The updated RHOMOLO impact assessment of the 2014-2020 European cohesion policy (including REACT-EU)

Casas, Pablo and Christou, Tryfonas and García Rodríguez, Abián and Heidelk, Tillmann and Lazarou, Nicholas Joseph and Monfort, Philippe and Salotti, Simone

European Commission, Joint Research Centre (JRC) Seville, European Commission, DG REGIO, Bruxelles

December 2024

The updated RHOMOLO impact assessment of the 2014-2020 European cohesion policy (including REACT-EU)

Pablo Casas[a], Tryfonas Christou[a], Abián García Rodríguez[a], Tillmann Heidelk[b], Nicholas-Joseph Lazarou[a], Philippe Monfort[b], and Simone Salotti[a]

a. European Commission, JRC Seville
b. European Commission, DG REGIO

Abstract. We analyse the macroeconomic impact of the European cohesion policy investments deployed during the 2014-2020 programming period on the basis of simulations carried out with the spatial dynamic general equilibrium model called RHOMOLO. We use the latest data on actual expenditures including the €50 billion falling under the REACT-EU programme extending the response to the COVID-19 crisis. We quantify the direct and indirect effects of the policy in the NUTS 2 regions of the European Union within a 20-year time frame. The results suggest that the impact of the policy is sizeable, especially in the less developed regions. Accordingly, regional disparities are shown to decrease due to the policy intervention. The investments have a positive impact on the European GDP, which is almost 0.6% higher in 2023 compared to a scenario without cohesion policy.

Keywords: Cohesion policy, REACT-EU, regional growth, regional development, general equilibrium modelling.

JEL Codes: C68, R13.

Acknowledgments: We thank Javier Barbero, Martin Christensen, Andrea Conte, Francesca Crucitti, Francesco Di Comite, Filippo Di Pietro, Jorge Díaz-Lanchas, Olga Diukanova, Patrizio Lecca, Giovanni Mandras, Damiaan Persyn, Stylianos Sakkas, and Yevgeniya Shevtsova for valuable comments. All remaining errors are our own.

1. Introduction

The main objective of the European cohesion policy is to reduce economic disparities between European regions, thereby promoting development and growth with a particular attention to the less developed areas of the European Union (EU). Cohesion policy is the main investment policy of the EU and it is therefore essential to evaluate its economic impact on EU countries and regions, which is the subject of a lively academic and policy debate (see, among others, von Ehrlich and Overman, 2020; and Iammarino et al., 2019).

Article 57 of the Common Provision Regulation 2014-2020[1] requires the Commission to carry out an ex-post evaluation of the European Structural and Investment Funds (ESIF). The macroeconomic impact assessment of the policy presented in this working paper complements the qualitative and quantitative work carried out as part of the formal ex-post evaluation.

This analysis updates the macroeconomic impact assessment presented by Crucitti et al. (2022), which was based on planned expenditure for the period 2014-2020, by using updated data on actual cohesion policy expenditure that took place between 2014 and 2023. In addition, this analysis includes the almost €50 billion added in the context of the emergency response to the social and economic consequences of the COVID-19 pandemic under the Recovery Assistance for Cohesion and the Territories of Europe (REACT-EU[2]).

The macroeconomic impact assessment presented here is based on simulations carried out with the spatial dynamic computable general equilibrium (CGE) model RHOMOLO. The model is developed and maintained by the Joint Research Centre (JRC) of the European Commission in cooperation with the Directorate-General for Regional and Urban Policy (DG REGIO).

The interventions financed by cohesion policy have both direct and indirect effects on economies, which can be difficult to estimate. For instance, programmes implemented in the main beneficiary countries and regions boost local demand which is partly served by exports from other countries, notably the more developed Member States which therefore indirectly benefit from these programmes (see Crucitti et al., 2023). Cohesion policy also entails long-term effects, which are likely to last long after the termination of the programmes and which must be accounted for to fully capture the impact of the policy. Finally, cohesion policy needs to be financed and the cost of the policy should be taken into account.

All these aspects can be addressed in a consistent manner by a spatial dyamic CGE model like RHOMOLO to gauge the net effect of the policy when it affects the allocation of resources across the EU economies. The economic foundations of the model are based on the well-established literature on general equilibrium models. The model itself is presented in numerous articles contributing to this literature (see, among others, Barbero et al., 2024a; Crucitti et al., 2024; Gianelle et al., 2024; and Crucitti et al., 2023). The version of the model used here is calibrated with data for 2017, the construction of which is explained by García Rodríguez et al. (2023), updating the procedure described by Thissen et al. (2019).

The RHOMOLO model is well-suited to assess the impact of cohesion policy on EU regions, taking into account both demand and supply side effects. The model is able to capture both short- and long-term effects of the policy, taking into account the economic characteristics of the regions and the

---

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1303.

[2] REACT-EU extends the crisis-response and crisis-repair measures delivered through the coronavirus response investment initiative (CRII) and the coronavirus response investment initiative plus (CRII+) and constitutes a bridge to the long-term recovery plan. See https://ec.europa.eu/regional_policy/funding/react-eu_en for additional details about REACT-EU.

interactions between them through interregional trade, as well as spillovers and mobility of production factors.

The analysis covers all expenditures channelled through the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund (ESF), the Youth Employment Initiative (YEI), and REACT-EU. In addition to modelling the transmission channels activated by the different types of interventions (which include, among others, public investment, subsidies to private investment, and labour market interventions), the simulations also take into account the cost of the policy which is assumed to be financed by taxes levied in the Member States and regions.

The report is structured as follows: section 2 briefly summarises the literature on the evidence of the impact of cohesion policy on economic growth and convergence. Section 3 describes the financial allocation of the policy for the period 2014-2020 and how it is categorised for the RHOMOLO analysis. Section 4 briefly describes the model. Section 5 presents the results of the simulations at both EU and NUTS 2 level. Section 6 concludes.

2. The literature on the impact of cohesion policy on growth and convergence

The impact of cohesion policy is the subject of extensive research and debate among academics and policymakers (Farole et al., 2011). Various studies have examined the effectiveness of cohesion policy in reducing economic disparities, fostering regional development and promoting growth across the European Union. In this section, we review the existing literature on the impact of cohesion policy on such variables, focusing on the methodologies, findings, and key insights that have emerged from previous research. This literature review excludes qualitative studies (e.g. case studies) and focuses on quantitative methods, both econometric (dealing with ex-post analyses) and modelling (either ex-ante or ex-post evaluations).[3]

One strand of the econometric literature is based on the neoclassical growth framework and uses econometric estimates of beta convergence models à la Barro et al. (1991). Authors using this approach typically estimate cross-country or cross-regional growth regressions augmented with cohesion policy variables. This type of evidence is rather inconclusive as regards the impact of cohesion policy. Dall'Erba and Fang (2017) provide a meta-analysis of the impact of the ESIF on regional growth, using the results of 17 different econometric studies published between 1996 and 2013. The estimated policy impacts range from negative to positive, sometimes not significantly different from zero. One of the main findings of this meta-analysis is that a learning effect may be at work, as more recent estimates tend to find more positive results, suggesting that the implementation of cohesion policy has become more effective over time. Similarly mixed results on the impact of cohesion policy on growth are highlighted by the surveys of Mohl (2016) and Pieńkowski and Berkowitz (2016), who also focus on econometric evidence based on neoclassical growth.[4]

The growth regressions whose results are analysed by these authors have a number of drawbacks, mostly related to endogeneity, model uncertainty (including omitted variables), spatial correlation across geographical areas, and the presence of poor quality controls, which can bias the results. A

[3] A review of the literature examining the impact of cohesion policy on variables other than economic growth and regional convergence is beyond the scope of this paper. It is worth mentioning that there are studies on the impact of cohesion policy on firm growth (Bachtrögler et al., 2020) and on innovative start-ups (Santoleri and Russo, 2025), on the resilience of labour markets (Di Caro and Fratesi, 2023), on migration (Cerqua et al., 2022), on the trade-off between employment and productivity (Bourdin et al., 2024), on household inequality (Psycharis et al., 2024), and on political outcomes (Rodríguez-Pose and Dijkstra, 2021), among other things.

[4] Giannini and Martini (2024) study regional convergence in the EU using a machine learning approach and find that cohesion policy has played a role in promoting it. They also challenge the existing evidence on regional convergence, thus contributing to the ongoing debate on the topic (see, among others, Cavallaro and Villani, 2021; Monfort, 2020; Bisciari et al., 2020; and Monfort et al., 2013).

key problem is that the decision to invest in certain regions depends on the GDP levels and growth rates of the regions themselves, which by design makes the policy variable negatively correlated with the dependent variable of the growth regressions, thereby undermining the robustness of the results (Brasili et al., 2023; Berkowitz et al., 2020).

Other approaches have been used to assess the impact of cohesion policy on economic growth such as counterfactual analyses based on regression discontinuity design, which allow for spatially heterogeneous results.[5] Such studies exploit the existence of categories of beneficiaries for whom the policy injection differs significantly between regions that could otherwise be considered relatively similar, or changes in aid intensity from one programming period to another. The evidence arising from this literature generally indicates a significant and positive impact of cohesion policy in this setting, albeit heterogeneously distributed across the EU territories (Crescenzi and Giua, 2020; Cerqua and Pellegrini, 2018; Gagliardi and Percoco, 2017; Ferrara et al., 2017; Percoco, 2017; European Commission, 2016; Pellegrini et al., 2013; and Becker et al. 2010).

Building on the literature on fiscal multipliers (Blanchard and Perotti, 2002), some authors have estimated the multipliers associated with the EU structural funds, with mixed results depending on the time horizon analysed, on the specific funds studied, and on the geographical level of analysis (Canova and Pappa, 2024; Fiuratti et al., 2023; Durand and Espinoza, 2021; and Coelho, 2019).

A significant part of the literature has convincingly argued that there may be key factors that condition the impact of cohesion policy on economic growth (Fratesi and Wishlade, 2017), such as the quality of institutions (Becker et al., 2013; Rodríguez-Pose and Garcilazo, 2015; Aiello et al., 2019; Albanese et al., 2021; Incaltarau et al., 2020; Mendez and Bachtler, 2024), fiscal decentralisation (Bähr, 2008), openness to trade (Ederveen et al., 2006), or the presence of certain assets and endowments (Pinho et al., 2015).

Model simulations have also been used to analyse the impact of cohesion policy. In general, model-based simulations tend to support a significant impact of the policy on key economic variables, especially in the main beneficiaries, and on economic convergence. In this type of studies, it is generally assumed that funds are spent efficiently on all projects, which may not be the case in all countries and regions. Moreover, the policy injection is sometimes measured using data on the ex-ante allocation of funds across regions and intervention areas, which may differ from the actual expenditure resulting from programme implementation. Model simulations should therefore be seen as estimates of the potential impact of the policy if implemented as planned.

A number of papers analyse the impact of the policy at the EU or national level using different models such as GIMF (Allard et al., 2008) or QUEST (Varga and in 't Veld, 2011a and 2011b; and Monfort et al., 2017). However, little work has been done using modelling frameworks to generate evidence at the regional level, which is mainly devoted to single-region or single-country analyses. For example, De la Fuente (2002) assesses the impact of policy on growth and convergence in Spanish regions using a supply-side model estimated with regional panel data over a 30-year period. Sosvilla-Rivero et al. (2006) use the HERMIN model to analyse the impact of structural funds in the Spanish region of Castilla la Mancha, Fortuna et al. (2016) use a CGE model to analyse the impact of cohesion investments in the Portuguese Azores, Garau and Lecca (2015) use a CGE model to study the impact of research and development (R&D) structural funds in the Italian region of Sardinia, while Arcalean et al. (2012) calibrate a two-region endogenous growth model for Portugal.

Multi-regional general equilibrium models also have the advantage of explicitly accounting for the spillovers generated by cohesion policy interventions.[6] The RHOMOLO model is such a model and has been used extensively to study the impact of cohesion policy. Other multi-regional models include the

[5] This can also be done with other methods, such as the geographically weighted regression approach used by Bourdin (2019), or heterogeneous coefficient modelling (Amendolagine et al., 2024; Di Caro and Fratesi, 2022).
[6] There are econometric studies in the literature that account for the existence of spillovers. See, for example, Kisiała and Stępiński (2024), Fiaschi et al. (2018), Mohl and Hagen (2010), and Ramajo et al. (2008).

CGE model used by Korzhenevych and Bröcker (2020) to study the ESIF impact in Poland and the Baltic EU Member States, the model used by Mogila et al. (2022) to study the impact of cohesion policy on intra-country disparities in Romania, Czechia, and Poland (this is a version of the HERMIN model, see Bradley and Untiedt, 2009), the GMR model used by Varga et al. (2020) to study the impact of Smart Specialisation in Hungary, and the general equilibrium model used by Blouri and von Ehrlich (2020) to study the impact of 2007-2013 cohesion policy investments.

The RHOMOLO model has been used to study the impact of cohesion policy programmes on all NUTS 2 regions in the EU over many programming periods. Di Comite et al. (2018) and Crucitti et al. (2022) focus on the 2007-2013 and 2014-2020 investments respectively, while more recently Christou et al. (2023) provided an impact assessment of the planned 2021-2027 interventions.[7] The same model has been used for more specific cohesion-related analyses focusing on the equity-efficiency trade-off of the policy (Barbero et al., 2024a), the impact on EU regional disparities (Crucitti et al., 2024), Smart Specialisation (Gianelle et al., 2024; Barbero et al., 2024b; and Barbero et al., 2022), the magnitude of regional and international spillovers (Lecca et al., 2020; Crucitti et al., 2023), the influence of the quality of institutions (Barbero et al., 2023), and the long-run effects of transport infrastructure investment (Persyn et al., 2023).

3. Cohesion policy expenditure 2014-2020

3.1. Overview and distribution over funds and time

For the period 2014-2020, EU funding for cohesion policy amounts to €355 billion, more than 34% of the total EU budget. Around €50 billion has been added as part of the emergency response to the social and economic consequences of the COVID-19 pandemic under the so-called REACT-EU. This brings the total amount injected into EU economies through the ERDF, ESF, CF, and YEI to almost €405 billion.[8] Taking into account an implementation period of 10 years due to the N+3 rule,[9] this corresponds on average to about 0.4% of EU GDP per year. Table 1 provides an overview of the financial allocation by fund.

Table 1. Budget by fund (euro, current prices)

Fund	Planned amount (€)
CF	61,434,784,152
ERDF	230,005,563,849
ESF	104,402,027,966
YEI	8,960,645,385
Total	**404,803,021,352**

Source: DG REGIO, Cohesion Open Data Platform (https://cohesiondata.ec.europa.eu/2014-2020/ESIF-2014-2020-FINANCES-PLANNED-DETAILS/e4v6-qrrq).

The data used in the analysis refer to expenditure figures up to 31 December 2023. For the sake of this exercise, we assume full absorption of funds, so that by 2023 the estimated cumulative expenditure is equal to the total allocation for the programming period (Annex 1 describes how the data are processed). The assumption of a 100% absorption rate is in line with evidence from previous programming periods. For example, for the 2007-2013 period, more than 98.5% of the allocation

[7] Christou et al. (2024), combine data for the 2014-2020 and 2021-2027 programming periods in a single simulation analysis (see also European Commission, 2024).

[8] In this analysis, we consider the funds managed under cohesion policy. Therefore, we exclude the Connecting Europe Facility (CEF), some of the funds transferred outside cohesion policy (e.g. transfers to HOME funds, Invest EU…), instruments managed by the Commission, and EU technical assistance in support of programming. Data for a limited number of programmes are also missing at the time of writing. The analysis therefore covers a total amount of around €404,293,374,570.

[9] The N+3 rule allows funds to be used up to three years after they have been committed which implies that the programmes are actually implemented over a period of 10 years.

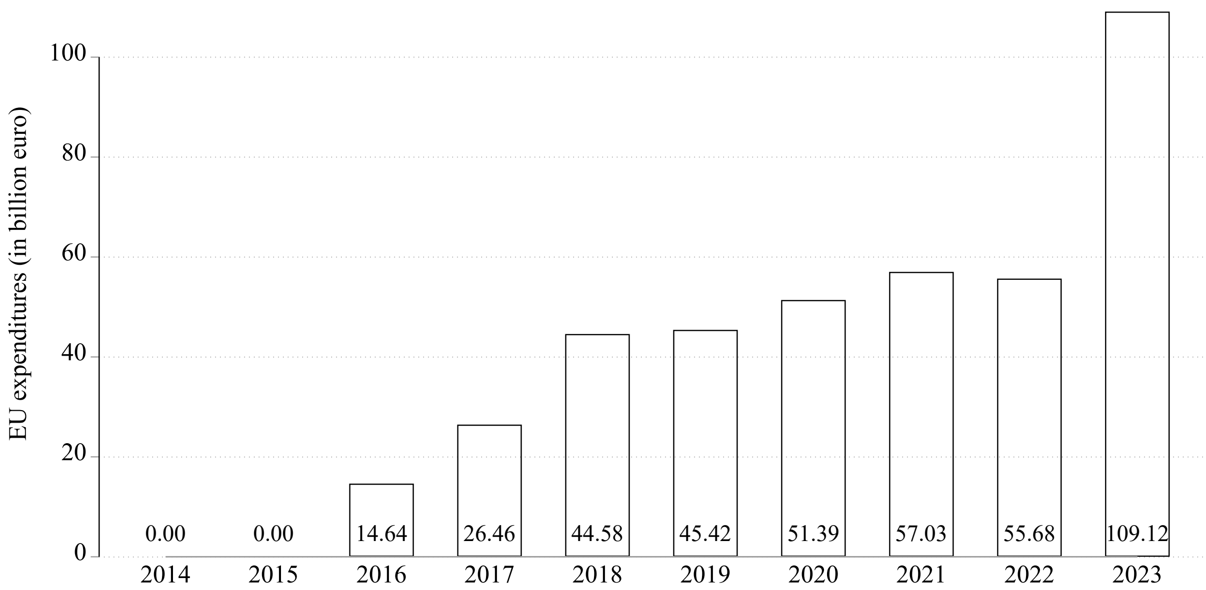
was spent. For the 2014-2020 period, the absorption rate is 96% as of August 2024, to a large extent due to the very significant additional funds injected through REACT-EU in the course of programme implementation. However, the amounts not yet invoiced to the Commission generally correspond to actions that have already taken place on the ground, so this working assumption of a 100% absorption rate may not be too far from reality.

Figure 1 shows the total annual expenditure from 2014 to 2023, highlighting the increase in annual amounts over time, while Figure 2 goes into more detail and shows the same data broken down by fund and time. The expenditure data start in 2016, i.e. the years 2014 and 2015 show zero expenditure. This can be explained by two factors:

(1) In the first years of the programming period, programmes have to be negotiated and adopted before starting;
(2) The data presented correspond to the reimbursement claims submitted by the managing authorities in the Member States to the European Commission following the start and implementation of projects in the EU regions. Therefore, actual expenditure may in some cases take place prior to the reporting year (see Lo Piano, 2020).

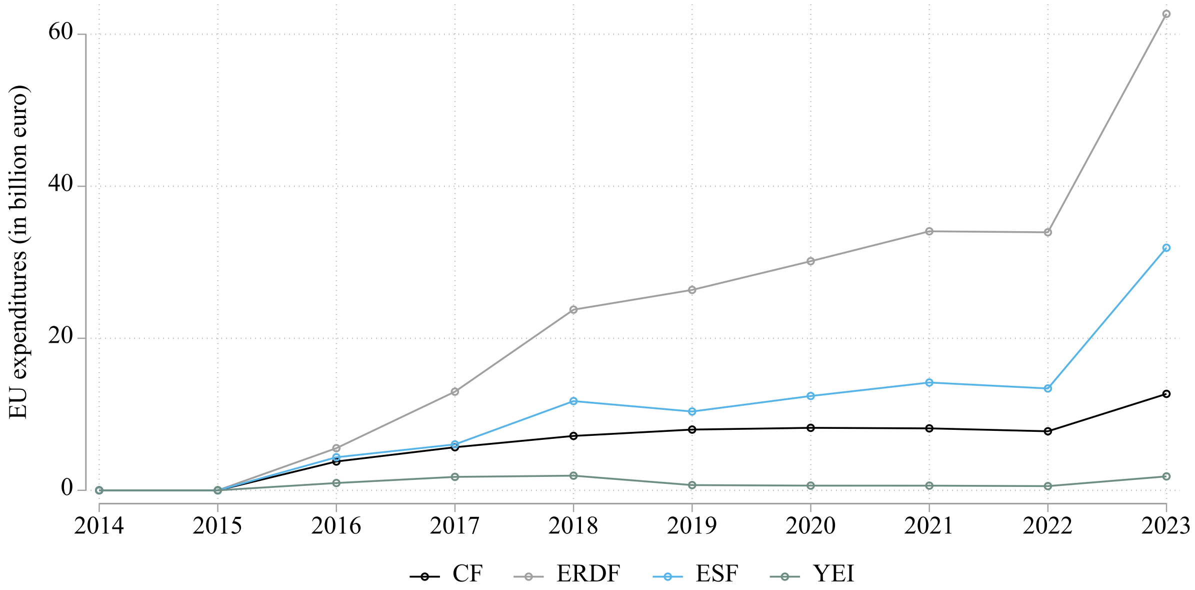
As a result, with the exception of the YEI, the annual share of expenditure increases over time. This is also explained by the implementation of REACT-EU, which increased the ERDF allocation by 14.96% and the ESF by 23.51%.

Figure 1. Total expenditures (in billion €), across years; all funds



Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.

Figure 2. Total expenditures (in billion €), across years and funds



Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.

3.2. Distribution of resources among geographical areas and fields of intervention

Investment is concentrated on key areas of intervention to promote growth and development. For the purposes of data presentation and subsequent modelling analysis, we group cohesion policy expenditure into the following six fields of intervention which are then modelled differently in RHOMOLO to reflect the different transmission channels through which policy interventions affect the economies of Member States and their regions:

1. **RTD**: support for R&D (research, technological development and innovation, creation of networks and partnerships between companies and/or research institutes);
2. **AIS**: support to the private sector (support to small and medium-sized enterprises, facilitation of credit, support to improve tourism and cultural services);
3. **TRSNP**: investment in transport infrastructure;
4. **INFR**: investment in non-transport infrastructure (telecommunications, energy, environmental, health and social infrastructure), possibly linked to industrial processes;
5. **HC**: investment in human capital (education and training, active labour market policies, and other labour market interventions); and
6. **TA**: technical assistance (administrative capacity building, monitoring, and evaluation).

The distribution of funds between the above fields of intervention varies from region to region and therefore from Member State to Member State, reflecting the policy mix resulting from the design of the programmes. Table 2 provides a breakdown of the allocation of funds by Member State and by field of intervention. In general, the less developed regions and Member States have a higher share of funding allocated to transport and other infrastructure-related interventions (TRNSP and INF). In contrast, the more developed regions and Member States allocate a higher share to support for R&D, the private sector, and to investment in human capital (RTD, AIS, and HC, respectively). For example, in Poland 35.4% of the funds are allocated to transport infrastructure (TRNSP), while in Lithuania 42.3% are allocated to investment in non-transport infrastructure. In contrast, the Netherlands allocates only 0.6% (lowest of all Member States) and 10.0%, respectively, to these areas, but more than 37.4% to RTD (highest of all Member States) and 42.5% to HC.

Table 2. Cohesion policy allocation by Member State, per field of intervention, % of total allocation

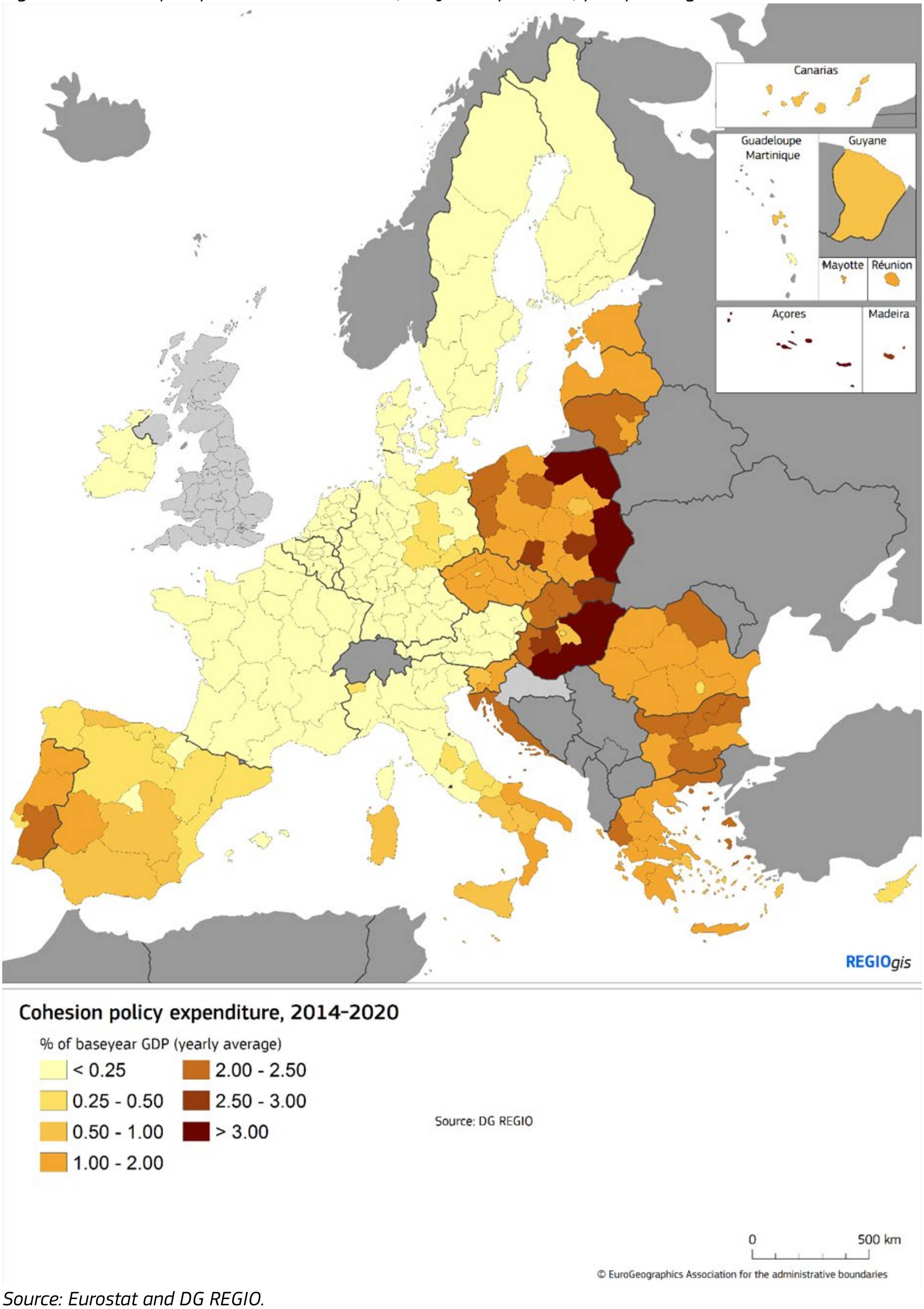
Country	RTD	AIS	TRNSP	INFR	HC	TA	Total
AT	21.8	18.0	3.4	15.8	37.8	3.2	100
BE	18.8	10.2	4.7	14.6	48.1	3.5	100
BG	10.0	15.8	23.6	25.6	22.0	3.1	100
CY	9.6	7.0	13.3	39.9	27.5	2.7	100
CZ	14.1	3.9	25.7	36.0	16.4	4.0	100
DE	26.6	9.6	2.7	19.5	38.2	3.3	100
DK	35.7	15.4	2.0	6.4	36.6	3.8	100
EE	21.1	2.1	13.9	43.3	16.8	2.9	100
EL	6.4	26.0	12.3	26.9	25.7	2.6	100
ES	10.5	6.7	6.0	41.3	34.1	1.5	100
FI	32.2	20.3	2.6	5.8	35.2	3.7	100
FR	14.5	6.4	6.5	30.9	38.1	3.5	100
HR	9.2	15.0	12.9	36.5	22.6	3.8	100
HU	8.8	16.2	17.3	33.7	22.6	1.4	100
IE	6.0	1.8	0.9	35.3	54.0	1.9	100
IT	9.5	12.4	7.7	23.2	44.7	2.5	100
LT	16.7	4.3	15.4	42.3	18.3	3.1	100
LU	6.3	0.1	15.9	28.1	48.0	1.6	100
LV	15.5	4.2	23.1	37.5	16.6	3.1	100
MT	7.1	5.3	12.3	40.4	32.6	2.3	100
NL	37.4	6.0	0.6	10.0	42.5	3.5	100
PL	16.8	2.2	35.4	27.0	15.5	3.2	100
PT	16.6	17.2	6.4	24.6	33.5	1.8	100
RO	4.2	7.8	31.0	31.9	22.0	3.2	100
SE	25.5	11.5	4.6	8.7	45.9	3.9	100
SI	23.2	8.7	13.3	30.1	21.5	3.3	100
SK	7.9	5.1	25.4	27.2	30.4	4.0	100
UK	23.3	13.1	5.7	12.0	43.4	2.5	100
EU-28	13.6	9.1	17.0	28.9	28.5	2.8	100

Source: DG REGIO.

Figure 3 shows the geographical distribution of the funding, which reflects the objective of cohesion policy to promote a balanced development of the EU and to reduce disparities between EU regions. A large part of the funding is therefore concentrated on less developed regions and Member States. To determine eligibility for the ERDF 2014-2020, cohesion policy distinguishes three groups of regions according to their level of development. The group of less developed regions (LD) includes regions with a GDP per capita of less than 75% of the EU average, the so-called transition regions (TR) have a GDP per capita between 75% and 90% of the EU average, and the more developed regions (MD) have a GDP per capita of over 90%.[10]

[10] These groups have been constituted in 2011 based on the average GDP per head for the years 2007, 2008 and 2009. The composition of the groups has then been frozen, and it is therefore constant throughout the whole period of analysis.

Figure 3. Cohesion policy allocation 2014-2020, % of base year GDP, yearly average



Source: Eurostat and DG REGIO.

For this analysis, all national or multiregional programmes have been regionalised at NUTS 2 level on the basis of their geographical coverage and the proportion of the population of the beneficiary regions. Around 63% of the funding is directed towards the less developed regions of the EU (Table 3). Aid intensity is also highest in these regions, with an average of €298.8 per inhabitant per year, more than five times higher than in the more developed regions.

Table 3. Population, cohesion policy allocation, and aid intensity, across categories of regions

Regions	**Share of population* (%)**	**Share of funding (%)**	**Aid intensity**
Less developed	24.2	62.7	292.8
Transition	13.6	12.5	103.9
More developed	62.3	24.9	45.0
EU-28	100.0	100.0	112.9

** Average 2014-2020. Note: Aid intensity is measured in euro per inhabitant and per year.*
Source: Eurostat and DG REGIO.

In some Member States, cohesion policy represents a significant injection of funds, up to 1.8% of base year GDP (2017) on average in Croatia and Hungary. For some less developed regions, the funding is even higher, for example in the Região Autónoma dos Açores in the Azores/Portugal or in Észak-Alföld in Hungary, where the policy injection exceeds 4% of GDP per year on average (Table 4).

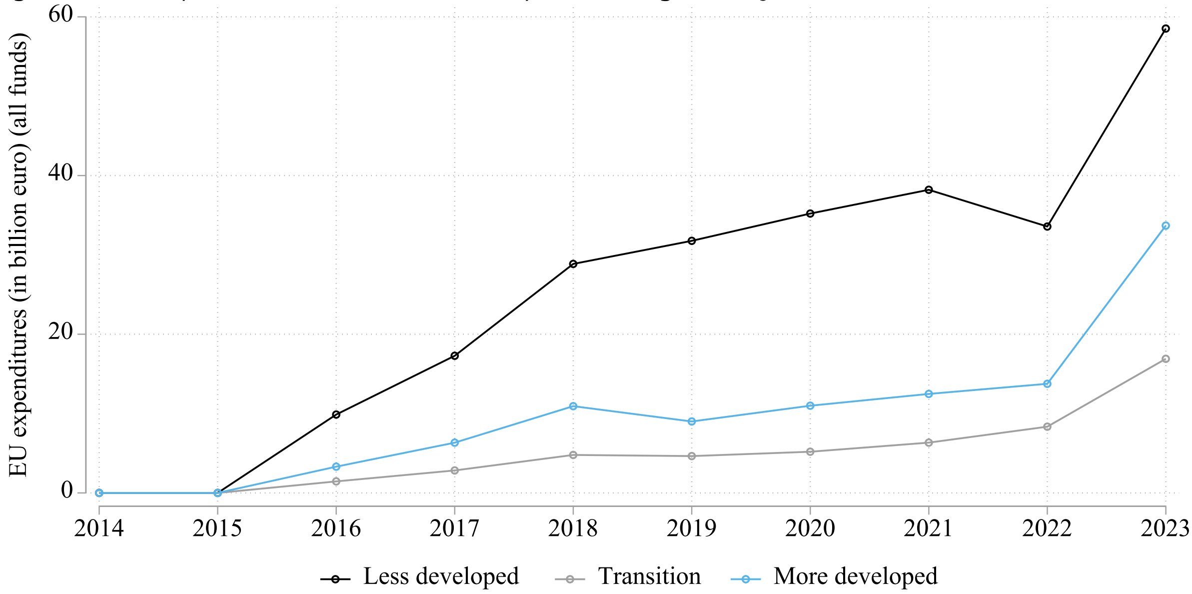
Table 4. Top 10 regions in terms of cohesion policy funding relative to GDP

Region	**Cohesion policy funding, % base year GDP**
PT20, Região Autónoma dos Açores	4.2%
HU32, Észak-Alföld	4.1%
HU23, Dél-Dunántúl	3.9%
HU33, Dél-Alföld	3.6%
HU31, Észak-Magyarország	3.6%
PL62, Warminsko-Mazurskie	3.4%
PL81, Lubelskie	3.2%
PL82, Podkarpackie	3.1%
PL84, Podlaskie	3.1%
PL72, Swietokrzyskie	3.0%

Source: Eurostat and DG REGIO.

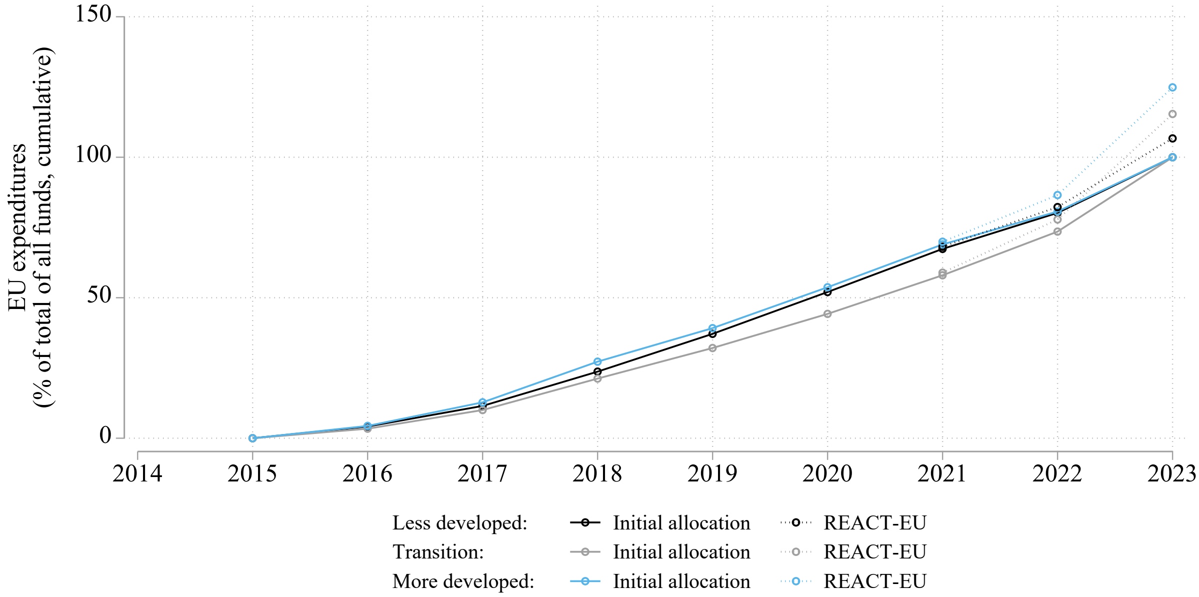
In terms of the temporal distribution across regions, Figure 4 shows the total absolute expenditure over time in the three groups of regions identified above. The less developed regions had higher absolute expenditure in all years, in line with the higher allocation (see also Table 3). Figure 5 shows the proportions of allocations spent by the regions, indicating the absorption rates. For the initial allocations (all funds, excluding the REACT-EU allocations), the more and less developed regions have the highest absorption rates, while the transition regions lag slightly behind. However, when initial allocations and REACT-EU allocations are considered together, the less developed regions have the fastest absorption rates, in line with the fact that REACT-EU allocations were relatively higher for the more developed regions (see Annex 2 for more details).

Figure 4. Total expenditures (in billion €), across years and regions; all funds



Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.

Figure 5. Cumulative annual share of expenditures within categories of regions, across years and regions; all funds



Note: Initial allocation sums up to 100% for each group of regions. The share of REACT-EU is added on top, calculated as the REACT-EU allocation divided by the total initial allocation.[11]
Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.

[11] For example: If one of the three groups of regions had an initial allocation total of €210 billion and an additional allocation of €10.5 billion in the context of REACT-EU, then the graph will reach 100% for the initial allocation and 100 * (€210 billion + €10.5 billion) / €210 billion = 105% in total, i.e. 100% + 5%.

4. The RHOMOLO model setup and the simulation strategy

4.1. Model description

The economic foundations of the spatial dynamic RHOMOLO model are based on the well-established literature on CGE models. In brief,[12] the model is calibrated to a set of integrated EU regional social accounting matrices (SAMs) for the year 2017, which include all the standard information of input-output tables on the production and use of goods and services, as well as information on the secondary distribution of income, detailing the roles of labour and households (García Rodríguez et al., 2023).

The model economies are divided into ten economic sectors (based on the NACE Rev. 2 industrial classification). Households consume a fixed proportion of their income and firms are assumed to maximise profits and produce goods and services according to a constant elasticity of substitution production function. Governments collect revenue and spend it on public goods and transfers (both tax rates and transfers are exogenous in the simulations presented in this paper). Capital and labour are used as factors of production (public capital also enters the production function as an unpaid factor, following Barro, 1990, and Baxter and King, 1993, among others). Trade in goods and services - within and between regions - is modelled following Armington (1969) and is assumed to be costly, with transport costs increasing with distance (Krugman, 1991). The valuation of transport costs is based on a transport model by Persyn et al. (2020). Regional economies are typically more open than national economies due to their smaller size, and this is accounted for in the model thanks to regional trade flows and the relatively high elasticity of substitution between domestic and imported goods and services (Németh et al., 2011; Olekseyuk and Schürenberg-Frhosch, 2016).

This setup ensures that the model captures the existence of interregional spillovers through trade flows and capital mobility, leading to endogenous firm location. Trade links imply that changes in economic activity in one region trigger changes in the regions of trading partners. The model also borrows from economic geography and incorporates a notion of spatial equilibrium, in which the balance between agglomeration forces (due to increasing returns to firms' technology) and dispersion forces (due to competition between rival varieties) determines the location of firms and workers. Policy shocks in a given region affect this equilibrium, leading to a redistribution of firms across space.

The base year is assumed to correspond to a steady state that does not change unless perturbed by the introduction of exogenous shocks. The interest rate is exogenous to the model and fixed at 4%. RHOMOLO is used for scenario analysis in the sense that shocks mimicking the effects of policies are introduced to perturb the initial steady state calibrated with the SAMs, resulting in different values for the model's endogenous variables such as GDP, employment, imports and exports, prices, and others. The model is solved in a recursively dynamic process, where a sequence of static equilibria are linked by the law of motion of the state variables. This implies that economic agents are not forward-looking and their decisions are based solely on current and past information.

4.2. Simulation strategy

In order to simulate the impact of cohesion policy in RHOMOLO, each of the six intervention fields defined in section 3.2 is associated with a set of model shocks designed to capture the economic transmission mechanisms that it is most likely to activate. More specifically, one or more model shocks are used to simulate each of the six fields of intervention (each one containing several of the 123 spending categories of the policies defined by the legislation, see European Union, 2014). The model shocks can be divided into demand-side shocks (with temporary effects) and supply-side shocks (with more permanent structural effects on the economy). The relationship between the shocks and the intervention areas is as follows:

[12] A full explanation of its functioning is beyond the scope of this paper (all model equations are presented in Lecca et al., 2018).

1. **RTD**: Investment in R&D is modelled as an increase in private investment via a reduction in the user cost of capital, which temporarily increases the stock of private capital (in the production function, the capital-labour elasticity of substitution is 0.4, in line with, among others, Chirinko, 2008, and Leon-Ledesma et al., 2010). Moreover, these investments are assumed to increase total factor productivity (TFP) according to an elasticity that ranges between 0.01 and 0.04 and depends on the regional R&D intensity (the estimates are in line with the existing literature, see Männasoo et al., 2018; Kancs and Siliverstovs, 2016; Bronzini and Piselli, 2009; and Griffith et al., 2004).
2. **AIS**: Aid to the private sector is modelled as an increase in private investment through a reduction in the user cost of capital, as for RTD investment, but with no impact on TFP.
3. **TRNSP**: Investment in transport infrastructure is assumed to have both demand-side and supply-side effects. Demand-side effects are generated by the temporary increase in government consumption, which accounts for the purchase of goods and services needed to build the actual infrastructure. On the supply side, these investments are assumed to reduce transport costs, thereby lowering the prices of goods, and stimulating trade flows (Ignatov, 2023). The induced reduction is based on the estimates obtained with the full transport cost model by Persyn et al. (2020) for the 2014-2020 cohesion policy investments in transport infrastructure.
4. **INFR**: Investment in non-transport infrastructure, such as electricity networks, water treatment plants, and waste management facilities, is modelled as public investment when linked to industrial processes, and otherwise as government consumption (in the latter case there are only temporary demand-side effects). In addition to increasing demand, public investment also has supply-side effects, as it temporarily increases the stock of public capital and thus stimulates the production of goods and services. We set the output elasticity of public capital at 0.1, in line with Ramey (2020) and slightly below the average of 0.12 found in the meta-study by Bom and Lightart (2014).[13] We set the congestion parameter of public capital to 0.5, which corresponds to a medium level of congestion (Alonso-Carrera et al., 2009; a value of zero would make public capital a pure public good).
5. **HC**: Investments in human capital are assumed to increase demand through government current expenditure. They are also assumed to have two alternative supply-side effects, depending on the nature of the interventions. On the one hand, the categories of expenditure related to human capital development, such as training, retraining, and upskilling, are assumed to increase labour productivity. The main assumption behind this effect is the increase in productivity caused by an additional year of training, which we take from the country-specific estimates of Psacharopoulos and Patrinos (2018a and 2018b) and is consistent with the evidence from Mincer (1974) type estimates in the literature (see also Card, 2001; De la Fuente and Ciccone, 2003; and Canton et al., 2018). The cost of one year of tertiary education per capita (source: OECD, 2018) is used to calculate the amount of training implied by the HC funds of cohesion policy. On the other hand, interventions aimed at promoting the socio-economic integration of marginalised communities, participation in the labour market or the modernisation of labour market institutions are assumed to generate an increase in aggregate labour supply (in this case, we use the cost of one year of secondary education as the cost per pupil for the calibration of the shock).
6. **TA**: Technical assistance is modelled as a demand-side shock increasing current public expenditure with no supply-side effects.

We also assume that all supply-side effects decay over time. Thus, changes in labour productivity, TFP, and transport costs are all assumed to decay at an annual rate of 5%. In addition, the stocks of private and public capital have a depreciation rate of 15% and 5%, respectively (a larger depreciation rate of private capital relative to public capital is a common assumption in the literature, see e.g.

[13] Foster et al. (2023) review the literature and highlight the uncertainty surrounding the magnitude of the output elasticity of public infrastructure investment.

Bom, 2017). This implies that, in the absence of further investment, the structural effects associated with the policy gradually disappear and the economy returns to its initial steady state.

The model simulations take into account the fact that cohesion policy is financed by Member States' *pro rata* contribution to the EU budget, which is assumed to be proportional to the weight of their GDP in the EU GDP. The Member States' contribution to the part of the EU budget corresponding to cohesion policy is assumed to be financed by a lump-sum tax, which reduces the disposable income of households, thereby negatively affecting economic performance and partly offsetting the positive effects of the programmes.[14] This implies that a larger share of Member States' contributions to cohesion policy comes from the more developed parts of the EU, while the bulk of interventions take place in its less developed territories. The next section presents the results of the analysis based on the policy shocks introduced as explained above.

5. Macroeconomic impact of cohesion policy 2014-2020

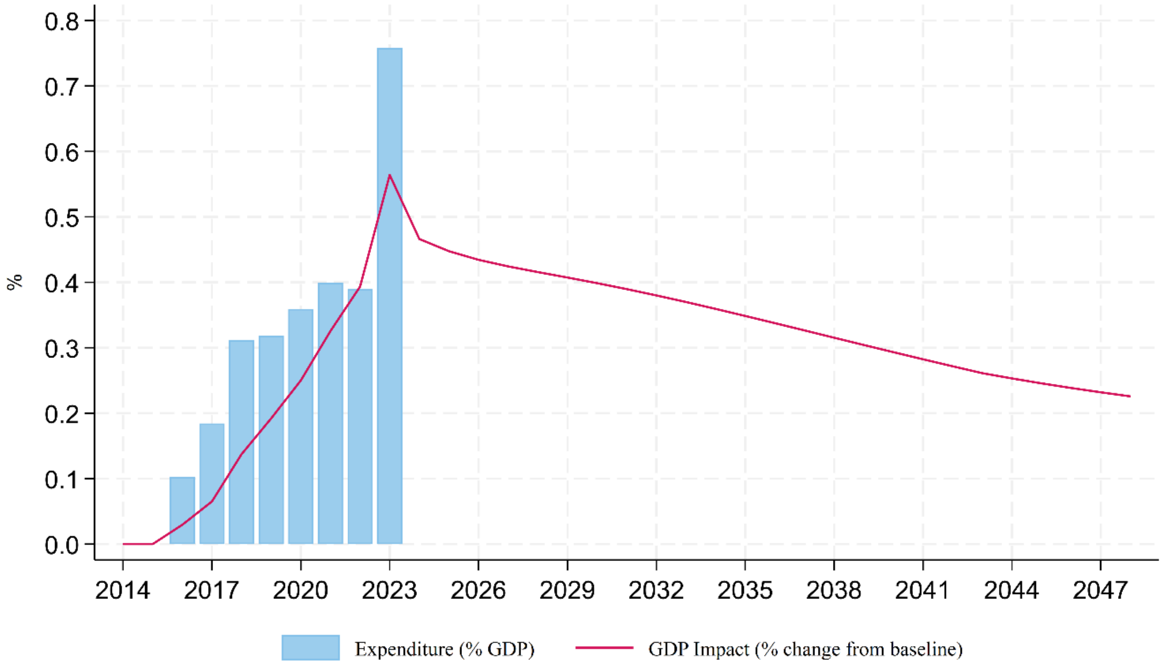
5.1. Impact at EU level of cohesion policy 2014-2020

The impact of the policy corresponds to the difference between a scenario with no policy (referred to as the baseline) and one with the shocks representing the policy, and the results are expressed as a percentage deviation from the baseline. The magnitude of the impact depends on the size of the policy injection, but also on the composition of the policy mix (which varies considerably from one region to another, even within the same Member States) and on the characteristics of the beneficiary economy, such as its industrial structure, endowment in physical and human capital, or location (which determines market access and transport costs).

Figure 6 shows the impact on EU GDP of all the cohesion policy interventions described above over time (magenta line), together with the time profile of cohesion policy expenditure expressed as a percentage of EU GDP (blue bars), from 2014 to 2045. The impact on GDP rises steadily during the implementation period, peaking at almost +0.6% in 2023. It then gradually declines after the end of programme implementation, as the increased private and public capital stock depreciates, while the increase in labour productivity and TFP, as well as the decrease in transport costs, decline. In 2045, however, the effects of the policy are still significant as annual GDP remains +0.3% above its initial level.

[14] This means that in the model, the EU regions are not constrained to run a balanced budget and can experience either deficits or surpluses. The EU budget is exogenously constrained to be balanced, as the amount of spending incurred by regions and which is financed through the programmes, is repaid with an equal amount of lump-sum transfers from the households.

Figure 6. Cohesion policy expenditure and GDP impact at EU level



Source: RHOMOLO simulations.

Table 5 shows the percentage deviations from baseline for some key macroeconomic variables in selected years and the cumulative GDP multiplier. The multiplier is the ratio of the cumulative change in GDP to the cumulative policy shock. It can be interpreted as the euro of GDP created for each euro invested in the policy, or the GDP impact per euro spent on the policy (broadly speaking, it is a kind of return on the policy investment). It increases over time as the GDP impact is positive throughout the simulation period, while the policy injection (in the denominator) stops increasing after the end of the implementation period. In the short term, the multiplier at EU level is usually less than one, as the benefits of the policy are not yet sufficient to outweigh its costs. However, this soon changes and, 25 years after the start of the programme, each euro spent on the policy has generated almost 3 euro of additional GDP. The policy injection also leads to improvements in employment, with the impact peaking at +0.91% in 2023, equivalent to around 2.1 million additional jobs compared to baseline.[15]

Table 5. Cohesion policy impact in selected years on a selection of macroeconomic variables at the EU level; EU-28

	Year			
	2023	**2030**	**2040**	**2045**
GDP (% change)	0.56	0.40	0.29	0.25
GDP Multipliers	0.69	1.75	2.97	3.43
Employment (% change)	0.91	0.31	0.23	0.19
Employment (change in thousands of people)	2,104	715	537	447

Source: RHOMOLO simulations.

5.2. National and regional impact of cohesion policy 2014-2020

The model allows results to be obtained at the level of EU NUTS 2 regions. Figures 7 and 8 below show the territorial distribution of the GDP impact of the 2014-2020 programmes in 2023 (the end of the implementation period) and 2045 (thirty years after the start of policy implementation). As expected, the GDP impact reflects the territorial distribution of the funds, especially in the short term,

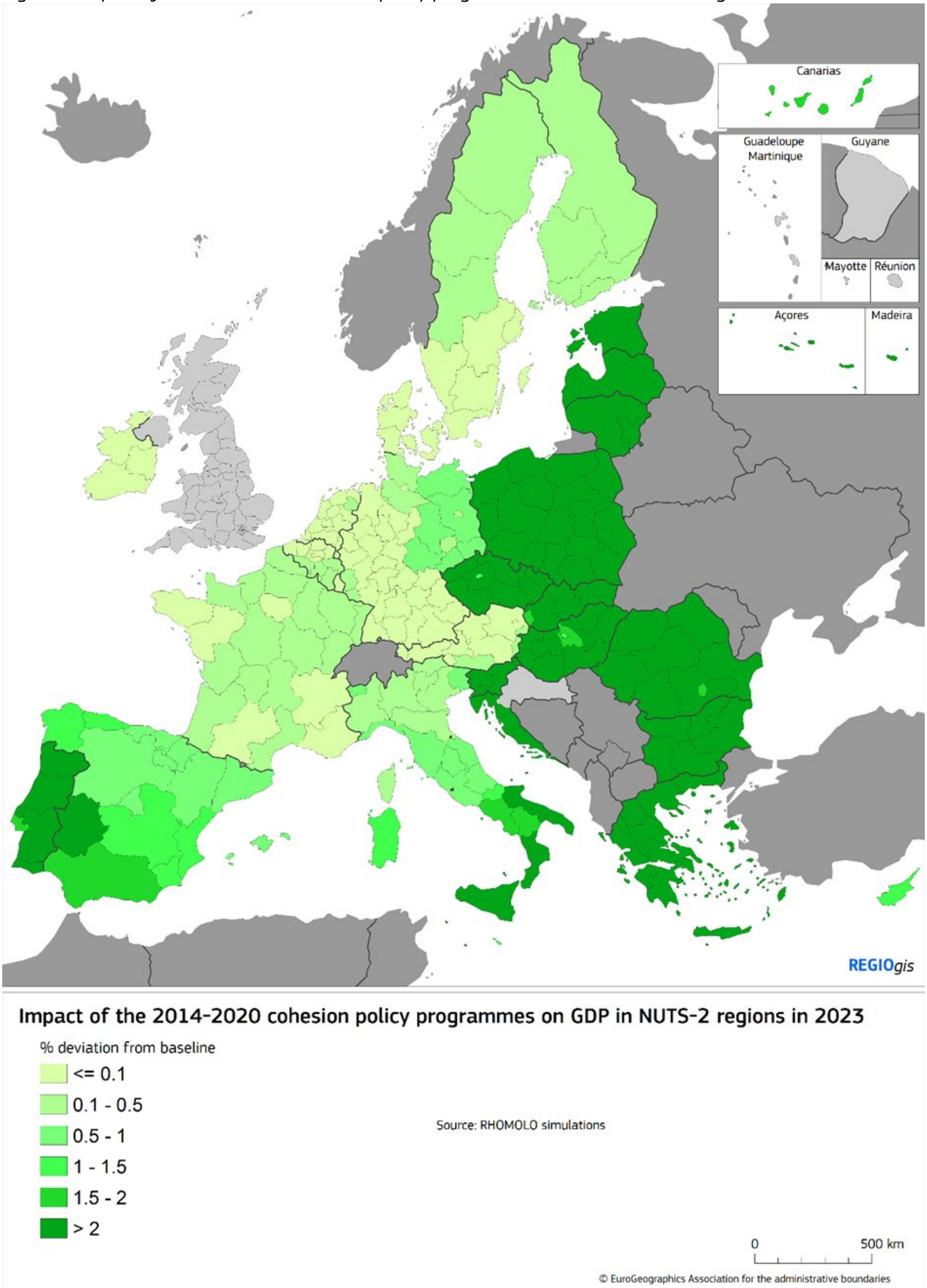
[15] The total number of persons employed in the EU-28 in the base year of the model is around 231.83 million (source: Eurostat).

where it is higher in the main beneficiaries of the policy, i.e. the Eastern European regions, as well as Portugal and Greece. By the end of the programmes, GDP is around +5.5% higher in Croatia than in a scenario without cohesion policy, +3.9% in Lithuania, +3.8% in Latvia, and around +3.7% in Portugal and Greece.

The results show considerable differences between regions within some Member States. For example, the impact on GDP ranges from +2.2% to +5.3% in Poland, from +1.5% to +6.6% in Hungary, and from +1.9% to +8.7% in Portugal.

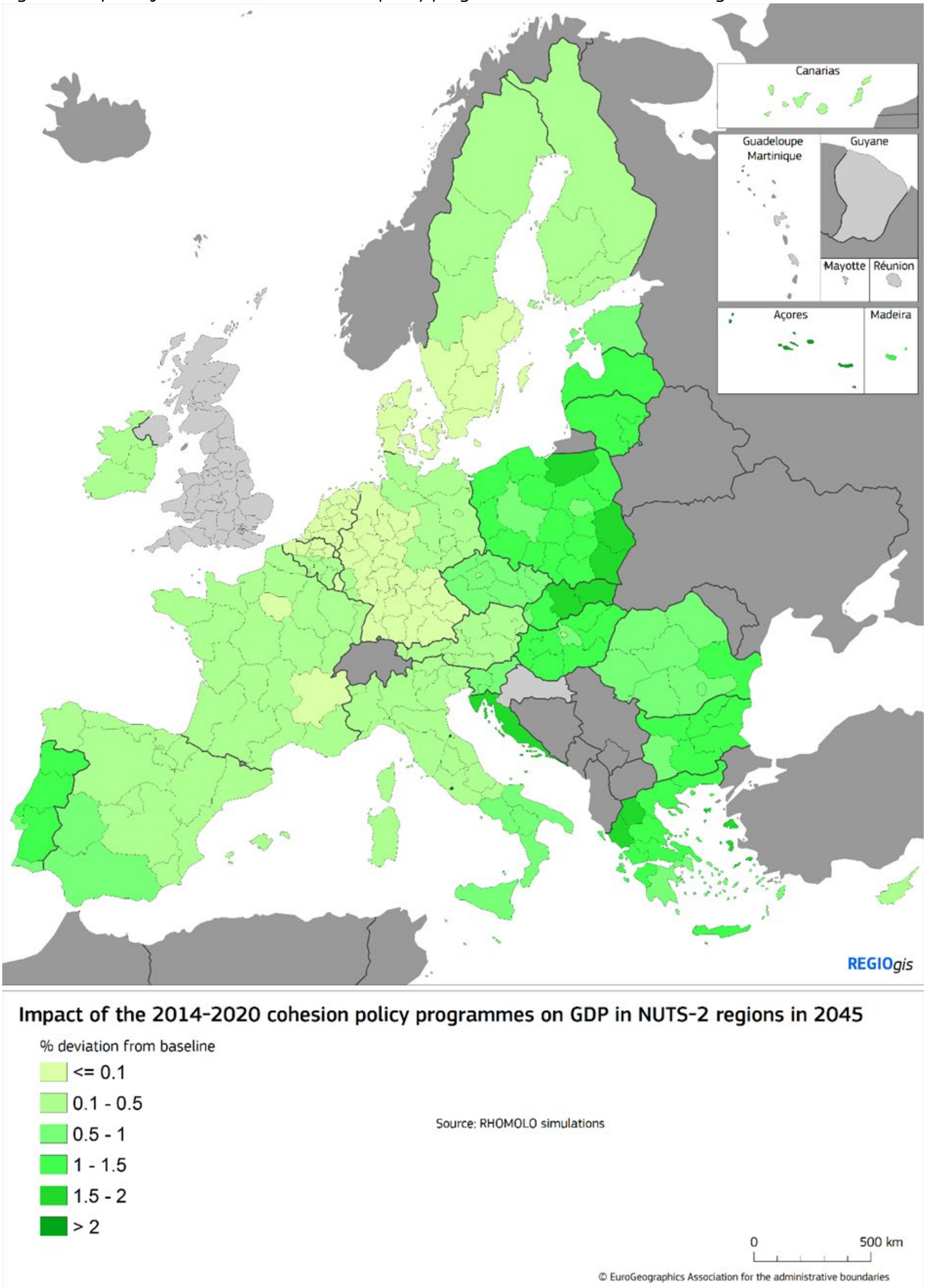
In the most developed regions of the EU, the short-term impact of the policy is more limited, and sometimes even negative, as many of these regions contribute more to the policy than they receive. However, once the interventions have been fully implemented (and financed), in the medium to long term the differences in terms of GDP impact between EU regions diminish and the impact becomes positive in all regions. This is partly due to the strong positive spatial spillovers generated by the policy, whereby programmes implemented in one region have an impact in other regions. These spillovers are mainly due to the fact that the main beneficiaries are often small, open economies with a narrow industrial base and limited R&D capacity. Many goods or services critical to the implementation of cohesion policy programmes are not produced domestically and therefore have to be imported to a large extent from the more developed regions of the EU.

Figure 7. Impact of the 2014-2020 cohesion policy programmes on GDP in NUTS 2 regions in 2023



Source: RHOMOLO simulations.

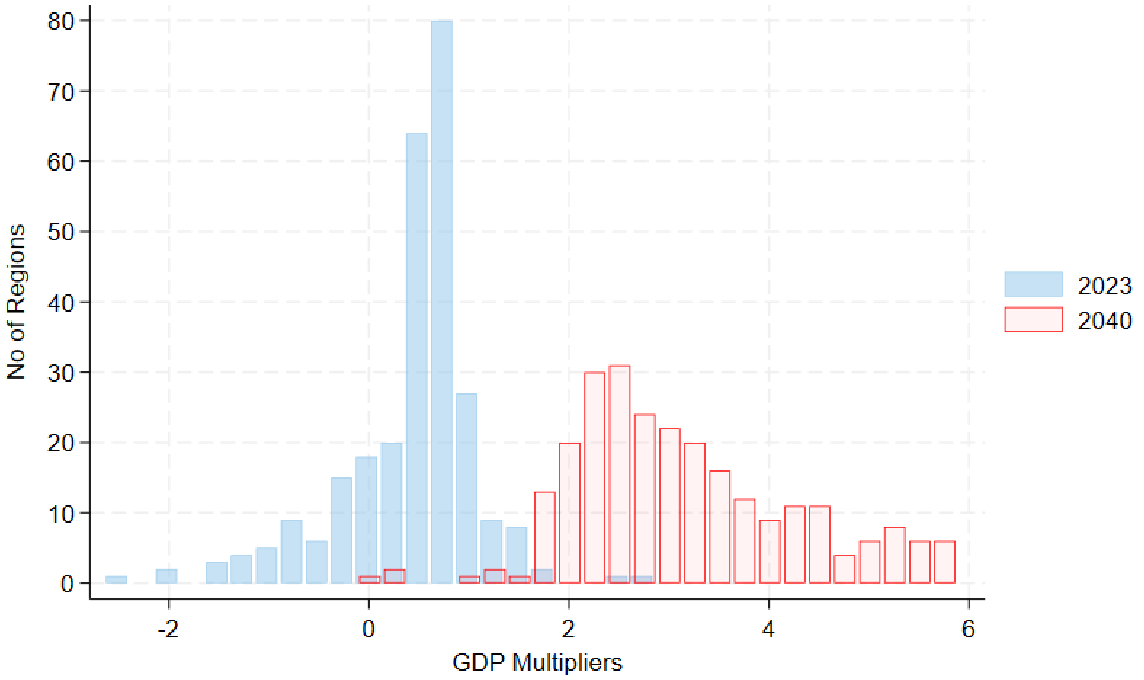
Figure 8. Impact of the 2014-2020 cohesion policy programmes on GDP in NUTS 2 regions in 2045



Source: RHOMOLO simulations.

Figure 9 shows the evolution of the distribution of cumulative regional GDP multipliers over time. Moving from the short run to the long run, the multipliers tend to move to the right, as the combined demand- and supply-side effects of cohesion policy generate more than one euro of GDP for each euro spent in most EU regions over the twenty years of the simulation. On average, the long-run GDP multipliers are higher in regions of beneficiary countries of cohesion policy than in regions in countries that are net contributors to the policy. However, there are some exceptions, as some of the highest multipliers are found in regions in more developed countries. This is because these regions benefit from substantial spill-over effects from the rest of the EU, leading to a significant impact on GDP despite low levels of policy investment (the latter being in the denominator of the multiplier formula).

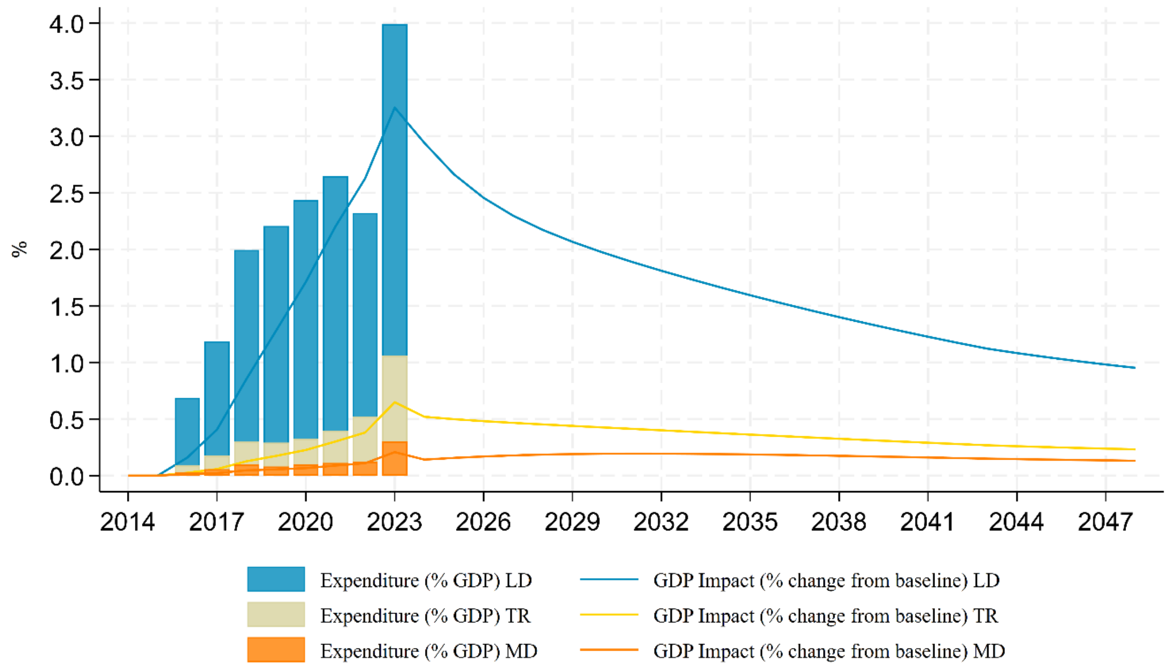
Figure 9. Distribution of regional GDP multipliers in 2023 and in 2045



Source: RHOMOLO simulations.

The geographical distribution of the macroeconomic impact of the policy is evident when looking at the impact per category of beneficiary (Figure 10). The impact of the policy is significantly higher in the less developed regions than in the other categories, both initially and over time. In 2023, the impact on GDP is +3.4% in the less developed regions, compared with +0.7% and +0.2% in the transition and more developed regions, respectively. The difference between the impact on the different categories decreases over time but remains significant: +1.1% in the less developed regions, +0.3% in the transition regions and +0.1% in the more developed regions in 2045.

Figure 10. Cohesion policy expenditure and GDP impact by group of regions

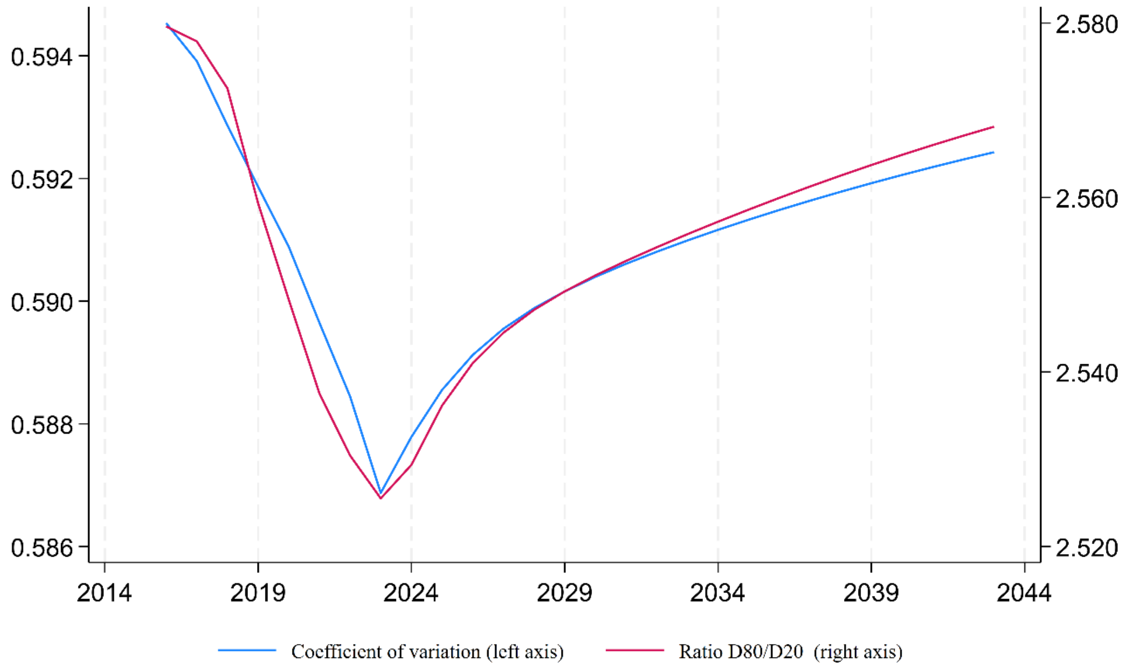


Source: RHOMOLO simulations.

The fact that cohesion policy produces most of its impact in the less developed regions of the EU demonstrates that it is in line with its mandate to strengthen economic and social cohesion by reducing disparities in the level of development between regions. Our simulation results permit us to investigate the impact of the policy on various measures of regional disparities, and they suggest that the policy reduces regional disparities both across and within Member States. At the aggregate EU level, the coefficient of variation[16] and the ratio of the 80th to 20th percentile values of the regional GDP per capita distribution are found to decrease with the implementation of the programmes (Figure 11). Both indices reach their minimum value at the end of the implementation period. However, thirty years after the start of the programmes, GDP per capita dispersion remains lower than the initial level.

[16] Defined as the ratio of the standard deviation regional GDP relative to the mean regional GDP per capita.

Figure 11. Cohesion policy impact on the coefficient of variation and on the 80/20 distribution in the EU



Source: RHOMOLO simulations.

The evidence presented in Figure 11 is confirmed by the changes in the Theil index, which shows the largest decrease, -4.0%, at the peak of the policy's impact on GDP in 2023 (see Table 6).[17] Both the between and the within country components of the index decline, implying that disparities within Member States are reduced, as well as disparities between Member States. 10 years after the start of the policy, disparities are nearly 4% lower than the initial level coinciding with the year of maximum GDP impact. Thereafter the reductions are slowly extinguishing: in 2030 and 2045 they are 2.5% and 1.15% lower than the initial level, respectively.

Table 6. Cohesion policy impact on the Theil Index

	Change in 2023	**Change in 2030**	**Change in 2040**	**Change in 2045**
Within	-2.11%	-1.28%	-0.62%	-0.5%
Between	-4.79%	-3.01%	-1.76%	-1.4%
Overall	-3.99%	-2.49%	-1.42%	-1.15%

Source: RHOMOLO simulations. Only countries with more than four NUTS 2 regions are reported to enable the calculations of the Theil index.

In order to understand the magnitude of changes in disparities within and between Member States, we report in Table 7 the maximum observed difference from the baseline in selected percentiles of regional GDP per capita (this occurs in 2023). For almost all Member States, there is a positive impact on the lowest 10% of the GDP per capita distribution, with an average increase of almost +0.5%. The impact is more pronounced in net beneficiary countries. In the higher parts of the distribution, the value of the percentiles tends to fall, although the evidence on changes in the income of the median regions within each country is mixed. The richest regions of both net contributors and net recipients

[17] The index is calculated as: $Theil = \frac{1}{N}\sum_i^N S_j \frac{y_{ij}}{\bar{y}} \ln\left(\frac{y_i}{\bar{y}}\right) + \frac{1}{M}\sum_i^M S_j \ln\left(\frac{y_i}{\bar{y}}\right)$, where the first term of the formula represents the within part of the decomposition and is the weighted averages of the Theil index of each Member State. The second term is the between component of the Theil index and represents the component of regional disparities that depends on disparities across countries. S_j are weights and are computed as the ratio between the country average of income per capita, y, and its EU average. Source: OECD (2016).

(at the 90th percentile) experience a decline of -0.9% on average. Overall, the country-level evidence on the distributional impact of the policy suggests that it reduces internal regional disparities.

Table 7. Regional income distribution by country (% change with respect to baseline)

Member State	Δ% p10	Δ% p50	Δ% p90
AT	0.235	-0.025	-0.045
BE	0.130	-0.064	-0.097
BG	0.428	0.279	-1.223
CZ	0.304	0.237	-1.815
DE	0.407	-0.015	-0.168
DK	0.062	-0.009	-0.033
EL	1.317	-0.737	-1.493
ES	0.368	-0.048	-0.581
FI	0.153	-0.023	-0.150
FR	0.182	0.017	-0.108
HU	1.826	-0.138	-4.700
IT	1.115	-0.234	-0.613
NL	0.051	0.004	-0.072
PL	1.109	-0.598	-0.534
PT	0.446	2.793	-2.717
RO	0.326	0.169	-1.213
SE	0.057	-0.028	-0.209
UK	-0.002	-0.025	-0.061

Source: RHOMOLO simulations. Only countries with more than four NUTS 2 regions are reported to enable the calculations of percentile values.

6. Conclusions

Assessing the macroeconomic impact of cohesion policy is challenging. The policy has effects well beyond those directly linked to the interventions, and many of these are fully realised in the long run as the policy affects the structure of the beneficiary economies. The cost of financing the policy must also be taken into account. While programme data and outcome indicators are essential to monitor the progress of implementation and effectiveness, they are not sufficient to properly assess the impact of the policy on overall economic aggregates such as GDP, employment or regional disparities. However, this must be considered when evaluating the policy and the extent to which it has achieved its overarching objectives.

In this analysis, we used RHOMOLO, a dynamic general equilibrium model, to estimate the potential impact of the 2014-2020 programmes financed by the three main cohesion policy funds, the YEI, and REACT-EU. The results suggest that cohesion policy interventions have a positive impact on the EU economy. EU GDP is estimated to be up to +0.6% higher at the end of the policy period compared to a hypothetical scenario without the policy. In the long run, the policy investments generate positive returns, with a 25-year GDP multiplier of almost 3 (equivalent to an annual rate of return of around 4%). The impact of the policy is particularly high in the less developed regions of the EU, which are its main beneficiaries. It is lower in the more developed Member States and regions, but in the long run the impact is positive even in net contributors to the policy. This is partly due to the interregional spill-over effects of the policy, whereby measures implemented in one region also benefit other regions in the EU, especially those with strong trade links to the main beneficiaries.

The GDP impacts and multipliers are greater in the less developed regions of the EU, which are the main target of the policy, with GDP in these regions being around +3.3% higher than the baseline at the end of the implementation period, compared to +0.7% and +0.2%, respectively, in transition and more developed regions. The interventions have contributed to reducing or limiting the increase in regional disparities, both at EU level and within most Member States.

Finally, as with any analysis based on economic modelling techniques, the results presented here are sensitive to the assumptions made in setting up the model, so future research could explore alternative settings and modelling choices to assess the policy implications offered here. A limitation of the analysis is that it does not consider the impact of the COVID-19 pandemic. According to Capello and Caragliu (2021), the pandemic led to a notable increase in regional disparities in the EU in the short term, although they are projected to decrease in the long term (but within-country disparities will increase). An analysis of the possible future development of territorial cohesion in the EU should take this into account. Other regional characteristics could also be considered in future research, such as the quality of institutions and the governance and management of policy programmes.

7. References

Aiello, V., Reverberi, P.M., and Brasili, C. (2019). Regional diversity in experiences of cohesion policy: The cases of Emilia-Romagna and Calabria. *Papers in Regional Science* 98(6), 2275-2294.

Albanese, G., de Blasio, G., and Locatelli, A. (2021). Does EU regional policy promote local TFP growth? Evidence from the Italian Mezzogiorno. *Papers in Regional Science* 100(2), 327-349.

Allard, C., Choueiri, N., Schadler, S. M., and Van Elkan, R. (2008). Macroeconomic effects of EU transfers in New Member States. IMF Working Papers no. 2008(223).

Alonso-Carrera, J., Freire-Serén, M.J., and Manzano, B. (2009). Macroeconomic effects of the regional allocation of public capital formation. *Regional Science and Urban Economics* 39(5), 563-574.

Amendolagine, V., Prota, F., and Serlenga, L. (2024). The impact of European cohesion policy: a spatial perspective. *Journal of Economic Geography* 24(4), 477-494.

Arcalean, C., Glomm, G., and Schiopu, I. (2012). Growth effects of spatial redistribution policies. *Journal of Economic Dynamics and Control* 36(7), 988-1008.

Armington, P. S. (1969). A theory of demand for products distinguished by place of production. Staff Papers (International Monetary Fund), 16(1), 159–178.

Bachtrögler, J., Fratesi, U., and Perucca, G. (2019). The influence of the local context on the implementation and impact of EU Cohesion Policy. *Regional Studies* 54(1), 21–34.

Bähr, C. (2008). How does sub-national autonomy affect the effectiveness of structural funds? *Kyklos* 61(1), 3-18.

Barbero, J., Diukanova, O., Gianelle, C., Salotti, S., and Santoalha, A. (2022). Economic modelling to evaluate Smart Specialisation: an analysis of research and innovation targets in Southern Europe. *Regional Studies* 56(9), 1496-1509.

Barbero, J., Christensen, M., Conte, A., Lecca, P., Rodríguez-Pose, A., and Salotti, S. (2023). Improving government quality in the regions of the EU and its system-wide benefits for Cohesion policy. *JCMS: Journal of Common Market Studies* 61, 38-57.

Barbero, J., Christou, T., Crucitti, F., Rodríguez, A. G., Lazarou, N. J., Monfort, P., and Salotti, S. (2024a). A spatial macroeconomic analysis of the equity-efficiency trade-off of the European cohesion policy. *Spatial Economic Analysis* 19(3), 394–410.

Barbero, J., Diukanova, O., Gianelle, C., Salotti, S., and Santoalha, A. (2024b). Technologically related diversification: One size does not fit all European regions. *Research Policy* 53, 104973.

Barro, R.J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy* 98(5), S103-S125.

Barro, R.J., Sala-i-Martin, X., Blanchard, O.J., and Hall, R.E. (1991). Convergence across states and regions. Brookings papers on economic activity, 107-182.

Baxter, M., and King, R.G. (1993). Fiscal policy in general equilibrium. *American Economic Review* 83(3), 315–334.

Becker, S. O., Egger, P. H., and von Ehrlich, M. (2010). Going NUTS: The effect of EU Structural Funds on regional performance. *Journal of Public Economics* 94(9-10), 578-590.

Becker, Sascha O., Peter H. Egger, and von Ehrlich, M. (2013). Absorptive capacity and the growth and investment effects of regional transfers: a regression discontinuity design with heterogeneous treatment effects. *American Economic Journal: Economic Policy* 5 (4): 29–77.

Berkowitz, P., Monfort, P., and Pieńkowski, J. (2020). Unpacking the growth impacts of European Union Cohesion Policy: transmission channels from Cohesion Policy into economic growth. *Regional Studies* 54(1), 60–71.

Bisciari, P., Essers, D., and Vincent, E. (2020). Does the EU convergence machine still work? NBB Economic Review, June, 1-42.

Blanchard, O., and Perotti, R. (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *The Quarterly Journal of Economics* 117(4), 1329-1368.

Blouri, Y., and von Ehrlich, M. (2020). On the optimal design of place-based policies: A structural evaluation of EU regional transfers. *Journal of international economics* 125, 103319.

Bom, P.R.D. (2017). Factor-biased public capital and private capital crowding out. *Journal of Macroeconomics* 52, 100–117.

Bom, P.R., and Lightart, J.E. (2014). What have we learned from three decades of research on the productivity of public capital? *Journal of Economic Surveys* 28(5), 889-916.

Bourdin, S. (2019). Does the cohesion policy have the same influence on growth everywhere? A geographically weighted regression approach in Central and Eastern Europe. *Economic Geography* 95(3), 256–287.

Bourdin, S., Destefanis, S., Coppola, G., and Kubara, M. (2024). What are the impacts of Cohesion Policy on the trade-off between employment and productivity? *Regional Studies*, online, doi: 10.1080/00343404.2024.2379444.

Bradley, J., and Untiedt, G. (2009). Analysis of EU Cohesion policy 2000–2006 using the CSHM: aggregate impacts and inter-country comparisons. Report to the European Commission (DG REGIO), Brussels.

Brasili, C., Calia, P.P., and Mogila, Z. (2023). Cohesion policy impact on regional development. Cross-sectional and panel data-based spatial analysis. In Capello, R., and Conte, A. (eds.) *Cities and Regions in Transition*. Francoangeli, Milano, 225-244.

Bronzini, R., and Piselli, P. (2009). Determinants of long-run regional productivity with geographical spillovers: The role of R&D, human capital and public infrastructure. *Regional Science and Urban Economics* 39(2), 187–199.

Canova, F., and Pappa, E. (2024). The macroeconomic effects of EU regional Structural Funds. *Journal of the European Economic Association*, jvae031

Canton, E., Thum-Thysen, A., and Voigt, P. (2018). Economist's musing on human capital investment: How efficient is public spending on education in EU member states? European Economy Discussion Paper No. 081.

Capello, R., and Caragliu, A. (2021). Regional growth and disparities in a post-COVID Europe: A new normality scenario. *Journal of Regional Science* 61(4), 710–727.

Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. *Econometrica* 69(5), 1127–1160.

Cavallaro, E., and Villani, I. (2021). Club convergence in EU countries. *Journal of Economic Integration* 36(1), 125-161.

Cerqua, A., and Pellegrini, G. (2018). Are we spending too much to grow? The case of Structural Funds. *Journal of Regional Science* 58(3), 535-563.

Cerqua, A., Pellegrini, G., and Tarola, O. (2022). Can regional policies shape migration flows?. *Papers in Regional Science* 101(3), 515-537.

Chirinko, R.S. (2008). σ: The long and short of it. *Journal of Macroeconomics* 30(2), 671-686.

Christou, T., Crucitti, F., Garcia Rodriguez, A., Lazarou, N., Monfort, P. and Salotti, S. (2023). The RHOMOLO ex-ante impact assessment of 2021-2027 cohesion policy. Territorial Development Insights Series, European Commission, JRC133844.

Christou, T., Garcia Rodriguez, A., Heidelk, T., Lazarou, N., Monfort, P. and Salotti, S. (2024). A RHOMOLO assessment of 2014-2027 cohesion policy. Territorial Development Insights Series, European Commission, JRC136790.

Coelho, M. (2019). Fiscal stimulus in a monetary union: evidence from Eurozone regions. *IMF Economic Review* 67, 573-617.

Crescenzi, R., and Giua, M. (2020). One or many Cohesion Policies of the European Union? On the differential economic impacts of Cohesion Policy across member states. *Regional Studies* 54(1), 10–20.

Crucitti, F., Lazarou, N.J., Monfort, P., and Salotti, S. (2022). The RHOMOLO impact assessment of the 2014-2020 cohesion policy in the EU regions. JRC Working Papers on Territorial Modelling and Analysis No. 01/2022, European Commission, Seville, JRC128208.

Crucitti, F., Lazarou, N., Monfort, P., and Salotti, S. (2023). Where does the EU cohesion policy produce its benefits? A model analysis of the international spillovers generated by the policy. *Economic Systems* 47(3), 101076.

Crucitti, F., Lazarou, N. J., Monfort, P., and Salotti, S. (2024). The impact of the 2014–2020 European Structural Funds on territorial cohesion. *Regional Studies* 58(8), 1568–1582.

Dall'Erba, S., and Fang, F. (2017). Meta-analysis of the impact of European Union Structural Funds on regional growth. *Regional Studies* 51(6), 822–832.

De la Fuente, A. (2002). Does cohesion policy work? Some general considerations and evidence from Spain, IAE-CSIC Barcelona. Mimeo.

De la Fuente, A., and Ciccone, A. (2003). Human capital in a global and knowledge-based economy (Vol. 918). Office for Official Publications of the European Communities.

Di Caro, P., and Fratesi, U. (2022). One policy, different effects: Estimating the region-specific impacts of EU cohesion policy. *Journal of Regional Science* 62(1), 307-330.

Di Caro, P., and Fratesi, U. (2023). The role of Cohesion Policy for sustaining the resilience of European regional labour markets during different crises. *Regional Studies* 57(12), 2426-2442.

Di Comite, F., Lecca, P., Monfort, P., Persyn, D., and Piculescu, V. (2018). The impact of Cohesion Policy 2007-2015 in EU regions: Simulations with the RHOMOLO interregional dynamic general equilibrium model. JRC Working Papers series on Territorial Modelling and Analysis no. 03/2018, JRC114044.

Durand, L., and Espinoza, R. (2021). The fiscal multiplier of European Structural Investment Funds: aggregate and sectoral effects with an application to Slovenia. IMF Working Paper No. WP/21/118.

Ederveen, S., De Groot, H.L., and Nahuis, R. (2006). Fertile soil for structural funds? A panel data analysis of the conditional effectiveness of European cohesion policy. *Kyklos* 59(1), 17-42.

European Commission (2016). Ex Post Evaluation of the ERDF and CF: Key outcomes of Cohesion Policy in 2007-2013, Work package 14c: Regression discontinuity design and Work package 14d: Propensity score matching. Directorate-General for Regional and Urban Policy.

European Commission (2024). Ninth report on economic, social and territorial cohesion. DG Regional and Urban Policy, Brussels. DOI: 10.2776/264833.

European Union (2014). COMMISSION IMPLEMENTING REGULATION (EU) No 215/2014 of 7 March 2014 laying down rules for implementing Regulation (EU) No 1303/2013 of the European Parliament and of the Council laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund and the European Maritime and Fisheries Fund with regard to methodologies for climate change support, the determination of milestones and targets in the performance framework and the nomenclature of categories of intervention for the European Structural and Investment Funds. L69/65, Official Journal of the European Union.

Farole, T., Rodríguez-Pose, A., and Storper, M. (2011). Cohesion policy in the European Union: Growth, geography, institutions. *JCMS: Journal of Common Market Studies* 49(5), 1089-1111.

Ferrara, A. R., McCann, P., Pellegrini, G., Stelder, D., and Terribile, F. (2017). Assessing the impacts of Cohesion Policy on EU regions: A non-parametric analysis on interventions promoting research and innovation and transport accessibility. *Papers in Regional Science* 96(4), 817-841.

Fiaschi, D., Lavezzi, A. M., and Parenti, A. (2018). Does EU cohesion policy work? Theory and evidence. *Journal of Regional Science* 58(2), 386-423.

Fiuratti, F., Nikolova, D., Pennings, S., and Schiffbauer, M. (2023). Are regional fiscal multipliers on EU Structural and Investment Fund spending large? A reassessment of the evidence. World Bank Policy Research Working Paper No. 10658.

Fortuna, M., Silva, F., and Medeiros, A. (2016). A CGE approach to measuring the impacts of EU structural funds in a small open economy. *Papers in Regional Science* 95(3), 507-539.

Foster, V., Gorgulu, N., Jain, D., Straub, S., and Vagliasindi, M. (2023). The impact of infrastructure on development outcomes. A meta-analysis. World Bank Policy Research Working Paper no. 10350.

Fratesi, U., and Wishlade, F.G. (2017). The impact of European Cohesion Policy in different contexts. *Regional Studies* 51(6), 817-821.

Gagliardi, L., and Percoco, M. (2017). The impact of European Cohesion Policy in urban and rural regions. *Regional Studies* 51(6), 857-868.

Garau, G., and Lecca, P. (2015). The impact of regional R&D subsidy in a computable general equilibrium model. *International Regional Science Review* 38(4), 319-357.

García-Rodríguez, A., Lazarou, N., Mandras, G., Salotti, S., and Thissen, M. (2023). A NUTS-2 inter-regional system of Social Accounting Matrices for the European Union with 2017 data: construction, and calibration of RHOMOLO V4. JRC Working Papers on Territorial Modelling and Analysis no. 01/2023, JRC132883.

Gianelle, C., Guzzo, F., Barbero, J., and Salotti, S. (2024). The governance of regional innovation policy and its economic implications. *The Annals of Regional Science* 72, 1231–1254.

Giannini, M., and Martini, B. (2024). Regional disparities in the European Union. A machine learning approach. *Papers in Regional Science* 103, 100033.

Griffith, R., Redding, S., and Reenen, J.V. (2004). Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *The Review of Economics and Statistics* 86(4), 883–895.

Iammarino, S., Rodriguez-Pose, A., and Storper, M. (2019). Regional inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*, 19(2), 273-298.

Ignatov, A. (2023). European highway networks, transportation costs, and regional income. *Regional Science and Urban Economics* 104, 103969.

Incaltarau, C., Pascariu, G.C., and Surubaru, N.C. (2020). Evaluating the determinants of EU funds absorption across old and new member states–The role of administrative capacity and political governance. *JCMS: Journal of Common Market Studies* 58(4), 941-961.

Kancs, D., and Siliverstovs, B. (2016). R&D and non-linear productivity growth. *Research Policy* 45(3), 634–646.

Kisiała, W., and Stępiński, B. (2024). European Funds and the dynamics of economic growth among EU Regions: A spatial modelling approach. *Quaestiones Geographicae* 43(2), 67-80.

Korzhenevych, A., and Bröcker, J. (2020). Investment subsidies and regional welfare: a dynamic framework and its application to the European regional policy. *Regional studies* 54(9), 1262-1274.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy* 99(3), 483–499.

Lecca, P., Barbero, J., Christensen, M.A., Conte, A., Di Comite, F., Diaz-Lanchas, J., Diukanova, O., Mandras, G., Persyn, D., and Sakkas, S. (2018). RHOMOLO V3: A spatial modelling framework. JRC Technical Reports JRC111861, EUR 29229 EN, Publications Office of the European Union, Luxembourg.

Lecca, P., Christensen, M., Conte, A., Mandras, G., and Salotti, S. (2020). Upward pressure on wages and the interregional trade spillover effects under demand-side shocks. *Papers in Regional Science* 99(1), 165-182.

Leon-Ledesma, M.A., McAdam, P., and Willman, A. (2010). Identifying the elasticity of substitution with biased technical change. *American Economic Review* 100(4), 1330-1357.

Lo Piano, S. (2020). Test and update of regionalised ESIF payments 1989-2018. *Final report, CCI Contract: 2018CE16BAT115*. https://ec.europa.eu/regional_policy/en/information/publications/studies/2020/test-and-update-of-regionalised-esif-payments-1989-2018.

Männasoo, K., Hein, H., and Ruubel, R. (2018). The contributions of human capital, R&D spending and convergence to total factor productivity growth. *Regional Studies* 52(12), 1598–1611.

Mendez, C., and Bachtler, J. (2024). The quality of government and administrative performance: explaining Cohesion Policy compliance, absorption and achievements across EU regions. *Regional Studies* 58(4), 690-703.

Mincer, J. A. (1974). Schooling and earnings. In *Schooling, Experience, and Earnings*, 41-63. NBER.

Mogila, Z., Miklošovič, T., Lichner, I., Radvanský, M., and Zaleski, J. (2022). Does Cohesion Policy help to combat intra-country regional disparities? A perspective on Central European countries. *Regional Studies* 56(10), 1783-1795.

Mohl, P. (2016). Econometric evaluation of EU Cohesion Policy: a survey. In *Empirical Evidence on the Macroeconomic Effects of EU Cohesion Policy* (pp. 7-35). Wiesbaden: Springer Fachmedien Wiesbaden.

Mohl, P., and Hagen, T. (2010). Do EU structural funds promote regional growth? New evidence from various panel data approaches. *Regional Science and Urban Economics* 40(5), 353-365.

Monfort, M., Cuestas, J. C., and Ordonez, J. (2013). Real convergence in Europe: A cluster analysis. *Economic Modelling* 33, 689-694.

Monfort, P. (2020). Convergence of EU regions redux. Recent trends in regional disparities. DG REGIO working papers no. 02/2020.

Monfort, P., Piculescu, V., Rillaers, A., Stryczynski, K., and Varga, J. (2017). The impact of cohesion and rural development policies 2007-2013: Model simulations with QUEST III. Directorate-General for Regional Policy WP 05/2017.

Németh, G., Szabó, L., and Ciscar, J. C. (2011). Estimation of Armington elasticities in a CGE economy–energy–environment model for Europe. *Economic Modelling* 28(4), 1993-1999.

OECD (2018). Education at a Glance 2018: OECD Indicators. OECD Publishing, Paris, https://doi.org/10.1787/eag-2018-en.

Olekseyuk, Z., and Schürenberg-Frosch, H. (2016). Are Armington elasticities different across countries and sectors? A European study. *Economic Modelling* 55, 328-342.

Pellegrini, G., Terribile, F., Tarola, O., Muccigrosso, T., and Busillo, F. (2013). Measuring the effects of European regional policy on economic growth: A regression discontinuity approach. *Papers in Regional Science* 92 (1), 217-233.

Percoco, M. (2017). Impact of European Cohesion Policy on regional growth: does local economic structure matter? *Regional Studies* 51(6), 833-843.

Persyn, D., Díaz-Lanchas, J., and Barbero, J. (2020). Estimating distance and road transport costs between and within European Union regions. *Transport Policy* 124, 33-42.

Persyn, D., Barbero, J., Díaz-Lanchas, J., Lecca, P., Mandras, G., and Salotti, S. (2023). The ripple effects of large-scale transport infrastructure investment. *Journal of Regional Science* 63(4), 755-792.

Pieńkowski, J., and Berkowitz, P. (2016). Econometric assessments of Cohesion Policy growth effects: how to make them more relevant for policymakers? In *EU Cohesion Policy* (pp. 55-68). Routledge.

Pinho, C., Varum, C., and Antunes, M. (2015). Under what conditions do structural funds play a significant role in European regional economic growth? Some evidence from recent panel data. *Journal of Economic Issues* 49(3), 749-771.

Psacharopoulos, G., and Patrinos, H. A. (2018a). Returns to investment in education: A decennial review of the global literature. *Education Economics* 26(5), 445–458. https://doi.org/10.1080/09645292.2018.1484426.

Psacharopoulos, G., and Patrinos, H. A. (2018b). Returns to investment in education: A decennial review of the global literature. World Bank Policy Working Paper No. 8402, Education Global Practice, World Bank Group, April 2018.

Psycharis, Y., Tselios, V., and Pantazis, P. (2024). Cohesion policy and household income inequality: evidence from the Greek regions. *The Annals of Regional Science*, online, doi: 10.1007/s00168-024-01304-y.

Ramajo, J., Márquez, M.A., Hewings, G.J., and Salinas, M.M. (2008). Spatial heterogeneity and interregional spillovers in the European Union: Do cohesion policies encourage convergence across regions? *European Economic Review* 52(3), 551-567.

Ramey, V.A. (2020). The macroeconomic consequences of infrastructure investment. Nation-al Bureau of Economic Research No. w27625.

Rodríguez-Pose, A., and Dijkstra, L. (2021). Does cohesion policy reduce EU discontent and Euroscepticism? *Regional Studies* 55(2), 354-369.

Rodríguez-Pose, A., and Garcilazo, E. (2015). Quality of government and the returns of investment: Examining the impact of cohesion expenditure in European regions. *Regional Studies* 49(8), 1274-1290.

Santoleri, P., and Russo, E. (2025). Spurring subsidy entrepreneurs. *Research Policy*, 105128. Doi: 10.1016/j.respol.2024.105128.

Sosvilla-Rivero, S., Bajo-Rubio, O., and Díaz-Roldán, C. (2006). Assessing the effectiveness of the EU's regional policies on real convergence: An analysis based on the HERMIN model. *European Planning Studies* 14(3), 383-396.

Thissen, M., Ivanova, O., Mandras, G., and Husby, T. (2019). European NUTS 2 regions: construction of interregional trade-linked Supply and Use tables with consistent transport flows. *JRC Working Papers on Territorial Modelling and Analysis* no. 01/2019, JRC115439.

Varga, J., and in't Veld, J. (2011a). A model-based analysis of the impact of Cohesion Policy expenditure 2000–06: Simulations with the QUEST III endogenous R&D model. *Economic modelling* 28(1-2), 647-663.

Varga, J., and in't Veld, J. (2011b). Cohesion policy spending in the new member states of the EU in an endogenous growth model. *Eastern European Economics* 49(5), 29-54.

Varga, A., Szabó, N., and Sebestyén, T. (2020). Economic impact modelling of smart specialization policy: Which industries should prioritization target? *Papers in Regional Science* 99(5), 1367-1389.

Von Ehrlich, M., and Overman, H.G. (2020). Place-based policies and spatial disparities across European cities. *Journal of Economic Perspectives* 34(3), 128-149.

8. Annex

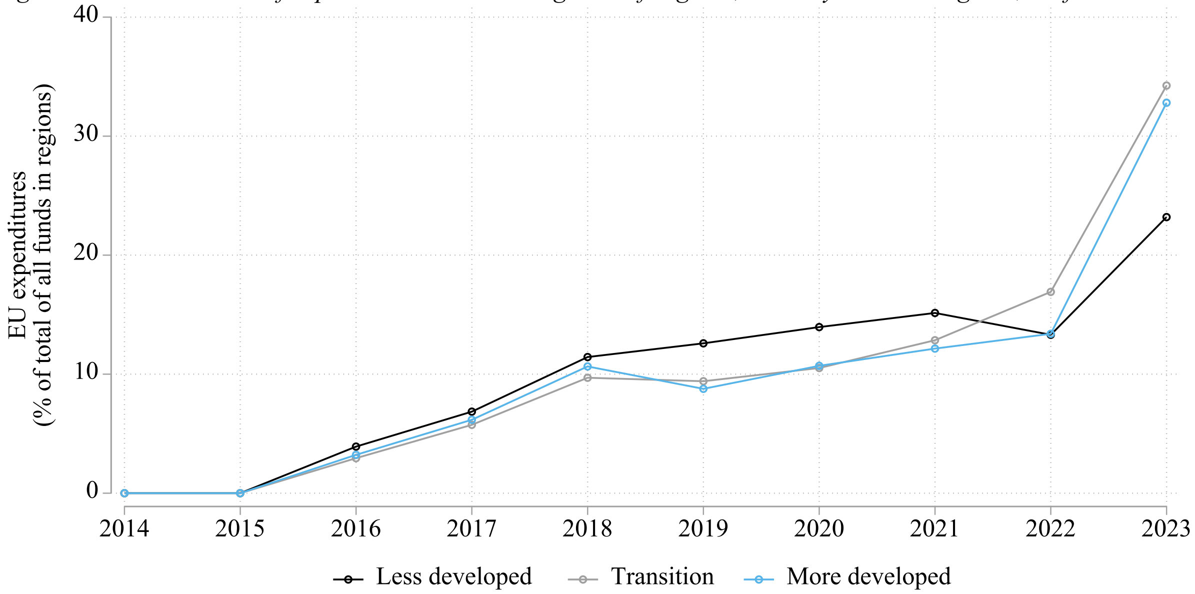
Annex 1. Data processing

The process to obtain the input data for the analyses proceeds in four steps:

1. The latest raw data are accessed from https://cohesiondata.ec.europa.eu/d/3kkx-ekfq. The raw data contain yearly cumulative aggregate financial amounts and are recorded at the programme level with information on fields of intervention, category of region, and specific objectives, among other elements.
2. The financial amounts indicated in the raw data are linked to the regions of the European Union, at the NUTS 2 level. On the one hand, the data are linked using a dedicated link-data set (https://cohesiondata.ec.europa.eu/d/466c-pqi8), on the other hand, for programmes which span more than one region, the financial amounts are allocated pro-rata to the relevant regions. The latter takes into account the category of region which the programmes target. Overall, this step yields insights concerning the financial intervention, per region, for each intervention field.
3. The data are aggregated at the level of analysis, with one observation per year, NUTS 2 region, and model shock (cf. section 4 on the RHOMOLO model). Further, the yearly cumulative aggregate financial amounts are adjusted to reflect yearly financial amounts by taking the difference between subsequent years.
4. The financial amounts reflect reports by national/regional managing authorities with regards to the implemented programmes and the related expenditures. In the reports, managing authorities indicate the financial amounts which are applicable for reimbursement by the European Union. This yields two cases. First, the managing authorities of a country may report more than 100% of the financial amounts allocated to the country in the Multiannual Financial Framework. In this case the financial allocation is capped at 100%, in line with the budgetary procedures in place. Similarly, second, for some countries the data reflect absorption rates below 100%. Based on experience from previous programming periods, full absorption is expected to be achieved. The gap amounts are allocated to the year 2023.

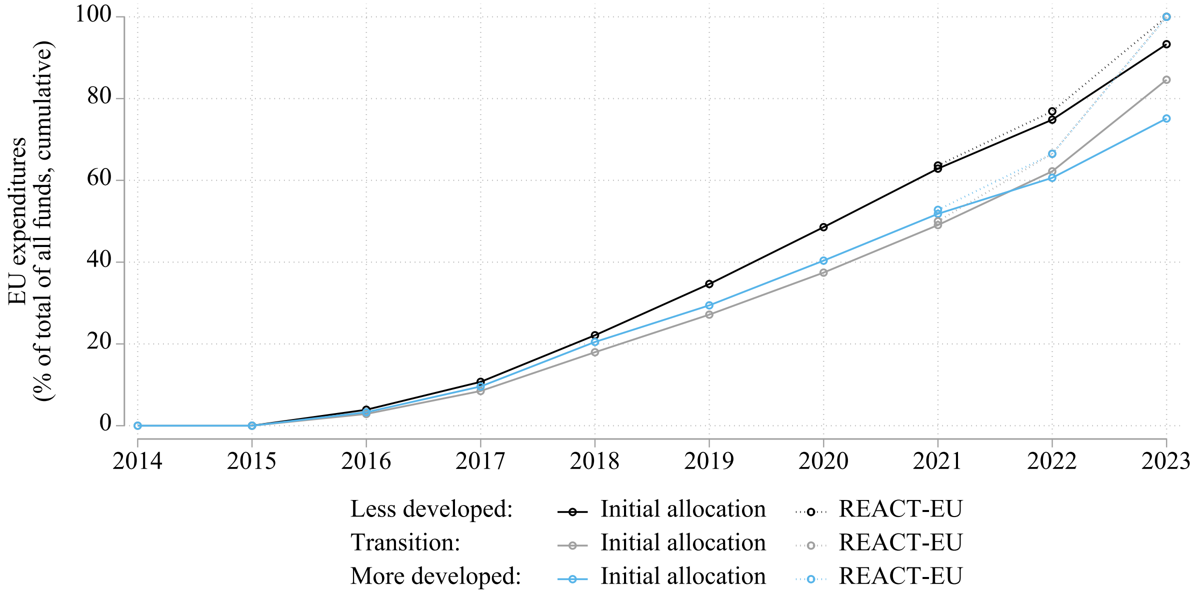
Annex 2. Allocations and absorption over time

Figure A1. Annual share of expenditures within categories of regions, across years and regions; all funds.



Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.

Figure A2. Cumulative annual share of expenditures within categories of regions, across years and regions; all funds.



Note: Figure A2 builds up on Figure A1. Joint allocation sums up to 100% for each group of regions.
Source: SFC open data platform (https://cohesiondata.ec.europa.eu); calculations by DG REGIO.