Productivity Growth across European Regions: the Impact of Structural and Cohesion Funds*

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Abstract

This paper analyses the impact of the European Union regional policy on the productivity growth of European regions. In the three programming periods we examined (1975-1988, 1989-1993 and 1994-1999) we find that Structural and Cohesion Funds have a positive effect on productivity growth, but the main effect is exerted by Objective 1 funds. Funds distributed to reach Objectives different from 1 have a negative (Objective 2) or nonsignificant effect on productivity. Secondly, the largest effect is found for the programming periods 1989-1993 and 1994-1999 when the size of the funds significantly increased and the allocation rules were reformed. Finally, the results are robust to funds' endogeneity and spatial dependence.

Keywords: European regional policy, economic growth, European regions.

JEL: *C21; E60; O52; R11; R12*

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1 Introduction

The European Union allocates a relevant part of its budget (about 35% for the period 2007-2013) to promote social and economic cohesion among the regions of the member states. The main instrument is represented by the Structural Funds, which are essentially allocated on regional basis. The Structural Funds are directed towards different aims: physical and human capital accumulation, development of transport infrastructures, aid to the unemployed, support to declining sectors, etc. The overall goal is to promote the competitiveness of European regions (Articles 130(f)-130(p), Single European Act, 1987) and, at the same time, to reduce: "disparities between the levels of development of various regions, and the backwardness of the less-favoured regions" (Article 130(a), Single European Act, 1987).

The effectiveness of EU funds has been mostly evaluated by analyses of growth and convergence in per capita GDP or labour productivity across European Regions but, so far, it is still under scrutiny. Although several studies find positive effects of EU policy, e. g. De la Fuente and Vives (1995), Cappelen *et al.* (2003), Beugelsdijk and Eijffinger (2005), Rodriguez-Pose and Fratesi (2004), Ederveen *et al.* (2006), Checherita *et al.* (2009) and Becker *et al.* (2010), other works find insignificant or even negative effects, e. g. Boldrin and Canova (2001), Dall'Erba and Le Gallo (2008) and Dall'Erba *et al.* (2009). In assessing these results, however, some qualification is often needed because the mentioned studies differ in terms of the type of fund analyzed, the sample size, and the period covered.

Specifically, De la Fuente and Vives (1995) study the effect of the ERDF (see below) on Spanish regions in the period 1986-1990; Cappelen *et al.* (2003) evaluate the effect of Structural Funds only for Objctives 1, 2 and 5 (see below) in regions from nine countries for the period 1980-1997; Beugelsdijk and Eijffinger (2005) consider regions from fifteen countries for the period 1995-2001; Rodriguez-Pose and Fratesi (2004) focus on Objective 1 regions from ten countries for the period 1989-1999, and find that only funds allocated to projects favoring human capital accumulation had a positive effect; Ederveen *et al.* (2006) study the effect of funds from the ERDF on thirteen EU *states* for the period 1960-1995, and find that a positive effect is conditional on the institutional quality of the country; Checherita *et al.* (2009) consider regions from nineteen countries in 1995-2005, and find that Structural and Cohesion Funds (see below) have a positive impact on growth if targeted to improving social and human resources, while funds allocated to the agricultural sector have a negative impact on growth (but the effect of funds disappears when country dummies are introduced); Becker *et al.* (2010), finally, study regions from twelve (or fifteen) countries for the period 1989-2006 and find a positive effect, but focus on Objective 1 regions only.

On the negative side, Boldrin and Canova (2001) study regions from fifteen countries between

1980 and 1996, and argue that indirect evidence of the ineffectiveness of the funds is the very weak convergence in the distributions of per capita GDP or labor productivity between 1980 and 1996. They also argue that, with respect to previous years, convergence among European regions slowed down in the early eighties, that is in a period in which the EU increased its efforts to favor cohesion through the distribution of funds. Dall'Erba and Le Gallo (2008) consider regions from twelve states in 1985-1995, while Dall'Erba *et al.* (2009) focus on the manufacturing sector only in the same sample for the period 1989-1999 and find that the effect of Objective 1 funding is negative, while the effect of Objective 2 funds is non significant.

Finally, most of these papers also differ in the econometric technique utilized (OLS, panel, with or without spatial effects or controls for endogeneity, etc.)[1], and for the choice of the variable of interest (per capita GDP, labour productivity, total factor productivity, unemployment, etc.)

Discrepancies in the results, therefore, are likely to depend on the differences across the various studies of the object of analysis. In this paper we aim at providing a more comprehensive analysis than those presented so far on growth and convergence of labour productivity at regional level. In particular, we consider a longer time-span, 1975-1999, which includes *three* programming periods (1975-1988, 1989-1993 and 1994-1999); a finer breakdown of the funds by Objective, and the joint consideration of Structural and Cohesion funds. Finally, we control for the possible presence of spatial effects and endogeneity (as in Dall'Erba and Le Gallo (2008) and Dall'Erba *et al.* (2009)).

We focus on labour productivity to evaluate the effectiveness of EU policy because: i) it is crucial to assess the attainment of the goal of increasing regional competitiveness. In fact, in the definition of competitiveness, productivity is an essential element;[2] ii) Increases of productivity can indirectly favour reduction of unemployment, another goal of EU policy;[3] iii) most of the growth models that are utilized to this aim, such as the one we introduce in Section 3, focus on labour productivity.

The main findings of the paper are the following. i) Structural and Cohesion Funds have a positive effect on productivity growth, but the main effect is exerted by Objective 1 funds. Funds distributed to reach Objectives different from 1 have a negative (Objective 2) or non significant effect on productivity. Objective 1 regions of Greece, Ireland, Portugal, Spain, Southern Italy and Northern UK, therefore, appear the have on average benefited the most from the European Regional Policy. Overall, since these regions were relatively poor, European Regional Policy seems to have favoured convergence in

[1] The recent paper of Becker *et al.* (2010) represents an exception being based on the regression discontinuity approach.

[2] See e. g. Annoni and Kozovska (2010).

[3] In a simple neoclassical framework as the one we adopt in this paper, an increase in labour productivity shifts labour demand upwards and reduces unemployment: voluntary, if wage is at its equilibrium level; involuntary, if it is above. Boldrin and Canova (2001), p. 235, suggest another possible channel: an increase in productivity in backward regions, through improvements in infrastructures, training, etc., attracts: "private investments, generates employment opportunities, brings down unemployment levels and increases per capita income in the long run".

European regions' productivities;[4] ii) the largest effect is found for the programming periods 1989-1993 and 1994-1999 when the size of the funds significantly increased and the allocation rules were reformed; iii) these results are robust to the potential endogeneity of funds and to the presence of spatial effects.

The paper is organized as follows. Section 2 summarizes the main features of EU regional policy and describes our dataset; Section 3 proposes a growth model incorporating EU regional Policy; Section 4 presents the results of the empirical analysis; Section 6 concludes.

2 The EU Regional Policy and the Dataset

In this section we present a short overview of EU regional policy, and discuss the characteristics of the dataset used in the analysis.

2.1 The European Union Regional Policy

Here we summarize the main characteristics of the process followed by the European Commission for the allocation of funds in the three programming periods: 1975-1988, 1989-1993 and 1994-1999.[5]

- 1975-1988. The European Regional Development Fund (ERDF) is established to finance infrastructure projects and productive investment in less-favoured regions.
- 1989-1993. Structural Funds are concentrated on the areas and/or social groups in greatest difficulty, according to socio-economic criteria. In particular, five main *Objectives* are introduced:
  - Objective 1: promoting the development and structural adjustment of backward regions, that is regions with a per capita GDP lower than 75% of EU average;
  - Objective 2: revitalising areas facing structural difficulties;
  - Objective 3: combating long-term unemployment;
  - Objective 4: facilitating the occupational integration of young people;
  - Objective 5: speeding up the adjustment of the agricultural and fishing sectors.

  Community Initiative Programmes (CIP) were added to these main objectives, by utilizing a limited portion of the Structural Funds on more specific issues.

[4] Fiaschi *et al.* (2010) analyse the impact of the European regional policy on the *distribution* dynamics of productivity across European regions, and provide further analysis on the issue of convergence.

[5] See `http://ec.europa.eu/regional_policy/policy/history/` and, e. g., Boldrin and Canova (2001), pp. 220-225, for more details.

- 1994-1999. The method of allocation of Structural Funds is partially revised. In particular:
  - Objectives 1, 2 and 5 remain unchanged, Objectives 3 and 4 are slightly redefined and the entry of Austria, Finland and Sweden in the European Union leads to the creation of Objective 6, to favour regions with very low population densities;
  - CIP are slightly redefined;
  - a Cohesion Fund of over 15 billions ecus is introduced to aid less-developed Member *states*, i. e. states with a per capita GDP below 90% of EU average, in their effort to attain the convergence criteria that were defined for the introduction of the Monetary Union (only countries in line with the program of convergence to the Monetary Union are indeed eligible). The specific purpose of the Cohesion Fund is to provide financial support for environmental investment projects and for transport infrastructure projects within the Trans-European Transport Network.

From our reading of the allocation criteria, funds do not unambiguously appear as a stimulus for productivity and, therefore, this could potentially interfere with the aim of favoring the competitiveness of European regions. In fact, only Objective 1 funds and Cohesion Funds are explicitly targeted to the poorest regions in order to favour productivity catching-up. On the contrary, Objective 2 funds, as long as they try to support declining industries, and Objective 5 funds, supporting the agricultural and fishing sectors, may actually slow down productivity growth. In particular, the latter funding is likely to interfere with the process of structural change in which mature sectors are gradually replaced by more innovative sectors, the size of the agricultural and fishing sectors shrinks, allowing resources to be reallocated to more productive industries.[6] These types of funding should be therefore considered more income support than stimuli to productivity growth.[7] In the same respect, Objectives 4, 6 and other types of funds of limited amount appear to be mainly income support. Our empirical analysis will try to shed light on this point.

2.2 The Structural and Cohesion Funds Dataset

We use data on Structural Funds covering three programming periods: 1975-1988 (Period I), 1989-1993 (Period II) and 1994-1999 (Period III).[8] Total *Commitments* are available for the whole period

[6] See, e.g., Temple (2001) for a discussion on structural change in Europe and the results of Section 4.

[7] As regards Objective 5 funds, it is explicitly stated that they aim at providing: "measures to support farm incomes and maintain activities in mountain, hill or less-favoured areas" (European Commission (2002)). Boldrin and Canova (2001), p. 211, argue that the overall EU policy appears: "to serve a redistributional purpose", and not to favour growth and convergence.

[8] Data are collected from different publications of the European Commission: European Commission (1989) (Period I), European Commission (1995) and and European Commission (1997) (Period II); European Commission (1997) and

1975-1999. Total *Payments* are available only for Period III, i. e. 1994-1999. All funds are expressed in 1995 constant prices. In our analysis we will mainly use commitments as proxy for actual payments, with the exception of the analysis of Period III.

We consider European regions at the NUTS 2 level[9] but, since only 33% of total funds are directly allocated to individual regions, we adopted the following criteria to approximate the actual amount of funds received by a region:

- if the fund is jointly allocated to a group of regions, we reassign it to individual NUTS 2 regions in an amount inversely proportional to their per capita GDP in the initial year of the programming period (11% of total funds);
- if the fund is allocated to a country, but it is possible to identify the eligible regions (e. g. Objective 1), then it is reassigned to all the, e. g., Objective 1 regions in an amount inversely proportional to their per capita GDP in the initial year of the programming period (38% of total funds);
- if the fund is allocated at country level, but it is not possible to identify the eligible regions (e. g. Cohesion Funds), then we reassign it to all the NUTS 2 regions of the country in an amount inversely proportional to their per capita GDP in the initial year of the programming periods (18% of total funds).[10]

We chose to reassign the funds proportionally to per capita GDP since this is the main criterion used for the allocation of most of the funds (e. g. Objective 1 and Cohesion Funds). The results presented below on the effects of Structural funds remain significantly unaffected if we reassign to individual regions equal shares of the funds allocated to a group of regions or to a country.[11]

2.3 Descriptive Statistics on Structural and Cohesion Funds

Our measure of the funds received by a region will be the ratio of the funds on regional gross value added (GVA). This variable will be labelled *SCF* in the following.[12] Table 1 shows that: i) the total amount of funds increased over time, raising from 0.06% of total European GVA in the Period I, to 0.5% in Period III; ii) average regional *SCF* slightly decreased; iii) the standard deviation of *SCF*

European Commission (2000) (Period III).

[9] Appendix C contains the list of regions.

[10] Such procedure is necessary because no detailed database on EU funds is available. See also the appendix of Rodriguez-Pose and Fratesi (2004).

[11] These results are available upon request.

[12] Data on regional GVA are from Cambridge Econometrics (2004). Codes and data are available in the authors' websites.

decreased, indicating that funds were distributed more and more equally across the regions over the three programming periods.

Programming Period	Share of funds on EU GVA	Average *SCF*	St. Dev. of *SCF*
Period I (1975-1988)	0.06	0.0054	0.0103
Period II (1989-1993)	0.28	0.0054	0.0082
Period III (1994-1999)	0.50	0.0049	0.0065

Table 1: Descriptive statistics on Structural and Cohesion Funds in the three programming periods

Table 2 illustrates the change over time in the allocation to the different objectives. Given that the Objectives were not defined in Period I, we label the whole allocation "Objective 0". We notice that Objective 1, since its introduction, attracted the largest share of funds, followed by the shares of Objective 2 and Cohesion funds, amounting to approximately 9% of total funds.[13]

Objective	Period I (1975-1988)	Period II (1989-1993)	Period III (1994-1999)
0	100	-	-
1	-	63.23	61.67
2	-	8.94	9.05
3	-	-	6.68
4	-	-	1.22
3 & 4	-	10.10	-
5	-	9.55	6.85
6	-	-	0.38
NL	-	4.66	-
PIM	-	1.02	-
2 Init.	-	-	3.07
Other Init.	-	-	1.68
Cohesion	-	2.50	9.39
Total	100	100	100

Table 2: Percentage of commitments of funds according to Objectives. "NL": New Länder in Germany in Period II; "PIM": regional program in Period II for regions outside Objective 1; "2 Init.": regional initiatives similar to Objective 2 for period III (*Adapt*, *Employment*, *Rechard*, *Resider*, *Retex*, *Konver*, *SMEs*), "Other Init.": other initiatives in Period III (*Leader*, *Regis*, *Urban*, *Pesca*, *Peace*)

In Table 3 we report the share of funds allocated to the least productive regions, i. e. regions with a per worker GVA at the beginning of a programming period lower than the 75% of the sample mean.[14] In Period I, only 55% of total Structural and Cohesion Funds was allocated to these regions,

[13] Although the Cohesion Fund was created with the 1993 reform, it began to operate in 1993 under a temporary regulation. Thus, a part of the total funds was allocated as Cohesion Fund also in Period II.

[14] We consider a threshold for labour productivity as this variable will be the focus of our empirical analysis. The correlation between the per capita GDP and the per worker GVA of regions in the three programming periods is however

while this share decreased in subsequent periods. As predictable, the share is higher for Objective 1 and Cohesion Funds, as these funds are allocated according to the level of regional per capita GDP. Notice that the share of funds different from Objective 1 and Cohesion allocated to the least productive regions, is relatively low (lower than 50%), and it *increased* in Period III.

	Period I (1975-1988)	Period II (1989-1993)	Period III (1994-1999)
All.Obj	54.03	47.13	35.15
Ob. 1	-	66.18	43.61
Ob. 2	-	11.70	4.68
Ob. 3 & 4	-	18.81	8.36
Ob. 5	-	8.00	3.51
Ob. NL & PIM & 6	-	0	0
Ob. 2 In. & Other In.	-	-	28.01
Cohesion	-	63.22	61.50

Table 3: Percentage of total funds given to regions with per worker GVA below 75% of sample mean

Thus, Table 3 highlights that a relevant share of funds is not actually channelled to the poorest (less productive in our case) regions. In other words, a non negligible part of EU funding does not appear to be strictly devoted to helping the less-developed regions.[15]

2.4 Commitments vs Payments

So far we have discussed data on *Commitments* of funds. However, a more precise measure of the impact of funds on regions' productivity should consider the amount of funds actually spent. Table 4 reports the ratio of Payments on Commitments for each country of our sample. The generalized reduction of this ratio from the first to the third period can be explained by the change in the regulation of funding adopted in 1988 and, in particular, by the adoption of the *additionality principle*.[16] Some countries, like Spain and Ireland, have however maintained high ratios of Payments on Commitments over all the three periods, while other countries, like the United Kingdom, Netherlands and Italy, had

very high (0.87, 0.83 and 0.86), respectively.

[15]Some caveats to this claim are the following. The percentage of Cohesion and Objective 1 funds allocated to the less productive regions of our sample can be lower than 100% because: i) our sample mean is different from the one considered by the Commission for the eligibility; ii) our sample includes some *phasing out* regions, i.e. regions having no longer a GDP lower than the 75% (or belonging to States with less than 90%) of the sample mean but still receiving the funds as Objective 1 or Cohesion.

[16]According to the *additionality principle*, the Structural Funds should not substitute national funding, but they should provide additional assistance. The Member States, therefore, must maintain their public expenditure at the level of the beginning of the programming period and contribute to financing the projects financed by the EU. Dall'Erba *et al.* (2009) consider the additional funds provided by the states in their empirical analysis. We cannot take this aspect into account in the present work for lack of data.

generally very low ratios (especially in the Period III).

Country	Period I (1975-1988)	Period II (1989-1993)	Period III (1994-1999)
AT	-	-	0.59
BE	0.94	0.81	0.70
DE	0.95	0.82	0.71
DK	0.96	0.78	0.76
ES	0.76	0.84	0.80
FI	-	-	0.63
FR	1.10	0.82	0.70
GR	1.08	0.83	0.72
IE	0.92	0.93	0.86
IT	0.89	0.70	0.60
LU	0.47	0.59	0.67
NL	0.99	0.76	0.60
PT	0.98	0.89	0.88
SE	-	-	0.70
UK	0.93	0.80	0.64

Table 4: Ratio of Payments on Commitments in the three programming periods at country level

Overall, the heterogeneity in the ratio of Payments on Commitments across countries suggests to use Payments in order to have a more precise estimate of the actual impact of *SCF* on productivity. Unfortunately, the type of analysis will be restricted only to Period III, for the lack of data at NUTS2 level for the other programming periods, for which Commitments will be used as proxy for Payments.

To sum up, we have documented that: i) the resources devoted by the European Union to the Regional Policy have increased over the three programming periods; ii) the largest amount of Structural Funds is allocated to reach Objective 1; iii) the share allocated to Cohesion Funds is relatively large, and has remarkably increased in the last programming period; iv) Objective 2 funding is also substantial, relative to the other Objectives different from 1; v) a non negligible share of EU funding is received by “not-so-poor” regions; vi) there exists remarkable heterogeneity in the ratio of Payments on Commitments across countries.

3 A Growth Model with Structural and Cohesion Funds

In this section we present a theoretical model which will guide our empirical analysis. In particular, we introduce the effect of structural and cohesion funds on productivity in a simplified version of the model by Ertur and Koch (2007) (EK hereafter). The EK model features spatial externalities across neighbour economies, an aspect that received attention in recent studies on economic growth, especially on regional growth (e. g. Fingleton and López-Baso (2006), Dall’Erba and Le Gallo (2008) and Dall'Erba *et al.* (2009)). Specifically, the model features technological externalities, by which the technological level of a region is positively affected by the technological level of its neighbours.

Consider a Cobb-Douglas production function, and assume that output of region i at time t, $Y_i(t)$, is defined as:

$$Y_i(t) = \Psi\left(SCF_i\right) K_i^{\alpha}(t) \left(L_i(t) A_i(t)\right)^{1-\alpha} \tag{1}$$

where SCF_i indicates the funds allocated to region i on its level of output $Y(i)$, i.e. the amount of fund per unit of output, while $\Psi(\cdot)$ describes their impact on $Y_i(t)$. We assume that there are constant returns to scale in the accumulable factors, i.e. $0 \leq \alpha \leq 1$, and that $\Psi(\cdot)$ is increasing in its argument(s), i. e. $\Psi'(\cdot) > 0$, and $\Psi(0) = 1$, i. e. the availability of structural funds is not essential to carry out production. With this specification SCF can be seen as a factor enhancing the private returns of factors, as public expenditure in Barro (1990).[17]

$K_i(t)$ and $L_i(t)$ respectively denote the capital stock and employment, while $A_i(t)$ is the aggregate level of technology. Following EK, we introduce the spillovers across regions as technological spillovers affecting the term A. In particular, we assume that:

$$A_i(t) = \Omega_i(t) \prod_{j \neq i}^{N} A_j(t)^{\theta w_{ij}}, \tag{2}$$

where $\Omega_i(t)$ measures the technological level of region i that does not depend on the technological level of neighbour regions, the parameter θ $(0 \leq \theta < 1)$ measures the intensity of the spatial externalities, and the parameters w_{ij} measure the relative connectivity between region i and its neighbours. These terms are non-negative, non-stochastic, finite, and such that $0 \leq w_{ij} \leq 1,$and $w_{ij} = 0$ if $i = j$ and we assume that $\sum_{j \neq i}^{N} w_{ij} = 1$for $i = 1, ..., N$.

Assuming that $\Omega_i(t) = \Omega_i(0) e^{\mu t}$ we obtain:[18]

$$A_i(t) = \Omega_i(0)^{\nu_{ii}} \prod_{j \neq i}^{N} \Omega_j(0)^{\nu_{ij}} e^{\frac{\mu t}{1-\theta}} = \bar{\Omega}_i(0) e^{\frac{\mu t}{1-\theta}}, \tag{3}$$

where $\bar{\Omega}_i(0) = \Omega_i(0)^{\nu_{ii}} \prod_{j \neq i}^{N} \Omega_j(0)^{\nu_{ij}}$, $\nu_{ii} = 1 + \sum_{r=1}^{\infty} \theta^r {w_{ii}}^{(r)}$ and $\nu_{ij} = \sum_{r=1}^{\infty} \theta^r {w_{ij}}^{(r)}$.

That is, we assume that the level of technology $A_i(t)$ of region i in period t depends on: an exogenous growth rate μ, which is constant across regions; its initial technological level, $\Omega_i(0)$, and the technological level A_j, $j = 1, ..., N$, of its N neighbour regions, which depends on μ and on their initial technological levels $\Omega_j(0)$.[19]

[17]With this specification, therefore, we aim at capturing the broad role that EU funds should play on the supply side which, in our view, is similar to the one played by total factor productivity. Globally, according to the specification of function $\psi(.)$, the production function may display constant, increasing or decreasing returns to scale. This aspect, however, will be irrelevant in our empirical analysis since we will estitate unrestricted specifications of regressions based on Eq. (1).

[18]See Appendix A for the proof.

[19]In the EK model the spatial externalities are generated by the externalities that the accumulation of capital in region

3.1 Equilibrium

For an economy i at time t, define $y_i(t)$ as the output per worker and $y_i^E(t)$ as the output per efficiency unit, that is:

$$y_i(t) \equiv \frac{Y_i(t)}{L_i(t)} = \Psi\left(SCF_i\right) k_i(t) A_i(t)^{1-\alpha}, \tag{4}$$

$$y_i^E(t) \equiv \frac{Y_i(t)}{A_i(t)L_i(t)} = \Psi\left(SCF_i\right) k_i^E(t)^{\alpha}. \tag{5}$$

As in the standard Solow model, we assume that the investment rate of region i is constant and equal to s_i and that L_i grows at constant rate n_i. Thus, the equation describing capital accumulation in region i is:

$$\dot{k}_i(t) = s_i y_i(t) - \left(\delta + n_i\right) k_i(t), \tag{6}$$

where δ is the depreciation rate of capital (assumed for simplicity equal for all regions). From Eqq. (4) and (6) we have:

$$\frac{\dot{k}_i(t)}{k_i(t)} = \frac{s_i y_i(t)}{k_i(t)} - \left(\delta + n_i\right), \tag{7}$$

while from Eqq. (5) and (7) we have:

$$\frac{\dot{k}_i^E(t)}{k_i^E(t)} = s_i \Psi\left(SCF_i\right) (k_i^E)^{\alpha-1} - \left(\delta + n_i + \frac{\mu}{1-\theta}\right). \tag{8}$$

The capital/labour ratio of region i, for $i = 1, ..., N$ converges to the balanced growth rate $g \equiv \frac{\mu}{1-\theta}$. Therefore, the equilibrium level of capital $k_{i,\infty}^E$ is given by:

$$k_{i,\infty}^E = \left[\frac{s_i \Psi\left(SCF_i\right)}{\delta + n_i + \frac{\mu}{1-\theta}}\right]^{\frac{1}{1-\alpha}}, \tag{9}$$

while the equilibrium level of output $y_{i,\infty}^E$ is:

$$y_{i,\infty}^E = \Psi\left(SCF_i\right)^{\frac{1}{1-\alpha}} \left[\frac{s_i}{\delta + n_i + \frac{\mu}{1-\theta}}\right]^{\frac{\alpha}{1-\alpha}}. \tag{10}$$

Since the technology is characterized by externalities across regions, the equilibrium level of output depends not only on the usual technological and preference parameters, but also on the technology in neighbouring regions: the influence of the spillover effect increases with θ (Ertur and Koch (2007), p. 1038). Following Durlauf *et al.* (2005), p. 577, we obtain the growth rate of income in efficiency unit:

$$\begin{aligned}\gamma_i &= \frac{\mu}{1-\theta} - \beta\frac{1}{1-\alpha}\log\Psi\left(SCF_i\right) - \beta\frac{\alpha}{1-\alpha}\left[\log s_i - \log(\delta + n_i + g)\right] + \\ &- \beta\log\bar{\Omega}_i(0) + \beta\log y_i(0). \end{aligned}\tag{11}$$

i generates on A_i and on the technological level of its neighbour regions. Given that with this hypothesis the specification of the regression to be estimated is not significantly affected, we do not introduce it. Differently from EK, in addition, we introduce heterogeneity across regions through different initial technological levels.

Recalling that $\bar{\Omega}_i(0) = \Omega_i(0)^{\nu_{ii}} \prod_{j \neq i}^N \Omega_j(0)^{\nu_{ij}}$, $\nu_{ii} = 1 + \sum_{r=1}^{\infty} \theta^r w_{ii}{}^{(r)}$ and $\nu_{ij} = \sum_{r=1}^{\infty} \theta^r w_{ij}{}^{(r)}$, we can rewrite Eq. (11) as:

$$\begin{aligned} \gamma_i &= g - \beta \frac{1}{1-\alpha} \log \Psi\left(SCF_i\right) - \beta \frac{\alpha}{1-\alpha} \left[\log s_i - \log(\delta + n_i + g)\right] + \\ &- \beta \log \Omega_i(0) - \beta \sum_{j=1}^{N} \sum_{r=1}^{\infty} \theta^r w_{ij}^{(r)} \log \Omega_j(0) + \beta \log y_i(0). \end{aligned} \tag{12}$$

Following Ertur and Koch (2007), we rewrite Eq. (12) in matrix form and we pre-multiply all terms by $(\mathbf{I} - \theta \mathbf{W})$:

$$\begin{aligned} (\mathbf{I} - \theta \mathbf{W})\gamma &= \frac{\mu}{1-\theta}(\mathbf{I} - \theta \mathbf{W})\mathbb{1} - \beta \frac{1}{1-\alpha}(\mathbf{I} - \theta \mathbf{W})\boldsymbol{\Psi} - \beta \frac{\alpha}{1-\alpha}(\mathbf{I} - \theta \mathbf{W})\left[\mathbf{s} - \mathbf{n}\right] + \\ &- \beta(\mathbf{I} - \theta \mathbf{W})\boldsymbol{\Omega}(0) - \beta \boldsymbol{\Omega}(0) + \beta(\mathbf{I} - \theta \mathbf{W})\mathbf{y}(\mathbf{0}). \end{aligned} \tag{13}$$

where γ is the $(N \times 1)$ vector of average growth rates of productivity, $\boldsymbol{\Psi}$ is the $(N \times 1)$ vector of (log of) SCF, $\mathbf{s}$ is the $(N \times 1)$ vector of (log of) investment rates, $\mathbf{n}$ is the $(N \times 1)$ vector of (log of) augmented employment growth rates, $\boldsymbol{\Omega}$ is the $(N \times 1)$ vector of (log of) initial level of technology, $\mathbb{1}$ is the $(N \times 1)$ vector of ones and $\mathbf{y}(\mathbf{0})$ is the $(N \times 1)$ vector of (log of) initial productivity. Finally, rewriting this equation for region i we obtain:

$$\begin{aligned} \gamma_i &= \mu - \beta \frac{1}{1-\alpha} \log \Psi\left(SCF_j\right) - \beta \frac{\alpha}{1-\alpha} \left[\log s_i\right] + \beta \frac{\alpha}{1-\alpha} \left[\log\left(\delta + n_i + g\right)\right] \\ &- 2\beta \log \Omega_i(0) + \beta \log y_i(0) + \theta \frac{\beta}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log \Psi\left(SCF_j\right)\right] + \\ &+ \theta\beta \frac{\alpha}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log s_j\right] - \theta\beta \frac{\alpha}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log\left(\delta + n_j + g\right)\right] + \\ &+ \theta\beta \left[\sum_{j=1}^{N} w_{ij} \log \Omega_j(0)\right] - \theta\beta \left[\sum_{j=1}^{N} w_{ij} \log y_j(0)\right] + \theta \sum_{j=1}^{N} w_{ij} \gamma_j. \end{aligned} \tag{14}$$

In Eq. (14) the growth rate of productivity of region i is, therefore, the sum of region-specific growth determinants, of spatially weighted growth determinants of neighbour regions, and of spatially weighted neighbour regions' growth rates. Eq. (14) will be the basis for the empirical analysis presented in the following section.

4 Empirical Analysis

This section evaluates the impact of funds by estimating an econometric model based on Eq. (14). Mankiw *et al.* (1992) argue that $\Omega_i(0)$ should be interpreted as reflecting not just technology (assumed constant across regions) but region-specific influences on growth such as resources endowments, climate and institutions. Therefore, we assume that $\log \Omega_i(0) = \log \Omega(0) + \pi Z_i(0)$, $\forall i$, that is the sources of heterogeneity in the initial technological levels of region i may be proxied by additional control variables $Z_i(0)$. Finally, we add an error term e_i reflecting country-specific shocks and we obtain:

$$\begin{aligned}
\gamma_i &= \mu - 2\beta\theta \log \Omega(0) - \beta \frac{1}{1-\alpha} \log \Psi\left(SCF_j\right) - \beta \frac{\alpha}{1-\alpha} \left[\log s_i\right] + \\
&+ \beta \frac{\alpha}{1-\alpha} \left[\log\left(\delta + n_i + g\right)\right] + \beta \log y_i(0) - 2\beta\pi Z_i(0) + \\
&+ \theta \frac{\beta}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log \Psi\left(SCF_j\right)\right] + \theta\beta \frac{\alpha}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log s_j\right] + \\
&- \theta\beta \frac{\alpha}{1-\alpha} \left[\sum_{j=1}^{N} w_{ij} \log\left(\delta + n_j + g\right)\right] - \theta\beta \left[\sum_{j=1}^{N} w_{ij} \log y_j(0)\right] + \\
&+ \theta\beta\pi \left[\sum_{j=1}^{N} w_{ij} Z_j(0)\right] + \theta \sum_{j=1}^{N} w_{ij}\gamma_j + e_i. \qquad (15)
\end{aligned}$$

Moreover, we specify $\Psi(\cdot)$ as:

$$\Psi(SCF_i) = e^{\eta_1 SCF_i + \eta_2 SCF_i^2}. \qquad (16)$$

Eq. (16) satisfies our assumptions on $\Psi(\cdot)$, i. e., $\Psi(0) = 1$ and $\Psi'(\cdot) > 0$, and allows for the presence of nonlinearities (e. g. decreasing returns) in the impact of the funds; in particular, it allows to test whether $\partial^2\theta_i/\partial SCF_i{}^2$ is negative by the estimated sign of the coefficient of SCF_i^2.

Rewriting Eq. (15) in matrix form, we have:

$$\gamma = \mathbf{X}\lambda + \mathbf{Z}\phi + \mathbf{WX}\tau + \mathbf{WZ}\xi + \theta\mathbf{W}\gamma + \mathbf{e} \qquad (17)$$

where γ is the $(N \times 1)$ vector of average growth rates of productivity, $\mathbf{X}$ is the $(N \times 6)$ matrix of explanatory variables, including the constant term, the Solow regressors (i.e., the investment rates, the augmented employment growth rates and the initial level of productivity) and the variables on structural funds SCF and SCF^2, $\mathbf{Z}$ is the $(N \times K)$ matrix of additional control variables. $\mathbf{W}$ is the row-standardized $(N \times N)$ spatial weight matrix, $\mathbf{WX}$ and $\mathbf{WZ}$ are respectively is the $(N \times 5)$ and $(N \times K)$ matrices of spatially lagged exogenous variables,[20] and $\mathbf{Wy}$ is the endogenous spatial lag variable. $\mathbf{e}$ is the $(N \times 1)$ vector of independently and identically distributed errors with mean zero and variance $\sigma^2 I$. Therefore, as in Ertur and Koch (2007) the empirical specification is a spatial Durbin model (SDM).

[20] The spatially lagged constant is not included in $\mathbf{WX}$ since the spatial lag of the constant is the constant itself.

4.1 Results

We study the period 1980-2002, and consider regions at NUTS2 level for 12 EU countries.[21] Our dependent variable is the annual average growth rate of per worker GVA of a region. For short, we will indicate this as labour productivity.

We include as explanatory variables:[22] the share of funds on regional GVA with a three-year lag (SCF);[23] the initial productivity level, normalized with respect to sample average ($PROD.REL.INI$); some variables suggested by the standard Solow model and present in the model of Section 3, such as the average annual investment rate ($INV.RATE$), and the average annual employment growth rate ($EMP.GR$). [24] As further controls, i. e. as elements of vector $\mathbf{Z}_i$, we consider the initial value of the density of economic activity, measured by GVA per km^2, to control for the possible presence of agglomeration effects (see Ciccone and Hall (1996)), and some variables that control for the initial structure of the regional economy, i. e. the relative share of GVA in Manufacturing, Mining, Construction, Non Market Services, Financial Services, Hotels and Restaurants, Transportation, Wholesale and Retail, Other Services, and Agriculture.[25] Finally, we introduce country dummies (excluding Germany) to capture the effects of variables like political institutions, regulation in labour and product markets, educational systems, etc., i. e. variables whose dimension is typically national, or for which we have no data at regional level. When we estimate a Spatial Durbin model, we add to the regressors the spatial lags for all explanatory variables and for the dependent variable, i. e. the level of productivity of neighbour regions.

In the empirical analysis we will estimate an unrestricted version of Eq. (15).[26] Moreover, we

[21] In particular, we do not consider Austria, Finland and Sweden since they jointed in the EU only on 1 January 1995 and, consequently, they received funds only in the third programming period.

[22] Appendix D contains the descriptive statistics of the variables.

[23] Specifically, for a given programming period, we consider the yearly average level of funds for the whole period divided by the level of GVA at the beginning of the period. For example, the growth rate of productivity over the period 1980-2002 is regressed on the yearly average of funds relative to the period 1977-1999 divided by the level of GVA in 1977. This procedure aims at reducing the possible endogeneity of the funds with respect to the growth rate of productivity and at taking into account possible delayed effects of the funds. Results are robust to alternative lags (1-4 years). Moreover, results are similar when region ES63 (Ceuta and Melilla) is removed from the sample (the value of region ES63's GVA appears uncertain, given that the values reported in Cambridge Econometrics (2004) and in Eurostat-Regio datasets present a huge discrepancy for the most recent years).

[24] The average growth rate of employment EMP.GR is augmented by the rate of depreciation of capital, but not by the long-run trend of productivity, as the latter is already taken into account by considering relative productivity. Given that have no data on capital at regional level, we use the value of 0.03 proposed by Mankiw *et al.* (1992).

[25] Fiaschi and Lavezzi (2007) show that the introduction of these controls improves the goodness of fit in this type of regressions. The role of the structure of the economy on the dynamics of productivity is explicitly studied in Fiaschi *et al.* (2010).

[26] For sake of completeness we also tested for the joint theoretical restrictions on coefficients. Tests of restrictions are

will use two different spatial matrices: the matrix **W1**, used in Ertur and Koch (2007), which is based on the inverse of the great circle distance (d_{ij}) between the centroids of two regions (see Ertur and Koch (2007), p. 1043); the matrix **W2**, a *first order contiguity matrix*, in which two regions are considered neighbours if they share a common border (both matrices are row-standardized).[27]

We will consider different specifications (models) of a growth regression based on Equation (17). In particular, in Models I-III we will examine the effect of the inclusion of an aggregate measure of *SCF*, but Models I and II consider *SCF* over the entire period, where the last two programming periods are jointly considered,[28] while Model III only considers funds in Periods II & III. While Models I and III are cross-section, Model II is based on a pooled regression with dummies on the different programming periods and on the coefficients of *SCF*.

In Models IV-VI we will introduce a breakdown of the funds according to the objectives and, therefore, we will only limit to the Periods II & III. Specifically, Model IV considers all the different objectives while Models V and VI only consider the most substantial funds, i.e. funds of Objective 1 and the Cohesion Fund.

Finally, Models VII and VIII separately consider the effects of Commitments and Payments for the third programming period, being the only one for which we have data on Payments (denoted PAY).

Before proceeding, we control for the presence of spatial effects and heteroschedasticity. Table 5 contains the results of Global Morans'I tests for the presence of spatial effects and the Breusch-Pagan test for heteroschedasticity.

MODEL	I	II	III	IV	V	VI	VII	VIII
Funds	SCF (1975-1999)	SCF (1975-1999)	SCF (1989-1999)	All Ob. (1989-1999)	OB1&CF (1989-1999)	OB1&CF (1989-1999)	Comm (1994-1999)	Pay (1994-1999)
Moran's I (**W1**)	0.0321 (0.0021)	−0.0049 (0.2263)	0.0008 (0.0780)	−0.0138 (0.2335)	0.0008 (0.0784)	0.0014 (0.0742)	−0.0020 (0.1006)	−0.0021 (0.1024)
Moran's I (**W2**)	0.1218 (0.0005)	0.1767 (0.0000)	0.0335 (0.0665)	0.0036 (0.1857)	0.0393 (0.0520)	0.0406 (0.0490)	0.0048 (0.2000)	0.0070 (0.1873)
BP test	71.6483 (0.0000)	94.0982 (0.0000)	33.7142 (0.1424)	42.1698 (0.0870)	33.6148 (0.1775)	34.354 (0.156)	50.2365 (0.0043)	51.5099 (0.0030)

Table 5: Tests for spatial effect and heteroschedasticity for models I-VIII, p-values in parenthesis

The results in Table 5 show that in the specification of Model I we must reject the null hypotheses of no spatial effects and homoskedasticity. In particular, both spatial matrices lead to the same conclusion. In Model II we reject the null hypothesis of no spatial effects with **W2** only, while in Models III and V we reject it at 10% significance level. In Model VI we reject it at 5% and 10%

always rejected.

[27]See Appendix B for details.

[28]This is motivated by the relatively shortness of the latter two periods with respect to the former, and is justified by the relative homogeneity of the rules governing the allocation of funds in Periods II & III with respect to Period I. We remarked in Section 2.1 that these rules significantly changed after the programming period 1975-1988.

with, respectively, **W2** and **W1**, while in Models IV, VII and VIII we do not reject it. Finally, we reject the null of homoskedasticity at 5% significance level in models I, II, VII and VIII, and at 10% significance level in Model IV. Overall, we find that spatial effects should be included in most models even if the presence of spatial effects seems to depend on the degree of disaggregation of the funds and on the period considered. As pointed out by McMillen (2003): "tests for spatial autocorrelation also detect functional form misspecification, heteroskedasticity, and the effects of missing variables that are correlated over space", and this can be particularly relevant when spatial dependence can be attributed to a mismatch between functional regions and administrative boundaries. Therefore, not surprisingly, when funds are more disaggregated (Model IV) or less subject to measurement errors (Models VII and VIII) we do not find evidence of spatial effects.

On the basis of the results in Table 5 we adopt the following criteria to proceed with the empirical analysis. We estimate a SDM for models I, II, III, V and VI using matrix **W2**, i. e. the matrix which more often suggested the presence of spatial effects,[29] and an OLS regression for models IV, VII and VIII.[30] When suggested by the Breusch-Pagan test, we will consider White-robust standard errors for the estimated coefficients.

The selection of the preferred specification will be based on a general to specific procedure where non significant terms are dropped until the goodness of fit is maximized on the basis of the value of the Akaike information criterion.[31]

[29]Regression results appear to be robust to the choice of the spatial matrix. Estimation results with matrix W1 are available upon request.

[30]We also estimated a SDM for Models IV, VII and VIII. In these estimations the coefficient relative to the spatial lag, i.e. θ, is never significant and the value of the Akaike information criteria (AIC) is higher than that resulting from the OLS estimation. This is also the case for Models V and VI where the preferred specification (still in terms of AIC) turns out to be an OLS with spatially lagged exogenous variables.

[31]In all specifications we will consider a squared term for SCF in the search for the preferred specifications. We will drop it if its inclusion makes the coefficient on SCF insignificant, and its exclusion makes the latter significant. We consider such piece of evidence as the result of the bias introduced by the high correlation between SCF and SCF^2.

Model	I	II	III
Estimation type	SD	SD	SD
COUNTRY DUMMIES	YES	YES	YES
TIME DUMMIES	NO	YES	NO
SECTORAL CONTROLS	YES	YES	YES
EC DENSITY	YES	YES	YES
Constant	-0.0128 (0.1063)	-0.0137 (0.0441)	-0.0534 (0.0003)
log.PROD.REL.IN	-0.0162 (0.0000)	$-0,0204$ (0.0000)	-0.0158 (0.0001)
log.INV.RATE	-	-0.0002 (0.9419)	0.0039 (0.2614)
log.EMP.GR	-0.0034 (0.0169)	-0.0104 (0.0000)	-0.0186 (0.0000)
SCF	0.1889 (0.0010)		0.0858 (0.0000)
SCF^2	-0.9757 (0.0077)		-
W.SCF	-0.5697 (0.0022)		-
W.SCF^2	12.1350 (0.0007)		-
Period I$*SCF$		0.2214 (0.1070)	
Period I$*$SCF^2			
(Period II & III) $*SCF$		0.0567 (0.0001)	
(Period II & III)$*$SCF^2		-	
Period I* $W.SCF$		0.1397 (0.5830)	
Period I*W.SCF^2			
(Period II & III)* $W.SCF$		0.0925 (0.1001)	
(Period II & III)*W.SCF^2		-	
Spatial lag (θ)	0.1773 (0.0870)	0.2840 (0.0002)	-
σ^2_ϵ	$6.59e^{-06}$	$2.13e^{-05}$	$1.76e^{-05}$
N.	173	342	173
Log likelihood	785.9	1341.7	731.4
AIC	-1471.8	-2587.4	-1366.8
Common Factor Test	66.0400 (0.0000)	79.7542 (0.0000)	-

Table 6: Estimation of Models I-III. Dependent variable: annual average growth rate of GVA per worker, *SCF* with three-year lags, p-values in parenthesis

Model	IV	V	VI	VII	VIII
Estimation type	OLS	SD	SD	OLS	OLS
COUNTRY DUMMIES	YES	YES	YES	YES	YES
TIME DUMMIES	NO	NO	NO	NO	NO
SECTORAL CONTROLS	YES	YES	YES	YES	YES
EC DENSITY	YES	YES	YES	YES	YES
Constant	-0.0711 (0.0001)	-0.0578 (0.0005)	-0.0544 (0.0005)	-0.0593 (0.0000)	-0.0590 (0.0000)
log.PROD.REL.IN	-0.0137 (0.0050)	-0.0157 (0.0000)	-0.0155 (0.0001)	-0.0181 (0.0006)	-0.0180 (0.0007)
log.INV.RATE	0.0049 (0.1992)	0.0038 (0.1850)	0.0041 (0.1601)	0.0058 (0.1475)	0.0063 (0.1224)
log.EMP.GR	-0.0210 (0.0000)	-0.0187 (0.0000)	-0.0189 (0.0000)	-0.0221 (0.0000)	-0.0222 (0.0000)
OB1	0.0765 (0.0013)	0.1036 (0.0000)			
$OB1^2$	-	-			
OB2	-1.6692 (0.0101)				
$OB2^2$	-				
OB3.OB4.OB5	0.1709 (0.3389)				
$OB3.OB4.OB5^2$	-				
W.OB1		-			
$W.OB1^2$		-			
OB1.CF			0.0879 (0.0000)		
$OB1.CF^2$			-		
W.OB1.CF			-		
$W.OB1.CF^2$			-		
SCF				0.1256 (0.0002)	
SCF^2				-0.1977 (0.0175)	
PAY					0.1926 (0.0001)
PAY^2					-0.4579 (0.0074)
σ_ϵ^2	$2.14e^{-05}$	$1.71e^{-05}$	$1.71e^{-05}$	$2.95e^{-05}$	$2.96e^{-05}$
N.	173	173	173	173	173
Log likelihood	698.6	731.5	731.2	669.8	669.3
AIC	-1343.1	-1366.9	-1366.5	-1289.7	-1288.7

Table 7: Estimation of Models IV-VIII. Dependent variable: annual average growth rate of GVA per worker, *SCF* with three-year lags, p-values in parenthesis

Tables 6 and 7 contain the results of the estimation of Models I-VIII. Results of Model I show that the consideration of the effect of the whole amount of structural and cohesion funds in the three programming periods returns a positive and significant coefficient for *SCF*. Moreover, this global effect is concave, indicating the presence of decreasing returns in *SCF*. In addition, the coefficients for the spatial lag of *SCF* suggests that the funds distributed to neighbours regions have a positive effect on the growth rate of region i, and that this effect is convex.[32] The coefficient of the explanatory variables suggested by the Solow model have the predicted signs (i. e. negative for EMP.GR and PROD.REL.INI, the latter suggesting conditional convergence), with the exception of the coefficient for the investment rate, which is dropped in the procedure to find the preferred specification in Model C.[33] Finally, the common factor constraint is not satisfied and, therefore, our specification cannot be reduced to a spatial error model. This implies that there is substantial spatial dependence to be taken into account.

In Model II we control for differences in the coefficients of *SCF* in the different programming periods. We find that the overall effect over the whole period essentially depends on the effect in Periods II & III: the coefficient for SCF in Period I is marginally significant at 10%, while it is strongly significant in Periods II & III and has a value consistent with the one found in Model B. Notice that we do not find evidence of decreasing returns. On the basis of this result, in Models III-VIII we focus on Periods II & III only.

In Model III we estimate a cross-section regression with *SCF* for Periods II & III only and find a positive and significant effect. Notice that in this model the coefficient for θ becomes non significant.

In Model IV we disaggregate the amount of funds by the Objectives. We find that the coefficient for the funds allocated for Objective 1 is positive and significant, the coefficient for the funds allocated for Objective 2 is *negative and significant*, and that the coefficient for Objectives 3, 4 and 5 is non significant.[34] In Model V, therefore, we isolate the effect of funds on Objective 1 and find a positive and significant coefficient, while in Model VI we also include the amounts distributed as Cohesion funds. In the latter case the coefficient is still positive and significant, albeit of smaller size with respect to Model V.

Finally, in Models VII and VIII we compare the results of regressions based on the commitments and on the payments. We restrict the analysis to Period III since we have data for this period only. In both cases we find a significantly positive and concave effect. In particular, we find that by estimating the effect of structural funds by means of commitments, we are likely to underestimate the true effect,

[32] We also tried to estimate the model without *SCF* and with the inclusion of only the linear term. Results are reported in Appendix E.

[33] Fiaschi and Lavezzi (2007) find a similar result for investment. For reasons of space, we omit to present the details on the coefficients of the other explanatory variables. These results are available upon request.

[34] We aggregated the funds relative to Objective 3, 4 and 5 because of their small amounts.

since the effect of structural funds measured by payments appear stronger, as shown in Figure 1.

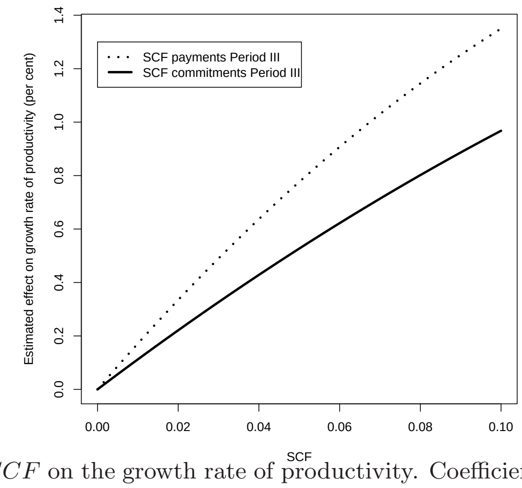

Figure 1: Estimated impact of SCF on the growth rate of productivity. Coefficients from Models VII and VIII in Table 7.

To sum up: in all specifications we find a positive effect of funds on the growth rate. However, we find that differences emerge when different programming periods are considered and when funds are disaggregated by Objective. Most of the effect seems to be ascribable to the second and third programming period that we considered. In addition, it appears that the funds explicitly devoted to regions lagging behind (i.e. Objective 1 regions) had a positive effect, while funds devoted to Objectives different from 1 had not a positive effect. In particular, funds allocated to reach Objective 2 had a negative effect, while funds allocated to reach other objectives had a non significant effect. When we use information on actual payments, and not their proxy (commitments), we find that the positive effect may be even stronger. In few cases we find a concave effect but, in any case, the concavity appears weak (see Figure 1). Finally, spatial effects seem to be relevant only when we consider the three programming periods together and an aggregated measure of funds. This suggests that, in specifications in which there is more variation in the variable of interest and/or when the latter is disaggregated, and when we include our set of control variables, we obtain a well-specified model, and the consideration of possible technological interdependence across regions does not provide significant value added to the empirical analysis.

Our results are consistent with those of Rodriguez-Pose and Fratesi (2004) and Becker *et al.* (2010) on the positive effect of funds distributed to reach Objective 1, while they are in contrast with those of Dall'Erba *et al.* (2009), who find a negative and significant effect of these funds. The negative or insignificant effect of the funds devoted to Objectives different from 1 indicates that, as remarked, the nature of these funds is mainly redistributive and, therefore, the general claim of Boldrin and Canova (2001) on the ineffectiveness of *all* funds should be qualified.[35] Also, results of papers in which funds have a high level of aggregation (e. g. Cappelen *et al.* (2003), Beugelsdijk and Eijffinger (2005), Ederveen *et al.* (2006), and Dall'Erba and Le Gallo (2008)) are likely to be misleading since we showed that a result on a coefficient of funds that have been aggregated, across different programming period or across objectives, may mask significant differences. A further result, i. e. that the funds became effective in Periods II and III, is not present in the current literature. In these periods the amount of funds increased and the rules governing their distribution and utilization changed but, from our results, it is not possible to disentangle these effects and we leave this question open for further research.[36]

5 Estimated Impact of SCF on Individual Regions

On the basis of the results of Section 4.1 in this section we present a visual representation of the marginal effect of funding on productivity of individual regions, i. e. we consider for every region the product of the amount of funding and the estimated coefficient. Given that the cleanest result obtains when we consider Periods II and III, we focus on the results for these periods.

Figure 2 refers to the effect of *SCF* in Periods II & III: i. e. to the results of Model III. Since the estimated effect is linear, the overall effect depends on the size of the funds received.

[35] Dall'Erba *et al.* (2009) find a nonsignificant effect of Objective 2 funds.

[36] In Appendix F we control for the possible endogeneity of the funds, and conclude on the negative. Dall'Erba *et al.* (2009) also find that funds are exogenous, while Dall'Erba and Le Gallo (2008) find that funds are endogenous.

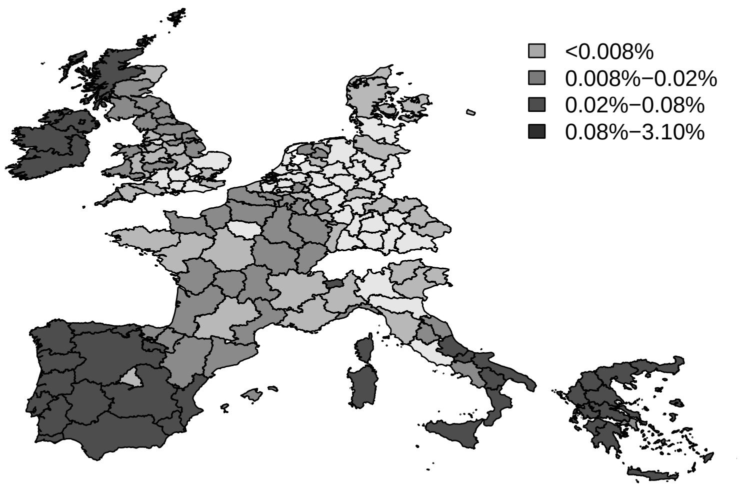

Figure 2: Estimated impact of *SCF* on productivity of individual regions (Model III)

From Figure 2 we notice that the overall fundings has benefited relatively more the regions in the periphery of Europe, i. e. of Southern Spain, Portugal, Southern Italy, Greece, Northern UK and Ireland.

Figure 3 shows that, within these macro areas, there is some variation. That is, when we restrict to the consideration of funds allocated to reach Objective 1, we find that some regions in Italy (Basilicata and Molise), Ireland (the NUTS2 region of Northern and Western Ireland), Spain (Extremadura), Greece (Iperios), Portugal (Alentejo and Algarve), received relatively more benefits from funding then other Objective 1 regions of their country.

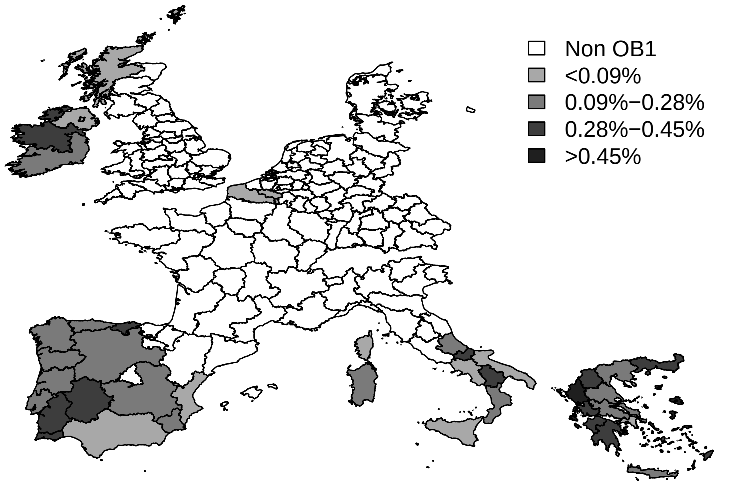

Figure 3: Estimated impact of Objective 1 funds on productivity of individual regions (Model IV)

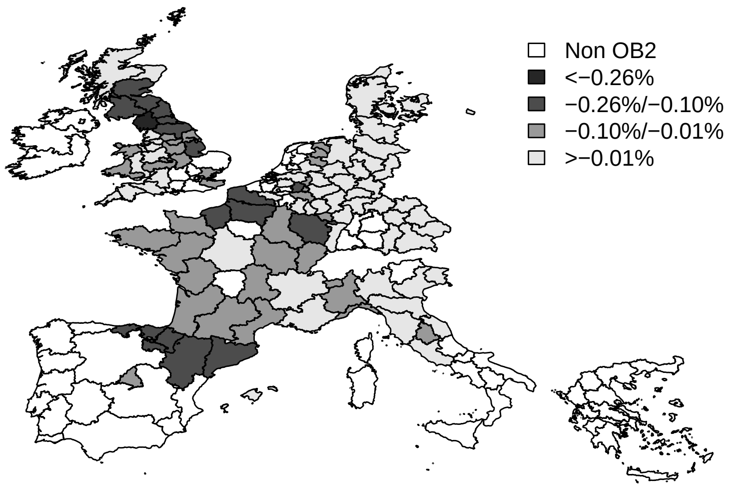

Figure 4: Estimated impact of Objective 2 funds on productivity of individual regions (Model IV)

Finally, when we focus on recipients of Objective 2 funding, we find that a region of England (Cumbria) had a relatively high negative impact of funding on the growth rate. Other regions had a non negligible negative effect: Scotland (Eastern and South Western), England (Northumberland, Tees Valley, Lincolnshire, North Yorkshire) northern Spain (Catalonia, Aragon, Comunidad de Navarra, Cantabria, Pais Vasco, La Rioja), Eastern France (Picardy, Nord-Pas-de-Calais, Haute-Normandie, Lorraine) and Belgium (Limburg).

6 Concluding Remarks

This paper estimates the effect of the European Union regional policy on productivity growth. We find that the funds had on average a positive impact. However, some qualifications of this general claim are needed. Firstly, not all funds are favourable to productivity growth. A large positive effect seems to be exerted by Objective 1 and Cohesion funds while, on the contrary, the allocation of funds to other objectives, in particular Objective 2, appears to *reduce* productivity growth, probably because it interferes with an efficient reallocation of resources across sectors in European regions.

Moreover, funding in the second and third programming period seems to have exerted the most significant effect. However, in these periods both the size of the funds and the allocation rules changed, but from the present analysis we cannot distinguish a threshold effect related to the size of the funds from the one exerted by the change in the rules. We also found that the impact appears concave in some specifications, so that funds may be subject to diminishing returns.

The analysis can be extended in many respects. Firstly, the impact of funds could be evaluated by conditioning on the output composition of regions. For example, Objective 1 funds could be more effective in regions whose output composition is more concentrated in industrial sectors, while the opposite could hold for Objective 2. The latter conditioning, along with a control for the institutional quality at regional level,[37] could provide additional information for a more efficient allocation of funds. Secondly, the hypothesis of whether the Regional Policy crowded out or, on the contrary, had complementarities with investments, could be examined. This piece of information is crucial to evaluate the long-run impact of *SCF* on regions' productivities. Thirdly, further information on the long-run impact of *SCF* could also be obtained from the analysis of the dynamics of regions which received funds in the past, but are no longer receiving them.

The availability of a dataset covering the fourth programming period 2000-2006 should allow to carry out these extensions,[38] with the further possibility to include in the analysis the regions of the

[37] Tabellini (2008) analyzes the effect of cultural traits on recent regional economic growth, and clarifies their relation with past regional institutional quality.

[38] Becker *et al.* (2010) study this programming period.

new EU accession countries, as well as to evaluate the impact of funds allocated to specific expenditure categories.

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A Derivation of A_i

We define the aggregate level of technology $A_i(t)$ as:

$$A_i(t) = \Omega_i(t) \prod_{j \neq i}^{N} A_j(t)^{\theta w_{ij}}. \tag{18}$$

Taking Eq. (18) in logs we get:

$$\log A_i(t) = \log \Omega_i(t) + \theta \sum_{j=1}^{N} w_{ij} \log A_j(t); \tag{19}$$

then, rewriting Eq. (19) in matrix form we obtain:

$$\mathbf{A} = \mathbf{\Omega} + \theta \mathbf{W}\mathbf{A}; \tag{20}$$

where $\mathbf{A}$ is the $(N \times 1)$ vector of logarithms of the level of technology, $\mathbf{\Omega}$ is the $(N \times 1)$ vector of logarithms of $\Omega_i(t)$, and $\mathbf{W}$ is the $(N \times N)$ Markov matrix with friction terms w_{ij}. Solving for $\mathbf{A}$ returns:

$$\mathbf{A} = (\mathbf{I} - \theta \mathbf{W})^{-1} \mathbf{\Omega}; \tag{21}$$

where $\mathbf{I}$ is the $(N \times N)$ identity matrix. From Eq. (21), if $|\theta| < 1$ the technological level of region i can be expressed as:

$$\begin{aligned}
A_i(t) &= \Omega_i(t) \prod_{j=1}^{N} \Omega_j(t)^{\sum_{r=1}^{\infty} \theta^r w_{ij}^{(r)}} = \\
&= \Omega_i(t) \Omega_i(t)^{\sum_{r=1}^{\infty} \theta^r w_{ii}^{(r)}} \prod_{j \neq i}^{N} \Omega_j(t)^{\sum_{r=1}^{\infty} \theta^r w_{ij}^{(r)}} = \\
&= \Omega_i(t)^{1+\sum_{r=1}^{\infty} \theta^r w_{ii}^{(r)}} \prod_{j \neq i}^{N} \Omega_j(t)^{\sum_{r=1}^{\infty} \theta^r w_{ij}^{(r)}} = \\
&= \Omega_i(t)^{\nu_{ii}} \prod_{j \neq i}^{N} \Omega_j(t)^{\nu_{ij}};
\end{aligned}$$

where the terms $w_{ij}^{(r)}$ are the elements of row i and column j of matrix W to the power of r, $\nu_{ii} = 1 + \sum_{r=1}^{\infty} \theta^r w_{ii}{}^{(r)}$ and $\nu_{ij} = \sum_{r=1}^{\infty} \theta^r w_{ij}{}^{(r)}$. Assuming $\Omega_i(t) = \Omega_i(0)e^{\mu t}$ we obtain :

$$A_i(t) = \left(\Omega_i(0)e^{\mu t}\right)^{\nu_{ii}} \prod_{j \neq i}^{N} \left(\Omega_i(0)e^{\mu t}\right)^{\nu_{ij}}. \tag{22}$$

Taking Eq. (22) in logs:

$$\begin{aligned}
\log A_i(t) &= \nu_{ii}\log\Omega_i(0) + \nu_{ii}\mu t + \sum_{j\neq i}^{N} \nu_{ij}\log\Omega_i(0) + \sum_{j\neq i}^{N} \nu_{ij}\mu t = \\
&= \nu_{ii}\log\Omega_i(0) + \mu t + \mu t \sum_{r=1}^{\infty} \theta^r {w_{ii}}^{(r)} + \sum_{j\neq i}^{N} \nu_{ij}\log\Omega_i(0) + \mu t \sum_{j\neq i}^{N}\sum_{r=1}^{\infty} \theta^r {w_{ij}}^{(r)} = \\
&= \nu_{ii}\log\Omega_i(0) + \sum_{j\neq i}^{N} \nu_{ij}\log\Omega_i(0) + \frac{\mu t}{1-\theta}. \qquad (23)
\end{aligned}$$

Finally, taking the exponential of Eq. (23) we obtain:

$$A_i(t) = \Omega_i(0)^{\nu_{ii}} \prod_{j\neq i}^{N} \Omega_j(0)^{\nu_{ij}} e^{\frac{\mu t}{1-\theta}} = \bar{\Omega}_i(0) e^{\frac{\mu t}{1-\theta}}. \qquad (24)$$

B Spatial Matrices

In the empirical analysis we consider two different spatial matrices: the matrix **W1**, used in Ertur and Koch (2007), which is based on the inverse of the great circle distance (d_{ij}) between the capitals of two regions (see Ertur and Koch (2007), p. 1043); the matrix **W2**, a *first order contiguity matrix*, in which two regions are considered neighbours if they share a common border (both matrices are row-standardized).In particular, for any couple of regions (i, j), the values of the elements of **W1** and **W2** are respectively given by:

- $w_1(i,j) = w_1^*(i,j)/\sum_j w_1^*(i,j)$ where:

$$w_1^*(i,j) = \begin{cases} 0 & \text{if } i = j \\ d_{ij}^{-2} & \text{otherwise} \end{cases}$$

- $w_2(i,j) = w_2^*(i,j)/\sum_j w_2^*(i,j)$ where:

$$w_2(i,j)^* = \begin{cases} 1 & \text{if } i \text{ and } j \text{ share a common border} \\ 0 & \text{otherwise} \end{cases}$$

C List of NUTS2 Regions in the Sample

AT11	Burgenland	DEA1	Düsseldorf	FR26	Bourgogne	IT52	Umbria	UKD1	Cumbria
AT12	Niederösterreich	DEA2	Köln	FR3	Nord - Pas-de-Calais	IT53	Marche	UKD2	Cheshire
AT13	Wien	DEA3	Münster	FR41	Lorraine	IT6	Lazio	UKD3	Greater Manchester
AT21	Kärnten	DEA4	Detmold	FR42	Alsace	IT71	Abruzzo	UKD4	Lancashire
AT22	Steiermark	DEA5	Arnsberg	FR43	Franche-Comté	IT72	Molise	UKD5	Merseyside
AT31	Oberösterreich	DEB1	Koblenz	FR51	Pays de la Loire	IT8	Campania	UKE1	East Riding, North Lincol.
AT32	Salzburg	DEB2	Trier	FR52	Bretagne	IT91	Puglia	UKE2	North Yorkshire
AT33	Tirol	DEB3	Rheinhessen-Pfalz	FR53	Poitou-Charentes	IT92	Basilicata	UKE3	South Yorkshire
AT34	Vorarlberg	DEC	Saarland	FR61	Aquitaine	IT93	Calabria	UKE4	West Yorkshire
BE1	Rég. Bruxelles	DEF	Schleswig-Holstein	FR62	Midi-Pyrénées	ITA	Sicilia	UKF1	Derbyshire, Nottingh.
BE21	Antwerpen	DK	Danmark	FR63	Limousin	ITB	Sardegna	UKF2	Leicestershire, Rutland
BE22	Limburg (B)	ES11	Galicia	FR71	Rhône-Alpes	LU	Luxembourg		and Northamptonshire
BE23	Oost-Vlaanderen	ES12	Principado de Asturias	FR72	Auvergne	NL11	Groningen	UKF3	Lincolnshire
BE24	Vlaams Brabant	ES13	Cantabria	FR81	Languedoc-Roussillon	NL12	Friesland	UKG1	Herefordshire, Worcest.
BE25	West-Vlaanderen	ES21	Pais Vasco	FR82	Prov.-Alpes-Côte d'Azur	NL13	Drenthe		and Warwickshire
BE31	Brabant Wallon	ES22	Comunidad de Navarra	FR83	Corse	NL21	Overijssel	UKG2	Shropshire and Staffordshire
BE32	Hainaut	ES23	La Rioja	GR11	Anatoliki Mak., Thraki	NL22	Gelderland	UKG3	West Midlands
BE33	Liège	ES24	Aragón	GR12	Kentriki Makedonia	NL31	Utrecht	UKH1	East Anglia
BE34	Luxembourg (B)	ES3	Comunidad de Madrid	GR13	Dytiki Makedonia	NL32	Noord-Holland	UKH2	Bedfordshire, Hertford.
BE35	Namur	ES41	Castilla y León	GR14	Thessalia	NL33	Zuid-Holland	UKH3	Essex
DE11	Stuttgart	ES42	Castilla-la Mancha	GR21	Ipeiros	NL34	Zeeland	UKI1	Inner London
DE12	Karlsruhe	ES43	Extremadura	GR22	Ionia Nisia	NL41	Noord-Brabant	UKI2	Outer London
DE13	Freiburg	ES51	Catalua	GR23	Dytiki Ellada	NL42	Limburg (NL)	UKJ1	Berkshire, Buckinghamshire
DE14	Tübingen	ES52	Comunidad Valenciana	GR24	Sterea Ellada	PT11	Norte		and Oxfordshire
DE21	Oberbayern	ES53	Islas Baleares	GR25	Peloponnisos	PT12	Centro (P)	UKJ2	Surrey, East, West Sussex
DE22	Niederbayern	ES61	Andalucia	GR3	Attiki	PT13	Lisboa, Vale do Tejo	UKJ3	Hampshire, Isle of Wight
DE23	Oberpfalz	ES62	Región de Murcia	GR41	Voreio Aigaio	PT14	Alentejo	UKJ4	Kent
DE24	Oberfranken	ES63	Ceuta y Melilla	GR42	Notio Aigaio	PT15	Algarve	UKK1	Gloucestershire, Wiltshire
DE25	Mittelfranken	ES7	Canarias	GR43	Kriti	PT2	Açores		and North Somerset
DE26	Unterfranken	FI13	Itä-Suomi	IE01	Border, Mid., Western	PT3	Madeira	UKK2	Dorset, Somerset
DE27	Schwaben	FI18	Etelä-Suomi	IE02	Southern and Eastern	SE01	Stockholm	UKK3	Cornwall, Isles of Scilly
DE5	Bremen	FI19	Länsi-Suomi	IT11	Piemonte	SE02	Östra Mellansverige	UKK4	Devon
DE6	Hamburg	FI1A	Pohjois-Suomi	IT12	Valle d'Aosta	SE04	Sydsverige	UKL1	West Wales, The Valleys
DE71	Darmstadt	FI2	land	IT13	Liguria	SE06	Norra Mellansverige	UKL2	East Wales
DE72	Gießen	FR1	Île de France	IT2	Lombardia	SE07	Mellersta Norrland	UKM1	North Eastern Scotland
DE73	Kassel	FR21	Champagne-Ardenne	IT31	Trentino-Alto Adige	SE08	Övre Norrland	UKM2	Eastern Scotland
DE91	Braunschweig	FR22	Picardie	IT32	Veneto	SE09	Småland med öarna	UKM3	South Western Scotland
DE92	Hannover	FR23	Haute-Normandie	IT33	Friuli-Venezia Giulia	SE0A	Västsverige	UKM4	Highlands and Islands
DE93	Lüneburg	FR24	Centre	IT4	Emilia-Romagna	UKC1	Tees Valley	UKN	Northern Ireland
DE94	Weser-Ems	FR25	Basse-Normandie	IT51	Toscana	UKC2	Northumberland		

D Descriptive Statistics of Variables

	GR.PROD	PROD.REL	INV.RATE	EMP.GR	ECO.DEN	
Mean	0.02	1.00	0.20	0.04	7.47	
St.Dev.	0.01	0.35	0.06	0.01	25.85	
	AGRI	MANU	MIN	CONS	NOMARKS	FIN
Mean	0.06	0.22	0.03	0.08	0.23	0.05
St.Dev.	0.07	0.09	0.05	0.03	0.06	0.02
	HOT	TRAN	WHOL	OTH	*SCF*	PAY
Mean	0.04	0.06	0.11	0.14	0.01	0.01
St.Dev.	0.04	0.02	0.03	0.04	0.02	0.04

Table 8: Mean and standard deviation of variables used in regressions.

	PROD.REL	INV.RATE	EMP.GR	ECO.DEN	AGRI
PROD.REL	1	0.14	0.12	0.50	−0.53
INV.RATE	0.14	1	0.18	−0.27	0.25
EMP.GR	0.12	0.18	1	0.14	−0.34
ECO.DEN	0.50	−0.27	0.14	1	−0.64
AGRI	−0.53	0.25	−0.34	−0.64	1
MANU	0.22	−0.26	−0.13	0.23	−0.36
MIN	0.12	−0.03	−0.01	−0.03	0.03
CONS	0.03	0.48	0.13	−0.28	0.08
NONMARKS	0.28	−0.07	0.25	0.30	−0.47
FIN	0.42	0.14	0.12	0.46	−0.39
HOT	−0.40	0.07	0.15	−0.32	0.24
TRAN	0.01	0.04	0.21	0.20	−0.27
WHOL	−0.27	0.07	−0.01	0.00	0.22
OTH	0.27	−0.33	0.14	0.44	−0.48
SCF	−0.50	0.29	0.01	−0.29	0.44
PAY	−0.45	0.28	0.09	−0.22	0.29

Table 9: Correlations between variables used in regressions

	MANU	MIN	CONS	NONMARKS	FIN	HOT
PROD.REL	0.22	0.12	0.03	0.28	0.42	−0.40
INV.RATE	−0.26	−0.03	0.48	−0.07	0.14	0.07
EMP.GR	−0.13	−0.01	0.13	0.25	0.12	0.15
ECO.DEN	0.23	−0.03	−0.28	0.30	0.46	−0.32
AGRI	−0.36	0.03	0.08	−0.47	−0.39	0.24
MANU	1	−0.15	−0.18	−0.29	−0.10	−0.31
MIN	−0.15	1	−0.16	−0.02	−0.23	−0.09
CONS	−0.18	−0.16	1	0.07	0.03	−0.12
NONMARKS	−0.29	−0.02	0.07	1	0.20	−0.37
FIN	-0.10	−0.23	0.03	0.20	1	−0.17
HOT	−0.31	−0.09	−0.12	−0.37	−0.17	1
TRAN	−0.22	−0.19	−0.10	0.06	0.35	0.09
WHOL	−0.40	−0.23	−0.12	−0.11	0.06	0.25
OTH	−0.03	−0.27	−0.17	0.28	0.27	−0.12
SCF	−0.41	0.00	0.30	−0.15	−0.20	0.23
PAY	−0.38	−0.01	0.34	−0.08	−0.11	0.19

	TRAN	WHOL	OTH	*SCF*	PAY
PROD.REL	0.01	−0.27	0.27	−0.50	−0.45
INV.RATE	0.04	0.07	−0.33	0.29	0.28
EMP.GR	0.21	−0.01	0.14	0.01	0.09
ECO.DEN	0.20	0.00	0.44	−0.29	−0.22
AGRI	−0.27	0.22	−0.48	0.44	0.29
MANU	−0.22	−0.40	−0.03	−0.41	−0.38
MIN	−0.19	−0.23	−0.27	0.00	−0.01
CONS	−0.10	−0.12	−0.17	0.30	0.34
NONMARKS	0.06	−0.11	0.28	−0.15	−0.08
FIN	0.35	0.06	0.27	−0.20	−0.11
HOT	0.09	0.25	−0.12	0.23	0.19
TRAN	1	0.24	0.15	0.17	0.24
WHOL	0.24	1	−0.14	0.25	0.19
OTH	0.15	−0.14	1	−0.30	−0.23
SCF	0.17	0.25	−0.30	1	0.96
PAY	0.24	0.19	−0.23	0.96	1

Table 10: Continued: Correlations between variables used in regressions

E Models without *SCF*

Table 11 contains the results of the estimation of Models with and without *SCF*.

Model	Without *SCF*	Linear *SCF*	Model I
estimation type	SD	SD	SD
COUNTRY DUMMIES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES
EC DENSITY	YES	YES	YES
Constant	-0.0803 (0.3284)	-0.0087 (0.3519)	-0.0128 (0.1063)
log.PROD.REL.IN	-0.0159 (0.0000)	-0.0166 (0.0000)	-0.0162 (0.0000)
log.INV.RATE	0.0035 (0.1272)	0.0025 (0.2813)	-
log.EMP.GR	-0.0051 (0.0007)	-0.0046 (0.0024)	-0.0034 (0.0169)
SCF	-	0.0418 (0.0312)	0.1889 (0.0010)
SCF^2	-	-	-0.9757 (0.0077)
W.SCF	-	0.0573 (0.5865)	-0.5697 (0.0022)
W.SCF^2	-	-	12.1350 (0.0007)
Spatial lag (θ)	0.2118 (0.0511)	0.1985 (0.0666)	0.1763 (0.0870)
σ^2_ϵ	$7.23e^{-06}$	$7.04e^{-06}$	$6.59e^{-06}$
N. Obs	173	173	173
Log likelihood	777.5	780.0	785.9
AIC	-1455.0	-1456.0	-1471.8
Common Factor Test	58.53***	56.21***	66.04***

Table 11: Estimation of Models with and without *SCF*. Dependent variable: annual average growth rate of GVA per worker, *SCF* with three-year lags, p-values in parenthesis

The second column of Table 11 shows that the coefficient of *SCF* is positive and statistically significant. It is worth noting (results not reported) that the coefficient of *SCF* becomes non significantly different from zero at usual levels of significance when sectoral controls are not included in the regression, suggesting that the statistically non significant impact of Structural and Cohesion Funds found in some contributions may be due to a misspecification error (see, e.g., Rodriguez-Pose and Fratesi (2004), Dall'Erba *et al.* (2009) and Checherita *et al.* (2009)).

When we introduce a quadratic term for *SCF* (in the third column), we obtain significant coefficients both for *SCF* and SCF^2 and the model results better specified in terms of AIC. In addition, the coefficients for the spatial lag of *SCF* suggests that the funds distributed to neighbours regions have a positive effect on the growth rate of region i, and that this effect is convex.

Finally, in all models the coefficient for the spatial lag θ is positive and significant at 10 % confidence level. This results is evidence of technological interdependence on growth across regions. The coefficient of θ, however, is significant at 10% confidence level only, and the p-value is higher in Model I, i. e. when the model is probably better specified.

F Tests for Endogeneity

In our analysis Structural and Cohesion Funds are potentially endogenous. The allocation of the funds is indeed non-random, but in principle conditional on the regional per capita GDP, implying a potential reverse causality of productivity growth on funds (on the assumption that an increase in productivity increases per capita GDP which affects the allocation of funds). Moreover, the endogeneity of funds could also arise by the measurement error induced by both the use of Commitments instead of Payments, and by our reassignment of some funds to NUTS2 regions. In order to test for the exogeneity of funds, the Durbin-Wu-Hausman test is performed in its regression-based form, using as instruments all the exogenous explanatory variables of the model and some additional instruments.[39] In particular the endogeneity test is performed on the sub-period 1989-1999 for Model I in Table 6 and for Models V-VI in Table 7, and on the sub-period 1994-1999 for Models VII-VIII in Table 7.[40] Results are reported in Tables 12-16.

Depending on the variable considered, we use the following instruments:

- For *SCF* we define four instruments. The first instrument, denoted *INSTR.3G*, is derived by the three-group method described in Kennedy (2008), in which the instrumental variable takes on values -1, 0 or 1 if the potentially endogenous variable is respectively in the top, middle or bottom third of its ranking. This instrument is usually utilized when variables are subject to measurement error. The second instrument is the lagged value of *SCF* (that is, the value of *SCF* in the first programming period, 1975-1988, denoted as *INSTR.SCF.1975_1988* for Model I and that in the second programming period, 1989-1993, denoted as *INSTR.SCF.1989_1993* for Model VII). The latter should be a valid instrument since it is correlated with *SCF* of the following period, but it should not be correlated with the error term. Finally, the last two instruments are variables that Parenti (2009) shows to be relevant determinants of funds' allocation, that is the regional share of population (*INSTR.POP.SH.1986_1988* for Model I and *INSTR.POP.SH.1991_1993* for Model VII), and relative per capita GDP (*INSTR.REL.GDP.1986_1988* for Model I and *INSTR.REL.GDP.1991_1993* for Model VII), in particular their 1986-1988 or 1991-1993 averages.

[39] For more details see Wooldridge (2002), pp. 118-122.

[40] The endogeneity test for Model III would be the same of that for Model I since we have to restrict the sample to get instruments for SCF. Moreover, it is not possible to perform endogeneity test for Model IV since we do not have any breakdown of the funds for the period 1975-1988.

- Accordingly, the instrument for SCF^2 derived by the three-group method, i.e. $INSTR.3G^2$, is calculated by SCF^2, while the other three instruments, i.e. $INSTR.SCF.1975\_1988^2$, $INSTR.POP.SH.1986\_1988^2$ and $INSTR.REL.GDP.1986\_1988^2$ in Model I and $INSTR.SCF.1989\_1993^2$, $INSTR.POP.SH.1991\_1993^2$ and $INSTR.REL.GDP.1991\_1993^2$ in Model VII, are calculated taking the square of respective variables.

- For W.SCF we use the spatial lag of the instruments defined for SCF, i.e. *W.INSTR.SCF.1975_1988*, *W.INSTR.POP.SH.1986_1988*, *W.INSTR.REL.GDP.1986_1988* in Model I and *W.INSTR.SCF.1989_1993*, *W.INSTR.POP.SH.1991_1993*, *W.INSTR.REL.GDP.1991_1993* in Model VII, as well as the instrument derived by the three-group method, i.e. $W.INSTR.3G$, calculated on W.SCF.

- For $W.SCF^2$ we use the spatial lag of the instruments defined for SCF^2, i.e. $W.INSTR.SCF.1975\_1988^2$, $W.INSTR.POP.SH.1986\_1988^2$, $W.INSTR.REL.GDP.1986\_1988^2$ for Model I and $W.INSTR.SCF.1989\_1993^2$, $W.INSTR.POP.SH.1991\_1993^2$, $W.INSTR.REL.GDP.1991\_1993^2$ for Model VII, as well as the instrument derived by the three-group method, i.e. $W.INSTR.3G^2$, calculated on W.SCF^2.

- Finally, for the spatial lag of endogenous variable W.θ we use as instruments different spatial lags of all explanatory variable (see Kelejian and Prucha (1999)). Since the spatial Durbin model explicitly includes as regressors WX, we only use W^2X.

The same instruments for *SCF* in Model I are also used for *OB1* and $OB1^2$ in Model V and for *OB1.CF* and $OB1.CF^2$ in Model VI; while the same instrument for *SCF* in Model VII are also used for PAY and PAY^2 in Model VIII.

For the sake of clarity we report the results of the first-stage regression for each potentially endogenous variable and the second-stage regression results.[41] Results of the first-stage regressions show that most of the instruments used are significant. Endogeneity tests assume that instruments used in the first-stage regressions are valid, i.e. they are assumed not to be correlated with the error term. However, this could not hold in our case (see, e.g., the discussion in Fingleton and Le Gallo (2008)). The Sargan test of overidentifying restrictions allows to check the hypothesis of validity of instruments, which we perform in its heteroskedasticity-robust version (for more details see Wooldridge (2002), pp. 122-124). In all the cases the instruments turn out to be valid.[42]

[41] For shortness we only report some of the instruments used for *W.θ*

[42] In particular, the resulting statistics of the Sargan test for Model I is equal to 21.92 against a critical value of 38.89; for Model V and Model VI is equal to 20.03 and 2.63 respectively, against a critical value of 33.92; finally, for Model VII and Model VIII is equal to 38.2 and 19.1 respectively, against a critical value of 38.89.

In the second-stage regression we use a heteroskedasticity-robust Wald statistic in all models and we find that the potentially endogenous variables are in fact jointly exogenous.

Dependent Variable	First Stage Estimation					Second Stage Estimation
	SCF (1989-1999)	SCF^2 (1989-1999)	*W.SCF* (1989-1999)	W.SCF^2 (1989-1999)	W.γ	γ (1992-2002)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES	YES	YES	YES
Constant	−0.1562 (0.0298)	−0.0385 (0.1049)	−0.0059 (0.6676)	0.0013 (0.4642)	−0.0153 (0.0327)	−0.0560 (0.0008)
log.PROD.REL.IN	0.0271 (0.2008)	0.0076 (0.1772)	−0.0018 (0.5686)	−0.0002 (0.5505)	0.0023 (0.2946)	−0.0068 (0.0866)
log.INV.RATE	−0.0004 (0.9804)	−0.0031 (0.5715)	0.0008 (0.7865)	0.0003 (0.4720)	0.0022 (0.2058)	−0.0016 (0.6737)
log.EMP.GR	−0.0283 (0.0223)	−0.0051 (0.2056)	−0.0033 (0.1471)	−0.0001 (0.6234)	−0.0034 (0.0203)	−0.0071 (0.0193)
INSTR.SCF.1977_1988	2.2432 (0.0023)					
INSTR.3G	−0.0142 (0.0003)					
INSTR.REL.GDP.1986_1988	−0.0181 (0.2713)					
INSTR.POP.SH.1986_1988	−0.0179 (0.0000)					
INSTR.SCF.1977_1988^2		4.0924 (0.6042)				
INSTR.3G^2		−0.0033 (0.0058)				
INSTR.REL.GDP.1986_1988^2		−0.0015 (0.7038)				
INSTR.POP.SH.1986_1988^2		0.0023 (0.0000)				
W.INSTR.SCF.1977_1988			2.2149 (0.0000)			
W.INSTR.3G			−0.0019 (0.0488)			
W.INSTR.REL.GDP.1986_1988			−0.0173 (0.0201)			
W.INSTR.POP.SH.1986_1988			−0.0076 (0.0000)			
W.INSTR.SCF.1977_1988^2				4.000 (0.0029)		
W.INSTR.3G^2				−0.0003 (0.0195)		
W.INSTR.REL.GDP.1986_1988^2				0.0019 (0.0263)		
W.INSTR.POP.SH.1986_1988^2				0.0004 (0.0002)		
W2.log.PROD.REL.IN					−0.0001 (0.9808)	
W2.log.INV.RATE					0.01027 (0.0078)	
W2.log.EMP.GR					0.0031 (0.4905)	
SCF						0.1770 (0.0007)
SCF^2						−0.3990 (0.0222)
W.SCF						0.1590 (0.4878)
W.SCF^2						−1.0580 (0.5965)
W.γ						0.0754 (0.8474)
*SCF*_RES						−0.0500 (0.3451)
SCF_RES^2						0.1060 (0.4935)
W.SCF_RES						0.1480 (0.4300)
W.SCF^2_RES						0.6010 (0.7805)
W.γ_RES						0.6750 (0.1361)
Obs. 173	$\bar{R}^2 = 0.84$	$\bar{R}^2 = 0.77$	$\bar{R}^2 = 0.96$	$\bar{R}^2 = 0.84$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.73$
Wald Test	H0: *SCF*_RES=SCF_RES^2=W.SCF_RES =W.SCF^2_RES =W.θ_RES =0 W= 3.9865 (0.551)					

Table 12: Exogeneity test of SCF, SCF^2, W.SCF, W.SCF^2 and W.θ. P-values in parenthesis. *SCF_RES*, SCF_RES^2, W.SCF_RES, W.SCF^2_RES and W.γ_RES are respectively the residuals of first-stage regressions.

	First Stage Estimation					Second Stage Estimation
Dependent Variable	*OB1* (1989-1999)	$OB1^2$ (1989-1999)	*W.OB1* (1989-1999)	$W.OB1^2$ (1989-1999)	$W.\gamma$	γ (1992-2002)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES	YES	YES	YES
Constant	−0.1127 (0.0748)	−0.0214 (0.1810)	−0.0010 (0.9369)	0.0007 (0.6142)	−0.0153 (0.0327)	−0.0653 (0.0000)
log.PROD.REL.IN	0.0239 (0.2027)	0.0063 (0.0993)	−0.0023 (0.3376)	0.0001 (0.6441)	0.0023 (0.2946)	−0.0053 (0.1861)
log.INV.RATE	0.0064 (0.6861)	−0.0013 (0.7241)	0.0005 (0.8447)	0.0003 (0.4100)	0.0022 (0.2058)	0.0025 (0.5352)
log.EMP.GR	−0.0176 (0.1012)	−0.0021 (0.4405)	−0.0032 (0.1220)	−0.0003 (0.2300)	−0.0034 (0.0203)	−0.0086 (0.0064)
INSTR.OB1.1977_1988	1.7494 (0.0080)					
INSTR.3G	0.0050 (0.1429)					
INSTR.REL.GDP.1986_1988	−0.0048 (0.7379)					
INSTR.POP.SH.1986_1988	−0.0104 (0.0000)					
$INSTR.OB1.1977\_1988^2$		2.7300 (0.6130)				
$INSTR.3G^2$		0.0004 (0.6575)				
$INSTR.REL.GDP.1986\_1988^2$		−0.0011 (0.6734)				
$INSTR.POP.SH.1986\_1988^2$		0.0014 (0.0000)				
W.INSTR.OB1.1977_1988			2.1401 (0.0000)			
W.INSTR.3G			0.0002 (0.7606)			
W.INSTR.REL.GDP.1986_1988			−0.0098 (0.1350)			
W.INSTR.POP.SH.1986_1988			−0.0043 (0.0010)			
$W.INSTR.OB1.1977\_1988^2$				3.6400 (0.0002)		
$W.INSTR.3G^2$				0.0000 (0.4190)		
$W.INSTR.REL.GDP.1986\_1988^2$				0.0013 (0.0408)		
$W.INSTR.POP.SH.1986\_1988^2$				0.0002 (0.0017)		
W2.log.PROD.REL.IN					−0.0001 (0.9808)	
W2.log.INV.RATE					0.0127 (0.0078)	
W2.log.EMP.GR					0.0031 (0.4905)	
OB1						0.1666 (0.0110)
$OB1^2$						−0.5716 (0.0186)
W.OB1_CF						−0.0909 (0.7316)
$W.OB1^2$						2.5186 (0.5310)
$W.\gamma$						0.00135 (0.9972)
*OB1*_RES						0.0268 (0.7082)
$OB1\_RES^2$						0.0330 (0.8899)
W.OB1_RES						0.2223 (0.3459)
$W.OB1^2\_RES$						−1.3338 (0.6894)
$W.\theta$_RES						0.6734 (0.1331)
Obs. 173	$\bar{R}^2 = 0.81$	$\bar{R}^2 = 0.75$	$\bar{R}^2 = 0.95$	$\bar{R}^2 = 0.82$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.73$
Wald Test	H0: *OB1*_RES=$OB1\_RES^2$=W.OB1_RES =$W.OB1^2\_RES$ =$W.\theta$_RES =0 W= 4.2768 (0.5103)					

Table 13: Exogeneity test of OB1, $OB1^2$, W.OB1, $W.OB1F^2$ and $W.\gamma$. P-values in parenthesis. *OB1_RES*, $OB1\_RES^2$, W.OB1_RES, $W.OB1^2\_RES$ and $W.\gamma$_RES are respectively the residuals of first-stage regressions.

Dependent Variable	First Stage Estimation					Second Stage Estimation
	OB1_CF (1989-1999)	$OB1\_CF^2$ (1989-1999)	*W.OB1_CF* (1989-1999)	$W.OB1\_CF^2$ (1989-1999)	$W.\gamma$	γ (1992-2002)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES	YES	YES	YES
Constant	−0.1281 (0.0839)	−0.0287 (0.1942)	−0.0004 (0.9774)	0.0010 (0.5755)	−0.0153 (0.0327)	−0.0659 (0.0000)
log.PROD.REL.IN	0.0271 (0.2179)	0.0086 (0.1046)	−0.0031 (0.3480)	− 0.0001 (0.7118)	0.0023 (0.2946)	−0.0049 (0.2178)
log.INV.RATE	0.0052 (0.7771)	−0.0022 (0.6700)	0.0005 (0.8594)	0.0003 (0.4015)	0.0022 (0.2058)	0.0027 (0.4961)
log.EMP.GR	−0.0193 (0.1243)	−0.0024 (0.5181)	−0.0034 (0.1405)	−0.0003 (0.2602)	−0.0034 (0.0203)	−0.0089 (0.0051)
INSTR.OB1_CF.1977_1988	2.0685 (0.0074)					
INSTR.3G	0.0055 (0.1639)					
INSTR.REL.GDP.1986_1988	−0.0060 (0.7206)					
INSTR.POP.SH.1986_1988	−0.0120 (0.0000)					
$INSTR.OB1\_CF.1977\_1988^2$		4.7432 (0.5251)				
$INSTR.3G^2$		0.0005 (0.6665)				
$INSTR.REL.GDP.1986\_1988^2$		−0.0013 (0.7275)				
$INSTR.POP.SH.1986\_1988^2$		0.0019 (0.0000)				
W.INSTR.OB1_CF.1977_1988			2.3407 (0.0000)			
W.INSTR.3G			0.0002 (0.8121)			
W.INSTR.REL.GDP.1986_1988			−0.0088 (0.2371)			
W.INSTR.POP.SH.1986_1988			−0.0043 (0.0033)			
$W.INSTR.OB1\_CF.1977\_1988^2$				4.6700 (0.0002)		
$W.INSTR.3G^2$				0.0000 (0.4664)		
$W.INSTR.REL.GDP.1986\_1988^2$				0.0015 (0.0553)		
$W.INSTR.POP.SH.1986\_1988^2$				0.0002 (0.0090)		
W2.log.PROD.REL.IN					−0.0001 (0.9808)	
W2.log.INV.RATE					0.0127 (0.0078)	
W2.log.EMP.GR					0.0031 (0.4905)	
OB1_CF						0.1470 (0.0102)
$OB1\_CF^2$						−0.4450 (0.0142)
W.OB1_CF						−0.0747 (0.7587)
$W.OB1\_CF^2$						1.8300 (0.5840)
$W.\gamma$						0.0018 (0.9964)
*OB1_CF*_RES						0.0232 (0.7075)
$OB1\_CF\_RES^2$						0.0302 (0.8637)
W.OB1_CF_RES						0.1910 (0.3912)
$W.OB1\_CF^2\_RES$						−1.0200 (0.7221)
$W.\theta$_RES						0.6780 (0.1295)
Obs. 173	$\bar{R}^2 = 0.81$	$\bar{R}^2 = 0.75$	$\bar{R}^2 = 0.95$	$\bar{R}^2 = 0.82$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.73$
Wald Test	H0: $OB1\_CF\_RES = OB1\_CF\_RES^2 = W.OB1\_CF\_RES = W.OB1\_CF^2\_RES = W.\theta\_RES = 0$; W= 4.134 (0.5303)					

Table 14: Exogeneity test of OB1_CF, $OB1\_CF^2$, W.OB1_CF, $W.OB1\_CF^2$ and $W.\gamma$. P-values in parenthesis. *OB1_CF_RES*, $OB1\_CF\_RES^2$, W.OB1_CF_RES, $W.OB1\_CF^2\_RES$ and $W.\theta$_RES are respectively the residuals of first stage regressions.

Dependent Variable	First Stage Estimation *SCF* (1994-1999)	SCF^2 (1994-1999)	*W.SCF* (1994-1999)	W.SCF^2 (1994-1999)	W.γ	Second Stage Estimation γ (1997-2002)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES	YES	YES	YES
Constant	−0.0638 (0.4395)	−0.0216 (0.5778)	−0.0160 (0.3664)	−0.0020 (0.3721)	−0.0221 (0.0046)	−0.0327 (0.0459)
log.PROD.REL.IN	−0.0044 (0.8513)	−0.0066 (0.4990)	0.00029 (0.9424)	−0.0001 (0.7769)	0.0032 (0.1278)	−0.0065 (0.0890)
log.INV.RATE	−0.0117 (0.4463)	−0.0052 (0.4622)	0.0050 (0.1176)	0.0006 (0.1246)	0.0036 (0.0224)	−0.0071 (0.0234)
log.EMP.GR	0.0070 (0.5353)	0.0044 (0.4017)	−0.0018 (0.4675)	−0.0001 (0.6704)	−0.0049 (0.0002)	0.0023 (0.3438)
INSTR.SCF.1989_1993	1.1901 (0.0000)					
INSTR.3G	−0.0028 (0.4917)					
INSTR.REL.GDP.1991_1993	−0.0134 (0.4516)					
INSTR.POP.SH.1991_1993	−0.0085 (0.0258)					
INSTR.SCF.1989_1993^2		1.8856 (0.0000)				
INSTR.3G^2		−0.0012 (0.5098)				
INSTR.REL.GDP.1991_1993^2		0.0011 (0.8614)				
INSTR.POP.SH.1991_1993^2		0.0008 (0.2255)				
W.INSTR.SCF.1989_1993			1.0335 (0.0000)			
W.INSTR.3G			0.0004 (0.6978)			
W.INSTR.REL.GDP.1991_1993			−0.0007 (0.9299)			
W.INSTR.POP.SH.1991_1993			−0.0045 (0.0199)			
W.INSTR.SCF.1989_1993^2				0.7480 (0.0000)		
W.INSTR.3G^2				−0.0002 (0.0645)		
W.INSTR.REL.GDP.1991_1993^2				0.0013 (0.1684)		
W.INSTR.POP.SH.1991_1993^2				0.0004 (0.0002)		
W2.log.PROD.REL.IN					0.0037 (0.5937)	
W2.log.INV.RATE					−0.0011 (0.7982)	
W2.log.EMP.GR					0.0130 (0.0011)	
SCF						0.2040 (0.0000)
SCF^2						−0.3750 (0.0016)
W.SCF						0.2810 (0.1556)
W.SCF^2						−0.0938 (0.9616)
W.γ						0.7330 (0.0241)
*SCF*_RES						−0.0869 (0.1346)
SCF_RES^2						0.1380 (0.3234)
W.SCF_RES						−1.6600 (0.4310)
W.SCF^2_RES						−1.7800 (0.3549)
W.γ_RES						−0.1350 (0.7342)
Obs. 173	$\bar{R}^2 = 0.88$	$\bar{R}^2 = 0.81$	$\bar{R}^2 = 0.95$	$\bar{R}^2 = 0.89$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.73$
Wald Test	H0: *SCF*_RES=SCF_RES^2=W.SCF_RES =W.SCF^2_RES =W.θ_RES =0; W= 7.4092 (0.1919)					

Table 15: Exogeneity test of SCF, SCF^2, W.SCF, W.SCF^2 and W.θ. P-values in parenthesis. SCF_RES, SCF_RES^2, W.SCF_RES, W.SCF^2_RES and W.γ_RES are respectively the residuals of first-stage regressions.

Dependent Variable	First Stage Estimation					Second Stage Estimation
	PAY (1994-1999)	PAY^2 (1994-1999)	$W.PAY$ (1994-1999)	W.PAY^2 (1994-1999)	$\text{W.}\gamma$	γ (1997-2002)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
SECTORAL CONTROLS	YES	YES	YES	YES	YES	YES
Constant	−0.0527 (0.3742)	−0.0120 (0.5401)	−0.0113 (0.3719)	−0.0007 (0.4921)	−0.0221 (0.0046)	−0.0313 (0.0570)
log.PROD.REL.IN	−0.0030 (0.8555)	−0.0034 (0.4251)	0.00041 (0.8860)	0.0000 (0.9751)	0.0032 (0.1278)	−0.0069 (0.0694)
log.INV.RATE	−0.0106 (0.3362)	−0.0028 (0.4622)	0.0037 (0.1036)	0.0003 (0.1580)	0.0036 (0.0224)	−0.0069 (0.0318)
log.EMP.GR	0.0050 (0.5410)	0.0021 (0.4222)	−0.0009 (0.5874)	0.0000 (0.8770)	−0.0049 (0.0002)	0.0023 (0.3351)
INSTR.PAY.1989_1993	0.7417 (0.0000)					
INSTR.3G	−0.0032 (0.2807)					
INSTR.REL.GDP.1991_1993	−0.0091 (0.4758)					
INSTR.POP.SH.1991_1993	−0.0064 (0.0180)					
$\text{INSTR.PAY.1989\_1993}^2$		0.8010 (0.0000)				
INSTR.3G^2		−0.0008 (0.3792)				
$\text{INSTR.REL.GDP.1991\_1993}^2$		0.0005 (0.8651)				
$\text{INSTR.POP.SH.1991\_1993}^2$		0.0004 (0.2182)				
W.INSTR.PAY.1989_1993			0.6087 (0.0000)			
W.INSTR.3G			−0.0002 (0.7629)			
W.INSTR.REL.GDP.1991_1993			−0.0010 (0.8679)			
W.INSTR.POP.SH.1991_1993			−0.0035 (0.0106)			
$\text{W.INSTR.PAY.1989\_1993}^2$				0.2060 (0.0001)		
W.INSTR.3G^2				0.0000 (0.2110)		
$\text{W.INSTR.REL.GDP.1991\_1993}^2$				0.0006 (0.1902)		
$\text{W.INSTR.POP.SH.1991\_1993}^2$				0.0002 (0.0004)		
W2.log.PROD.REL.IN					0.0037 (0.5937)	
W2.log.INV.RATE					−0.0011 (0.7982)	
W2.log.EMP.GR					0.0130 (0.0011)	
PAY						0.3210 (0.0000)
PAY^2						−0.8700 (0.0015)
W.PAY						0.4620 (0.1594)
$\text{W.}PAY^2$						−0.0002 (0.9999)
$\text{W.}\gamma$						0.6870 (0.0359)
PAY_RES						−0.1570 (0.0684)
PAY_RES^2						0.3910 (0.2035)
W.PAY_RES						−0.2340 (0.4476)
$\text{W.}PAY^2\_RES$						−4.2900 (0.3492)
$\text{W.}\gamma\text{\_RES}$						−0.0768 (0.8461)
Obs. 173	$\bar{R}^2 = 0.87$	$\bar{R}^2 = 0.79$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.89$	$\bar{R}^2 = 0.94$	$\bar{R}^2 = 0.73$
Wald Test	H0: $PAY\_RES = \text{PAY\_RES}^2 = \text{W.PAY\_RES} = \text{W.}PAY^2\_RES = \text{W.}\theta\text{\_RES} = 0$ W= 5.9272 (0.3134)					

Table 16: Exogeneity test of PAY, PAY^2, W.PAY, W.PAY^2 and W.θ. P-values in parenthesis. PAY_RES, PAY_RES^2, W.PAY_RES, W.PAY^2_RES and W.γ_RES are respectively the residuals of first-stage regressions.