Under what conditions do Structural Funds play a significant role for European regional economic growth? Some evidence from recent panel data.

Abstract

Strengthening economic, social and territorial cohesion is a central objective of the European Union. However, disparities among European regions are considerable, and there are doubts if they are likely to reduce. In recent years there has been an increasing literature examining the effectiveness of the European Union's funds for promoting growth and reducing asymmetries between Members. In this article we contribute to the literature by examining under which conditions European Union financial aid may be affecting regional growth. Doing so, we explore the interactions between transfers and income and other regional characteristics, such as human capital or innovation. The study is applied to a panel of 137 European regions, covering the period 1995-2009. The conclusions suggest a positive and significant marginal impact of Funds only in regions with low levels of human capital and innovation.

JEL Codes: C23, O40, R11

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Introduction

The analysis of public spending and its impact over growth dates back to the 1990s, mostly under the framework of endogenous growth models. Public capital is considered to be an unpaid additional input to the production function that increases marginal productivity of the other inputs, thus fostering growth. In fact, public investment in areas like infrastructure endowment release private financial flows that can thus be invested in production.

Structural Funds are instruments of the European Union (EU) regional policy destined to achieve the central goals established in the Treaty of Rome, about strengthening economic and social cohesion by reducing disparities among regions. EU transfers can thus be regarded as public expenditure, being complementary to national investments.

The first mention to a formal regional policy occurred in the Single European Act (1986).[1] Since then the EU has completed four programming periods (1989-1993, 1994-1999, 2000-2006 and 2007-2013). For the latter of these periods, funding for regional and cohesion policy represented 35.7% of the EU budget, which reveals the central role of the regional policy in the EU agenda. 82% went to the Convergence Objective (to regions with *per capita* GDP lower than 75% of the EU average); 16% to the Competitiveness and Employment Objective (covering all regions excluded from the previous objective) and the remaining 3% to the European Territorial Cooperation Objective (cross-border, transnational and interregional cooperation programmes). Moreover, about 55% of the funding for regional and cohesion policy during this programming period was concentrated in three areas: transport (22%); research and technological development, innovation and technology (19%); and environment protection and risk prevention (14%), thus supporting the Europe 2020 growth strategy.[2]

For the current programming period (2014-2020), Structural Funds will increase the focus upon innovation and smart growth specialisation, in line with the increasing importance of education and innovation for growth. Given the current constraints on national public funding, this orientation of Funds (associated with increased co-financing rates) appears as crucial to fill the gaps on national investments.

An intense debate, lasting for decades, questions the effectiveness of Structural Funds for achieving the EU goals of economic growth, disparities reduction and social and economic cohesion. In fact, financial aid, instead of reducing disparities, may lead to centripetal forces that favour the centre in detriment of peripheral areas. In fact, especially in the beginning, Structural Funds were mainly oriented towards infrastructure, with the most visible outcome being the concentration of economic activities in the core. This led to a circular causation process in favour of the centre, since people move to where economic activities are and, on the other hand, economic activities are located near workers and consumers. The increased competition enabled by improvements in accessibility and the reduction of transport costs often benefited the fiercest firms from the centre. In fact, those firms have proved to be in best conditions to face the global market, producing high value-added products both for Europe and worldwide.

Furthermore, many regions that have been major net beneficiaries of financial aid have not grown beyond the threshold of assistance, raising doubts about the efficiency of the regional policy. Thus, a moral hazard problem may exist, given that regions avoid investing to keep welfare levels low in order to continue receiving EU transfers. Additionally, the presence of substitution effects may divert factors from more productive projects to those financed by Structural Funds (Beugelsdijk and Eijffinger, 2005; Kyriacou and Roca-Sagalés, 2012).

The 2004 enlargement of the EU came to challenge even further the EU regional policy and its effectiveness over economic growth. On the one hand, the Cohesion countries highly dependent on EU financial assistance and, on the other hand, the new Member States from Central and Eastern Europe with lower *per capita* income levels asking for transfers to tackle structural difficulties, dispute limited financial resources. The constraints upon the available resources, the sizeable needs and the different challenges regions face in the context of increasing globalisation, may hamper the functioning of the regional policy.

In our opinion, we contribute to the literature by analysing the impact of Structural Funds on growth for the 1995-2009 period, using a dataset that includes the new EU members from the 2004 enlargement (Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia). We examine the indirect channels through which Structural Funds possibly affect growth, by analysing the links with income, human capital and innovation. Only a few studies on this subject have included interaction terms, although in a different perspective. This addresses the discussion about the effectiveness of financial transfers and the conditions under which the marginal impact of Funds over growth is significant and positive.

The outline of the study is the following: in Section 1 we reflect upon the role of public expenditure on growth. In Sections 2 and 3 we discuss results from the literature about the relevance of Structural Funds and highlight the importance of human capital and innovation for regional growth. In Section 4 we present the growth model and the variables used in the empirical analysis. Section 5 discusses the main outcomes and the last section concludes the main findings.

1. Economic growth theories and the impact of public expenditure

The neoclassical approach to convergence is derived from the Solow's growth (1956) model with diminishing marginal returns to capital and exogenous technical progress. The idea was that poorer economies would tend to grow faster than richer ones in earlier stages of economic development and then in the long-run they would grow at similar rates, due to the law of diminishing returns to capital. According to this approach, Structural Funds would increase physical capital and the steady-state income level, with only a short-term impact on growth during the transition to the steady-state.

Given the unsatisfactory results provided by absolute convergence under the neoclassical approach, the endogenous growth theories relaxed some of the previous assumptions, to explain reality more accurately. Thus, convergence is conditioned by structural factors with increasing returns to scale properties, coming mostly from human and physical capital accumulation, technological progress and innovation. Therefore, economies converge to different steady-states determined by idiosyncratic characteristics (Barro and Sala-i-Martin, 2004). According to these theories, public expenditures (Funds included) are important for determining long-run growth. If these expenditures are considered additional inputs to the production function, they may increase the marginal product of private capital and consequently encourage capital accumulation and growth.

In fact, it was not until the late 1980s that the first group of studies relating investment in physical infrastructure to growth appeared in the literature (Aschauer, 1989; Barro, 1990; Munnell, 1990). The importance of public investment comes partly from the fact that it works as an unpaid input that increases the productivity of all the other inputs. Moreover, it influences the location decision of firms and industries, while at the same time it influences productivity and labour costs, thus avoiding inefficiencies and encouraging competitiveness.

This view is challenged by arguments questioning the direction of causality between infrastructure and growth and the long-lasting effects of public investment for growth. Moreover, it is questionable whether public investment works as an incentive for private investment or, conversely, crowds out private agents from the market (Aschauer, 1989; Munnell, 1990). In addition, investing excessively may result in very high public deficits with governments ending up issuing debt. Furthermore, if public investments in infrastructure are not carried out in the right timing, they may leave less competitive firms in the least developed areas unprotected (Crescenzi and Rodríguez-Pose, 2008).

Following this reasoning, at earlier stages public investment as an instrument to deepen the integration process may even increase disparities among regions (Moreno *et al.*, 1997). Thus, investment in infrastructure must be coordinated with policies designed to promote human capital and R&D.

The link between infrastructure and economic growth is complex, but currently there is more consensus than in the past about public capital fostering growth. It must also be taken into account that the same policy may have diverse effects in different locations, depending on how infrastructure is articulated with other elements, the size of the network and the degree of congestion, as well as the level of regional economic development. Moreover, empirical evidence at the regional level shows lower impacts of public investment than at the aggregated national level, partly explained by methodological issues (Romp and De Haan, 2005).[3]

In the EU, investment in infrastructure, especially in the least developed regions, is closely related to transferences in the form of Structural Funds and in some Member States it consumes most of the Funds (Rodríguez-Pose and Fratesi, 2004). In fact, Structural Funds have been mainly oriented to physical infrastructures and particularly to transport infrastructures, following the belief that a more dense net promotes efficiency and enables peripheral and laggard regions to catch up. Infrastructure is simultaneously considered to be a way of intensifying the benefits coming from

European integration and of spreading them throughout (Crescenzi and Rodríguez-Pose, 2008).

2. The role of Structural Funds on regional growth

Following the previous considerations, our focus on Structural Funds is deeply related to the discussion about the role of public investment for growth. Since a large share of EU investment is oriented to infrastructure, it is also a way to check whether the theoretical view about the importance of better linkages across Europe is having the desired impact on growth.

In fact, the role of Structural Funds is at the centre of the discussion about the effectiveness of the EU regional policy to attain the desired goals of growth, competitiveness, disparities reduction and economic, social and (more recently) territorial cohesion. According to Rodríguez-Pose and Fratesi (2004), the criticisms to Structural Funds and to their inability to promote convergence rely especially on: (i) the progressive concentration of economic activity in the EU core; (ii) national policies distorting EU regional policy effects; (iii) (still) insufficient amounts of Funds in relative terms to achieve the desired goals; (iv) medium to long-term effects of the EU regional policy and difficult assessment of the effects of the reforms of Funds on growth; and (v) orientation towards short-term goals that result in income assistance rather than in true development strategies.

Table 1 summarises the main results from recent studies regarding the impact of EU financial assistance over European regional growth.

[INSERT TABLE 1 HERE]

Firstly, it is hard to establish comparisons mainly due to the indicator used for Structural Funds, the time period and the sample used, and the estimation method applied. Moreover, poor quality data on Structural Funds also contributes to major differences in the outcomes.

Some studies argue that financial transfers helped regions to grow faster (Cappelen *et al.*, 2003; Puigcerver-Peñalver, 2007; Ramajo *et al.*, 2008; Becker *et al.*, 2010).

A different conclusion comes from Dall'erba and Le Gallo (2008), who find a non-significant impact of EU transfers over growth. Moreover, De Freitas *et al.* (2003) show that it is indifferent in terms of growth if a region is eligible as an Objective 1 region or not. Latter, Le Gallo *et al.* (2011) find a weak effect of Structural Funds on regional growth, but very different local impacts, with a positive influence being found on the growth of British, Greek and Southern Italian regions.

Fagerberg and Verspagen (1996) conclude that Funds contribute negatively to regional growth during the 1980s.

Most of the studies get to inconclusive outcomes. Ederveen *et al.* (2003) reach different conclusions depending on the specification of the growth model: Funds are found to have a negative impact when no other explanatory variables are considered nor regional or country dummies; the impact turns out insignificant when country dummies are added and no further explanatory variables are accounted for; and it becomes positive when regional dummies are introduced. Bussoletti and Esposti (2004) also get to different conclusions depending on the way Structural Funds are proxied: for the first *proxy* (dummy for treated Objective 1 regions), the impact on growth is rarely significant and sometimes even negative; for the second (*per capita* expenditures), the effect is positive and significant, although the magnitude remains small and differs across the estimators. Esposti and Bussoletti (2008) find positive limited impacts of Funds over growth, being negative or insignificant for some countries. Moreover, Llussá and Lopes (2011) find that Structural Funds have helped convergence in Member States but not across the EU.

Mohl and Hagen (2010) and Fiaschi *et al.* (2011) unveil the existence of a territorially uneven impact. Rodríguez-Pose and Fratesi (2004) find that only investments in education and human capital have a positive effect over regional growth. Rodríguez-Pose and Novak (2013) conclude that European transfers have a positive impact over regional growth conditional on other elements during the third programming period, with higher returns in richer countries and better-off regions within countries.

Bearing in mind the discussion presented and the variety of conclusions, we explore the impact of Structural Funds. A positive effect would go along those arguments defending the relevance of structural aid to help deprived regions and reduce regional disparities.

Otherwise, a negative effect would question whether EU regional policy has been oriented in the right direction and whether it has been efficiently allocated.

In addition we explore the way in which EU transfers work, *i.e*, the conditions under which Structural Funds affect growth significantly. The idea is to check if Funds affect growth differently according to the region's level of income, human capital or innovation. Depending on the sign and significance of such an impact, we can contribute to the discussion about whether the goals of EU aid are in fact being attained or, conversely, the mechanism of transfers is maintaining poorer regions in a trap and showing perverse effects. We think this to be the main contribution of our paper.

Some previous studies focusing on the impact of Structural Funds for growth use interaction terms. Examples at the national level are Beugelsdijk and Eijffinger (2005), Ederveen *et al.* (2006) and Bähr (2008). Beugelsdijk and Eijffinger (2005) and Ederveen *et al.* (2006) interact Funds with a corruption index to analyse the relationship between institutional quality and the effectiveness of EU transfers for growth.[4] Bähr (2008) combines Funds with an indicator of tax decentralization to check how the federal structure acts over the Structural Funds efficiency.

At the regional level, De Freitas *et al.* (2003), Cappelen *et al.* (2003), Puigcerver-Peñalver (2007), Esposti and Bussoletti (2008), Llussá and Lopes (2011) and Rodríguez-Pose and Novak (2013) also use interactive effects. Cappelen *et al.* (2003) combine Funds with a temporal dummy and Puigcerver-Peñalver (2007) interacts Funds with tendency. With the aim to analyze learning effects, Rodríguez-Pose and Novak (2013) interact alternatively Funds with national or relative regional income to check the conditions under which transfers are more effective. De Freitas *et al.* (2003) combine a dummy for Objective 1 regions with productivity, just like Llussá and Lopes (2011) interact income with a dummy variable representing eligibility to each of the Objectives, to examine how it affects the growth performance. In a different way, Esposti and Bussoletti (2008)combine Funds with infrastructure, human capital and (public and private) R&D, arguing that EU transfers affect growth through investment, which in turn is mainly focused in the mentioned areas, in the regions studied.

3. Additional factors of regional growth: the role of human capital and innovation

Undeniably, regions differ along several endogenous characteristics. On this regard, the models of endogenous growth confer a special role to human capital, considered as a measure of the ability and skills of the labour force and evaluated by the level of formal education or by job accumulated experience, with potential to contribute to increase the productivity of physical capital (Lucas, 1988). A better-educated and well-trained workforce is expected to exert a positive effect on growth (Ciccone and Papaioannou, 2009). However, the empirical results have sometimes shown a different pattern, with the impact of human capital on growth being negative and/or statistically insignificant, especially in panel data studies. This may happen due to poor quality data and inadequate proxies to capture qualitative rather than quantitative aspects of human capital (Islam, 1995). In addition, more educated workers may migrate when no jobs are locally available or wages are found to be insufficient and in that case the impact may not be as expected (Garcia-Milà and McGuire, 1992).

According to another line of research, it is the accumulation of technological change the key factor for growth (Romer, 1986; Di Liberto, 2007). On the one hand, technology is non-rival, which implies the existence of knowledge spillovers, increasing returns and externalities (Grossman and Helpman, 1991a). On the other hand, non-excludability depends both on the kind of knowledge produced and on the mechanisms protecting property rights, like the patents. The patents system as an incentive to protect the R&D sector is thus determinant for growth (Grossman and Helpman, 1991b).

Human capital and innovation are reflected into faster economic growth only if economies show the "social capability" to benefit from higher education skills and more protection to R&D (Abramovitz, 1986; Crescenzi and Rodríguez-Pose, 2012).[5] Bearing this in mind, Alexiadis *et al.* (2010) argue that the European policy should focus on R&D activities in order to promote regional growth in an enlarged area. This goes along the target of an investment share in R&D of 3% of GDP stated in the European 2020 growth strategy.

Hence, we expect both human capital and innovation to play a positive role on growth. Furthermore we explore how (and if) the regional performance regarding human capital and innovation condition the impact of the EU assistance upon growth.

4. Description of the model and the data used

In order to address our research issue, we consider the following alternative augmented versions of the neoclassical growth model for panel data:

$$gy_{i,t} = b\ln(y_{i,t-2}) + c_1\ln(gpop_{i,t-2}) + c_2[\ln(s_{i,t-2}) - \ln(s_{i,t-3})] + c_3\ln(hc_{i,t-2}) + \\ + c_4\ln(pat_{i,t-2}) + c_5\ln(sf_{i,t-2}) + v_{i,t} \quad \textbf{(1)}$$

$$gy_{i,t} = b\ln(y_{i,t-2}) + c_1\ln(gpop_{i,t-2}) + c_2[\ln(s_{i,t-2}) - \ln(s_{i,t-3})] + c_3\ln(hc_{i,t-2}) + \\ + c_4\ln(pat_{i,t-2}) + c_5\ln(sf_{i,t-2}) + c_6\ln(y_{i,t-2}) * \ln(sf_{i,t-2}) + v_{i,t} \quad \textbf{(2)}$$

$$gy_{i,t} = b\ln(y_{i,t-2}) + c_1\ln(gpop_{i,t-2}) + c_2[\ln(s_{i,t-2}) - \ln(s_{i,t-3})] + c_3\ln(hc_{i,t-2}) + \\ + c_4\ln(pat_{i,t-2}) + c_5\ln(sf_{i,t-2}) + c_6\ln(hc_{i,t-2}) * \ln(sf_{i,t-2}) + v_{i,t} \quad \textbf{(3)}$$

$$gy_{i,t} = b\ln(y_{i,t-2}) + c_1\ln(gpop_{i,t-2}) + c_2[\ln(s_{i,t-2}) - \ln(s_{i,t-3})] + c_3\ln(hc_{i,t-2}) + \\ + c_4\ln(pat_{i,t-2}) + c_5\ln(sf_{i,t-2}) + c_6\ln(pat_{i,t-2}) * \ln(sf_{i,t-2}) + v_{i,t} \quad \textbf{(4)}$$

In all equations, $v_{i,t} = \alpha_i + \lambda_t + u_{i,t}$. α_i refers to region-specific effects, λ_t reveals time-specific effects and $u_{i,t}$ is the idiosyncratic error term. The subscript i indicates regions[6] and t is the time index, ranging from 1995 to 2009.

The dependent variable is the annual growth rate of real *per capita* income ($gy_{i,t}$).[7]The set of explanatory variables includes: $\ln(y_{i,t-2})$, real *per capita* income; $\ln(gpop_{i,t-2})$, annual population growth rate; $\ln(s_{i,t-2}) - \ln(s_{i,t-3})$, growth of the investment share;[8] $\ln(hc_{i,t-2})$, human capital measured by the ratio of students in tertiary education over 20-24 year-olds; $\ln(pat_{i,t-2})$, innovation proxied by the number of patents *per* million inhabitants;[9] and $\ln(sf_{i,t-2})$, (interpolated) Structural Funds.[10] All the explanatory variables are lagged twice; we consider this to be more proper than the standard one-year lagged variables, to capture initial conditions and avoid reverse causality (Rodríguez-Pose and Fratesi, 2004).[11] **Table 2** contains summary statistics of the data.

[INSERT TABLE 2 HERE]

Equation (1) expresses the model with only direct impacts, whereas Equations (2)-(4) consider alternative interactive terms between Funds and income, human capital and innovation, to ascertain under what conditions financial transfers may be effective for promoting growth. The marginal effect of Funds depends on the value of the other element that constitutes the interactive term.

From Equation (2), the marginal impact of Funds is given by:

$$\frac{\partial gy_t}{\partial ln(sfpc_{t-2})} = c_5 + c_6 ln(y_{i,t-2}) \qquad \textbf{(5)}$$

The same reasoning applies to Equations (3) and (4). Thus, the effect of a change on Funds over growth depends on the value of the conditioning variable (income *per capita*, human capital or innovation).[12] While it is possible to compute the marginal effect using Equation (5) and the results from the estimation table, it is more difficult to do so for the standard errors, at least for continuously defined variables. In what follows, we focus on the sign of the marginal effects of Structural Funds for different levels of the conditioning variables and the interval for which they are significantly affecting growth, following Brambor *et al.* (2006), Mohl and Hagen (2011) and Lessmann (2012).

5. Empirical results

We estimate the model by Fixed Effects (FE)[13] using Rogers standard errors, which are heteroscedasticity and autocorrelation (HAC) consistent. This approach is limited in the sense that it does not take into account the possible existence of cross-sectional correlations, *i.e*, it assumes that residuals are correlated within but not between groups of individuals.

Conversely, Driscoll and Kraay's approach deals with an error structure that is assumed to be heteroscedastic, autocorrelated up to some lag and possibly correlated between groups. With this correction, HAC standard errors are robust to general forms of spatial and temporal dependence asymptotically, but their small-sample properties are considerable better than those of alternative techniques, in the presence of cross-sectional dependence (Hoechle, 2007).[14] Nevertheless, weak cross-sectional error dependence is not a serious problem for estimation and inference (Pesaran, 2012).

We are not able to perform Pesaran's CD test on residuals cross-sectional dependence after the FE regression (De Hoyos and Sarafidis, 2006) for not having enough common observations in the panel. We thus opted for comparing outcomes from FE with robust standard errors and FE with standard errors from Driscoll and Kraay's correction.

Table 3 displays the results of the estimation of the growth equation with *per capita* Structural Funds as the *proxy* for financial assistance.

[INSERT TABLE 3 HERE]

Common to all the estimations is the evidence of conditional convergence, given the negative and significant sign of the convergence coefficient. The evolution of physical capital is almost always significant with the expected positive sign.[15]Moreover, annual population growth displays a negative coefficient and the impact over income growth is insignificant, a common finding in the literature.

Human capital is positively and significantly influencing growth, as expected. This is the only variable that maintains its significance in all the estimations ran. The patents ratio is rarely significant, but removing it from the estimations does not improve overall results and by keeping it we avoid the omitted variable bias.[16]

Regarding Funds, in columns (1) and (2) we see that they are not statistically significant. When interactive terms are added to the regression, the marginal impact of Funds depends (alternatively) on varying levels of income, human capital and innovation. In **Figure 1**, we graph the corresponding marginal effects.

[INSERT FIGURE 1 HERE]

The solid line indicates how the marginal effect of Funds changes with the level of the other conditioning variable (income, human capital or innovation). Dashed lines give 90% confidence intervals and indicate the conditions under which the marginal effect has a statistically significant impact on growth. Statistical significance is found when the zero line is out from the confidence band, *i.e*, for the marginal impact to have a significant impact, both the lower and upper bonds of the confidence interval must be above (or below) the zero line (Brambor *et al.*, 2006; Wooldridge, 2009).[17] The negative slope of the marginal effect comes from the negative coefficient on the interaction term.

In panels (a) and (b) we show the marginal effect of Funds for varying levels of *per capita* income, for Robust FE and Driscoll and Kraay's correction, respectively. The effect of Structural Funds in a region with an average degree of income is close to zero and insignificant. Moreover, the value of *per capita* income for which the marginal impact of Funds is null (cut-off point) is given by:

$$\frac{\partial gy_t}{\partial ln(sfpc_{t-2})} = 0 \Leftrightarrow ln(y_{i,t-2}) = -\frac{c_5}{c_6} \Leftrightarrow ln(y_{i,t-2}) = \frac{0.0712}{0.0073} \Leftrightarrow ln(y_{i,t-2}) =$$

$= 9.753 \Leftrightarrow y_{i,t-2} = 17213€$. In regions with lower *per capita* incomes than this, Funds have a positive impact on growth, while the contrary occurs for higher figures. However, the information on the sign of the impact has to be completed with that about significance.

In panel (a) the marginal impact of Funds on growth is positive and significant for values of *per capita* income below the average, whereas for high income values (near the maximum) the impact is significantly negative. In panel (b), only the last of these effects prevails. Comparing common elements from both panels, we conclude that for high *per capita* incomes, more Funds have a negative and significant impact on growth.

From panels (c) and (d), we see that for regions with an average human capital level, the marginal impact of Funds is close to zero; the significance depends on the method used. The cut-off point (in logs) is 4.283, meaning that for education levels lower than this, more Funds mean additional growth. However, this positive marginal impact is only significant for education levels considerably lower than the threshold.

From panels (e) and (f), the marginal impact of Funds is null and insignificant for the average value of the patents ratio. The cut-off point (in logs) is 2.465; hence, the marginal impact of Funds is positive for a patents ratio lower than 11.76. However, this impact is only significant for extremely low values of innovation. In addition, in regions with high innovative standards, the marginal impact of EU transfers is negative and significant.

To sum up and considering common elements, (i) Funds are not significant when isolated; (ii) in richer regions more Funds contribute significantly to less growth; (iii) the marginal impact of Funds in regions with low education levels is positive and statistically significant; (iv) in low (high) -innovative regions, Funds have a positive (negative) and statistically significant effect on growth; and (v) regions performing close to the average in terms of the conditioning variables do not assist to a significant impact of Funds on growth.

In **Table 4** we use as the Structural Funds *proxy* the share of Funds on GDP. **Figure 2** depicts the marginal effect of Funds on growth.

[INSERT TABLE 4 HERE]

[INSERT FIGURE 2 HERE]

Once more, there is evidence of conditional convergence and the population growth does not have a significant impact. In addition, the human capital *proxy* is always statistically significant, displaying the expected positive sign. Physical capital and innovation are also positive, but there are some cases of statistical insignificance, though less than in the previous table.

Regarding our variable of interest, the Funds' impact is negative in columns (1) and (2), but only significant in the first case. By including interactive terms, the sign and significance of the marginal impact of the Funds can be observed in **Figure 2**.

The first aspect to notice is that for the average values of the conditioning variables, the marginal impact of Funds on growth is negative and close to zero. From the panels on the left we observe that the impact is significant, whereas from the right-panels there is evidence of insignificance.

The results differ according to the estimation method. Regarding interaction with income (panels (a) and (b)), in regions with *per capita* incomes relatively close and above the average, the impact is significantly negative, meaning that for those regions more Funds translate into slower growth.

From panels (c) and (d), we conclude that for human capital levels below the threshold, the impact of Funds on growth is positive. However, it is only significant for very low values. For high educated regions the contrary is observed, *i.e*, the impact is negative and significant.

Considering only the common findings, in regions with high patents ratios (panels (e) and (f)), the marginal impact of Funds is negative and significant.

Overall, (i) in regions with *per capita* incomes close and slightly above the average Funds have a negative and significant impact on growth; (ii) for low (high) levels of human capital the marginal impact of Funds is significant and positive (negative); (iii) for regions that innovate more, the effect is significantly negative; and (iv) for the average values of the conditioning variables, the marginal impact is negative, with significance depending on the estimation method considered.

Running the same regressions only for (102) regions from the EU-15, the marginal impact of *per capita* Funds turns out to be significant (and positive) for growth only for low levels of human capital. When the share of Funds on GDP is considered, it significantly and negatively (positively) affects growth in poorer (richer) regions, thus questioning the effectiveness on the allocation of transfers with the ultimate goal of reducing disparities. Moreover, in regions with low (high) human capital standards, Funds have a positive (negative) marginal impact on growth. Finally, for regions showing close-to-average patents ratios, EU regional policy impacts negatively and significantly on growth.

6. Conclusion

Structural Funds are financial instruments of the EU regional policy, designed to support laggard areas to catch-up, thus reducing regional asymmetries and promoting cohesion and sustainable growth. Being considered as public expenditure, according to the endogenous growth models Funds have the potential to foster growth in the long-term. There is an extensive research on the impact of Structural Funds to reduce EU regional asymmetries and to promote sustained growth. However, the outcomes vary widely and it is hard to establish comparisons.

We find evidence of conditional convergence. Regarding our variable of interest - Structural Funds - the results differ depending on the *proxy* used.

For *per capita* Funds, we observe that they do not act significantly when considered isolated. Thus, by adding interaction terms we check the conditions under which this financial aid is effective for promoting growth. The starting point was that the impact of EU transfers could possibly depend on the level of income, human capital or innovation. Comparing the results for each pair of regressions and focusing on common outcomes, richer regions assist to a negative and statistically significant marginal impact of Funds on growth. Moreover, in regions with low human capital standards more Funds turn significantly into faster growth. In addition, the Funds' marginal impact is positive (negative) and significant for low (high) innovative levels. From these we can imply that regions may be stuck in a trap and may lack the incentive to improve their skills. Provided that regions display low values of human capital and innovation, Funds positively and significantly contribute to growth; otherwise, the impact is insignificant and may even be statistically negative.

When the share of Funds on GDP is considered, regions with a *per capita* income close to the average assist to a negative and significant impact of Funds on growth. In addition, in regions with low (high) human capital skills, Funds have a statistically significant and positive (negative) marginal impact. Finally, in regions with high patents ratios, a statistically negative marginal impact of EU transfers on growth is observed.

If fact, Funds are apparently more effective for growth promotion in regions with low standards of human capital and innovation (depending on the estimation method and the *proxy*). Nevertheless, our findings may raise questions about the effectiveness of the EU regional policy, originally designed to assist deprived regions and reduce regional asymmetries. In fact, EU regional policy should explicitly be oriented for the less developed areas lagging behind in crucial sectors (like education or R&D), allowing them to improve their skills and catch-up. Nonetheless, our outcomes indicate the possible existence of a moral hazard problem, deviating policy makers from their expected behaviour, due to the lack of incentives to improve human capital skills. As a matter of fact, EU transfers' marginal impact on growth is apparently positive and significant only for regions with low human capital skills. This collides directly with the Europa 2020 growth strategy, focusing on smart, sustainable and inclusive growth. The defined targets regard progresses in education, R&D, employment, efficient energy and social inclusion, but according to our findings, improving (*per capita* income, human capital or innovation) skills may result on an insignificant or negative impact of regional policy on growth. Thus, the effect of public policy would turn out to be contrary to that originally intended for promoting growth and cohesion.

We are aware that some of the effects of Structural Funds may take time to be visible, but our main goal was to ascertain the links through which Funds might be affecting growth and the conditions under which they are most effective. This is even more important given that we have just recently started the fifth programming period (2014-2020).

Appendix I. Definitions of the variables and data sources

- $y_{i,t}$ – Real p*er capita* Gross Domestic Product (GDP) (Euros per inhabitant)

Computed by the authors using data on: (i) GDP at current market prices (Million euro (from 1.1.1999)/Million ECU (up to 31.12.1998)), (ii) Price deflator GDP at market prices (national currency; annual percentage change) and (iii) Annual average population (1 000).

Data Sources: (i) Eurostat, Regional Economic Statistics (data extracted on 6th November 2012); (ii) European Commission (2011) - Knowing the base year (2005=100), we computed the annual national GDP deflator and used it to divide the regional current GDP. Given that regional price indexes are not available, we converted nominal into real figures using national GDP deflator assuming that for each region of a given country, the price index is the same; (iii) Eurostat, Regional Demographic Statistics (data extracted on 20th November 2012).

- $gy_{i,t}$ – Annual growth rate of real *per capita* GDP (annual logarithmic difference of real *per capita* GDP)
- $gpop_{i,t}$ – Annual growth rate of population

Computed by the authors using data on "Annual average population (1 000)". To the annual logarithmic difference of population we added 5%, to account for the rate of (human and physical) capital depreciation and the rate of technological progress.

Data Source: Eurostat, Regional Demographic Statistics (data extracted on 20th November 2012).

- $s_{i,t}$ – Investment share (%)

Computed by the authors using data on: (i) Gross fixed capital formation (Million euro (from 1.1.1999)/Million ECU (up to 31.12.1998)) and (ii) GDP at current market prices (Million euro (from 1.1.1999)/Million ECU (up to 31.12.1998)).

Data Source: (i) and (ii) Eurostat, Regional Economic Statistics

$hc_{i,t}$ – Human capital (%)

Students in tertiary education as a percentage of the population aged 20-24 years

Data Source: Eurostat, Regional Education Statistics (data extracted on 6th November 2012)

- $pat_{i,t}$ –Patent applications to the European Patents Office (EPO) by priority year - Total (per million of inhabitants)

Computed by the authors using data on: (i) Number of patent applications to the EPO by priority year and (ii) Annual average population (1 000).

Data Sources: (i) Eurostat, Regional Science and Technology Statistics (data extracted on 16th January 2013) and (ii) Eurostat, Regional Demographic Statistics.

- $sfpc_{i,t}$ –Interpolated real *per capita* Structural Funds terms (Euros per inhabitant)

Computed by the authors using data on: (i) payments for 1995- 1998; (ii) calculation of payments for 1999 as the difference between commitments and payments in 1994-1998; (iii) payments for 2000-2009; (iv) Price deflator GDP at market prices (national currency; annual percentage change) and (v) Annual average population (1 000).

Data Sources: (i) European Commission (1996; 1997; 1998; 1999); (ii) European Commission (1999); (iii) European Commission – DG Regional and Urban Policy; (iv) European Commission (2011) and (v) Eurostat, Regional Demographic Statistics.

- $sfshare_{i,t}$ –Interpolated Structural Funds share over GDP (%)

Computed by the authors using data on: (i) payments for 1995- 1998; (ii) calculation of payments for 1999 as the difference between commitments and payments in 1994-1998; (iii) payments for 2000-2009; (iv) GDP at current market prices (Million euro (from 1.1.1999)/Million ECU (up to 31.12.1998))

Data Sources: (i) European Commission (1996; 1997; 1998; 1999); (ii) European Commission (1999); (iii) European Commission – DG Regional and Urban Policy; (iv) Eurostat, Regional Economic Statistics.

Appendix II. Construction of the Structural Funds dataset

The choice on the level of regional disaggregation (NUTS) for each country depended on the availability of data for Structural Funds.

For the years 1995-1998, data on Structural Funds payments were collected from the European Commission's Annual Reports (European Commission, 1996; 1997; 1998; 1999). For 1999, we computed the payments as the residual difference between commitments and payments in the 1994-1998 period.[18]

From 2000 onwards, we relied on data sent on 12th December 2012 by the European Commission – DG Regional and Urban Policy, following a formal request. The aggregated payments for 2000-2006 refer to the programmes ERDF (European Regional Development Fund), ESF (European Social Fund), EAGGF (European Agricultural Guidance and Guarantee Fund), FIFG (Financial Instrument for Fisheries Guidance) and Cohesion Fund. For 2007-2013, overall payments concern funds received under ERDF, ESF and the Cohesion Fund. The information is disaggregated at the NUTS2 level. For some countries, data on the Reports is available only for NUTS1 and thus we had to reconcile different databases. Moreover, since only data from the Reports was disaggregated by Objective we kept aggregated figures, to guarantee consistency.

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Table 1. Comparative studies on the relevance of Structural Funds for European regional growth

Study	Impact of Structural Funds (SF) on economic growth	*Proxy* for SF	Period	Sample	Method
Rodríguez-Pose and Novak (2013)	Improvement in the returns of investment in SF between the second and third programming periods. The returns are higher in richer countries and better-off regions within a country.	Obj1, 2, 5b and 6 payments *per capita*	1994-1999, 2000-2006	133 NUTS1-2 regions (EU 15)	Panel: HAC Robust FE
Fiaschi *et al.* (2011)	The effect of SF on productivity growth is positive, but the main effect is put forth by Obj1 funds.	Commitments and payments (for 1994-1999) (% GVA)	1980-2002	173 NUTS2 regions (EU 12)	Cross-section: Spatial Durbin model; Robust OLS
Llussá and Lopes (2011)	Structural policies tend to increase convergence inside the Member States but are ineffective fostering regional convergence across the EU.	Dummies=1 if the region is eligible for Obj1, Obj 2 and Obj 5b	1989-1999	194 NUTS2 regions (EU 14)	Panel: Pooled OLS
Le Gallo *et al.* (2011)	SF have a weak global impact on the EU regional growth process, but their local impacts are very diverse, with a positive influence on the growth of British, Greek, and Southern Italian regions.	Payments and total costs	1989-1999	145 NUTS2 regions (EU12)	Cross-section: Spatial lag model with global and local Bayesian spatial method (MCMC)
Mohl and Hagen (2010)	Only Obj1 payments promote regional growth.	Obj 1, 2 and 3 payments *per capita*	1995-2005	126 NUTS1-2 regions (EU 14)	Panel: FE with Driscoll and Kraay's correction; SYS-GMM; ML (FE spatial lag model)
Becker *et al.* (2010)	Positive *per capita* growth effects of Obj1 transfers but no employment growth transfers.	Dummy=1 for regions receiving Obj1 transfers	1989-1993, 1994-1999, 2000-2006	Up to 3301 NUTS3 regions (EU12/25)	Panel: Regression Discontinuity Analysis
Dall'erba and Le Gallo (2008)	Significant convergence takes place, but the funds have no impact on it.	SF payments and remaining commitments over 1994-99 (% GDP)	1989-1999	145 NUTS2 regions (EU12)	Cross-section: Spatial lag model with IV
Esposti and Bussoletti (2008)	The impact of the Obj1 policy on growth is positive but quite limited for the whole EU. In some regions or groups it has a negligible or even negative effect.	Obj 1 payments *per capita* (PPS)	1989-1999	206 NUTS2 regions (EU15)	Panel: DIFF-GMM, SYS-GMM
Ramajo *et al.* (2008)	Regions in the Cohesion-countries converge separately from the rest of the European regions.	Separate regressions for regions belonging to Cohesion vs. non-Cohesion countries	1981-1996	163 NUTS2 regions (EU12)	Cross-section: Robust OLS, Spatial lag model

Table 1. Comparative studies on the relevance of Structural Funds for European regional growth (continued)

Study	Impact of Structural Funds (SF) on economic growth	*Proxy* for SF	Period	Sample	Method
Puigcerver-Peñalver (2007)	SF have positively influenced the growth process of Obj1 regions, although their impact has been stronger during 1989-1993 than 1994-1999.	Total SF (%GDP); total SF; (SF of region *i* /total SF received by all regions)	1989-1999, 1989-1993	41 NUTS2 regions (EU10)	Panel: Pooled OLS, FE
Rodríguez-Pose and Fratesi (2004)	Limited impact of SF on growth; only investment in education and human capital has medium-term positive and significant returns.	Obj1 commitments (% GDP)	1989-1999	152 NUTS2 regions (EU8)	Cross-section and panel: OLS, Pooled GLS, LSDV
Bussoletti and Esposti (2004)	The impact of the Obj1 policy on growth depends on the poxy used. An increase of the employment share on agriculture reduces the effect of SF payments.	Dummy=1 for Obj1; Obj 1 payments *per capita*	1989-2000	206 NUTS2 regions (EU15)	Panel: DIFF-GMM, SYS-GMM
De Freitas *et al.* (2003)	Obj1 regions do not show faster convergence than non-Obj1 regions	Dummy=1 for regions receiving Obj1 funding	1990-2001	196 NUTS2 regions (EU15)	Cross-section: OLS
Cappelen *et al.* (2003)	EU regional support has a significant and positive impact on the growth performance of European regions. SF have been more effective since the reform of 1989. The impacts are stronger in more developed regions.	Obj1, 2, 5b (% GDP)	1980-1997, 1980-1988, 1989-1997	105 NUTS1-2 regions (EU9)	Cross-section: OLS
Ederveen *et al.* (2003)	The results depend on the model considered. The impact of SF may be negative, insignificant or positive.	Structural and Cohesion Funds (% GDP)	1981-1996	183 NUTS2 regions (EU13)	Panel: Pooled OLS
Fagerberg and Verspagen (1996)	EU support is significantly negative for growth, indicating that this kind of support goes to slow-growing regions.	ERDF (%GDP)	1980-1990	70 NUTS1-2 regions (EU6)	Cross-section: OLS

Note: OLS – Ordinary Least Squares; HAC – Heteroscedasticity and autocorrelation robust; FE – Fixed Effects; MCMC – Markov Chain Monte Carlo; SYS-GMM – System Generalised Method of Moments; ML – Maximum likelihood; IV – Instrumental Variables; DIFF-GMM – Difference Generalised Method of Moments; GLS – Generalised Least Squares; LSDV – Least Squares Dummy Variables.

Table 2. Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations	
gy	overall	0.01689	0.05779	-0.22740	0.21702	N=	1918
	between		0.01516	-0.01758	0.08136	n=	137
	within		0.05578	-0.22732	0.20600	T=	14
ln(y)	overall	9.69596	0.62794	7.64241	11.16561	N=	2055
	between		0.61498	8.35715	10.97989	n=	137
	within		0.13669	8.95177	10.32036	T=	15
ln(s)	overall	3.03513	0.33280	0.81814	3.97198	N=	1910
	between		0.27056	2.15504	3.50897	n=	137
	within		0.18684	1.69823	3.66675	T-bar=	13.942
ln(gpop)	overall	-2.93207	0.12929	-3.90032	-2.34485	N=	2051
	between		0.11175	-3.23004	-2.45586	n=	137
	within		0.06556	-3.81386	-2.60158	T-bar=	14.971
ln(hc)	overall	3.85127	0.46522	0.91629	5.23378	N=	1356
	between		0.48355	1.45480	4.99391	n=	137
	within		0.13408	2.49201	5.12467	T-bar=	9.898
ln(pat)	overall	2.94942	1.85263	-2.41609	6.60331	N=	1916
	between		1.79029	-0.77532	6.12036	n=	137
	within		0.60696	0.10669	5.57558	T-bar=	13.985
ln(sfpc)	overall	3.36152	1.74925	0.00000	6.81785	N=	2055
	between		1.29700	1.47512	6.24744	n=	137
	within		1.17861	-1.09506	7.42664	T=	15
ln(sfshare)	overall	0.34861	0.42354	0.00000	2.14606	N=	2055
	between		0.34029	0.01689	1.65978	n=	137
	within		0.25373	-0.50636	1.62888	T=	15

Table 3. FE with robust and Driscoll-Kraay's standard errors. 137 European regions, 1995-2009. (Structural Funds *per capita*)

	No interaction term		Interaction with income		Interaction with h.capital		Interaction with patents	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay
$\ln(y_{i,t-2})$	-0.2285***	-0.2285***	-0.2387***	-0.2387***	-0.2309***	-0.2309***	-0.2608***	-0.2608***
	(-5.037)	(-3.342)	(-4.991)	(-3.616)	(-5.078)	(-3.381)	(-5.343)	(-4.071)
$\ln(s_{i,t-2})-\ln(s_{i,t-3})$	0.0225*	0.0225*	0.0197	0.0197*	0.0225*	0.0225*	0.0193	0.0193*
	(1.662)	(1.866)	(1.438)	(1.805)	(1.669)	(1.853)	(1.434)	(1.793)
$\ln(gpop_{i,t-2})$	-0.0163	-0.0163	-0.0037	-0.0037	-0.0150	-0.0150	-0.0045	-0.0045
	(-0.612)	(-0.673)	(-0.144)	(-0.138)	(-0.528)	(-0.593)	(-0.158)	(-0.161)
$\ln(sfpc_{i,t-2})$	0.0026	0.0026	0.0712**	0.0712	0.0227*	0.0227***	0.0106***	0.0106
	(1.604)	(0.346)	(2.547)	(1.365)	(1.687)	(5.353)	(4.169)	(1.174)
$\ln(hc_{i,t-2})$	0.1013***	0.1013***	0.1006***	0.1006***	0.1178***	0.1178***	0.0984***	0.0984***
	(4.503)	(3.216)	(4.543)	(3.052)	(5.402)	(3.783)	(4.353)	(3.040)
$\ln(pat_{i,t-2})$	0.0061	0.0061	0.0042	0.0042	0.0061	0.0061	0.0185***	0.0185**
	(1.180)	(0.993)	(0.834)	(0.822)	(1.169)	(0.996)	(3.020)	(2.211)
$\ln(y_{i,t-2})*\ln(sfpc_{i,t-2})$			-0.0073**	-0.0073				
			(-2.510)	(-1.501)				
$\ln(hc_{i,t-2})*\ln(sfpc_{i,t-2})$					-0.0053	-0.0053***		
					(-1.552)	(-2.822)		
$\ln(pat_{i,t-2})*\ln(sfpc_{i,t-2})$							-0.0043***	-0.0043**
							(-4.270)	(-2.581)
Constant	1.6915***	1.6915**	1.8536***	1.8536***	1.6577***	1.6577**	2.0393***	2.0393***
	(4.142)	(2.394)	(4.220)	(2.748)	(4.167)	(2.337)	(4.621)	(3.079)
Time dummies	Yes		Yes		Yes		Yes	
Number of regions	137		137		137		137	
Observations	1031		1031		1031		1031	
Avg. Obs. per Group	7.526		7.526		7.526		7.526	
R^2 overall	0.163		0.149		0.162		0.152	
R^2 within	0.517		0.522		0.519		0.528	
R^2 between	0.242		0.244		0.241		0.245	
p-value F test	0.000		0.000		0.000		0.000	
p-value F test time dummies	0.000		0.000		0.000		0.000	

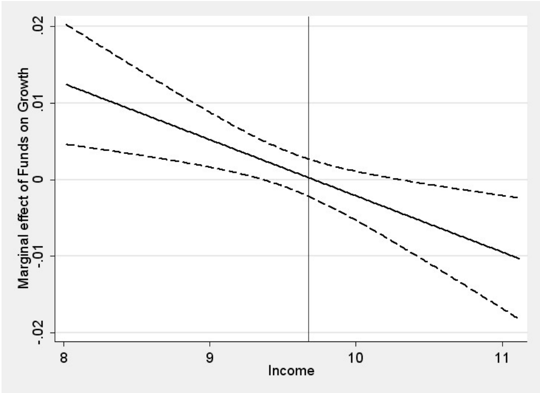
Note: Coefficient significant at the 10 % (*), 5 % (**) or 1 % level (***)

Table 4. FE with robust and Driscoll-Kraay's standard errors. 137 European regions, 1995-2009. (Structural Funds as a percentage of GDP)

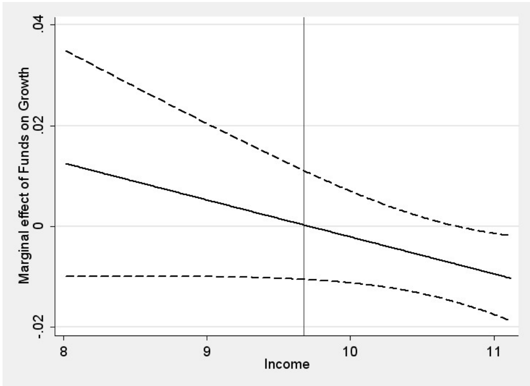
	No interaction term		Interaction with income		Interaction with h.capital		Interaction with patents	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay	Robust FE	Driscoll-Kraay
$\ln(y_{i,t-2})$	-0.1938***	-0.1938***	-0.1993***	-0.1993***	-0.2030***	-0.2030***	-0.2112***	-0.2112***
	(-4.532)	(-2.876)	(-4.505)	(-2.883)	(-4.826)	(-3.033)	(-4.723)	(-3.291)
$\ln(s_{i,t-2})-\ln(s_{i,t-3})$	0.0240*	0.0240*	0.0233*	0.0233*	0.0219	0.0219	0.0232*	0.0232*
	(1.774)	(1.779)	(1.737)	(1.822)	(1.644)	(1.652)	(1.720)	(1.882)
$\ln(gpop_{i,t-2})$	-0.0197	-0.0197	-0.0164	-0.0164	-0.0257	-0.0257	-0.0090	-0.0090
	(-0.768)	(-0.795)	(-0.663)	(-0.502)	(-0.899)	(-0.949)	(-0.347)	(-0.338)
$\ln(sfshare_{i,t-2})$	-0.0251***	-0.0251	0.0752	0.0752	0.1429**	0.1429***	0.0068	0.0068
	(-3.485)	(-0.723)	(0.596)	(0.159)	(2.035)	(4.644)	(0.575)	(0.138)
$\ln(hc_{i,t-2})$	0.1079***	0.1079***	0.1087***	0.1087***	0.1232***	0.1232***	0.1054***	0.1054***
	(5.231)	(3.461)	(5.258)	(3.463)	(6.045)	(4.145)	(5.055)	(3.284)
$\ln(pat_{i,t-2})$	0.0086	0.0086*	0.0082	0.0082**	0.0090	0.0090*	0.0147**	0.0147**
	(1.612)	(1.744)	(1.525)	(2.418)	(1.652)	(1.839)	(2.544)	(2.169)
$\ln(y_{i,t-2})*\ln(sfshare_{i,t-2})$			-0.0107	-0.0107				
			(-0.806)	(-0.227)				
$\ln(hc_{i,t-2})*\ln(sfshare_{i,t-2})$					-0.0430**	-0.0430***		
					(-2.484)	(-13.082)		
$\ln(pat_{i,t-2})*\ln(sfshare_{i,t-2})$							-0.0164***	-0.0164*
							(-2.841)	(-1.739)
Constant	1.3269***	1.3269*	1.3893***	1.3893*	1.3404***	1.3404*	1.5221***	1.5221**
	(3.407)	(1.866)	(3.453)	(1.875)	(3.665)	(1.876)	(3.714)	(2.253)
Time dummies	Yes		Yes		Yes		Yes	
Number of regions	137		137		137		137	
Observations	1031		1031		1031		1031	
Avg. Obs. per Group	7.526		7.526		7.526		7.526	
R^2 overall	0.183		0.177		0.178		0.178	
R^2 within	0.521		0.521		0.526		0.527	
R^2 between	0.230		0.233		0.224		0.232	
p-value F test	0.000		0.000		0.000		0.000	
p-value F test time dummies	0.000		0.000		0.000		0.000	

Note: Coefficient significant at the 10 % (*), 5 % (**) or 1 % level (***)

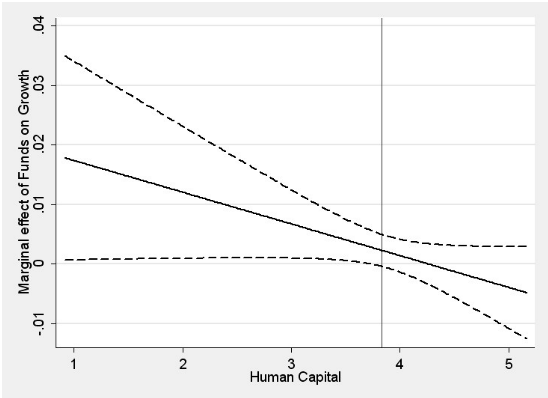
Figure 1. Marginal effect of *per capita* Structural Funds on growth



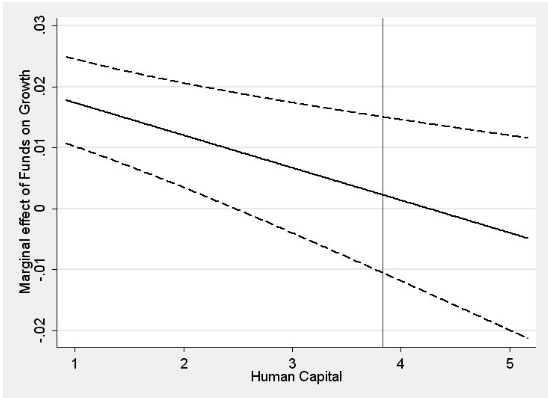
(a)



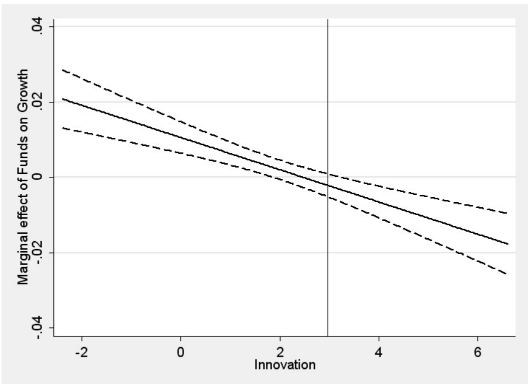
(b)



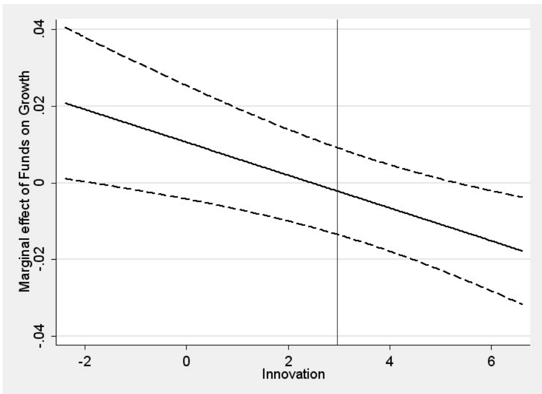
(c)



(d)



(e)



(f)

Notes: Dashed lines give 90% confidence interval. Vertical line is the average value of the variable combined with the Funds.

(a) FE Robust – interaction with income

(b) FE with Driscoll-Kraay's correction - interaction with income

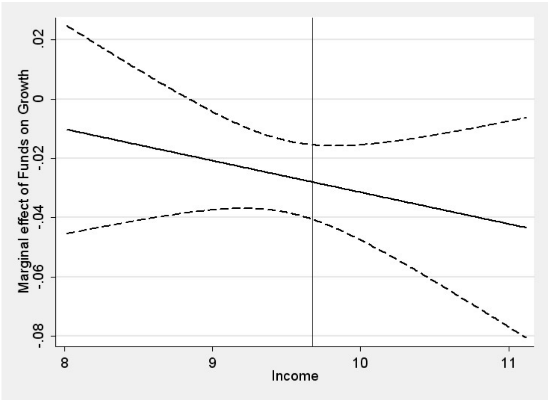
(c) FE Robust – interaction with human capital

(d) FE with Driscoll-Kraay's correction - interaction with human capital

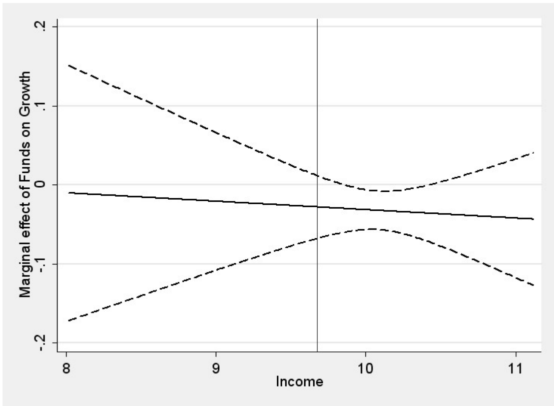
(e) FE Robust – interaction with innovation

(f) FE with Driscoll-Kraay's correction - interaction with innovation

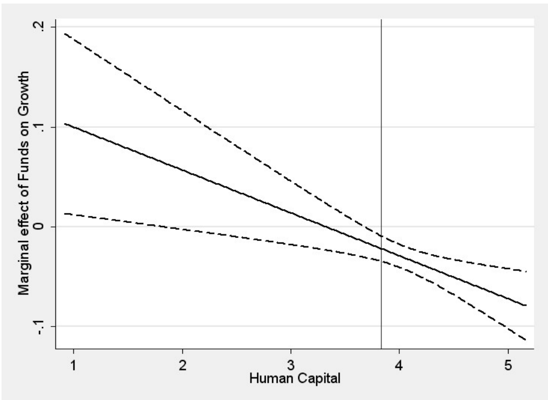
Figure 2. Marginal effect of the Structural Funds share on growth



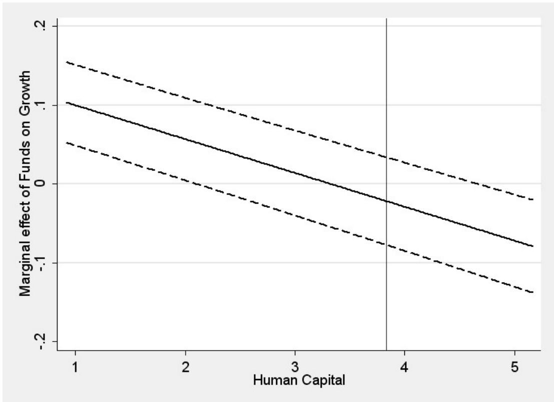
(a)



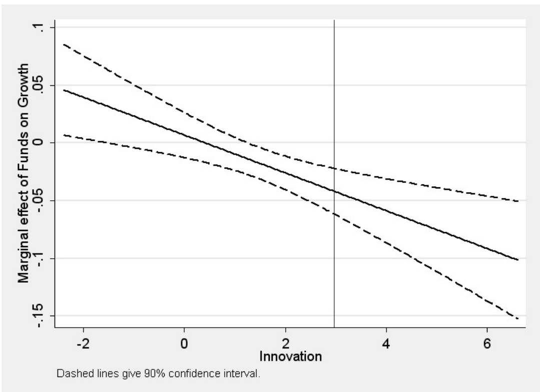
(b)



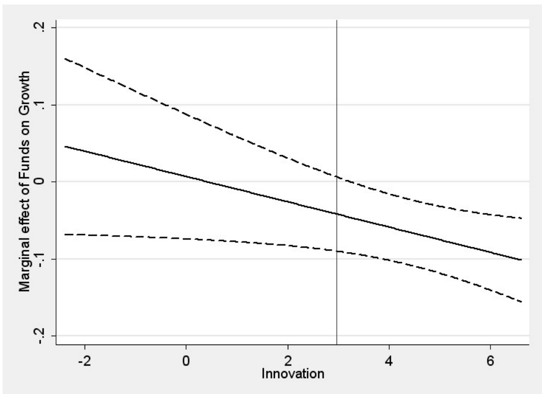
(c)



(d)



(e)



(f)

Notes: Dashed lines give 90% confidence interval. Vertical line is the average value of the variable combined with the Funds

(a) FE Robust – interaction with income

(b) FE with Driscoll-Kraay's correction - interaction with income

(c) FE Robust – interaction with human capital

(d) FE with Driscoll-Kraay's correction - interaction with human capital

(e) FE Robust – interaction with innovation

(f) FE with Driscoll-Kraay's correction - interaction with innovation

Endnotes

1 For an overview of EU regional policy, see Ederveen *et al.* (2006).

2 Computed by the authors from
http://ec.europa.eu/regional_policy/thefunds/funding/index_en.cfm

3 The authors present a summary of the main studies about the impact of public capital on growth and their conclusions.

4 Apart from the corruption index, Ederveen *et al.* (2006) alternatively consider as proxies for institutional quality, the openness degree and an institutional quality index.

5 For a study about the impact of innovation on regional growth, see Fagerberg *et al.* (1997). For the joint impact of human capital and innovative performance, see Rodríguez-Pose and Crescenzi (2008).

6 The 137 regions considered are distributed as follows: Belgium (3 NUTS1), Czech Republic (8 NUTS2), Denmark (1 NUTS1), Germany (16 NUTS1), Estonia (1 NUTS2), Greece (11 NUTS 2), Spain (17 NUTS2), France (25 NUTS2), Ireland (1 NUTS1), Cyprus (1 NUTS2), Latvia (1 NUTS2), Lithuania (1 NUTS2), Luxembourg (1 NUTS2), Malta (1 NUTS2), Netherlands (4 NUTS1), Poland (16 NUTS2), Portugal (7 NUTS2), Slovenia (2 NUTS2), Slovakia (4 NUTS2), Finland (2 NUTS1), Sweden (2 NUTS1) and the United Kingdom (12 NUTS1). Regional *per capita* GDP is not available from Eurostat for Austria, Hungary and Italy before 2007 and thus these countries were not considered. For the new Member States, there is information on Funds from 2000 or 2001 onwards, depending on the country (for previous years we considered null figures). The exceptions are Bulgaria (no information) and Romania (2007 onwards) and thus these two countries were excluded from the analysis.

7 For the description and explanation on the computation of the variables, see the Appendix I. *ln* stands for natural logarithms.

8 Structural Funds are essentially destined to support investments in several fields, but the overall investment of a given region is not limited to the financially assisted projects from the EU (although the weight is of course variable from region to region). We are aware that there is a relation between Funds and investment or Funds and innovation, but investment and innovation do not resume to amounts from EU financial transfers. By including all these variables we are able to analyze their impact on growth and the way they interact with each other.

9 Patents are a “technology output measure”, which according to Fagerber and Verspagen (1996), are often regarded as better indicators of innovative efforts. Nevertheless, we alternatively used the share of R&D expenditures on GDP, but this variable never displayed statistical significance. Moreover, the average and the total number of observations dropped steadily when this proxy was considered.

10 We use *per capita* real Structural Funds, $\ln(sfpc_{i,t-2})$, and alternatively, Structural Funds as a percentage of GDP, $\ln(sfshare_{i,t-2})$. There are few missing values and to avoid gaps in the series, we used linear interpolation. Since some values are null, to avoid losing observations we add 1 to the Funds before computing the logarithm. For details on the Structural Funds dataset, see the Appendix II.

11 An alternative to deal with endogeneity would be to use instrumental variables methods, like GMM. However, small-sample properties of the GMM estimator in dynamic panel data models are unpredictable (Esposti, 2008) and the analysis is sensitive to the choice of the instruments. Still, we estimated our growth regressions by GMM but no reasonable outcomes (in terms of the *Hansen J-test*) were obtained.

12 Brambor *et al.* (2006) discuss multiplicative models and how they should be analysed: the tested hypothesis must be conditional in nature; all constitutive elements of the interaction term must be included and cannot be interpreted as unconditional marginal effects; and the interest lies in computing meaningful marginal effects and standard errors. Only 10% of the studies analysed by the authors follow these recommendations.

13 The fixed effects estimation assumes that the explanatory variables are correlated with the unobserved (time-invariant) individual effects. The idea behind this method is to subtract to the model the individual averages of each variable. This way, the individual effects are eliminated, with the transformed equation estimated by OLS. The FE estimator is also known as the within estimator. For a detailed explanation on panel data methods, including the FE estimation, see Wooldridge (2009), Chapter 14. The F-test that follows the FE regressions points to the existence of significant individual (regional) effects, implying that pooled OLS would be inappropriate. The results are available upon request. In addition, Islam (2003) argues that the random effects (RE) specification should be excluded under the neoclassical growth framework. The fixed effects specification is more adequate for policy inferences about the sample under analysis. In fact, Wooldridge (2009) reinforces the idea that is often more adequate to use FE than RE with aggregated data, in terms of policy analysis. The regressions were run using Stata 12.

14 If the unobserved elements responsible for cross-sectional dependence are uncorrelated with the included explanatory variables, the standard panel estimators (like FE or RE) are consistent although not efficient and the estimated standard errors are biased. One option is to use Driscoll and Kraay's correction of standard errors. If conversely the unobserved elements are correlated with the included regressors, the FE and RE estimators will be biased and inconsistent, but procedures like IV or GMM to deal with unobserved cross-sectional dependence in the disturbances are inconsistent in short dynamic panels as N grows large.

15 The alternative use of the lagged investment share resulted on a negative (and generally non-significant) impact.

16 The R^2 is relatively low, thus showing room for improvement, namely by exploring further spatial interactions. Nevertheless, it is somehow in line with Rodríguez-Pose and Fratesi (2004), Bähr (2008) and Rodríguez-Pose and Novak (2013).

17 To infer about statistical significance, it is not correct to look at the individual significance of the interaction term and its constitutive elements (Wooldridge, 2009). In fact, if the covariance term is negative, as it is often the case, it is possible for the marginal impact to be significant for a wide range of values of the other conditioning variable, even if all the model parameters are insignificant (Brambor *et al*., 2006).

18 We were not able to successfully download the European Commission's 11th Annual Report on the Structural Funds 1999 (published in 2000), from

http://ec.europa.eu/regional_policy/sources/docoffic/official/repor_en.htm.