response function (left panel) as well as the treatment effect function for the central programming period, 1994-99.

The dose-response function indicates that at low values of the treatment (Objective 1 transfer volumes that are small relative to a region's GDP) regions grow at around 3 percent per year, similar to regions without Objective 1 status. An increase in Objective 1 transfers leads to a more-than-proportionate increase in average annual growth of per-capita GDP at PPP growth until a level of transfers of 1.25% of the recipient region's GDP is reached. Beyond that value, the marginal effect of further transfers declines. That is also evidenced by the treatment effect function (the derivative of the dose-response function) where confidence bands include a zero additional growth effect for transfer-to-GDP ratios above 1.25 percent. These results point to the possibility of leakage effects if transfers exceed a certain value.

## 6 Concluding remarks

This paper considers the estimation of causal effects of the European Union's (EU) Objective 1 transfers on economic growth. Objective 1 funds aim at facilitating convergence and cohesion within the EU and constitute the major part of the EU's *Structural Funds Programme*. They target fairly large, sub-national regional aggre-

---

<sup>27</sup>The latter could not be done throughout our analysis, because of the limited availability of continuous information about Objective 1 transfers.

gates – referred to as NUTS2 regions – to foster growth in regions, whose per-capita GDP in purchasing power parity is lower than 75% of the EU’s average per-capita income.

The 75%-rule gives rise to a regression-discontinuity design that exploits the jump in the probability of Objective 1 recipience. In the vast majority of cases (93% of the observations at NUTS2 level), the 75%-rule is strictly applied. Only 7% of our observations do not comply with the assignment mechanism. These are regions which either obtained Objective 1 funds although they were not eligible according to the rule or they did not receive funds although they should have. When we exclude non-complying regions, we have a sharp regression-discontinuity design. Including non-compliers leads to a fuzzy regression-discontinuity design. We perform regressions both at the NUTS2 level (the level of aggregation at which Objective 1 status is generally decided) and at the NUTS3 level for sharp and fuzzy regression-discontinuity design. In some specifications, we include further covariates to control for selection into treatment. Amongst others, we include a country’s voting power in the EU council to account for non-compliance with the 75%-rule.

Our results can be summarized as follows. On average, Objective 1 status raises real GDP per capita growth by about 2.0% within the same programming period. Second, different from the positive effects on per-capita GDP, we do not find significant employment effects during the period in which transfers are allocated. There may be various reasons for that. One reason could be that Objective 1 transfers mainly stimulate investment. Another reason could be that the creation of jobs takes longer than the duration of a programming period of five to seven years.

We perform several robustness checks. First, we deal with possible spillovers of Objective 1 funds on neighboring regions by estimating separate regressions in which we exclude control regions adjacent to treated regions. Second, we use a switching regression model as an alternative model of selection into treatment. Our results are robust to these changes in estimation sample and estimation method. Finally, we shed light on the role of the magnitude of funds received for economic outcome. With regard to the latter, we find that an marginal increase in Objective 1 transfers at low levels leads to a disproportionate increase in growth of per-capita GDP at PPP. However, beyond a certain level, further increases in Objective 1 funding do not seem to lead to additional growth effects.

A simple back-of-the envelope calculation of the net benefits of Objective 1 transfers suggests the following. According to conservative benchmark estimates, every Euro spent on Objective 1 transfers leads to 1.21 Euros of additional GDP. The latter seems to be associated with investment (e.g., in infrastructure) and, eventually, productivity gains but not with the creation of new jobs. From this, we may conclude that, on average, Objective 1 transfers under the EU’s *Structural Funds*

*Programme* are effective and not wasteful on net.

## A Generalized propensity scores

Index a sample of regions with  $i = 1, \dots, N$  and consider the *unit-level dose-response function* of outcomes  $Y_i(\tau)$  as a function of treatments  $\tau \in \mathcal{T}$ . In the binary treatment case  $\mathcal{T} = \{0, 1\}$ . In the continuous case, we allow  $\mathcal{T}$  to be an interval  $[\tau_0, \tau_1]$ . We restrict  $\tau_0 > 0$  to study the range of transfers (as fraction of GDP) that we used to summarize with a treatment indicator of one and in order to exclude the probability mass at zero treatment in accordance with the ? approach. We are interested in the average dose-response function across all regions  $i$ ,  $\mu(\tau) = E[Y_i(\tau)]$ . We observe the vector  $X_i$ , the treatment  $T_i$ , and the outcome corresponding to the level of treatment received,  $Y_i = Y_i(T_i)$ . We drop the index  $i$  for simplicity and assume that  $Y(\tau)_{\tau \in \mathcal{T}}, T, X$  are defined on a common probability space, that  $\tau$  is continuously distributed with respect to a Lebesgue measure on  $\mathcal{T}$ , and that  $Y = Y(T)$  is a well defined random variable.

In this setting, the definition of unconfoundedness for binary treatments generalizes to *weak unconfoundedness* for continuous treatments

$$Y(\tau) \perp T|X \quad \text{for all } \tau \in \mathcal{T}. \quad (7)$$

Regions differ in their characteristics  $x$  so that they are more or less likely to receive Objective 1 funds. The weak unconfoundedness assumption says that, after controlling for observable characteristics  $X$ , any remaining difference in Objective 1 transfers  $T$  across regions is independent of the potential outcomes  $Y(\tau)$ . Assumption (7) is called weak unconfoundedness because it does not require joint independence of all potential outcomes,  $Y(\tau)_{\tau \in [\tau_0, \tau_1]}, T, X$ . Instead, it requires conditional independence to hold at every treatment level.

? define the generalized propensity score as

$$R = r(T, X), \quad (8)$$

where  $r(\tau, x) = f_{T|X}(\tau|x)$  is the conditional density of the treatment given the covariates. The generalized propensity score is assumed to have a *balancing property* similar to that of the conventional propensity score under binary treatment: within strata with the same value of  $r(\tau, X)$ , the probability that  $T = \tau$  does not depend on the value of  $X$ . In other words, when looking at two regions with the same probability (conditional on observable characteristics  $X$ ) of being exposed to a particular EU transfer, their treatment level is independent of  $X$ . That is, the generalized propensity score summarizes all information in the multi-dimensional vector  $X$  so that

$$X \perp 1\{T = \tau\} | r(\tau, X).$$

This is a mechanical property of the generalized propensity score, and does not require unconfoundedness. In combination with unconfoundedness, the balancing property implies that assignment to treatment is *weakly unconfounded given the generalized propensity score* (see ? for a proof): if assignment to the treatment is weakly unconfounded given pre-treatment variables  $X$ , then

$$f_T(\tau|r(\tau, X), y(T)) = f_T(\tau|r(\tau, X)) \quad (9)$$

for every  $\tau$ . This result says that we can evaluate the generalized propensity score at a given treatment level by considering the conditional density of the respective treatment level  $\tau$ . In that sense we use as many propensity scores as there are treatment levels, but never more than a single score at one treatment level.

We eliminate biases associated with differences in the covariates in two steps (for a proof that the procedure removes bias, see ?):

1. Estimate the conditional expectation of the outcome as a function of two scalar variables, the treatment level  $T$  and the generalized propensity score  $R$ ,  $\beta(\tau, r) = E[y|T = \tau, R = r]$
2. Estimate the dose-response function at a particular level of the treatment by averaging this conditional expectation over the generalized propensity score at that particular level of the treatment,  $\mu(\tau) = E[\beta(\tau, r(\tau, X))]$ .

It is important to note that, in the second step, we do not average over the generalized propensity score  $R = r(\tau, X)$ ; rather we average over the score evaluated at the treatment level of interest,  $r(\tau, X)$ . In other words, we fix  $\tau$  and average over  $X_i$  and  $r(\tau, X_i) \forall i$ .

## B Tables and Figures

Table 1: OBJECTIVE 1 REGIONS

|   | 1989-1993 | 1994-1999 | 2000-2006 |
|---|-----------|-----------|-----------|
|   | (1)       | (2)       | (3)       |
| <b>NUTS2</b>  |           |           |           |
| Total Number of NUTS2 Regions                                 | 193       | 215       | 285       |
| Number of Obj.1 NUTS2 Regions                                 | 58        | 64        | 129       |
| <b>NUTS3</b>  |           |           |           |
| Total Number of NUTS3 Regions                                 | 1015      | 1091      | 1213      |
| Number of Obj.1 NUTS3 Regions                                 | 286       | 309       | 417       |
| Overall yearly funds (Mio. Euro)                              | 8763.600  | 15661.670 | 23144.020 |
| Overall yearly funds (Mio. Euro PPP)                          | 10278.840 | 17479.010 | 26480.150 |
| Yearly funds as fraction of Obj. 1 NUTS2 region GDP           | .014      | .018      | .017      |
| Yearly funds per inhabitant of Obj. 1 NUTS2 region (Euro PPP) | 125       | 193       | 229       |

*Notes:* Data on EU Structural Funds stem from European Commission (1997 pp. 154-155 and 2007 p. 202). To obtain average yearly funds we divide period-specific figures by the number of years the respective programming period lasted. We calculate the funds in PPP terms by weighting the funds each single country received in the respective programming period with the country's Purchasing Power Parity Index of the programming period's initial year. Funds per GDP and funds per inhabitant are calculated as the average yearly funds divided by regional GDP and regional population, respectively, prior to the programming period. This is 1988 and 1989 for the EU12 and the German New Länder, respectively, in the first period, 1993 for the EU12 regions in the second period but 1994 for the countries joining in 1995 (Austria, Finland, and Sweden), and 1999 for the EU15 in the third period but 2003 for the accession countries of 2004. Moreover, we adjust for the number of years the respective countries actually received funds. This is 5 years and 4 years for the EU12 and the German New Länder, respectively, in the first period, 6 years and 5 years for the EU12 and the new members of 1995, respectively, in the second period, and 7 years for the EU15 but 3 years for the new accession countries of 2004.



Table 2: DISPARITIES IN THE EU25 1999 (GDP PER CAPITA PPP)

|                 | Country Avg.<br>(Euro PPP) | Country Max<br>(Euro PPP) | Country Min<br>(Euro PPP) | Country Avg.<br>rel. to EU25 | Country Max<br>rel. to EU25 | Country Min<br>rel. to EU25 |
|-----------------|----------------------------|---------------------------|---------------------------|------------------------------|-----------------------------|-----------------------------|
| Austria         | 18855.38                   | 29546.84                  | 13446.46                  | 1.02                         | 1.59                        | .72                         |
| Belgium         | 18466.26                   | 43347.16                  | 14331.10                  | .99                          | 2.34                        | .77                         |
| Cyprus          | 14861.88                   | 14861.88                  | 14861.88                  | .80                          | .80                         | .80                         |
| Czech Republic  | 11411.80                   | 23708.24                  | 9554.07                   | .61                          | 1.28                        | .51                         |
| Germany         | 19929.09                   | 35739.29                  | 12738.76                  | 1.07                         | 1.93                        | .69                         |
| Denmark         | 22634.88                   | 27954.49                  | 17869.64                  | 1.22                         | 1.51                        | .96                         |
| Estonia         | 6252.50                    | 10644.65                  | 4636.73                   | .34                          | .57                         | .25                         |
| Spain           | 16005.10                   | 22823.61                  | 11146.41                  | .86                          | 1.23                        | .60                         |
| Finland         | 20302.39                   | 28662.20                  | 15392.66                  | 1.09                         | 1.54                        | .83                         |
| France          | 19790.04                   | 32908.45                  | 16100.37                  | 1.07                         | 1.77                        | .87                         |
| Greece          | 12530.61                   | 16631.15                  | 9377.14                   | .68                          | .90                         | .51                         |
| Hungary         | 8598.66                    | 14861.88                  | 6192.45                   | .46                          | .80                         | .33                         |
| Ireland         | 21651.46                   | 24769.80                  | 16454.23                  | 1.17                         | 1.33                        | .89                         |
| Italy           | 21184.88                   | 29900.69                  | 12915.68                  | 1.14                         | 1.61                        | .70                         |
| Lithuania       | 6243.72                    | 9153.68                   | 4171.41                   | .34                          | .49                         | .22                         |
| Luxembourg      | 40693.25                   | 40693.25                  | 40693.25                  | 2.19                         | 2.19                        | 2.19                        |
| Latvia          | 5296.85                    | 10829.71                  | 3191.77                   | .29                          | .58                         | .17                         |
| Malta           | 14508.03                   | 14508.03                  | 14508.03                  | .78                          | .78                         | .78                         |
| Netherland      | 22107.05                   | 29016.05                  | 16808.08                  | 1.19                         | 1.56                        | .91                         |
| Poland          | 8382.42                    | 13092.61                  | 6015.52                   | .45                          | .71                         | .32                         |
| Portugal        | 13250.58                   | 21408.19                  | 12207.97                  | .71                          | 1.15                        | .66                         |
| Sweden          | 19942.22                   | 30431.47                  | 18754.28                  | 1.07                         | 1.64                        | 1.01                        |
| Slovenia        | 12438.66                   | 19182.09                  | 9761.78                   | .67                          | 1.03                        | .53                         |
| Slovak Republic | 8824.24                    | 18931.21                  | 6546.31                   | .48                          | 1.02                        | .35                         |
| United Kingdom  | 19392.81                   | 49362.68                  | 12384.90                  | 1.04                         | 2.66                        | .67                         |

*Notes:* The table shows average, maximum and minimum GDP per capita (PPP terms) within country for NUTS2 regions.

Table 3: OBJECTIVE 1 RECIPIENT VS. NON-RECIPIENT REGIONS

|                     | Mean<br>recipient<br>(1) | Mean<br>non-recipient<br>(2) | Difference<br>col.(1)-col.(2)<br>(3) | Std. Err.<br>of col.(3)<br>(4) |
|---------------------|--------------------------|------------------------------|--------------------------------------|--------------------------------|
| <b>EU12</b>         |                          |                              |                                      |                                |
| GDP per capita 1988 | 8586.20                  | 13634.19                     | -5047.99                             | 478.23                         |
| No. of observations | 52                       | 134                          |                                      |                                |
| <b>EU15</b>         |                          |                              |                                      |                                |
| GDP per capita 1993 | 10795.99                 | 16298.13                     | -5502.14                             | 536.56                         |
| No. of observations | 58                       | 151                          |                                      |                                |
| <b>EU25</b>         |                          |                              |                                      |                                |
| GDP per capita 1999 | 11157.73                 | 21251.68                     | -10093.94                            | 556.27                         |
| No. of observations | 123                      | 156                          |                                      |                                |

*Notes:* The table shows differences in GDP per capita (PPP) of recipient and non-recipient regions at the NUTS2 level. We miss information on the four French overseas-départements and the two autonomous Portuguese regions Madeira and Azores for all three years. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 4: ELIGIBILITY AND ACTUAL TREATMENT UNDER OBJECTIVE 1 ACCORDING TO 75% GDP PER CAPITA THRESHOLD

|                     | Recipients | Non-recipients | Recipients | Non-recipients |
|---------------------|------------|----------------|------------|----------------|
|                     | NUTS2      | NUTS2          | NUTS3      | NUTS3          |
| <b>1989-93 EU12</b> |            |                |            |                |
| Eligible            | 43         | 4              | 246        | 98             |
| Non Eligible        | 9          | 130            | 34         | 631            |
| <b>1994-99 EU15</b> |            |                |            |                |
| Eligible            | 44         | 3              | 260        | 108            |
| Non Eligible        | 14         | 148            | 43         | 674            |
| <b>2000-06 EU25</b> |            |                |            |                |
| Eligible            | 111        | 4              | 345        | 95             |
| Non Eligible        | 12         | 152            | 66         | 701            |

*Notes:* Eligible regions are characterized by a GDP per capita of less than 75% of EU average in the qualifying years of each programming period (3-year average over the years preceding the start of a new programming period). Recipient regions are those that did effectively receive Objective 1 status. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three years. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 5: DESCRIPTIVE STATISTICS

|  | Mean     | Std. Dev. | Min      | Max      |
|--|----------|-----------|----------|----------|
|  | (1)      | (2)       | (3)      | (4)      |
| GDP per capita growth (NUTS2)                      | .042     | .018      | -.008    | .131     |
| GDP per capita growth (NUTS3)                      | .041     | .022      | -.039    | .251     |
| Employment growth (NUTS2)                          | .005     | .014      | -.062    | .079     |
| Employment growth (NUTS3)                          | .005     | .022      | -.162    | .273     |
| Objective 1 (NUTS2)                                | .306     | .461      | 0        | 1        |
| Objective 1 (NUTS3)                                | .305     | .460      | 0        | 1        |
| Avg. GDP per capita in threshold years             | 12927.27 | 4562.467  | 3343.816 | 37835.19 |
| Employment share                                   | .427     | .119      | .017     | 1.634    |
| Agricultural share                                 | .082     | .102      | 0        | .849     |
| Service share                                      | .613     | .122      | .031     | .997     |
| Population growth                                  | .003     | .008      | -.058    | .078     |
| Population density                                 | .492     | 1.065     | .002     | 20.381   |
| Shapley-Shubik index of voting power in EU Council | .106     | .040      | 0        | .134     |

*Notes:* We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three years. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 6: RDD NUTS2 - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|             | sharp RDD         |                  | fuzzy RDD         |                   |                   |                   |
|-------------|-------------------|------------------|-------------------|-------------------|-------------------|-------------------|
|             | Pooled OLS        | FE               | Pooled OLS        | FE                | Pooled OLS        | FE                |
|             |                   |                  | linear 1st        |                   | nonlinear 1st     |                   |
|             | (1)               | (2)              | (3)               | (4)               | (5)               | (6)               |
| Objective 1 | .016<br>(.002)*** | .012<br>(.005)** | .018<br>(.002)*** | .015<br>(.004)*** | .019<br>(.002)*** | .020<br>(.004)*** |
| Const.      | .073<br>(.016)*** | .033<br>(.027)   | .070<br>(.016)*** | .090<br>(.023)*** | .068<br>(.016)*** | .088<br>(.023)*** |
| Obs.        | 628               | 628              | 674               | 674               | 674               | 674               |
| Regions     | 263               | 263              | 279               | 279               | 279               | 279               |
| $R^2$       | .220              | .023             | .172              | .200              | .166              | .180              |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In all pooled OLS regressions the standard errors are clustered by NUTS2 code. The first two columns report sharp RDD specifications while columns four to six show the fuzzy RDD specifications using a two stage instrumental variable procedure. The first stage is estimated linearly in specifications three and four whereas specifications five and six build on nonlinear first stage estimations. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The sample consists of the EU12 NUTS2 regions for the first period, the EU15 NUTS2 regions for the second and the EU25 NUTS2 regions for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 7: FUZZY RDD NUTS3 - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|             | sharp RDD         |                   | fuzzy RDD         |                   |                   |                   |
|-------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|             | Pooled OLS        | FE                | Pooled OLS        | FE                | Pooled OLS        | FE                |
|             |                   |                   | linear 1st        |                   | nonlinear 1st     |                   |
|             | (1)               | (2)               | (3)               | (4)               | (5)               | (6)               |
| Objective 1 | .009<br>(.002)*** | .011<br>(.004)*** | .010<br>(.002)*** | .009<br>(.004)**  | .011<br>(.002)*** | .017<br>(.004)*** |
| Const.      | .111<br>(.023)*** | .111<br>(.014)*** | .109<br>(.023)*** | .109<br>(.029)*** | .106<br>(.023)*** | .093<br>(.028)*** |
| Obs.        | 3142              | 3142              | 3300              | 3300              | 3300              | 3300              |
| Regions     | 1150              | 1150              | 1207              | 1207              | 1207              | 1207              |
| $R^2$       | .158              | .049              | .144              | .151              | .143              | .142              |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. The first two columns report sharp RDD specifications while columns four to six show the fuzzy RDD specifications using a two stage instrumental variable procedure. The first stage is estimated linearly in specifications three and four whereas specifications five and six build on nonlinear first stage estimations. In each case we run the pooled OLS regressions as well as the fixed effects regressions. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The standard errors are always clustered by NUTS2 code. The sample consists of the EU12 NUTS3 regions for the first period, the EU15 NUTS3 regions for the second and the EU25 NUTS3 regions for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 8: FUZZY RDD NUTS3 WITH CONTROLS - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|                               | Pooled OLS         | FE                 | Pooled OLS         | FE                 | Pooled OLS         | FE                 |
|-------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                               | (1)                | (2)                | (3)                | (4)                | (5)                | (6)                |
| Objective 1                   | .012<br>(.002)***  | .017<br>(.004)***  | .010<br>(.002)***  | .014<br>(.004)***  | .015<br>(.003)***  | .017<br>(.003)***  |
| Empl. share                   | .007<br>(.006)     | -.063<br>(.024)*** | .008<br>(.006)     | -.063<br>(.024)*** | .009<br>(.006)     | -.061<br>(.026)**  |
| Agri. share                   | -.030<br>(.006)*** | -.031<br>(.028)    | -.040<br>(.006)*** | -.028<br>(.028)    | -.057<br>(.009)*** | -.046<br>(.026)*   |
| Serv. share                   | .007<br>(.005)     | .054<br>(.017)***  | .005<br>(.005)     | .057<br>(.017)***  | .002<br>(.005)     | .050<br>(.017)***  |
| Pop. growth                   | -.197<br>(.087)**  | -.273<br>(.127)**  | -.196<br>(.089)**  | -.274<br>(.127)**  | -.334<br>(.085)*** | -.352<br>(.110)*** |
| Pop. density                  | -.0002<br>(.0005)  | .073<br>(.028)***  | -.0001<br>(.0004)  | .071<br>(.028)**   | -.001<br>(.0006)** | .059<br>(.028)**   |
| Voting power<br>in EU council |                    |                    | -.077<br>(.014)*** | .067<br>(.063)     |                    |                    |
| Country-time<br>dummies       | no                 | no                 | no                 | no                 | yes                | yes                |
| Const.                        | .100<br>(.020)***  | .075<br>(.025)***  | .110<br>(.020)***  | .074<br>(.023)***  | .122<br>(.019)***  | .126<br>(.037)***  |
| Obs.                          | 3300               | 3300               | 3300               | 3300               | 3300               | 3300               |
| Regions                       | 1207               | 1207               | 1207               | 1207               | 1207               | 1207               |
| $R^2$                         | .175               | .202               | .193               | .226               | .314               | .331               |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In each column we estimate fuzzy RDD specifications using a two stage instrumental variable procedure where the first stage is estimated nonlinearly. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The standard errors are always clustered by NUTS2 code. The sample consists of the EU12 NUTS3 regions for the first period, the EU15 NUTS3 regions for the second and the EU25 NUTS3 regions for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 9: SWITCHING REGRESSIONS - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|  | NUTS2             |                   | NUTS3               |                    |
|--|-------------------|-------------------|---------------------|--------------------|
|  | Pooled OLS        | FE                | Pooled OLS          | FE                 |
|  | (1)               | (2)               | (3)                 | (4)                |
| Objective 1                                | .016<br>(.002)*** | .014<br>(.003)*** | .013<br>(.002)***   | .013<br>(.002)***  |
| Empl. share                                |                   |                   | .008<br>(.004)**    | -.059<br>(.020)*** |
| Agri. share                                |                   |                   | -.055<br>(.006)***  | -.040<br>(.024)    |
| Serv. share                                |                   |                   | .004<br>(.004)      | .050<br>(.021)**   |
| Pop. growth                                |                   |                   | -.340<br>(.062)***  | -.360<br>(.107)*** |
| Pop. density                               |                   |                   | -.001<br>(.0005)*** | .059<br>(.018)***  |
| Country-time<br>dummies                    |                   |                   | yes                 | yes                |
| Selection correction<br>terms <sup>a</sup> | yes               | yes               | yes                 | yes                |
| Const.                                     | .070<br>(.016)*** | .089<br>(.023)*** | .122<br>(.013)***   | .114<br>(.029)***  |
| Obs.                                       | 674               | 674               | 3300                | 3300               |
| Regions                                    | 279               | 279               | 1207                | 1207               |
| R <sup>2</sup>                             | .215              | .228              | .324                | .340               |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In each column we estimate fuzzy RDD specifications using a two stage instrumental variable procedure where the first stage is estimated nonlinearly. The first two columns report NUTS2 specifications while columns four to six show NUTS3 level regressions. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The standard errors are clustered by NUTS2 code in the NUTS3 regressions as well as in the NUTS2 pooled OLS estimations. We take the sample of EU12 NUTS3 regions for the first period, EU15 NUTS3 regions for the second and EU25 for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook. <sup>a</sup> Following Wooldridge (2002, p.631), we compute inverse Mills ratios for treated and control regions as regressors in the second stage regression.

Table 10: SPATIAL EXCLUSION MECHANISM RDD NUTS2 - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|             | 100km             | 150km             | 200km             |
|-------------|-------------------|-------------------|-------------------|
|             | (1)               | (2)               | (3)               |
| Objective 1 | .017<br>(.003)*** | .020<br>(.004)*** | .020<br>(.004)*** |
| Const.      | .084<br>(.023)*** | .084<br>(.022)*** | .081<br>(.022)*** |
| Obs.        | 625               | 586               | 544               |
| Regions     | 261               | 226               | 213               |
| $R^2$       | .188              | .190              | .192              |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In each column we estimate fuzzy RDD specifications using a two stage instrumental variable procedure where the first stage is estimated nonlinearly. All specifications include region fixed effects. The distance matrices are used such that only those non-Objective 1 regions are included in the control group that are more than 100 km away from the next Objective 1 region in the first column 150km in the second and 200km in the third. The sample consists of the EU12 NUTS2 regions for the first period, the EU15 NUTS2 regions for the second and the EU25 NUTS2 regions for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 11: SPATIAL EXCLUSION MECHANISM FUZZY RDD NUTS3 - OBJECTIVE 1 AND GDP/CAPITA GROWTH

|                      | 100km              | 150km              | 200km              |
|----------------------|--------------------|--------------------|--------------------|
|                      | (1)                | (2)                | (3)                |
| Objective 1          | .007<br>(.003)***  | .019<br>(.004)***  | .019<br>(.004)***  |
| Empl. share          | -.067<br>(.028)**  | -.042<br>(.023)*   | -.037<br>(.022)*   |
| Agri. share          | -.008<br>(.020)    | -.082<br>(.030)*** | -.080<br>(.031)*** |
| Serv. share          | .037<br>(.017)**   | .047<br>(.020)**   | .050<br>(.021)**   |
| Pop. growth          | -.388<br>(.124)*** | -.424<br>(.124)*** | -.443<br>(.134)*** |
| Pop. density         | .003<br>(.010)     | .066<br>(.035)*    | .076<br>(.036)**   |
| Country-time dummies | yes                | yes                | yes                |
| Const.               | .005<br>(.031)     | .128<br>(.041)***  | .127<br>(.042)***  |
| Obs.                 | 2861               | 2567               | 2420               |
| Regions              | 1040               | 876                | 828                |
| $R^2$                | .362               | .325               | .324               |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In each column we estimate fuzzy RDD specifications using a two stage instrumental variable procedure where the first stage is estimated nonlinearly. All specifications include region fixed effects. The standard errors are clustered by NUTS2 code. The distance matrices are used such that only those non-Objective 1 regions are included in the control group that are more than 100 km away from the next Objective 1 region in the first column 150km in the second and 200km in the third. The sample consists of the EU12 NUTS3 regions for the first period, the EU15 NUTS3 regions for the second and the EU25 NUTS3 regions for the third programming period. We miss information on the four French overseas-départements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated GDP per capita growth for the years 1989 and 1990 using information from the GDR's statistic yearbook.

Table 12: RDD NUTS2 - OBJECTIVE 1 AND EMPLOYMENT GROWTH

|             | sharp RDD       |                    | fuzzy RDD       |                  |                 |                 |
|-------------|-----------------|--------------------|-----------------|------------------|-----------------|-----------------|
|             | Pooled OLS      | FE                 | Pooled OLS      | FE               | Pooled OLS      | FE              |
|             | (1)             | (2)                | linear 1st      | (4)              | nonlinear 1st   | (6)             |
| Objective 1 | .001<br>(.002)  | .009<br>(.005)*    | .001<br>(.002)  | -.005<br>(.003)* | .002<br>(.002)  | -.003<br>(.003) |
| Const.      | -.005<br>(.018) | -.071<br>(.020)*** | -.009<br>(.018) | .024<br>(.026)   | -.011<br>(.018) | .023<br>(.026)  |
| Obs.        | 628             | 628                | 674             | 674              | 674             | 674             |
| Regions     | 263             | 263                | 279             | 279              | 279             | 279             |
| $R^2$       | .037            | .136               | .031            | .061             | .031            | .065            |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In all pooled OLS regressions the standard errors are clustered by NUTS2 code. The first two columns report sharp RDD specifications while columns four to six show the fuzzy RDD specifications using a two stage instrumental variable procedure. The first stage is estimated linearly in specifications three and four whereas specifications five and six build on nonlinear first stage estimations. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The sample consists of the EU12 NUTS2 regions for the first period, the EU15 NUTS2 regions for the second and the EU25 NUTS2 regions for the third programming period. We miss information on the four French overseas-departements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated employment growth for the first period by relying on information for the years 1991-1993 only.



Table 13: FUZZY RDD NUTS3 WITH CONTROLS - OBJECTIVE 1 AND EMPLOYMENT GROWTH

|                               | Pooled OLS         | FE                 | Pooled OLS         | FE                 | Pooled OLS         | FE                 |
|-------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                               | (1)                | (2)                | (3)                | (4)                | (5)                | (6)                |
| Objective 1                   | .0006<br>(.002)    | -.001<br>(.003)    | -.002<br>(.002)    | -.004<br>(.003)    | -.008<br>(.003)*** | -.003<br>(.002)    |
| Empl. share                   | -.045<br>(.011)*** | -.241<br>(.067)*** | -.044<br>(.011)*** | -.241<br>(.067)*** | -.045<br>(.013)*** | -.243<br>(.068)*** |
| Agri. share                   | .015<br>(.012)     | .058<br>(.038)     | .003<br>(.012)     | .057<br>(.038)     | .022<br>(.016)     | .069<br>(.037)*    |
| Serv. share                   | .025<br>(.008)***  | .017<br>(.023)     | .022<br>(.008)***  | .016<br>(.023)     | .029<br>(.011)***  | -.005<br>(.029)    |
| Pop. growth                   | .918<br>(.096)***  | .998<br>(.200)***  | .918<br>(.095)***  | .997<br>(.200)***  | .888<br>(.099)***  | .761<br>(.195)***  |
| Pop. density                  | .0008<br>(.0006)   | -.003<br>(.011)    | .001<br>(.0007)    | -.002<br>(.011)    | .0008<br>(.0006)   | -.024<br>(.012)**  |
| Voting power<br>in EU council |                    |                    | -.093<br>(.014)*** | -.044<br>(.038)    |                    |                    |
| Country-time<br>dummies       | no                 | no                 | no                 | no                 | yes                | yes                |
| Const.                        | -.027<br>(.019)    | .014<br>(.028)     | -.013<br>(.018)    | .012<br>(.025)     | -.028<br>(.023)    | -.063<br>(.030)**  |
| Obs.                          | 3300               | 3300               | 3300               | 3300               | 3300               | 3300               |
| Regions                       | 1207               | 1207               | 1207               | 1207               | 1207               | 1207               |
| $R^2$                         | .213               | .28                | .237               | .304               | .297               | .372               |

*Notes:* All regressions include a fourth order polynomial of the average GDP per capita on NUTS2 level over the years decisive for the eligibility threshold. In each column we estimate fuzzy RDD specifications using a two stage instrumental variable procedure where the first stage is estimated nonlinearly. In each case we run the pooled OLS regressions as well as the fixed effects regressions. The standard errors are always clustered by NUTS2 code. The sample consists of the EU12 NUTS3 regions for the first period, the EU15 NUTS3 regions for the second and the EU25 NUTS3 regions for the third programming period. We miss information on the four French overseas-départements and the two autonomous Portuguese regions Madeira and Azores for all three periods. For the Dutch region Flevoland we miss information for the first period only. Regarding the East-German NUTS3 regions we calculated employment growth for the first period by relying on information for the years 1991-1993 only.

Figure 1: OBJECTIVE 1 REGIONS

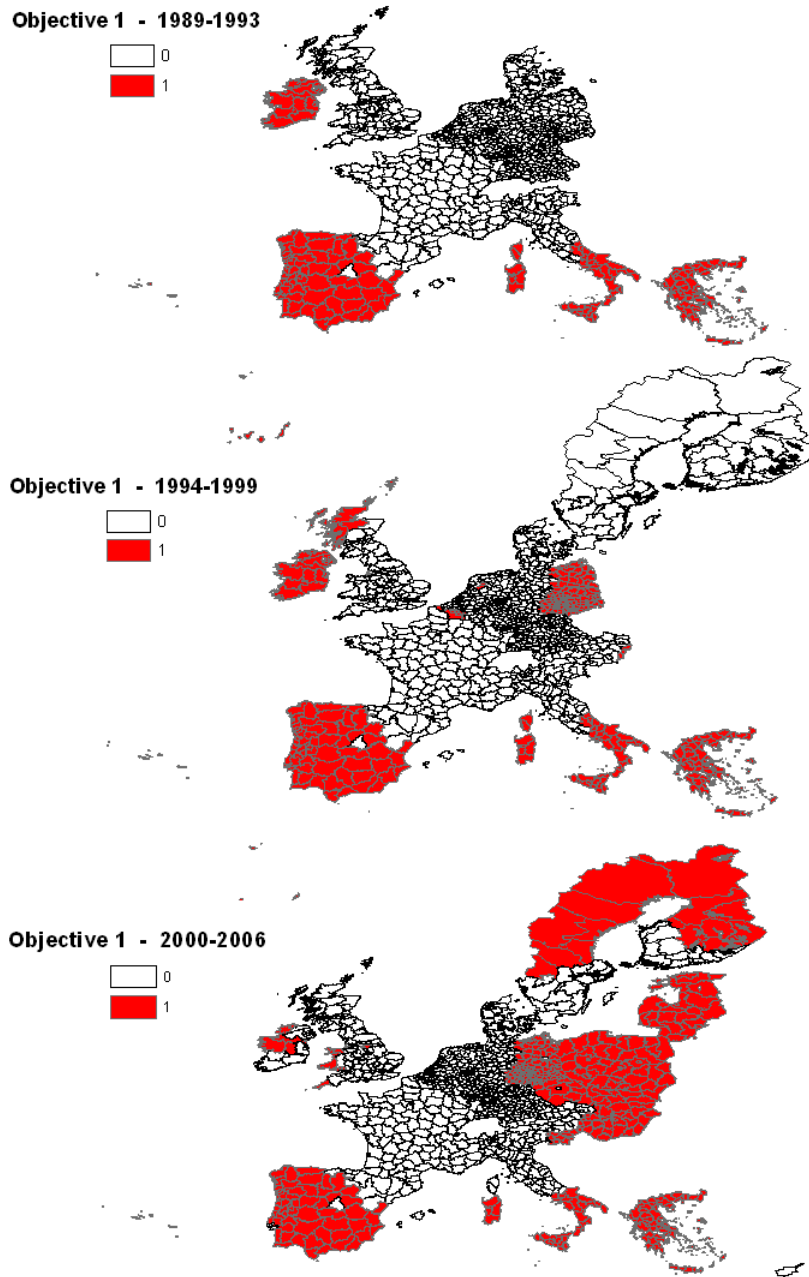
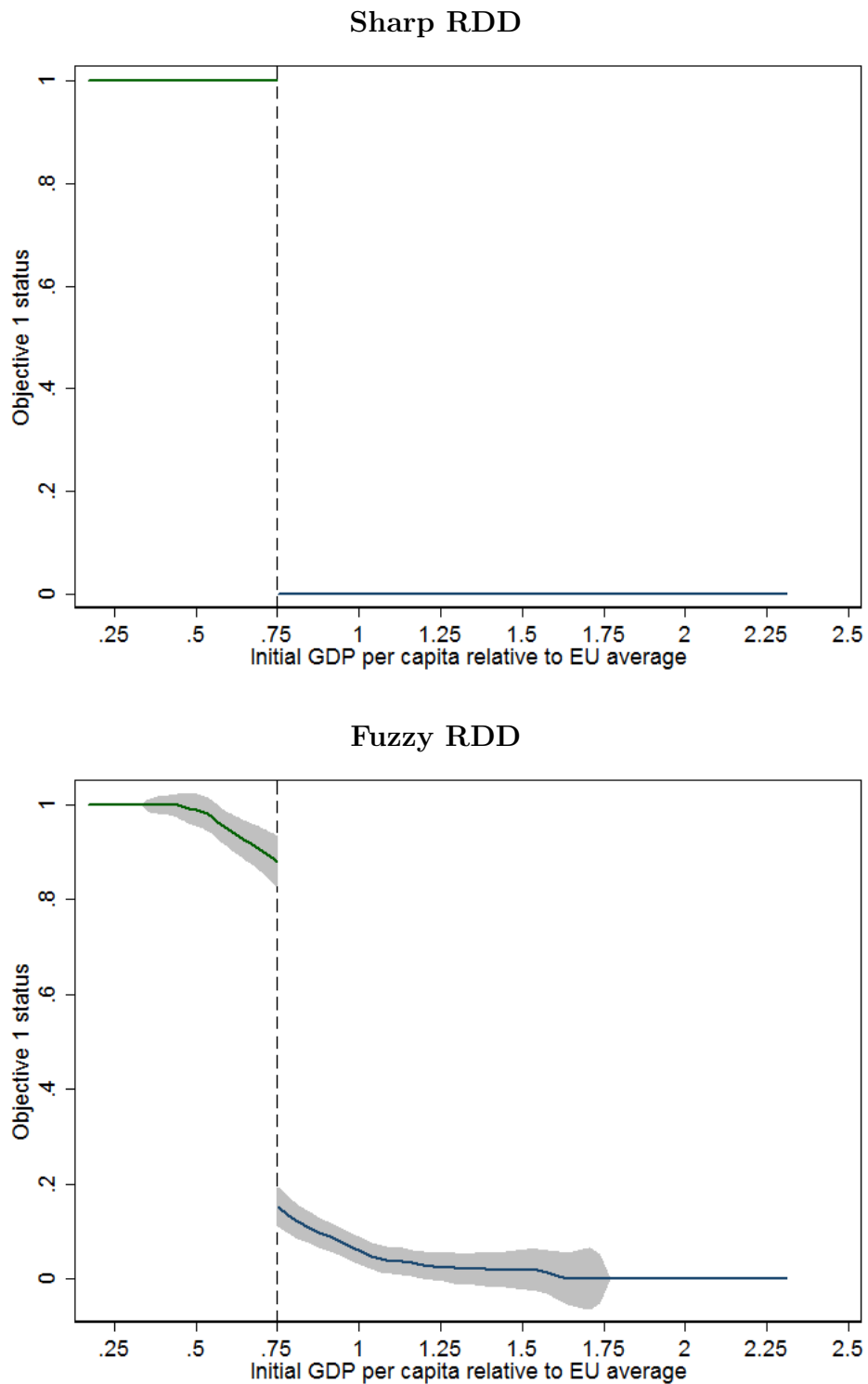


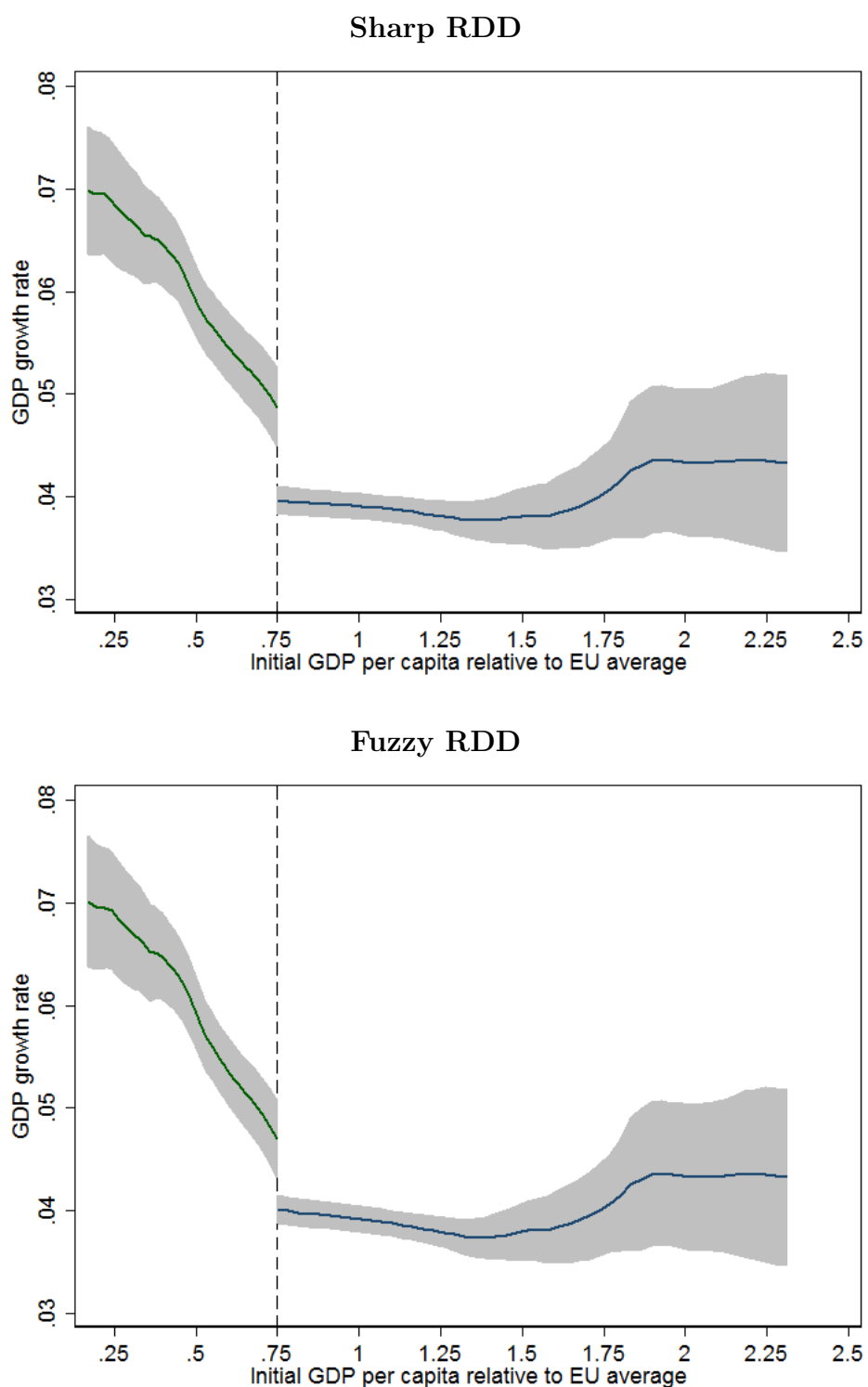
Figure 2: OBJECTIVE 1 STATUS AND THE 75% GDP THRESHOLD



*Note:* The sharp RDD is based on those NUTS2 regions (628 out of 674) where eligibility according to the 75% rule coincides with actual Objective 1 status. The fuzzy RDD uses all NUTS2 regions, including those that constitute exceptions from the 75% rule. See main text for details.

Local polynomial smooth along with confidence intervals; based on Epanechnikov kernel with rule-of-thumb bandwidth.

Figure 3: GROWTH AND THE 75% GDP THRESHOLD



*Note:* The sharp RDD is based on those NUTS2 regions (628 out of 674) where eligibility according to the 75% rule coincides with actual Objective 1 status. The fuzzy RDD uses all NUTS2 regions, including those that constitute exceptions from the 75% rule. See main text for details.

Local polynomial smooth along with confidence intervals; based on Epanechnikov kernel with rule-of-thumb bandwidth.

Figure 4: REGIONS CHANGING OBJECTIVE 1 STATUS

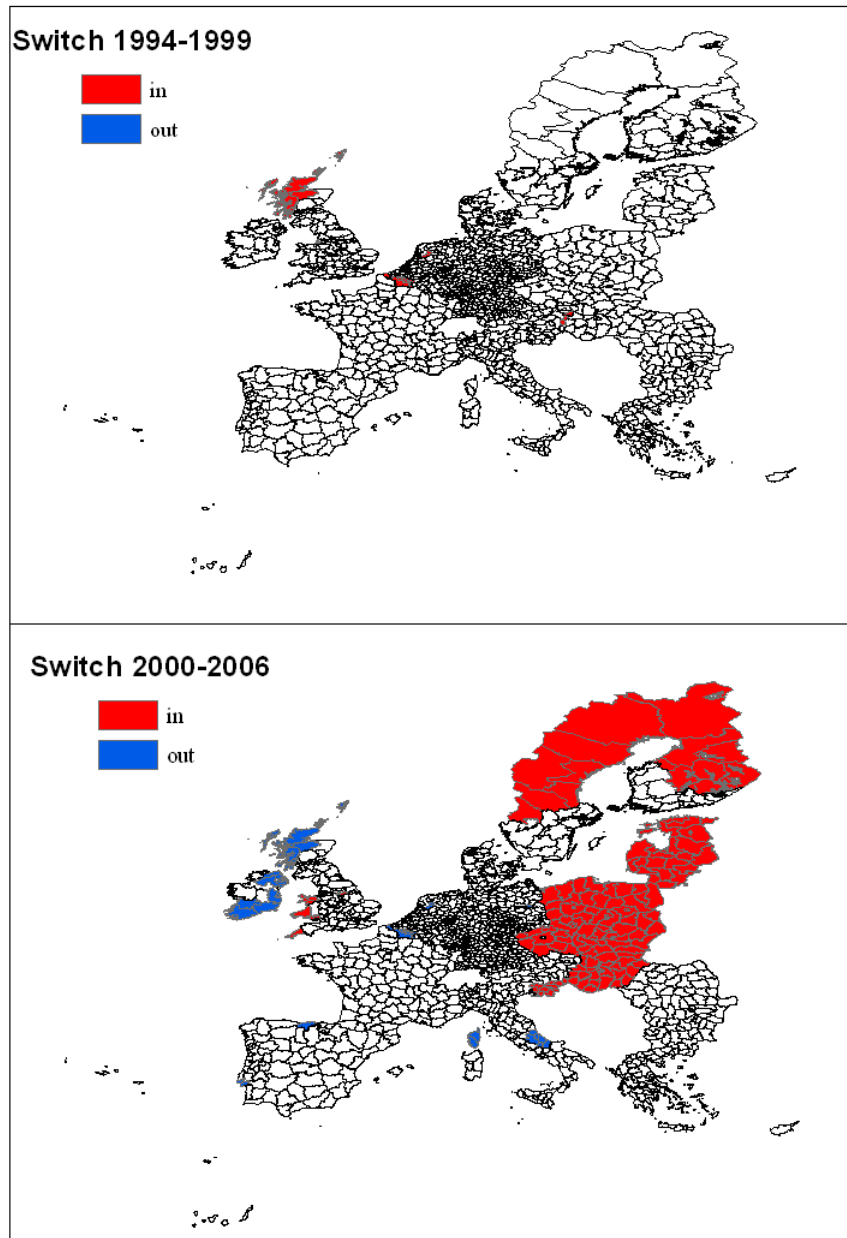
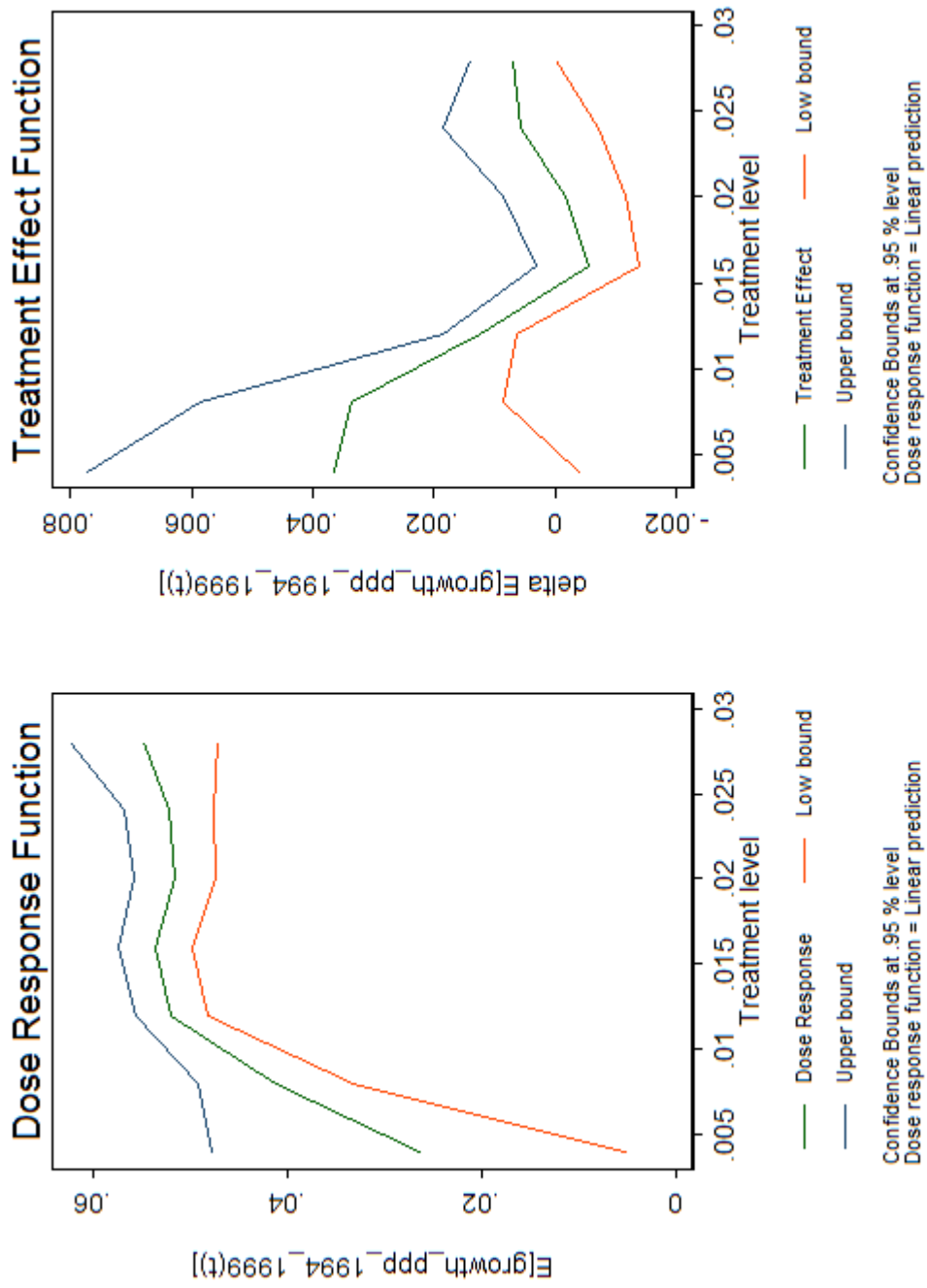


Figure 5: DOSE-RESPONSE ESTIMATES OF OBJECTIVE 1 TRANSFERS



Note: Objective 1 transfers are computed as a fraction of beginning of period GDP. See main text for details.