



ARE THE MARGINAL CONVERGENCE OUTCOMES OF THE COHESION POLICY DIMINISHING?

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Abstract. Significant disparities still exist between regions of the European Union, even though substantial Cohesion investments are directed to address this issue. To adjust the Cohesion Policy (CP), researchers assess the returns of the CP, but almost all studies are carried out at NUTS1&2 or a country level, even though significant disparities occur at NUTS3 level. Moreover, just a few studies examine the non-linear effects of the CP, and none of them covers the NUTS3 disaggregation level. Filling the gap of previous contributions, the paper aims to investigate convergence outcomes of the CP at NUTS2&3 level and to identify whether the marginal effect of the CP is diminishing. The estimation strategy is based on the modified specification of the difference-in-differences estimator that has an advantage while examining policy effects, using non-experimental data. Based on research findings, the essential guidelines for the improvement of the CP can be drawn up: i) the distribution policy of Cohesion investments should focus on smaller territorial units to reduce disparities at NUTS3 level; ii) the intensity of the CP's transfers has to be optimised because excessive intensity does not provide a positive return.

Keywords: Cohesion Policy, Cohesion investments, regional disparities, convergence, diminishing return, NUTS2, NUTS3.

JEL Classification: O47, O52, R11, R12, R15, R58.

Introduction

One of the issues of the European Union (EU) is the disparities between and within Member States (MS). The European Commission (EC) is addressing this issue by shaping CP and the allocation of the support from European Regional Development (ERDF) and Cohesion Funds (CF). One of the ultimate goals of CP's investments is to strengthen economic

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and social cohesion by correcting imbalances between EU regions. Given the importance of CP's goals, great attention was paid in previous research to examine how successfully CP implemented these goals. However, the scientific studies most often investigate the impact of the CP on economic growth at countries, NUTS1&2 disaggregation level and leave open the question what are the convergence outcomes of the CP and especially at NUTS3 level.

Most of the previous studies (Becker, 2012; Becker et al., 2015, 2018; Pellegrini et al., 2013; Maynou et al., 2016; Gagliardi & Percoco, 2017; Di Cataldo, 2017; Piętak, 2018; Cerqua & Pellegrini, 2018; Bourdin, 2019; Butkus et al., 2019; Berkowitz et al., 2020; Crescenzi & Giua, 2020; among others) analyse linear relationship between economic growth and CP transfers, just a few studies (Wostner & Šlander, 2009; Becker et al., 2012; Kyriacou & Roca-Sagales, 2012; Pinho et al., 2015a; Pellegrini & Cerqua, 2016; Pontarollo, 2017; Cerqua & Pellegrini, 2018; Di Cataldo & Monastiriotis, 2020) assessed non-linear outcomes of CP's investments. The results of these studies allow us to conclude that after a certain level of CP investments' intensity, additional investments do not generate significant positive outcomes. The analysis of previous studies has highlighted, that sources of non-linear relationship are related to moral hazard, substitution effects and diminishing return. These effects might lead to inefficient use of regional support.

Some authors identified an "optimal" level of CP investments' intensity but their studies cover NUTS1&2 or country disaggregation, leaving the question what is the "optimal" level of the intensity at NUTS3 disaggregation level in terms of the impact on regional disparities. To address this gap, the paper aims to evaluate non-linear convergence outcomes of the CP at NUTS2&3 disaggregation level and to provide main guidelines for the adjustment of the EU's CP. This research supplements previous contributions by identifying an "optimal" level of CP investments' intensity for positive marginal convergence outcomes at NUTS2&3 disaggregation level.

The methodology is based on a difference-in-differences (DiD) approach to test empirically non-linear convergence effects of the EU's regional support at NUTS 3 level over the 2000–2006 and 2007–2013 programming periods.

The rest of the paper is organized as follows: Section 1 presents a literature review focusing on the non-linear relationship between CP and its outcomes. Section 2 describes the model based on difference-in-differences estimator to estimate the conditional marginal convergence outcomes of the CP. Section 3 presents and discusses the results of the estimations and provides possible directions for the improvement of the CP. The last section concludes the paper.

1. Literature review on the non-linear relationship between the Cohesion Policy and its outcomes

Analysis of previous research (Becker, 2012; Pellegrini et al., 2013; Becker et al., 2015, 2018; Maynou et al., 2016; Eberle & Brenner, 2016; Gagliardi & Percoco, 2017; Di Cataldo, 2017; Cerqua & Pellegrini, 2018; Piętak, 2018; Bourdin, 2019; Berkowitz et al., 2020; Crescenzi & Giua, 2020, etc.) reveals that most of the studies consider the linear relationship between CP and its outcomes, i.e. that the marginal effect of the CP is constant (unconditional). Au-

thors confirm the positive and significant impact of regional support on economic growth or convergence. However, it should be noted that research also provides evidence on the heterogeneity of the CP outcomes, which might be related to diminishing return, substitution effect and moral hazard phenomenon (see Table 1). These effects may impose a non-linear (in the form of inverted U-shaped letter) relationship between CP investments' intensity and its outcomes, i.e. that marginal effect of the CP is not constant (conditional).

Table 1. Justification of non-linear relationship between CP and its outcomes (source: author's construction based on analysed literature)

Effect	Explanation	Source
Diminishing return	Concept of diminishing return states that additional investments in one of the production factors, when the amount of other factors remains constant, decrease the marginal output of the production. Since CP is mainly directed towards investment projects, ERDF and CF transfers may generate diminishing returns, i.e. the additional amount of transfers to investment projects is expected to associate with lower marginal outcomes. Therefore, it is assumed that when CP investments' intensity reaches the threshold level, additional investments do not generate positive marginal productivity in the region and thus, GDP per capita growth and convergence. Moreover, the marginal effect of the CP might become negative.	Wallace et al. (2010), Becker (2012), Becker et al. (2012, 2015, 2018), Gorzelak (2016), European Commission (2016)
Substitution effect	This effect occurs when beneficiary regions reduce their local and/or national resources and substitute them with CP's investments. Those public support schemes are inefficient and are accompanied by such undesirable results: i) if projects funded by ERDF and/or CF are close substitute for private capital, this may have the effect of crowding out private investment; ii) public entities would have to invest even more if/when ERDF and CF support will end; iii) ERDF and CF support loses its importance and without multiplicative investments becomes unnecessary in lagging regions; iv) local authorities lose motivation to generate enough revenue from their own source; v) the usage of ERDF and CF transfers as a substitute of local or national funds may reduce the potential returns of CP enlisting inputs from more productive areas.	Ederveen et al. (2003), Beugelsdijk and Eijffinger (2005), Cibulskiene and Butkus (2007), Barca (2009), Del Bo et al. (2016), Marzinotto (2012), Sztásiová et al. (2014), European Commission (2016)
Moral hazard phenomenon	This phenomenon is related to the considered parties' aspirations to obtain additional benefits taking higher risks and often violating established rules. As regions receive ERDF and CF support only below a certain level of development, to achieve or preserve beneficiary status, the regional or national government may manipulate statistics. It can lead to funding cut-off from productive projects and result in lower or even negative outcomes of the CP. The rate of convergence between regions may decrease or even increase regional divergence if ERDF and/or CF transfers are directed to regions that have already reached a high level of development. Corruption in support allocation schemes is also related to a moral hazard phenomenon and can lead to the same results.	Beugelsdijk and Eijffinger (2005)

Diminishing returns, substitution effects and moral hazard phenomenon justify the importance to determine the “optimal” intensity level of ERDF and CF transfers. Determining the “optimal” intensity level would allow a more rational redistribution of CP funds and make CP more effective. However, just a few previous studies (Mohl & Hagen, 2008; Wostner & Šlander, 2009; Becker et al., 2012; Kyriacou & Roca-Sagales, 2012; Pinho et al., 2015a; Pellegrini & Ceruqua, 2016; Pontarollo, 2017; Cerqua & Pellegrini, 2018; Di Cataldo & Monastiriotis, 2020) investigated potentially diminishing marginal outcomes of the CP. They all (except Mohl & Hagen, 2008) have revealed that after a certain level of ERDF and/or CF commitments’ intensity, additional payments do not generate significant positive outcomes. Mohl and Hagen (2008) revealed that CP’s transfers do not affect economic growth rate significantly and, considering this, conclude that it does not matter which “dose” of CP’s transfers regions have received.

Becker et al. (2012) identified that beyond approximately 1.3 per cent of regional GDP, additional ERDF and CF transfers do not promote economic growth and the optimal desirable level of ERDF and CF transfer’s intensity is 0.4 per cent of regional GDP. Pontarollo (2017) investigated non-linear relation between CP’s transfers decomposed by intervention area (productive environment, human capital and infrastructure) and productivity as well as economic growth. The assessment results revealed that when the intensity of transfers exceeds 0.15–0.70 per cent of regional GDP (depending on the intervention area), the marginal effect of transfers becomes negative. According to Pinho’s et al. (2015a) findings, this boundary line is 3 per cent of countries GDP. According to Cerqua and Pellegrini’s (2018) estimations, the outcomes of CP’s transfers become statistically negligible and negative when intensity exceeds 305–350 Euro per capita. Di Cataldo and Monastiriotis (2020) have confirmed the hypothesis of diminishing returns of EU Funds in the UK case. Authors conclude that none of the regions in the UK exceeds the maximum desirable intensity threshold estimated by Cerqua and Pellegrini (2018).

It should be noted that Becker et al. (2012) expected to find a minimum desirable level of ERDF and CP transfer intensity below which transfers would not generate positive growth effect but above which they would. However, the evaluation results rejected this assumption and the authors conclude that there is no evidence for existence of a minimum desirable level of regional transfers.

Bandonio and Pellegrini (2016), European Commission (2016), Pellegrini and Cergua (2016) agree that ERDF and CF transfers’ intensity matters for returns, but do not highlight a desirable level. Also, it should be noted that previous studies do not determine the desirable level of ERDF and CF transfer’s intensity at NUTS3 level and for positive impact on convergence.

2. Methodology and data

Most of the papers that deal with the outcomes of the CP adopt the model of conditional beta-convergence. This model allows to estimate the linear and non-linear effect of the CP on growth directly since the average growth rate is used as a dependent variable. Aiming to estimate the relation between transfers’ intensity and disparities among EU regions, we can

not rely on the same approach. Our model is grounded on a difference-in-differences (DiD) approach. The initial specification of the linear regression equation, which allows to estimate unconditional DiD parameter, is:

$$Y_{i,t} = b_0 + b_1 \times t2_t + b_2 \times CP_{i,t} + b_{DiD} \times t2_t \times CP_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $Y_{i,t}$ is the variable in the i -th region whose disparities between CP's beneficiaries and developed regions are under examination. b_0 is the estimated average $Y_{i,t}$ in the group of developed regions over the reference period. $t2_t$ is a dummy variable equal to 1 for the CP intervention period and equal to 0 for the reference period. b_1 shows how the average $Y_{i,t}$ in the group of developed regions changed over the CP intervention period, compared with the reference period, i.e. how variable under consideration has changed without CP intervention. $CP_{i,t}$ is a dummy variable equal to 1 if the region received CP's transfers and 0 otherwise. b_2 shows how the average Y_{it} differed between CP's beneficiaries and developed regions already before the CP took place, i.e. shows the initial (over the reference period) difference between CP's beneficiaries and developed areas. The parameter on b_2 is expected to be negative since CP focuses on less developed areas. b_{DiD} is the DiD parameter which shows the effect of the CP, i.e. whether the initial negative differences between CP beneficiaries and developed regions became smaller due to the CP. Positive parameter on b_{DiD} would give evidence that initial differences over the reference period became smaller over CP's intervention period, i.e. CP's transfers contributed to diminishing regional disparities. $\varepsilon_{i,t}$ is the error term.

Research assumes that regions will not respond to CP's transfers in the same way simply because the amount of transfers is not constant across regions. To put in other words, the effect of the CP hinges on the amount of transfers. Thus, some heterogeneity in the impact across regions is expected as well. It is possible to estimate DiD, assuming heterogeneity of the CP's effect by interacting $CP_{i,t}$ dummy with the intensity of CP's transfers, $ICP_{i,t}$. If a region does not receive CP's transfers, $CP_{i,t}$ and $ICP_{i,t}$ as well as their interaction equal to zero. If a region receives CP's transfers, $CP_{i,t}$ is equal to unity and its interaction with $ICP_{i,t}$ is equal to $ICP_{i,t}$. Thus, $CP_{i,t}$ substituting with $ICP_{i,t}$ will allow to estimate the effect of transfers' intensity on the disparities among regions:

$$Y_{i,t} = b_0 + b_1 \times t2_t + b_2 \times ICP_{i,t} + b_{DiD} \times t2_t \times ICP_{i,t} + \varepsilon_{i,t}, \quad (2)$$

where b_{DiD} now measures the effect of CP transfers' intensity change by one unit on regional disparities.

To relax an assumption that the marginal effect of $ICP_{i,t}$ on the disparities is constant, i.e. the relationship is linear, and aiming to estimate the maximum desirable intensity level of CP's transfers, which still has a positive effect, and a minimal level of intensity that starts to have a significant impact, quadratic specification is introduced. To account for other factors affecting $Y_{i,t}$, $C_{j,i,t}$ that corresponds to a vector of time-varying factors, and θ_j that corresponds to a vector of time-constant factors are added:

$$Y_{i,t} = b_0 + b_1 \times t2_t + b_{21} \times ICP_{i,t} + b_{22} \times ICP_{i,t}^2 + b_{DiD1} \times t2_t \times ICP_{i,t} + b_{DiD2} \times t2_t \times ICP_{i,t}^2 + c_j \times C_{j,i,t} + \mu \times \theta_j + \varepsilon_{i,t}. \quad (3)$$

Positive b_{DiD1} and negative b_{DiD2} would give evidence of a quadratic form of relationship in the form of an inverted U. In the case of interactive Eqs (1) and (2), after the first differencing or time-demeaned transformations¹, they collapse to simple additive models for the second (CP intervention) period, and estimated standard errors on coefficients associated with DiD parameter are unconditional. However, in the case of the Eq. (3) the multiplicative term is retained after the first differencing or time-demeaned transformations for the second period ($t2 = 1$):

$$\begin{aligned} \ddot{Y}_i &= b_0 + b_1 \times (1) + b_{DiD1} \times (1) \times \ddot{ICP}_i + b_{DiD2} \times (1) \times \ddot{ICP}_i^2 + c_j \times \ddot{C}_{j,i} + \varepsilon_i; \\ \ddot{Y}_i &= (b_0 + b_1) + \left(b_{DiD1} + b_{DiD2} \times \ddot{ICP}_i \right) \times \ddot{ICP}_i + c_j \times \ddot{C}_{j,i} + \varepsilon_i, \end{aligned} \tag{4}$$

where $\ddot{\cdot}$ stands for the time-demeaned variable². Therefore, not only the marginal effect of ICP_i on Y_i , i.e. the slope $(b_{DiD1} + b_{DiD2} \times ICP_i)$ is conditioned on the value of ICP_i itself, but following Rodriguez-Pose and Garcilazo (2015) and Pinho et al. (2015b), it can be argued that the standard error of the estimated slope coefficient is also conditioned on ICP_i value and standard error of the sum $(\hat{b}_{DiD1} + \hat{b}_{DiD2} \times ICP_i)$ is:

$$SE(\hat{b}_{DiD1} + \hat{b}_{DiD2} \times ICP_i) = \sqrt{var(\hat{b}_{DiD1}) + ICP_i^2 \times var(\hat{b}_{DiD2}) + 2 \times ICP_i \times cov(\hat{b}_{DiD1}, \hat{b}_{DiD2})}. \tag{5}$$

This implies that the estimated marginal effect of ICP_i on Y_i can potentially be not significant over the all range of observed ICP_i values, i.e. it is not necessary to reach the tipping point of ICP_i the marginal effect not to differ from zero. In line with the usual logic of constructing a coefficient a test of statistical significance against the possibility that the population is zero, the t-value for the marginal effect of ICP_i on Y_i can be calculated, whad-ded to the equation, as:

$$t = \frac{\hat{b}_{DiD1} + \hat{\delta}_{DiD2} \times ICP_i}{SE(\hat{b}_{DiD1} + \hat{\delta}_{DiD2} \times ICP_i)}.$$

Having an empirical relationship between Y_i and ICP_i in the form of inverted U letter, Eq. (6) enables us to test what the minimum level of ICP_i is required for the marginal effect of ICP_i on Y_i to become significant and whether the marginal effect of ICP_i is still significant when the tuing point is reached, and the marginal effect becomes negative.

Examination hodifferent intensity levels of CP transfers’ intensity over the two last programming periods is related to diminishing regional disparities at NUTS2&3 disaggregation

¹ These two alternative transformations are used to control all region-specific time-constant effects, i.e. θ_i . For example, geographical position of the region, which determines its access to infrastructure, such as seaports, highways, etc. or economic linkages between regions, which can be an important growth factor for peripheral regions situated near the core regions. Having little possibility to control these effects by including all necessary variables at NUTS2&3 disaggregation level, an unexplained variation which now would account for a part of the error term could lead to a correlation between $\varepsilon_{i,t}$ and $Y_{i,t}$ as well as between $\varepsilon_{i,t}$ and $ICP_{i,t}$. This correlation is very likely to occur since CP’s transfers are not randomly distributed among regions, but depends on region’s characteristics, which are also related to its growth and thus impose endogeneity problem.

² Using the first differencing, would yield quite the same equation, just b_0 would not be retained.

is based on two databases. Compared to the study carried out concerning 2000–2006 programming period (SWECO, 2008), the report for 2007–2013 programming period (Ciffolilli et al., 2015) collects data on expenditure and not only allocations to selected projects. Having just allocations data for 2000–2006 period, but aiming to compare effects of two last fully expired programming periods, and considering that expenditure but not allocations could make an effect, few assumptions are put forward regarding policy intervention periods and calculation of CP transfers' intensity:

- (i) Under the framework of the EU CP for 2000–2006 programming period, old MS could spend the last allocation available until the end of the year 2008 (the $n+2$ rule), and for the central and eastern European countries the rule was applied as $n+3$ of that time. From this perspective, 2000–2009 is considered as a CP intervention period for 2000–2006, since over 2000–2009 allocations could be spent and could make an effect. Financial support intensity is calculated as the ratio between allocations over 2000–2006 and total GDP over 2000–2009. 1995–1999 is considered as the reference period.
- (ii) Since report for 2007–2013 programming period collected actual expenditure data by the end of 2014, 2007–2014 is considered as CP intervention period. Financial support intensity is calculated as the ratio between expenditures by the end of 2014 and the total GDP over 2007–2014. 2007, 2008 and 2009 overlap with the years over which the effect of the previous programming period is evaluated. The assumption here is that expenditures over 2007–2009 from the 2007–2013 programming period had no significant impact since the absorption capacity is increasing progressively when the end of the programming period is approaching. 2002–2006 is considered as the reference period.

For both periods, ERDF and CF allocations/expenditure combined are analysed. For 2000–2006 SWECO (2008) database contains data at NUTS2&3 levels for the Cohesion Fund, ERDF Objective 1, ERDF Objective 2, URBAN and INTERREG IIIA allocations. The total amount mapped in the database for NUTS3 is 149.819 bill. EUR which is 93.5% and for NUTS2 is 156.174 bill. EUR which is 97.5% of the total CF and ERDF budget for the 2000–2006 programming period. All current EU MS except Bulgaria, Romania and Croatia could receive funding for the 2000–2006 programming period. Thus there were 1251 NUTS3 and 260 NUTS2 level regions (according to NUTS classification that existed) under CP consideration. 188 NUTS 2 regions received funding and 72 did not. According to descriptive statistics, a minimum of transfers' intensity was 0.03%, maximum – 2.92% with the average and median of 0.39% and 0.20%, respectively. Over the same period, 871 NUTS 3 regions received funding a 380 did not. According to descriptive statistics, a minimum of transfers' intensity was 0.01%, maximum – 8.44% with the average and median of 0.37% and 0.13%, respectively.

For the 2007–2013 programming period, Ciffolilli's et al. (2015) database contains cumulative expenditures of both ERDF and CF programmes at the NUTS2 (276) and 3 (1342) levels of EU reg f all 28 EU countries and covers the Convergence, Regional Competitiveness a Employment as well as the European Territorial Cooperation Objectives for the 2007–2013 programming period. The total amount mapped in the database for NUTS3 is

200.193 bill. EUR which is 97.3% and for NUTS2 is 202.854 bill. EUR which is 98.6% of the total expenditures by the end of 2014. 191 NUTS2 regions received funding, and 85 did not. According to descriptive statistics, a minimum of transfers' intensity was 0.03%, maximum – 4.66% with the average and median of 0.72% and 0.34%, respectively. Over the same period, 958 NUTS3 regions received funding, and 384 did not. According to descriptive statistics, a minimum of transfers' intensity was 0.02%, maximum – 8.81% with the average and median of 0.63% and 0.15%, respectively.

Table A1 (see Appendix) reports information on two variables considered in the research as the dependent since the aim is to estimate to what extent CP contributed to diminishing disparities among regions in terms of development level and productivity. Data on productivity over 1995–1999 is missing for Greece, except for Attiki, the Netherlands, and four UK regions. Data on Mayotte (France) is missing for all years. For Poland, the average was calculated including just two years, 1998 and 1999. Table A2 (see Appendix) reports information about control variables included in the model.

3. Research results and discussion

Tables 2 and 3 report fixed-effects estimates of Eq. (3) for two last programming periods. Estimations are made separately for a sample of NUTS2&3 regions and two dependent variables – per capita GDP and productivity.

Table 2. Fixed effects estimates of 2000–2006 programming period

Variable	Parameter	NUTS2		NUTS3	
		ln GDP ⁽¹⁾	ln GVA ⁽²⁾	ln GDP ⁽¹⁾	ln GVA ⁽²⁾
Intercept	b_0	9.81***	10.82***	9.82***	10.81***
		(0.00)	(0.01)	(0.00)	(0.00)
$t2_t$	b_1	0.19***	0.02	0.17***	0.01
		(0.01)	(0.01)	(0.00)	(0.01)
$t2_t \times ICP_{it}$	b_{DiD1}	0.08**	0.17***	0.04***	0.10***
		(0.03)	(0.05)	(0.01)	(0.02)
$t2_t \times ICP_{it}^2$	b_{DiD2}	-0.04**	-0.03	-0.00	-0.01***
		(0.02)	(0.03)	(0.00)	(0.00)
IGDP	c_{IGDP}	0.01***			
		(0.00)			
ln IWORK	c_{IWORK}		0.28***		
			(0.10)		
PEDUC	c_{PEDUC}	-0.03**	-0.03**		
		(0.01)	(0.01)		
TEDUC	c_{TEDUC}	0.02	0.01*		
		(0.02)	(0.02)		

End of Table 2

Variable	Parameter	NUTS2		NUTS3	
		ln GDP ⁽¹⁾	ln GVA ⁽²⁾	ln GDP ⁽¹⁾	ln GVA ⁽²⁾
HTEC	c_{HTEC}	0.00**			
		(0.00)			
ln MINFR	c_{MINFR}		0.13		
			(0.10)		
ln INOV	c_{INOV}		0.20***		0.16***
			(0.08)		(0.06)
ln PDENS	c_{PDENS}	0.15**		0.13**	
		(0.06)		(0.05)	
PSTR	c_{PSTR}	0.01		0.01	
		(0.10)		(0.07)	
AGVA	c_{AGAV}	-0.02**		-0.03**	
		(0.00)		(0.00)	
IGAV	c_{IGAV}	0.01**		0.01**	
		(0.00)		(0.00)	
AEMPL	c_{AEMPL}		-0.03**		-0.03**
			(0.00)		(0.00)
IEMPL	c_{IEMPL}		0.01**		0.01**
			(0.00)		(0.00)
N		520	466	2502	2326
Within R-squared		0.57	0.62	0.49	0.55
Estimated turning point, %		1.08	2.69	5.95	3.99

Notes: Robust (using HCCME) standard errors are presented in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. ⁽¹⁾ ln GDP refers to estimates where logged regional per capita GDP is used as a dependent variable. ⁽²⁾ ln GVA refers to estimates where logged regional GVA per worker is used as a dependent variable.

Table 3. Fixed effects estimates of 2007–2013 programming period

Variable	Parameter	NUTS2		NUTS3	
		ln GDP ⁽¹⁾	ln GVA ⁽²⁾	ln GDP ⁽¹⁾	ln GVA ⁽²⁾
Intercept	b_0	9.92***	10.75***	9.88***	10.72***
		(0.00)	(0.00)	(0.00)	(0.00)
$t2_t$	b_1	0.03***	0.04***	0.04***	0.05**
		(0.00)	(0.01)	(0.00)	(0.00)
$t2_t \times ICP_{it}$	b_{DiD1}	0.10***	0.10***	0.08***	0.05***
		(0.02)	(0.01)	(0.01)	(0.01)
$t2_t \times ICP_{it}^2$	b_{DiD2}	-0.02***	-0.03***	-0.01***	-0.01***
		(0.01)	(0.00)	(0.00)	(0.00)

End of Table 3

Variable	Parameter	NUTS2		NUTS3	
		ln GDP ⁽¹⁾	ln GVA ⁽²⁾	ln GDP ⁽¹⁾	ln GVA ⁽²⁾
IGDP	c_{IGDP}	0.01***			
		(0.00)			
ln IWORK	c_{IWORK}		0.23***		
			(0.07)		
PEDUC	c_{PEDUC}	-0.02***	-0.01***		
		(0.00)	(0.00)		
TEDUC	c_{TEDUC}	0.02*	0.02*		
		(0.01)	(0.01)		
HTEC	c_{HTEC}	0.00**			
		(0.00)			
ln MINFR	c_{MINFR}		0.15		
			(0.12)		
ln INOV	c_{INOV}		0.19***		0.18***
			(0.06)		(0.05)
ln PDENS	c_{PDENS}	0.16**		0.15**	
		(0.07)		(0.06)	
PSTR	c_{PSTR}	0.02		0.02	
		(0.08)		(0.05)	
AGVA	c_{AGAV}	-0.02**		-0.03**	
		(0.00)		(0.00)	
IGAV	c_{IGAV}	0.01**		0.01**	
		(0.00)		(0.00)	
AEMPL	c_{AEMPL}		-0.03**		-0.03**
			(0.00)		(0.00)
IEMPL	c_{IEMPL}		0.01**		0.01**
			(0.00)		(0.00)
N		552	550	2684	2682
Within R-squared		0.57	0.51	0.59	0.40
Estimated turning point, %		1.08	2.20	1.84	3.07

Notes: Robust (using HCCME) standard errors are presented in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. ⁽¹⁾ ln GDP refers to estimates where logged regional per capita GDP is used as a dependent variable. ⁽²⁾ ln GVA refers to estimates where logged regional GVA per worker is used as a dependent variable.

The estimated direction of the effect on control variables seems to be reasonable. Higher investment ratio, a more significant share of employed in high-technology sectors, higher population density and thus agglomeration effect, bigger industry sector according to a share of created GVA have a positive and statistically significant effect on regional per capita GDP. A bigger proportion of the working-age population and share of it with tertiary education

seems to have a positive but insignificant effect on per capita GDP in a region. On the contrary, a more significant proportion of the working-age population with primary education and size of the agriculture sector in a region is negatively and significantly related to its per capita GDP. Amount of investment per worker, workers' tertiary education, innovations, and a higher share of empd in industry sector have a significant positive correlation, whereas primary education and employment in agriculture have a significant negative correlation with productivity. Infrastructure measured as the density of motorways has an insignificant positive effect.

All estimations show that CP contributed to diminishing disparities among regions in terms of their development level and productivity. Nevertheless, the relationship between funding intensity and the effect on disparities is non-linear, suggesting that not in all regions and not all support had a positive effect. The last row in Tables 2 and 3 reports the estimated turning point of CP transfer's intensity. The marginal effect of transfer's intensity above this point on diminishing disparities is estimated to be negative. Table A3 (see Appendix) reports which regions were overfunded according to estimated turning points in Tables 2 and 3. Calculations are made separately for both programming periods, taking into account disaggregation level and dependent variable under consideration.

Some differences are comparing two programming periods and two disaggregation levels. The overfunding was more typical for 2007–2013 programming period and NUTS 2 level (over both periods under investigation). Among mostly overfunded dominate regions from Portugal and Greece (over 2000–2006 programming period) and regions from Poland, Hungary, Bulgaria, Portugal and Greece (over 2007–2013 programming period). It seems that a vast amount of ERDF and CF funding for the least developed regions did not help to increase their productivity and development level significantly enough for convergence to occur.

Figures 1–4 present the following relationships: (i) between level of CP's transfers intensity and estimated effect on disparities; (ii) between level of CP's transfers intensity and estimated conditional effect on disparities; (iii) between level of CP's transfers intensity and

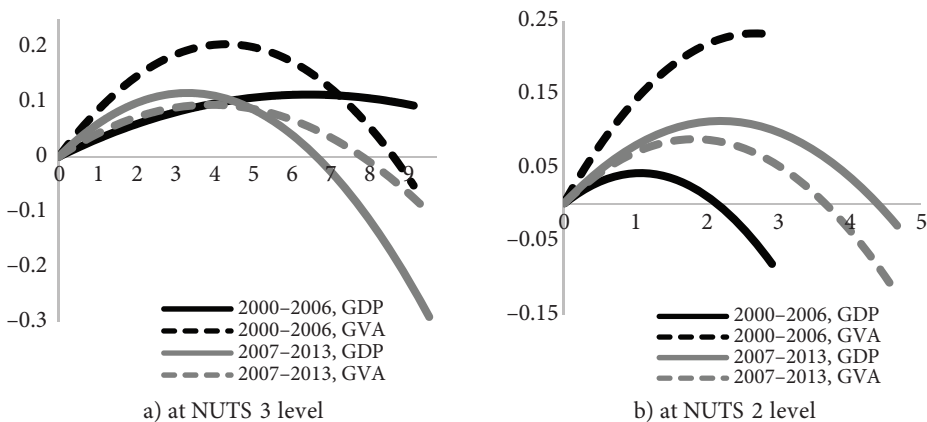


Figure 1. The estimated effect of CP's transfers' intensity (ICP_i , horizontal axis) on disparities ($b_{DiD1} \times ICP_i + b_{DiD2} \times ICP_i^2$, vertical axis)

standard error of estimated conditional effect on disparities, and (iv) between level of CP's transfers intensity and t-ratio of estimated conditional effect on disparities, respectively. They allow to analyse not only the size but also the significance of the estimated effect.

According to estimation results, distribution of ERDF and CF transfers across regions over the last two programming periods was far from being an optimal, considering maximising the effect of ERDF and CF expenditures on diminishing disparities. The same is true for both disaggregation levels and both dependent variables under consideration. Although in a wide range of relatively high transfers' intensity levels its marginal positive (or negative) effect on disparities is estimated as statistically insignificant, in some extreme cases of transfers' intensity not only marginal but also total effect on convergence was significant and negative.

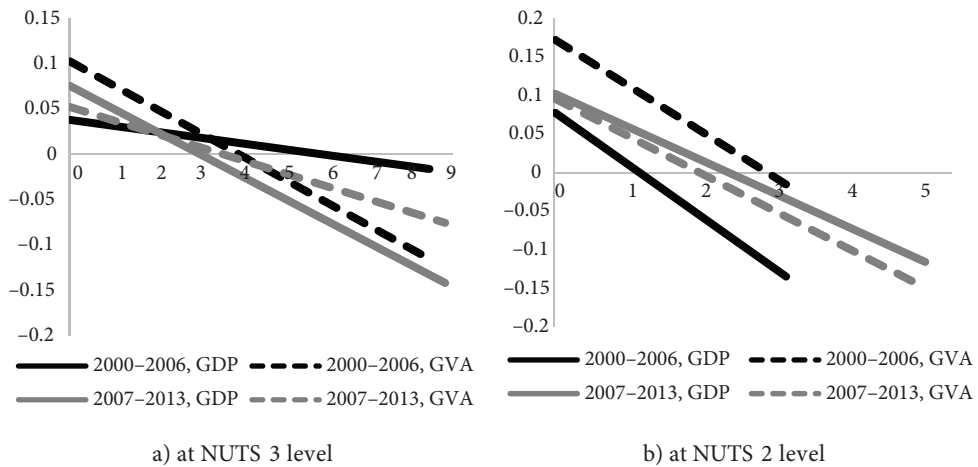


Figure 2. Estimated conditional effect, i.e. slope ($b_{DiD1} + b_{DiD2} \times ICP_i$, vertical axis) of CP transfers' intensity (ICP_i , horizontal axis)

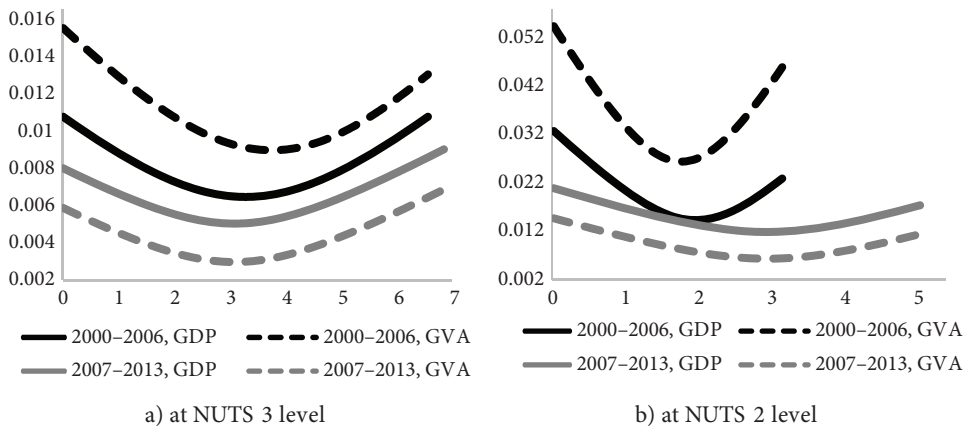


Figure 3. Relationship between CP transfers' intensity (ICP_i , horizontal axis) and standard error (vertical axis) of estimated conditional effect ($b_{DiD1} + b_{DiD2} \times ICP_i$, vertical axis)

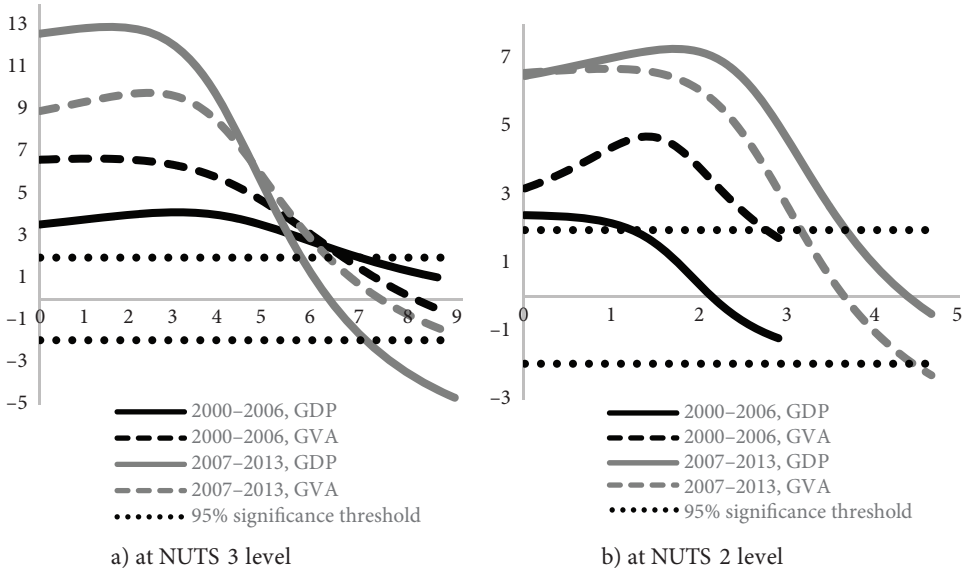


Figure 4. Relationship between CP transfers' intensity (ICP_i , horizontal axis) and t-ratio (vertical axis) of estimated conditional effect ($b_{DiD1} + b_{DiD2} \times ICP_i$)

These results are in line with previous research analysing earlier programming periods and effect on other than convergence outcomes. Despite the fact that estimated turning points (the maximum desirable funding intensity) are higher compared to existing empirical evidence (probably due to different outcome variable, analysed period, and method), general conclusion is quite the same – there are too many too much funded regions, which are not spending ERDF and CF allocations efficiently to boost their productivity and growth to ensure regional convergence.

Therefore, the re-allocation of ES funds, avoiding overfunding, is crucial over the following programming period to ensure more efficient use. This conclusion also brings us to one more question – what causes the inefficient use of SF and CF funding in highly supported regions? Is it a matter of a simple diminishing returns to investment or more complicated issue related to corruption, misallocation of funds due to shortage of managerial knowledge or weak institutional environment? Having a robust answer to this question would allow to firstly direct funding to solve problems in the areas which interfere efficient use of regional support.

Conclusions

The previous contributions have left the question what is the “optimal” intensity level of the CP in terms of the impact on regional disparities and especially at NUTS3 disaggregation by covering exclusively NUTS1&2 or country levels and analysing just growth. Our research which includes two last fully expired programming periods, i.e. 2000–2006 and 2007–2013, allowed to evaluate the “optimal” intensity level of CP investments that ensures positive marginal convergence outcomes at NUTS2&3 disaggregation level.

Results considering diminishing marginal outcomes of the CP are in line with previous research which focuses on earlier programming periods and the effect on other than convergence outcomes. Research shows higher turning points (the maximum desirable funding intensity) compared to previous contributions, and this could be due to different applied methodology, alternative CP outcome under consideration, and disaggregation level as well as more recent programming period that is covered in presented research.

Estimation results shed some light on the sources of the heterogeneous outcomes of the CP, i.e. why the effects of CP's investments vary across regions. This analysis also gives some insights on the inter-regional allocation of ERDF and CF: (i) there is a need to focus on smaller territorial units setting the aims and negotiating regarding allocation commitments in order to reduce disparities at NUTS3 disaggregation; ii) the intensity of the CP's investments has to be optimised since excessive intensity does not provide positive returns, thus setting the maximum allocations to GDP ratio and avoiding concentration of the investment in a few heavily underdeveloped regions would increase the overall effectiveness of the CP.

Our study has some limitations that could be addressed in future research. First, estimated turning points based on two last fully expired programming periods could change at some point when the data on ongoing 2014–2020 programming period will become available and will be included in the research. Nevertheless, planning allocations for the next, i.e. programming period of 2021–2027 it is essential to take into account which regions were previously overfunded avoiding same inefficiencies in the future. Second, our research assumes that the marginal effect of the CP on convergence is homogenous across regions. A growing body of literature on moderators of CP outcomes suggests that this could be not the case, and future research could concentrate on finding which factors may shift this turning point.

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Author contributions

Conceptualization, AMS, MB and KM; methodology, MB.; data collection KM, theoretical analysis, AMS and KM., writing – original draft preparation, AMS, MB and KM. All authors contributed to the experiment design and have read and approved the final manuscript.

Disclosure statement

We declare that we do not have any competing financial, professional, or personal interests from other parties.

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APPENDIX

Table A1. Dependent variables of the research

Short name	Full name	Description and source of data
GDP	Regional per capita GDP at constant prices	The main source of the data is <i>Gross domestic product indicators (reg_eco10gdp)</i> , subsection for the <i>Gross domestic product (GDP) at current market prices by NUTS3 regions (nama_10r_3gdp)</i> . To correct the changes at price levels over time, <i>Price index (implicit deflator), 2010 = 100, euro (PD10_EUR)</i> is used. To calculate per capita GDP, <i>Average annual population to calculate regional GDP data (thousand persons) by NUTS 3 regions (nama_10r_3popgdp)</i> is used. Data for GDP and population in the aforementioned Eurostat data sources are not available prior to 2000. Data for 1995–1999 on <i>Gross domestic product (GDP) at current market prices at NUTS level 3</i> and <i>Average annual population</i> was retrieved from <i>nama_r_e3gdp</i> and <i>demo_r_d3avg</i> datasets, respectively, that were available on Eurostat previously and merged with currently available dataset.
GVA	Regional GVA per employed at constant prices	The main source of the data is <i>Branch and household accounts (reg_eco10brch)</i> , subsection for <i>Gross value added (GVA) at basic prices by NUTS 3 regions (nama_10r_3gva)</i> . To correct the changes at price levels over time, <i>Price index (implicit deflator), 2010=100, euro (PD10_EUR)</i> is used. To calculate GVA per worker, <i>Employment (thousand persons) by NUTS 3 regions (nama_10r_3empers)</i> is used. Data for GVA and employment in aforementioned Eurostat data sources is not available prior to 2000. Data for 1995–1999 on <i>Gross value added at basic prices at NUTS level 3</i> and <i>Employment (in persons) at NUTS level 3</i> was retrieved from <i>nama_r_e3vabp95</i> and <i>nama_r_e3empl95</i> datasets, respectively, that were available on Eurostat previously and merged with currently available dataset.

Table A2. Control variables³ of the research

Short name	Full name, description and source of data	Measurement unit	NUTS level at which data is available		Model for which variable is used	
			2	3	GDP	GVA
IGDP	<i>Investment</i> calculated as the ratio between <i>Gross fixed capital formation by NUTS 2 regions (nama_10r_2gfcf)</i> and <i>Gross domestic product (GDP) at current market prices by NUTS 2 regions (nama_10r_2gdp)</i> .	%	X		X	
IWRK	<i>Investment</i> calculated per worker, as the ratio between <i>Gross fixed capital formation by NUTS 2 regions (nama_10r_2gfcf)</i> and <i>Employment (thousand persons) by NUTS 3 regions (nama_10r_3empers)</i> .	Eur.	X			X
PEDUC	<i>Primary education</i> , i.e. proportion of population aged 25–64 years with less than primary, primary and lower secondary education (levels 0–2). Data retrieved from <i>Population aged 25–64 by educational attainment level, sex and NUTS 2 regions (%) (edat_lfse_04)</i> .	%	X		X	X
TEDUC	<i>Tertiary education</i> , i.e. proportion of population aged 25–64 years – with tertiary education (levels 5–8). Data retrieved from <i>Population aged 25–64 by educational attainment level, sex and NUTS 2 regions (%) (edat_lfse_04)</i> .	%	X		X	X
HTEC	<i>Employment in High-technology sectors (high-technology manufacturing and knowledge-intensive high-technology services)</i> . Data for 1995–2007 retrieved from <i>Employment in technology and knowledge-intensive sectors by NUTS 2 regions and sex (1994–2008, NACE Rev. 1.1) (htec_emp_reg)</i> . For 2007–2017 from <i>Employment in technology and knowledge-intensive sectors by NUTS 2 regions and sex (from 2008 onwards, NACE Rev. 2) (htec_emp_reg2)</i> .	Percentage of total employment	X		X	

³ If the data for 1995–1999 according to The European System of National and Regional Accounts (ESA, 2010) was missing, it was collected according to ESA 1995 and merged with current dataset.

Continued Table A2

Short name	Full name, description and source of data	Measurement unit	NUTS level at which data is available		Model for which variable is used	
			2	3	GDP	GVA
MINFR	<i>Motorways. Retrieved from Road, rail and navigable inland waterways networks by NUTS 2 regions (tran_r_net).</i>	Kilometres of motorways per thousand square kilometres	X			X
PDENS	<i>Population density by NUTS 3 region (demo_r_d3dens).</i>	Inhabitants per square kilometre	X	X	X	
PSTR	<i>Population structure calculated as proportion of population aged 15–64 years to total number of inhabitants in the region. Calculations are made using data from Population on 1 January by broad age group, sex and NUTS 3 region (demo_r_pjanaggr3).</i>	%	X	X	X	
INOV	<i>Patents per million inhabitants. Data retrieved from Patent applications to the EPO by priority year by NUTS 3 regions (pat_ep_rtot).</i>	Number of patents per million inhabitants	X	X		X
AEMPL	<i>Employment in the agriculture sector. Calculated as the proportion of workers employed in agriculture, forestry and fishing (A in NACE activities). Data retrieved from Employment (thousand persons) by NUTS 3 regions (nama_10r_3empers).</i>	%	X	X		X
IEMPL	<i>Employment in the industry sector. Calculated as the proportion of workers employed in industry (except construction, B-E in NACE activities). Data retrieved from Employment (thousand persons) by NUTS 3 regions (nama_10r_3empers).</i>	%	X	X		X
AGVA	<i>Agriculture gross value added. Calculated as the proportion of GVA created in agriculture, forestry and fishing (A in NACE activities). Data retrieved from Gross value added at basic prices by NUTS 3 regions (nama_10r_3gva).</i>	%	X	X	X	

End of Table A2

Short name	Full name, description and source of data	Measurement unit	NUTS level at which data is available		Model for which variable is used	
			2	3	GDP	GVA
IGVA	<i>Industry gross value added.</i> Calculated as the proportion of GVA created in industry (except construction, B-E in NACE activities). Data retrieved from <i>Gross value added at basic prices by NUTS 3 regions (nama_10r_3gva)</i> .	%	X	X	X	

Table A3. Analysis of overfunding

Dis-aggregation level	Estimated turning point of positive marginal effect on convergence	Regions that were overfunded, their actual funding intensity and the country	Amount of overfunding
Programming period of 2000–2006			
NUTS 2	1.08% for convergence according to GDP	Notio Aigaio-1.17-(EL); Norte-1.25-(PT); Algarve-1.37-(PT); Anatoliki Makedonia, Thraki-1.41-(EL); Extremadura-1.42-(ES); Dytiki Ellada-1.42-(EL); Centro-1.43-(PT); Ionia Nisia-1.44-(EL); Sterea Ellada-1.55-(EL); Dytiki Makedonia-1.72-(EL); Alentejo-1.99-(PT); Voreio Aigaio-2.04-(EL); Região Autónoma da Madeira-2.26-(PT); Região Autónoma dos Açores-2.74-(PT); Ipeiros-2.92-(EL)	6.967 Bill. EUR
	2.69% for convergence according to GVA	Região Autónoma dos Açores-2.74-(PT); Ipeiros-2.92-(EL)	116 Mill EUR
NUTS 3	5.95% for convergence according to GDP	Alto Tâmega-8.27-(PT); La Palma-8.44-(ES)	507 Mill EUR
	3.99% for convergence according to GVA	Terras de Trás-os-Montes-4.32-(PT); Alto Tâmega-8.27-(PT); La Palma-8.44-(ES)	960 Mill EUR
Programming period of 2007–2013			
NUTS 2	2.20% for convergence according to GDP	Lubelskie-2.26-(PL); Dytiki Ellada-2.29-(EL); Közép-Dunántúl-2.62-(HU); Nyugat-Dunántúl-2.68-(HU); Warminsko-Mazurskie-2.90-(PL); Podkarpackie-2.95-(PL); Dél-Dunántúl-3.10-(HU); Észak-Magyarország-3.40-(HU); Região Autónoma dos Açores (PT)-3.42-(PT); Dél-Alföld-4.46-(HU); Észak-Alföld-4.66-(HU)	7.337 Bill EUR

End of Table A3

Dis-aggregation level	Estimated turning point of positive marginal effect on convergence	Regions that were overfunded, their actual funding intensity and the country	Amount of overfunding
	1.84% for convergence according to GVA	Jihozápad-1.85-(CZ); Severozapaden-1.88-(BG); Střední Morava-1.92-(CZ); Eesti-1.93-(EE); Lietuva-1.97-(LT); Ipeiros-1.98-(EL); Latvija-2.01-(LV); Yuzhen tsentralen-2.01-(BG); Podlaskie-2.02-(PL); Alentejo-2.07-(PT); Swietokrzyskie-2.08-(PL); Yugoiztochen-2.10-(BG); Lubelskie-2.26-(PL); Dytiki Ellada-2.29-(EL); Közép-Dunántúl-2.62-(HU); Nyugat-Dunántúl-2.68-(HU); Warminsko-Mazurskie-2.90-(PL); Podkarpackie-2.95-(PL); Dél-Dunántúl-3.10-(HU); Észak-Magyarország-3.40-(HU); Região Autónoma dos Açores (PT)-3.42-(PT); Dél-Alföld-4.46-(HU); Észak-Alföld-4.66-(HU)	11.940 Bill EUR
NUTS 3	3.07% for convergence according to GDP	Gozo and Comino / Ghawdex u Kemmuna-3.11-(MT); Tarnowski-3.12-(PL); Inowroclawski-3.21-(PL); Zemgale-3.34-(LV); Bács-Kiskun-3.35-(HU); Kesk-Eesti-3.36-(EE); Slupski-3.41-(PL); Aitolokarnania-3.42-(EL); Kyustendil-3.42-(BG); Região Autónoma dos Açores (PT)-3.42-(PT); Somogy-3.44-(HU); Pomurska-3.44-(SI); Baranya-3.48-(HU); Hajdú-Bihar-3.51-(HU); Elblaski-3.52-(PL); Borsod-Abaúj-Zemplén-3.55-(HU); Sliven-3.56-(BG); Baixo Alentejo-3.57-(PT); Vidzeme-3.58-(LV); Kurzeme-3.59-(LV); Veszprém-3.61-(HU); Nógrád-3.62-(HU); Tauragės apskritis-3.67-(LT); Sieradzki-3.80-(PL); Latgale-4.08-(LV); Terras de Trás-os-Montes-4.11-(PT); Yambol-4.29-(BG); Rzeszowski-4.30-(PL); Haskovo-4.40-(BG); Békés-4.42-(HU); Jász-Nagykun-Szolnok-4.97-(HU); Csongrád-5.79-(HU); Alto Alentejo-5.82-(PT); Szabolcs-Szatmár-Bereg-5.92-(HU); Íthaki, Kefallinia-7.30-(EL); Alto Tâmega-7.52-(PT); Thesprotia-8.81-(EL).	5.801 Bill EUR
	3.62% for convergence according to GVA	Tauragės apskritis-3.67-(LT); Sieradzki-3.80-(PL); Latgale-4.08-(LV); Terras de Trás-os-Montes-4.11-(PT); Yambol-4.29-(BG); Rzeszowski-4.30-(PL); Haskovo-4.40-(BG); Békés-4.42-(HU); Jász-Nagykun-Szolnok-4.97-(HU); Csongrád-5.79-(HU); Alto Alentejo-5.82-(PT); Szabolcs-Szatmár-Bereg-5.92-(HU); Íthaki, Kefallinia-7.30-(EL); Alto Tâmega-7.52-(PT); Thesprotia-8.81-(EL).	3.108 Bill EUR