European Commission

JRC TECHNICAL REPORT

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JRC Working Papers on
Territorial Modelling and Analysis
No 01/2022

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2022

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EU Science Hub
https://ec.europa.eu/jrc

JRC128208

Seville: European Commission, 2022

How to cite this report: Crucitti, F., Lazarou, N., 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.

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The RHOMOLO impact assessment of the 2014-2020 cohesion policy in the EU regions

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Abstract. We assess the macroeconomic impact of the EU cohesion policy investments deployed during the 2014-2020 programming period, employing updated data on planned expenditures, which in most Member States will take place until 2023. We use the spatial dynamic general equilibrium RHOMOLO in order to quantify the direct and indirect effects of the policy investments in the NUTS 2 regions of the EU within a 20-year time frame. The results suggest that the impact of the policy is sizeable, especially in the less developed regions of the EU. Accordingly, regional disparities are shown to decrease thanks to the policy intervention. The policy also has a positive impact at the EU level, GDP in the EU being 0.4% higher in 2021 compared to a scenario without cohesion policy.

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

JEL Codes: C68, R13.

Executive summary

The European cohesion policy is the main investment policy of the European Union (EU), and this makes it fundamental to evaluate the economic effects that it generates on EU countries and regions. The interventions funded by the policy produce direct as well as indirect effects on the economy, which are both difficult to estimate. For instance, output and employment may increase in the supported small and medium enterprises but they may decrease elsewhere due to the competition effects caused by the policy. At the same time, the increased production in the supported enterprises may generate additional economic activity elsewhere thereby multiplying the direct effects of the interventions. In general, cohesion policy is likely to generate important spillovers and externalities outside the economies directly benefitting from the programmes. For example, programmes implemented in the main beneficiaries boost local demand which is partly served by exports from other countries, notably other Member States, which therefore may end up indirectly benefitting from the policy.

Cohesion policy exerts both short-term and long-term effects on the economies it targets. The former emerge during the implementation phase of the programmes, and the latter build up progressively in time, and last long after the interventions have taken place. Finally, the cost of the policy should also be taken into consideration when assessing its impact.

In this paper, we use a dynamic general equilibrium model calibrated with data for the NUTS 2 regions of the EU in order to estimate the potential impact of the 2014-2020 investments of the three main cohesion policy funds. We model the policy interventions with a number of demand- and supply-side economic transmission mechanisms in order to mimic the various spending categories of the programmes.

We show that the EU GDP is 0.4% higher in 2021 compared to a hypothetical scenario in which cohesion policy would not exist, with the 20-year GDP discounted multiplier (GDP impact per euro spent) standing at 1.7. The GDP impacts and multipliers are substantially larger in the less developed regions of the EU which are the main target of the policy. We show that regional disparities decrease thanks to the policy intervention, with the S80/20 ratio of GDP per capita being 2 percentage points lower in 2023 compared to the no policy scenario.

1. Introduction

The European cohesion policy is the main investment policy of the European Union (EU). It is the second most important policy in the EU budget after the Common Agricultural Policy (CAP). It is therefore essential to evaluate its effectiveness in delivering its objectives of promoting a balanced development of the EU and reduce disparities among EU regions.[1] However, assessing the impact of cohesion policy at macroeconomic level is particularly challenging. Monitoring data obtained from the programmes generally concern the output or at best the outcome of the interventions but they cannot provide information on their net impact.

The programmes produce direct as well as indirect effects on the economy, which are both difficult to estimate. For instance, output and employment may increase in the supported small and medium enterprises but they may decrease elsewhere due to the competition effects caused by the policy. At the same time, the increased production in the supported enterprises may generate additional economic activity elsewhere. In general, cohesion policy is likely to generate important spillovers and externalities outside the economies directly benefitting from the programmes. For example, programmes implemented in the main beneficiaries boost local demand which is partly served by exports from other countries, notably other Member States, which therefore may end up indirectly benefitting from the policy.

Cohesion policy entails both short-term and long-term effects. While the former principally emerge during the implementation of the programmes, the latter are likely to progressively build up in time, and last long after the interventions are closed. Finally, cohesion policy needs to be financed and the cost of the policy should also be taken into consideration when assessing its impact.

In this paper, we use a dynamic general equilibrium model calibrated with data for all the NUTS 2 regions of the EU in order to estimate the potential impact of the 2014-2020 investments of the three main cohesion policy funds, namely the European Regional and Development Fund (ERDF), the Cohesion Fund (CF), and the European Social Fund (ESF). We assume that the policy interventions activate a number of demand- and supply-side economic transmission mechanisms depending on the distribution of the funding across various spending categories. We first present results at the EU level before exploring those obtained at NUTS 2 level, concentrating on the policy impact on key macroeconomic variables such as GDP and employment. Then, we look at how regional disparities and convergence are affected by the policy, and we investigate some potential determinants of the responses of the regional economies to the policy. The main results of this analysis are featured in the eighth cohesion report by the European Commission (2022).

The rest of the paper is organised as follows. Section 2 presents a brief literature review on the macroeconomic impact of cohesion policy. Section 3 details the investments data related to the 2014-2020 programming period. Section 4 presents the RHOMOLO model and the strategy followed to introduce the cohesion policy shocks in it, while Section 5 presents the results of the analysis. The latter is divided into three sub-sections, the first two dealing with

[1] Article 174 of the Treaty on the Functioning of the European Union says that: "In order to promote its overall harmonious development, the Union shall develop and pursue its actions leading to the strengthening of its economic, social and territorial cohesion. In particular, the Union shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions."

the macroeconomic impact on GDP, employment and other key macroeconomic variables, and the third dealing with the impact on regional disparities. Finally, Section 6 concludes.

2. The literature on the macroeconomic impact of cohesion policy

Two main approaches have been used to assess the macroeconomic impact of cohesion policy: econometric analysis and model simulations. Econometric estimations of the impact of cohesion policy are mainly based on cross-country or cross-region growth regressions augmented with cohesion policy variables. This strand of the literature is rather inconclusive regarding the impact of cohesion policy on growth (see for instance the surveys by Dall'erba et al., 2006; Mohl, 2011; and Berkowitz and Pieńkowski, 2016). Some contributions conclude to a positive and significant impact (e.g. Beugelsdijk and Eijffinger, 2005, or Dall'erba, 2005), sometimes conditioned by other factors such as openness to trade, the quality of institutions, or the regions' absorption capacity (Ederveen et al., 2006; Becker et al., 2013; or Rodríguez-Pose and Garcilazo, 2015). Others point to no significant or even negative impact (e.g. Dall'erba and Le Gallo, 2008, or Breidenbach et al., 2016).

Growth regressions entail a series of drawbacks, mostly related to endogeneity, model uncertainty (including omitted variables), exchangeability and the presence of bad quality controls (see for instance Angrist and Pischke, 2009) which can seriously bias the results. A key issue lies in the fact that the decision to invest in certain regions depends on the GDP levels and growth rates of the regions themselves, which makes the policy variable negatively correlated with the dependent variable of the growth regressions by construction, thereby undermining the robustness of the results.

Other approaches offer interesting alternatives. For instance, regression discontinuity analysis or propensity score matching exploit the existence of categories of beneficiaries for which the policy injection significantly differs between regions which could otherwise be considered as relatively similar, or changes in aid intensity from one programming period to another. This type of analysis generally concludes to a significant positive impact of cohesion policy, albeit sometime modest (see for instance Pellegrini et al., 2013; Ferrara et al., 2017; and European Commission, 2016).

Model simulations have also been used to analyse the impact of cohesion policy. A series of contributions analyse the effects of the policy at the national level using various models like HERMIN (Bradley and Untiedt, 2009), EcoMod (Bayar, 2007), GIMF (Allard et al., 2008) or QUEST (Varga and in 't Veld, 2011a and 2011b; and Monfort et al., 2017). However, little has been done using modelling frameworks to produce evidence at the regional level, which is mainly devoted to case studies and single region analyses. For instance, De la Fuente (2002) assesses the impact of the policy on growth and convergence in the Spanish regions using a supply oriented model estimated with regional panel data covering a period of 30 years. Sosvilla-Rivero et al. (2006) use the HERMIN model to analyse the impact of the structural funds in Castilla la Mancha, while Arcalean et al. (2007) calibrate a two-regions endogenous growth model to Portugal. An exception is constituted by Di Comite et al. (2018), who use the RHOMOLO model to assess the impact of the 2007-2013 cohesion policy programmes on all the EU NUTS 2 regions. That same model has been used for more specific cohesion-related analyses such as country-specific contributions (see Barbero and Salotti, 2021, on Portugal, and Crucitti et al., 2021, on Bulgaria) or to focus on the international spillover effects of the policy (Monfort and Salotti, 2021).

In general, model-based simulations tend to support a sizeable impact of the policy on key economic variables, especially in the main beneficiaries. This approach generally assumes that funding is spent efficiently on all projects, which may not be the case in all countries and regions. Moreover, the policy injection is sometimes measured with the ex-ante allocation of funding across regions and fields of interventions which can depart from the actual expenditure resulting from the programme implementation. Hence, model simulations are to be taken as estimates of the potential impact of the policy provided that it is implemented as planned.

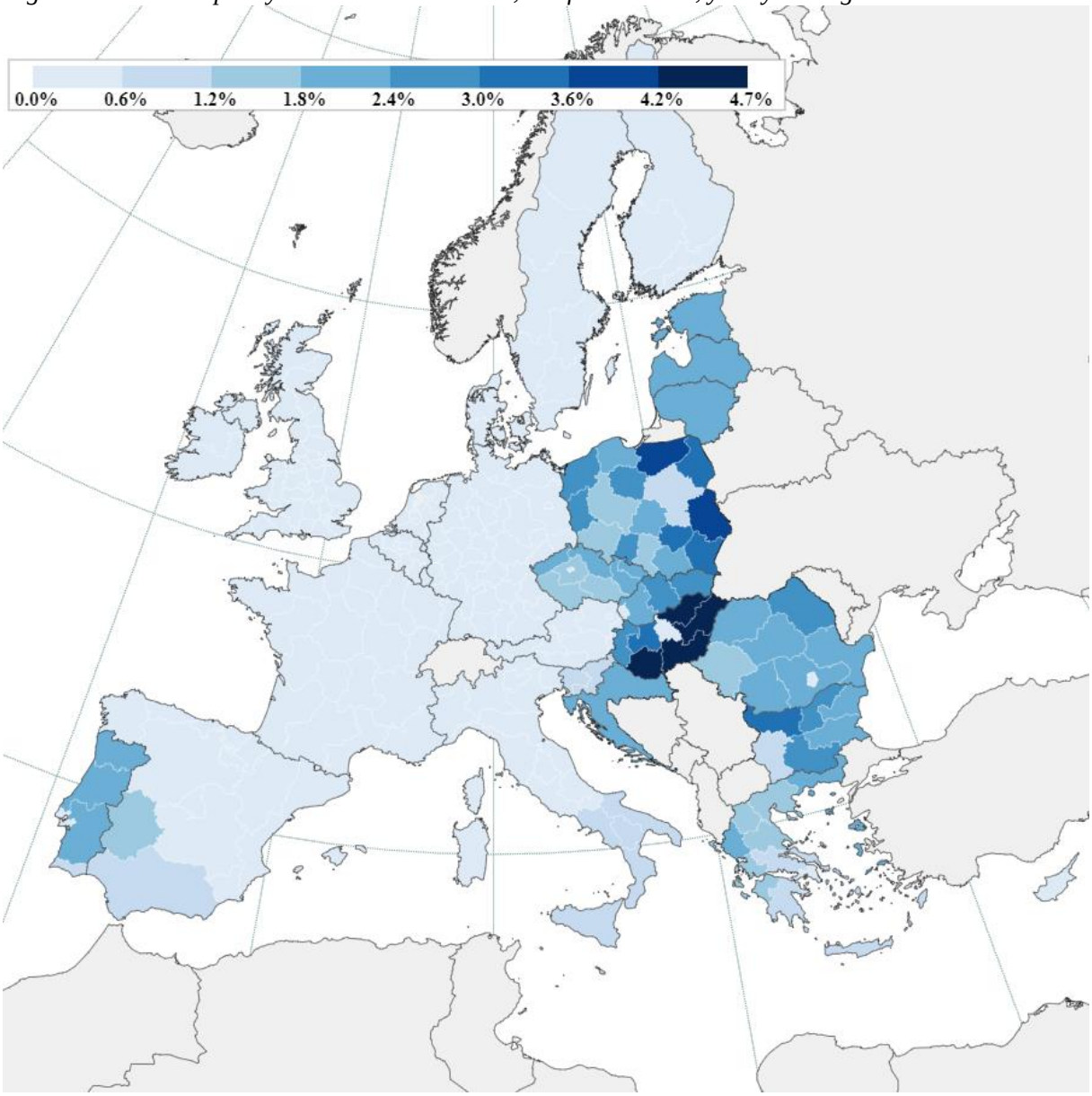
In this paper, we use the spatial general equilibrium model RHOMOLO to analyse the impact of the 2014-2020 period on the economies of the EU28 NUTS 2 regions. Data on policy interventions corresponds to the programmes allocation after their mid-term revision which took place in 2018 and covers investments undertaken between 2014 and 2023.[2]

3. The 2014-2020 cohesion policy expenditure

Considerable resources are devoted to cohesion policy, which accounts for around one third of the multi-annual financial framework. For the 2014-2020 period, the EU allocated around €352 billion (at current prices) to cohesion policy which corresponds to about 0.3% EU GDP (the UK was part of the EU at the time). However, this number masks substantial territorial heterogeneity as funding is mainly channelled to the less developed regions and Member States. In some countries, cohesion policy funding represents more than 2.0% of 2013 GDP per year on average, peaking at 2.5% for Croatia. For some less developed regions, the funding corresponds to even higher values, like Região Autónoma dos Açores in Portugal or Észak-Alföld in Hungary in which the policy injection of more than 3.5% of GDP per year on average (Figure 1).

[2] 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 which is longer than the 2014-2020 programming one. As a consequence, data on actual expenditure will only be available once the programmes are terminated, after 2023.

Figure 1. Cohesion policy allocation 2014-2020, % of 2013 GDP, yearly average



Source: DG REGIO and own calculations.

Cohesion policy investments are concentrated on key fields of interventions with the aim of fostering growth and development. In line with the EU regulations (European Union, 2014), data on the programmes break down the funding into 123 investment categories. For the sake of this analysis, we regrouped them into six fields of interventions which are meaningful from a modelling point of view (the complete mapping is presented in Table A1 in the Appendix): transport infrastructures (TRNSP), non-transport infrastructures (INFR), research and development (RTD), human capital (HC), aid to private sector (AIS), and technical assistance (TA).

The distribution of the funds across the six fields of interventions varies from one region to another, reflecting the policy mix which results from the programmes' design. In general, the share of funds allocated to infrastructures is higher in the less developed regions and Member States, while the most developed ones devote a higher share to research and development, support to the private sector, and human capital. For instance, at the national level more than 62% of the funds are allocated to transport and other infrastructures in Romania, while in the

Netherlands, only 12% of the total is allocated to these two fields, 82% being dedicated to research and development and human capital (Table 1).

Table 1. 2014-2020 cohesion policy allocation by country and by field of intervention, % of total allocation

	TRNSP	INFR	RTD	HC	AIS	TA
AT	4.2	16.0	26.3	34.0	15.2	4.4
BE	4.2	17.2	20.1	47.1	8.3	3.1
BG	24.9	33.6	11.3	19.5	7.0	3.7
CY	14.8	36.1	9.1	24.0	12.8	3.2
CZ	27.9	31.4	16.6	16.8	3.3	3.9
DE	3.2	20.3	27.4	38.5	7.0	3.6
DK	2.3	6.2	41.2	45.0	0.5	4.7
EE	15.3	35.7	22.9	16.5	6.7	3.0
EL	16.9	30.0	7.8	26.0	15.7	3.6
ES	9.6	30.5	16.1	31.1	10.9	1.9
FI	2.7	5.6	39.5	35.3	13.3	3.5
FR	4.3	23.0	19.5	43.3	6.1	3.8
HR	15.1	37.6	9.1	18.1	16.0	4.0
HU	17.6	33.4	10.4	22.2	15.0	1.6
IE	0.9	39.4	6.8	48.7	2.0	2.1
IT	10.1	24.7	12.4	34.0	15.4	3.3
LT	15.4	42.9	17.1	18.5	3.0	3.1
LU	4.2	9.0	9.8	74.6	0.1	2.3
LV	27.8	33.1	14.7	15.5	6.5	2.4
MT	16.6	45.6	9.1	18.8	7.0	2.8
NL	0.5	11.6	39.7	42.2	1.7	4.3
PL	35.8	26.8	14.1	15.8	4.2	3.3
PT	7.5	22.8	19.9	34.8	12.3	2.7
RO	29.6	32.7	4.8	20.9	8.7	3.3
SE	5.7	10.2	31.6	39.8	8.4	4.3
SI	12.2	32.5	23.7	23.3	4.3	4.0
SK	27.2	32.4	9.8	18.8	7.8	4.1
UK	4.8	15.0	23.5	43.2	10.0	3.5
EU-28	19.3	27.9	15.0	25.7	8.9	3.2

Source: DG REGIO and own calculations.

4. The modelling set up

4.1 Model description

Assessing the global impact of cohesion policy requires the use of general equilibrium models, which are capable of endogenously capturing the direct and indirect responses of a wide range of variables to the deployment of the policy. In this analysis, we use the dynamic spatial general equilibrium model RHOMOLO whose main purpose is to provide scenario simulations with sector-, region-, and time-specific results (for a full mathematical description of the model, see Lecca et al., 2018).

The economic foundations of the model are grounded on the well-established literature on general equilibrium models, and the model itself is featured in numerous articles contributing to that same literature (see, among others, Lecca et al., 2020, and Di Pietro et al., 2021). The model is routinely used for policy impact assessment purposes. Besides the aforementioned contributions related to cohesion policy, other recent examples include studies on Horizon Europe (Christensen, 2021) and on the portfolio of the European Investment Bank (EIB) portfolio (including the so-called Juncker Plan - Christensen et al., 2019).

The model is calibrated on a set of fully integrated EU regional Social Accounting Matrices (SAMs) for the year 2013 produced by Thissen et al. (2019), which is taken as the baseline state of the economy. The SAMs 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.

In a nutshell, the model economies are disaggregated into ten economic sectors (based on the NACE Rev. 2 industry classification). Firms are assumed to maximise profits and produce goods and services according to a constant elasticity of substitution production function. The remaining agents in the model include utility-maximising households and a government which collects taxes and spends money on public goods and transfers. Capital and labour are used as factors of production (public capital also enters the production function as an unpaid factor). Trade in goods and services – within and between regions- is assumed to be costly, with transport costs increasing with distance. The valuation of transport costs is based on a transport model by Persyn et al. (2020). Regional economies are typically more open than national ones, due to their smaller size, and this is taken into account in the model thanks to the regional trade flows and the relatively high elasticity of substitution between domestic and imported goods and services. The Armington trade elasticity of substitution is set to 4, based on empirical estimates on European data by Németh et al. (2011) and Olekseyuk and Schürenberg-Frhosch (2016). The presence of significant interregional spillovers is an important feature of the model and it is mainly due to trade flows and capital mobility coupled with endogenous firms location.

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 endogenous variables of the model 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 is linked to each other through the law of motion of state variables. This implies that economic agents are not forward-looking and their decisions are solely based on current and past information.

4.2 Modelling the policy interventions

In order to simulate the impact of cohesion policy in RHOMOLO, each field of intervention (see Table 1 above) is associated to a set of model shocks supposed to capture the economic transmission mechanisms it most likely activates. More specifically, either one or more model shocks are used to simulate the spending categories pertaining to each of the six fields of interventions. The model shocks can be broadly distinguished between 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 fields of intervention is as follows:

I) Transport infrastructures (TRNSP) – Investments in transport infrastructure are assumed to generate both demand and supply side effects. Demand side effects are produced by the temporary increases in government consumption accounting for the purchase of goods and services required to build the actual infrastructures. On the supply side, these investments are assumed to reduce the transport costs, hence decreasing the prices of goods and stimulating trade flows. The induced decrease is based on the estimates obtained with the fully-fledged transport cost model by Persyn et al. (2020) for the 2014-2020 cohesion policy transport infrastructure investments.

II) Other Public Infrastructures (INFR) – Investment in non-transport infrastructures, such as electricity networks, water treatment plants and waste management facilities, are modelled as public investments when associated with industrial processes, as government consumption otherwise (only temporary demand-side effects are produced in the latter case). Public investments not only trigger an increase in demand, but they also entail supply-side effects, since they increase the stock of public capital and therefore foster the production of goods and services. We set the output elasticity of public capital equal to 0.1, in line with Ramey (2020), and slightly below the average of 0.12 found by the meta-study by Bom and Lightart (2014). We set the congestion parameter of public capital equal to 0.5, equivalent to a medium level of congestion (Alonso-Carrera et al., 2009 - a value of zero would make public capital a pure public good).

III) Research and development (RTD) – Investments in research and development are modelled as increases in private investments via a reduction in the risk premium, which increase 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 which depends on the importance of spending in research and development in the region relative to GDP and is based on the study by Kancs and Siliverstovs (2016).

IV) Human capital (HC) – Investments in human capital are assumed to increase demand via government current expenditure. They are also assumed to have two alternative supply-side effects, depending on the nature of the interventions. The spending categories associated to human capital development, such as training, re- and up-skilling and other active labour market policies, are assumed to generate an increase in labour productivity. The main assumption behind this effect lies in the productivity increase caused by an additional training year, which we set at 7% based on the literature (De la Fuente and Ciccone, 2003; and Canton et al., 2018). The cost of education per pupil is used to calculate the amount training implied by the HC funds of cohesion policy, with country-specific efficiency corrections based on PISA scores. On the other hand, the interventions aimed at promoting the socio-economic integration of marginalised communities, the participation to the labour market, or to the modernisation of labour market institutions, are assumed to generate an increase in the aggregate labour supply. In this case we assume a higher cost per trainee, and that it takes two to three years of training to integrate a worker in the labour supply.

V) Aid to private sector (AIS) - Aid to private sector is modelled as an increase in private investments via a reduction in the risk premium, like the RTD investments, but without any impact on TFP.

VI) Technical assistance (TA) - This type of interventions is modelled as a demand-side shock increasing public current expenditure with no supply-side effects.

We further assume a fixed interest rate of 4% across regions, and that all the long-run supply-side effects decay over time. Thus, the changes in labour productivity, TFP, and transport

costs are all assumed to decay at a 5% yearly rate. Moreover, the stocks of private and public capital have a depreciation rate of 15%, and 5%, respectively. This implies that, in the absence of further investments, the structural effects related to the policy gradually vanish and the economy returns back to its initial steady state.

The model simulations take into account the fact that cohesion policy is financed by the Member States' *pro rata* contribution to the EU budget which is assumed to be proportional to the weight of their GDP in EU GDP. The Member States' contribution to the funding of cohesion policy is assumed to be financed by a lump-sum tax, thereby decreasing household disposable income, thus adversely affecting the economic performance and partly offsetting the positive impact of the programmes.[3] This implies that a larger share of the Member States' contributions to cohesion policy comes from the more developed parts of the EU, while the bulk of the interventions takes 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. Main results

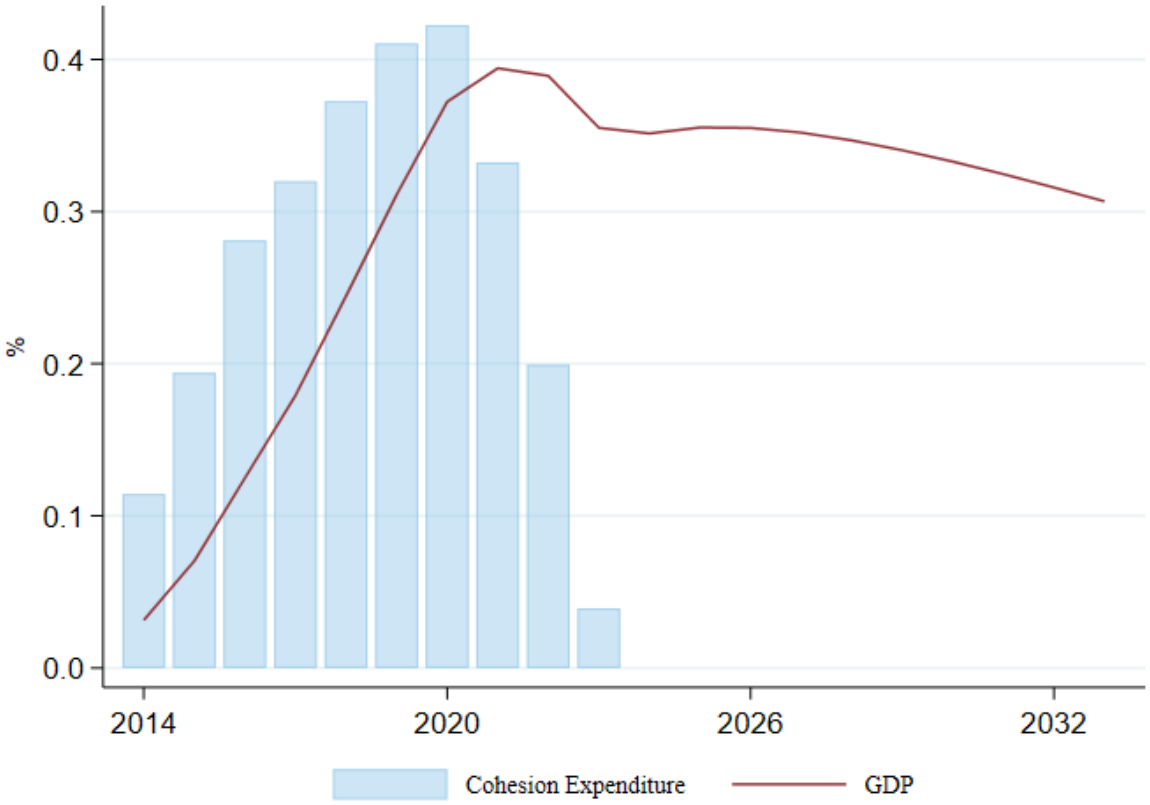
5.1 The impact of cohesion policy at the EU and Member States level

The results of the model simulations are presented as percentage differences in the values of the variables of interest compared to the no policy scenario, that is the initial calibrated steady state based on 2013 data. The resulting deviations from the initial equilibrium are then interpreted as due solely to the impact of the policy. The simulation period lasts twenty years, and policy investments are deployed gradually over the first ten years according to a time profile which is region-specific and which generally concentrates most of the spending in the central part of the period (source: DG REGIO). Observing the state of the model variables ten years after the end of the policy implementation allows to comment on the long-run structural effects of the policy.

The simulations suggest that the 2014-2020 cohesion policy interventions have overall positive effects on the EU economy (Figure 2). The programmes have a positive effect on GDP, which increases over time during the financing period reaching a peak in 2021 when EU GDP is expected to be almost 0.4% higher than in the absence of the policy. The GDP impact is persistent thanks to the supply-side effects of the policy, and it is still substantial long after the end of the implementation period. In 2033, the EU GDP is supposed to be 0.3% higher than in the absence of the policy. The policy-induced increases in productivity and stocks of private and public capital, as well as lower transport costs, continue to stimulate economic activity as expected from a policy aimed at improving the structure the EU regional economies.

[3] 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.

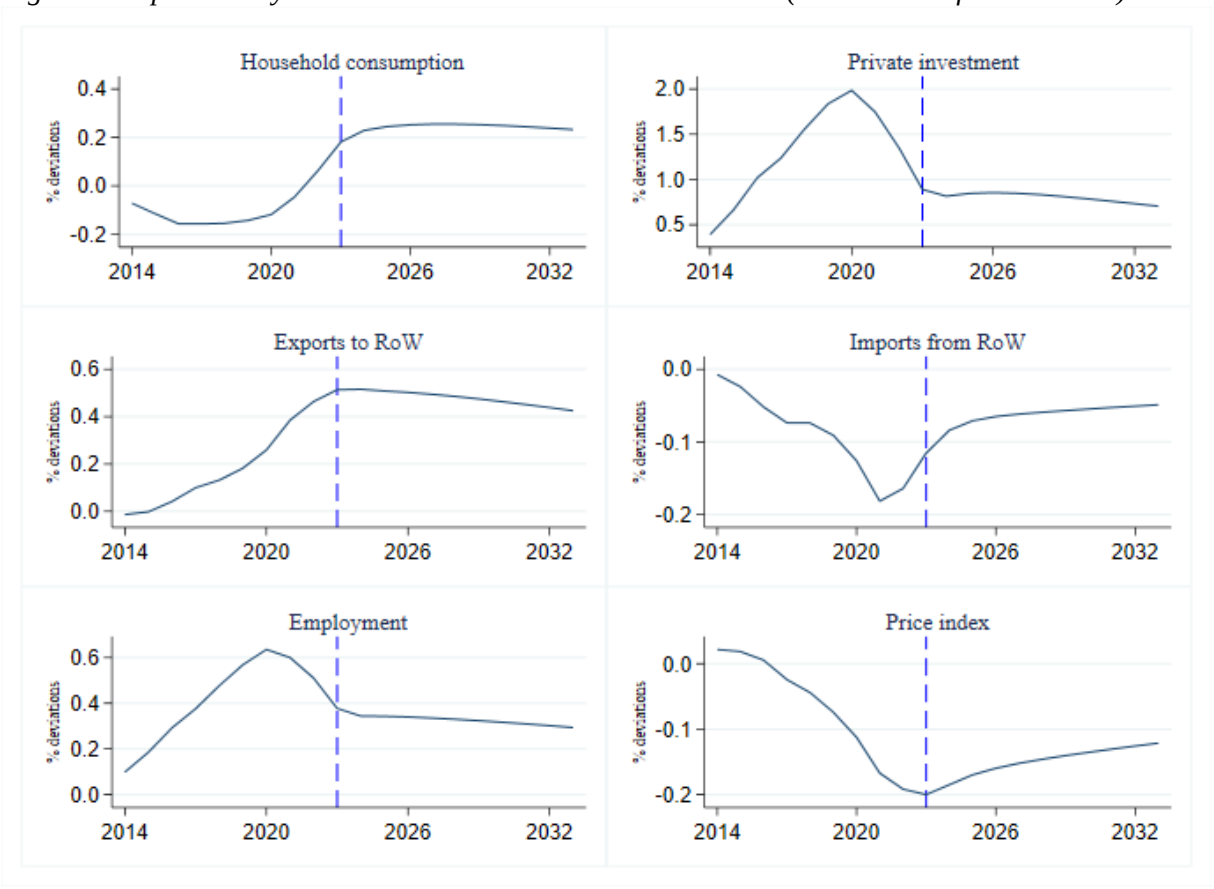
Figure 2. Impact on EU GDP (line: % deviations from baseline) of cohesion investments (bars: % of GDP)



Source: RHOMOLO simulations.

We now present the effects of the policy on a selected set of macroeconomic variables in order to better understand the nature of the adjustments taking place in the EU economy following the deployment of the cohesion investments. Figure 3 shows the impact of the policy interventions on the following variables: household consumption, private investments, exports and imports to the rest of the world, employment, and prices.

Figure 3: Impact on key macroeconomic variables at the EU level (% deviations from baseline)



Source: RHOMOLO simulations. Note: the dashed vertical line indicates the end of the implementation period.

In the short run, the responses of employment, private investment and exports are closely aligned to that of GDP. Employment increases with GDP in the short run. After the end of the programming period in 2023, the impact on employment reflects the increase in labour productivity which stems from interventions in the field of human capital but also from those increasing TFP and the stocks of private and public capital.

Corporate investment is directly stimulated by the interventions targeting support to the private sector which lower the usage cost of capital. It is also boosted by measures indirectly affecting the productivity of capital, as well as by the increase in economic activity. In the medium to long run, the impact is gradually driven more by the supply-side effects than the purely demand-side shocks, and private investment gradually returns towards its steady state value (due to the fact that the structural supply-side effects all decay and eventually vanish).

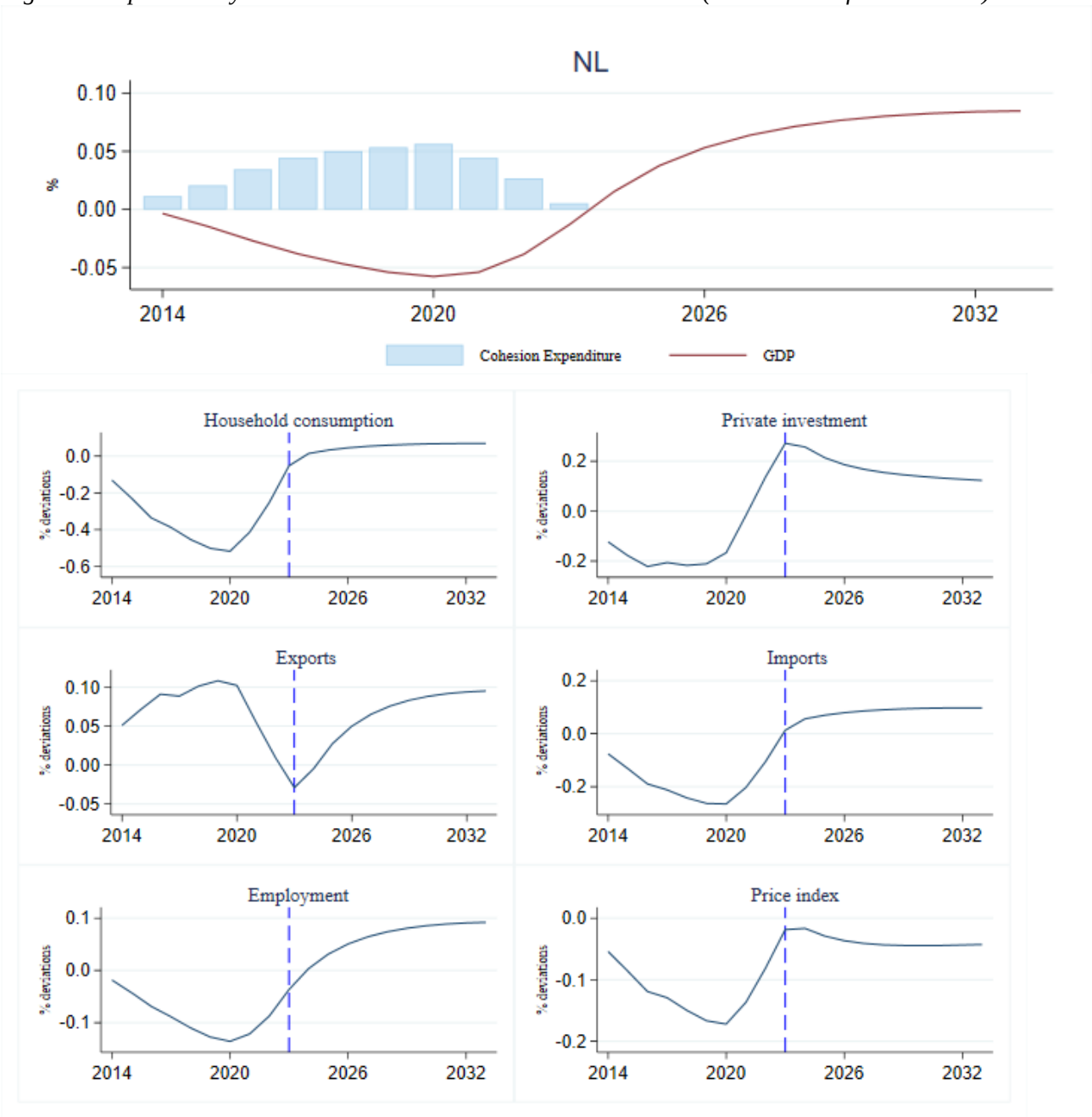
Policy interventions tend to create inflation during the first years of the implementation period in the regions mostly benefitting from the investments, and this results in an increase in EU aggregate prices at the beginning of the period. However, as soon as the productivity-enhancing effects materialise, the inflationary pressure disappears and the level of prices decreases. Household consumption reacts mostly negatively during the implementation period, due to the decrease in net income resulting from the taxes levied to finance the policy, which also explains the low inflationary response at the EU level even in the short run. Consumption deviations from the baseline become positive by 2021, and then increases over time when the supply-side shocks improve the structure of the EU economies.

The EU trade balance is hardly affected by the policy intervention at the beginning of the implementation period, but then it improves over time as improvement in the structure of the regional economies makes boosts the competitiveness of the EU on global markets. However, the EU aggregate hides different national patterns. In particular, the policy tends to deteriorate the trade balance of the main beneficiaries in the short run, as their imports increase with the implementation of the programmes and the resulting stimulus to their economies, while their exports decrease due to the prices being driven up by the demand stimulus resulting in a competitiveness loss. In the long run, their trade balance improves when exports are boosted by the structural changes brought by the programmes. In the more developed countries, which are net contributors of the policy, the trade balance improves in the short run as exports to the main beneficiaries increase. This positive impact is maintained in the long run as the increase in economic activity generated in the main beneficiaries more than offsets the fact that the policy also makes them more competitive, allowing to gain market shares at the expense of the main contributors.

As an illustration of these country variations in the response to the policy shocks, Figures 4 and 5 report the evolution of some key macroeconomic variables for a high income country (the Netherlands) and for a less developed one (Romania), respectively. The first panels in each Figure show the GDP response to cohesion policy in the two countries. The funds allocated to the Netherlands, which is a net policy contributor, are small relative to the country GDP and are not sufficient to offset the negative effect of the lump sum tax used to finance the policy in the short run. On the other hand, Romania is a net beneficiary of cohesion policy and it receives substantial investments relative to its GDP, causing a substantial response both in the short run and in the long run.

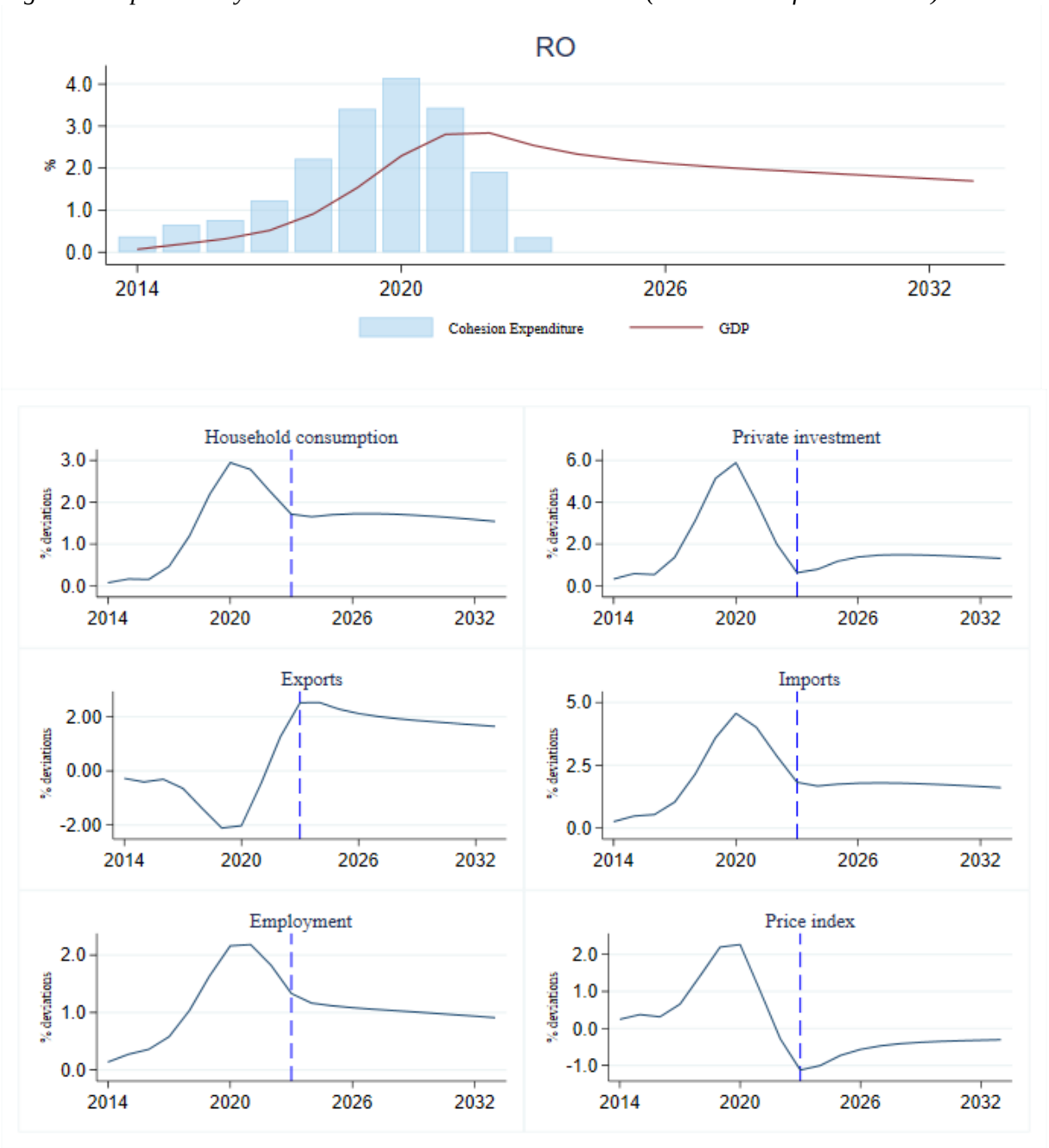
In Romania (Figure 5), the initial increase in prices drives down exports, while imports increase due to the boost in economic activity generated by policy interventions. However, in the long run the increased competitiveness related to the improved structure of the economy has positive effects on the trade balance. In the Netherlands (Figure 4), exports increase almost for the whole simulation period as prices remain below their initial value. Figures A2 and A3 in the Appendix report similar findings for Belgium and Bulgaria, respectively.

Figure 4: Impact on key macroeconomic variables in the Netherlands (% deviations from baseline)



Source: RHOMOLO simulations. Note: the dashed vertical line indicates the end of the implementation period.

Figure 5: Impact on key macroeconomic variables in Romania (% deviations from baseline)



Source: RHOMOLO simulations. Note: the dashed vertical line indicates the end of the implementation period.

5.2 The impact of cohesion policy on the regions of the EU

The macroeconomic impact of the policy shows wide regional variation. This reflects the differences in the policy injection, the fact that the policy mix strongly varies from one region to another, even within the same Member State, and the specific features of the regional economies, which affect their response to the policy.

The impact of the policy is the highest in the main beneficiaries that is, the Eastern European Member States and regions as well as Portugal and the south of Spain. By the end of the programming period, GDP in Croatia, Latvia and Lithuania is respectively about 5%, 4% and 3% higher than in a scenario without cohesion policy, respectively. At the regional level, the impact of the policy peaks at more than 5% in the Hungarian regions of Észak-Alföld and

Dél-Alföld or the Portuguese Região Autónoma dos Açores. There are also significant differences among the regions within each country. For instance, the GDP impact in Hungary ranges between +1.13% and +5.31%, in Poland between +1.49% and +3.89%, in Romania between 1.80% and 2.89%, and in Portugal between +0.60% and +5.15%.

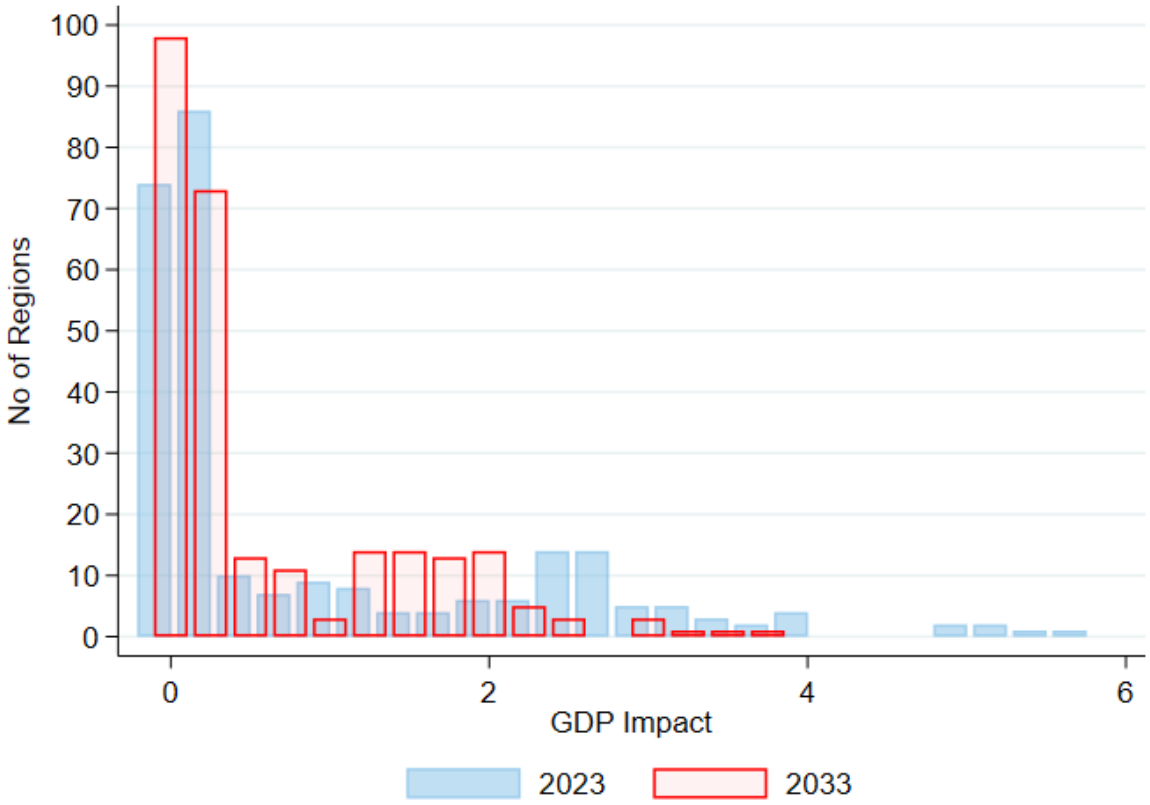
In the more developed Member States and regions, the impact of the policy is generally smaller and sometimes even negative in the short run. Indeed, for many of these regions, the policy support is low relative to the size of their economies and that they contribute to finance a larger share of the policy. However, in the long run, the impact of the policy strengthens as once the programmes are terminated, they no longer generate costs but still produce some benefits. Eventually, the GDP impacts become positive in all regions.

This is partly due to the strong spatial spillovers generated by the policy, through which the programmes implemented in a given region also have an impact in other regions.[4] These spillovers mostly stem from the fact that the main beneficiaries are often small open economies with narrow industrial bases and limited research and development capacity. Many goods or services critical for the implementation of cohesion policy programmes are not produced domestically and hence need to be imported. The policy also contributes to accelerate development in these regions, which triggers higher levels of imports of a wide range of goods and services from their main, and more advanced, trading partners.

Figure 6 shows that the distribution of the 2023 GDP impacts is wider than that of the 2033 impacts, the former being characterised by more extreme values both on the right and the left tails. This means that, by the end of the implementation period, on the one hand the combination of demand and supply side effects generate large GDP impacts in some targeted regions which gradually diminish over time. On the other hand, some of the net contributor regions are recording negative impacts in 2023 due to the burden posed by the financing of the policy, a burden which disappears in the following years, leading to higher GDP impacts over time in these regions. The narrower distribution of the 2033 GDP impacts implies less negative and extreme positive values, with the average impact decreasing as it gradually disappears due to the disappearance of the effects of the demand-side shocks and the decay rates applied to the supply-side ones.

[4] Monfort and Salotti (2021) analyse the international spillovers generated by the 2007-2013 cohesion policy programmes, with a focus on those generated in the net beneficiary Member States and spilling over to the net contributors. They find that in the long run, around 15% of the policy impact on EU GDP is due to international spill-over effects among Member States. On average, in the more developed countries (those not eligible to receive the Cohesion Fund transfers), around 45% of the impact is due to the programmes implemented in the main beneficiaries.

Figure 6. Distribution of regional GDP impacts at the end of the implementation period (2023 - blue bars) and ten years after (2033 - red bars) - % deviations from baseline



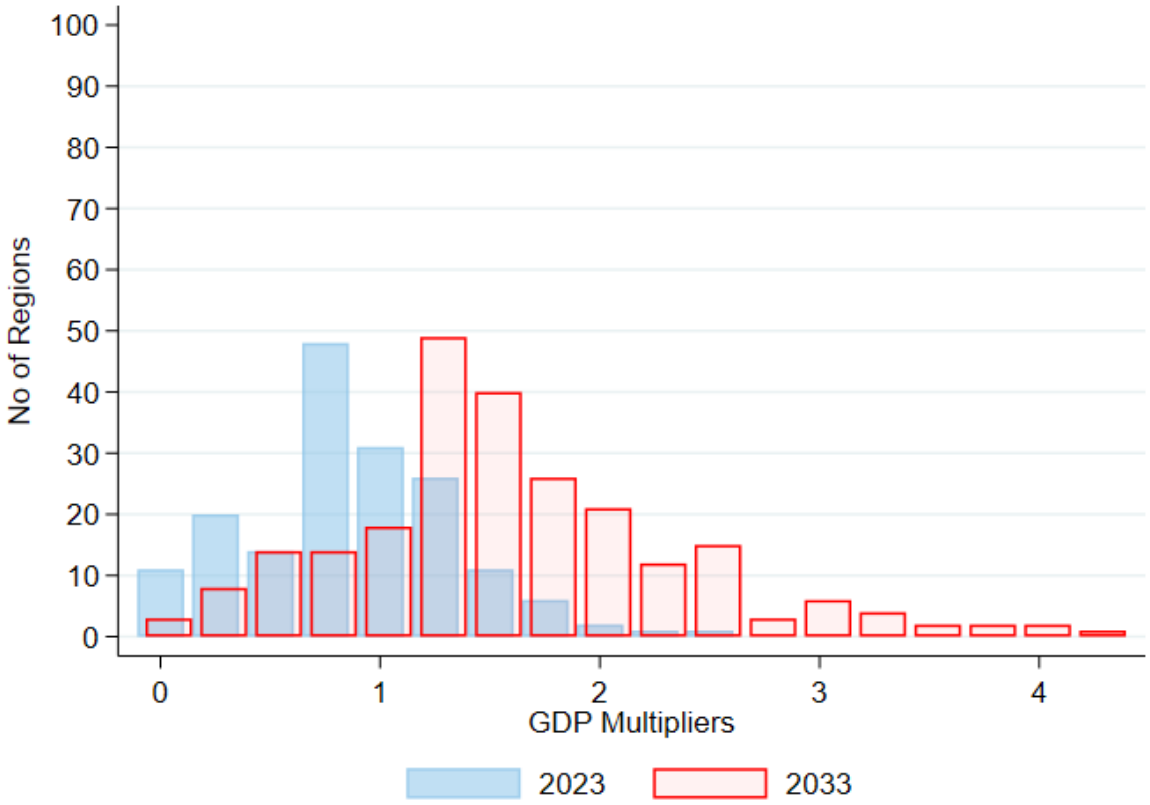
Source: RHOMOLO simulations.

The regional GDP impacts are helpful in revealing the impact of cohesion policy, but in order to understand the returns of the policy investments, it is more informative to analyse the GDP multipliers. The latter are calculated as the ratio between the cumulated impact on GDP up to a given year, and the cumulated policy injection up to the same year, both expressed in present value terms. Thus, the multiplier can be interpreted as the GDP impact for each euro spent on cohesion policy.

In the short run, the multiplier at the EU level is lower than one as the benefits of the policy are not sufficient yet to outweigh its costs. The situation changes after the termination of the programmes, and ten years after, when each euro spent on the policy has generated 1.73 euros of additional GDP in the EU, which corresponds to an annual rate of return of around 2.7%. Figure 7 shows the distribution of the regional GDP discounted multipliers in 2023 and 2033.[5]

[5] The multipliers are discounted into present value terms according to the following formula: $Present\ Value\ Multiplier_{t0} = \frac{Multiplier_t}{(1+interest\ rate)^{t-t0}}$, where the interest rate employed is the exogenous calibrated interest rate of the model.

Figure 7. Distribution of regional GDP multipliers at the end of the implementation period (2023 - blue bars) and ten years after (2033 - red bars)



Source: RHOMOLO simulations.

Over time, the distribution of multipliers tends to move to the right, as the joint demand-side and supply-side effects of cohesion policy generate more than one euro of GDP for each euro spent over the course of the twenty years of the simulation in most EU regions. On average, the long run GDP multipliers are higher in the regions belonging to the countries targeted by cohesion policy than in the regions in countries which are net contributors for the policy. There are some exceptions, though, as some of the highest multipliers are found in regions in more developed countries. This happens because those regions benefit from substantial spillover effects originating in the rest of the EU leading to significant GDP impacts despite little policy investments (the latter is at the denominator of the formula of the multiplier). These findings are consistent with those by Monfort and Salotti (2021) mentioned above who studied international spillovers using data on the 2007-2013 cohesion policy.

We investigate some potential drivers of the long run regional GDP multipliers arising from the implementation of cohesion policy. Table 2 reports the correlations between trade openness (captured both by the imports and exports to output ratio) and the initial levels of public and private capital stocks on one side, and the 2033 GDP discounted multipliers on the other side.

There is a negative relationship between the stocks of private and public capital and the GDP multipliers. This implies that the provision of funds to regions with higher (lower) initial levels of capital, public or private, are expected to generate relatively lower (higher) GDP impacts. Thus, cohesion policy investments seem to be subject to decreasing returns, in the sense that they would be more productive in regions lagging behind in terms of private and

public capital endowments. This finding is consistent with Ramey (2020) who analyses the effects of government investment in infrastructure in the U.S. and observes that the multipliers associated to such investments are greater if the economy starts from a low (below the socially optimal) amount of public capital.

Table 2. Correlations between long run GDP multipliers and initial regional economic conditions

	Long run GDP multipliers
Public capital stock/GDP	-0.132
Private capital stock/GDP	-0.072
Imports/Output	-0.354
Exports/Output	0.164

Source: RHOMOLO simulations.

As for trade, it appears that the long run GDP multipliers are strongly and negatively correlated with the initial level of imports over output. This is explained by the fact that in economies characterised by a high propensity to imports, a large share of the policy impact leaks to other places. On the other hand, the long run multipliers are positively correlated with the exports to output ratio, as regions with a strong export basis tend to benefit from the trade spillovers of the policy discussed above.

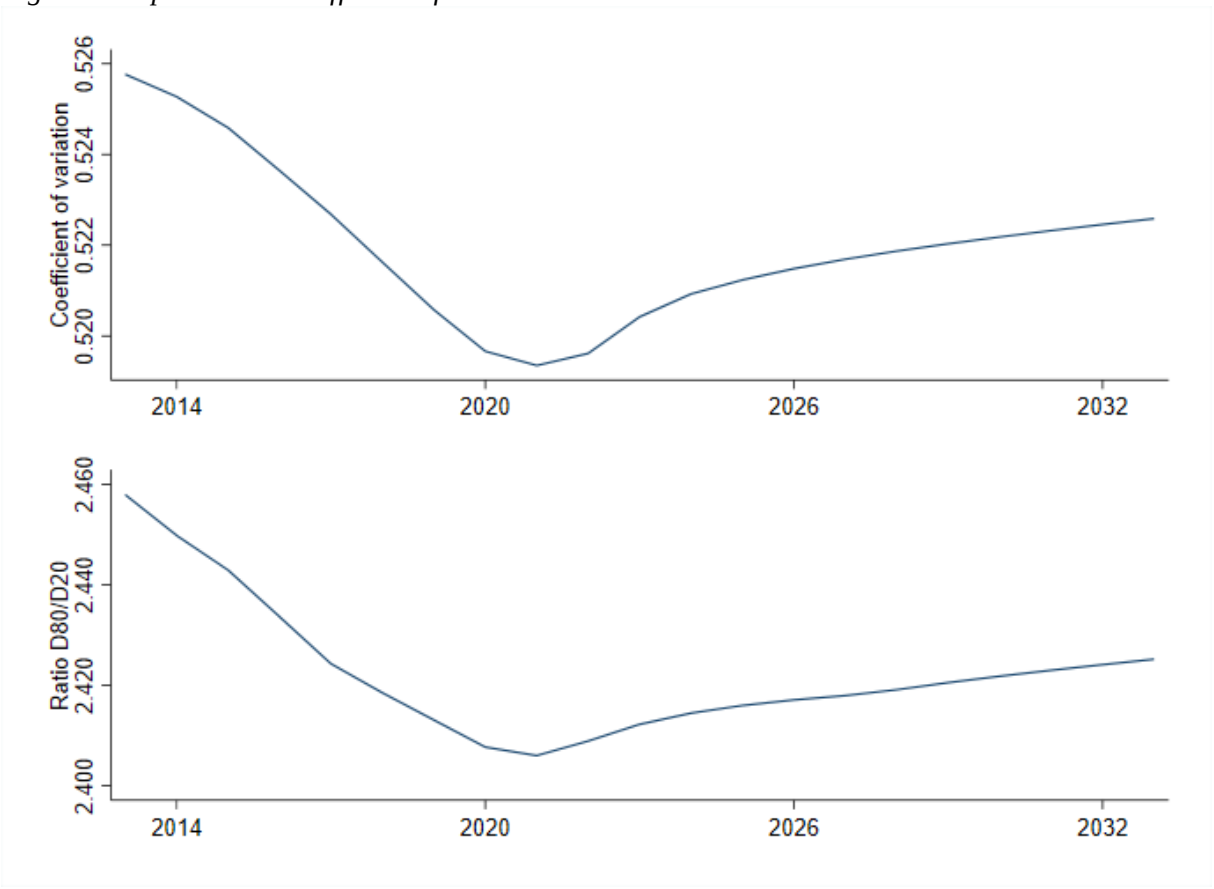
5.3 The distributional impact of cohesion policy

In the long run, cohesion policy produces a positive impact both in the more and less developed regions of the EU, but its effects on regional disparities is *a priori* uncertain. However, as the funding is concentrated on the less developed regions, the GDP impact of the policy is negatively correlated with the level of GDP per capita, with a correlation coefficient of about -0.4 stable for the whole simulation period. This implies that cohesion policy produces most of its impact in the less developed regions of the EU, in line with its mandate to strengthen economic and social cohesion by reducing disparities in the level of development between regions.

According to the simulations, the policy reduces regional disparities across and within Member States. At the aggregate EU level, the coefficient of variation[6] and the ratio of the 80^{th} to 20^{th} percentile values of the regional GDP per capita distribution are found to decrease with the implementation of the programmes (Figure 8). Both indices reach their minimum value at the end of the implementation period. However, twenty years after the start of the programmes, GDP per capita dispersion remains lower than the initial level.

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

Figure 8: Impact on the coefficient of variation and on the 80/20 distribution in the EU



Source: RHOMOLO simulations.

The evidence reported in Figure 8 is confirmed by the changes in the Theil index, which exhibits the largest decrease, -3.5%, at the peak of the GDP impact of the policy in 2021 (see Table 3).[7] Both the between and the within country components of the index decline, implying that disparities within Member States are reduced, as well as disparities across Member States. The reductions are stable, as 20 years after the start of the policy, disparities are 1.77% lower than the initial level. .

Table 3: Impact on the Theil Index

	2013 Theil index	Change in 2021	Change in 2028	Change in 2033
Within	0.039	-1.99%	-1.25%	-0.99%
Between	0.114	-3.98%	-2.44%	-2.04%
Overall	0.153	-3.46%	-2.13%	-1.77%

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

[7] 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).

In order to understand the scale of the changes in disparities within and across Member States, we report the maximum observed difference from the baseline in selected percentile values of regional GDP per capita (this occurs in 2021).

Table 4. Regional income distribution by country (% change with respect to baseline)

Member State	Δ% p10	Δ% p50	Δ% p90
AT	0.07	-0.01	0.10
BE	0.10	-0.06	-0.08
BG	0.74	0.03	-1.20
CZ	0.42	0.22	-1.70
DE	0.10	-0.01	-0.13
DK	0.02	0.00	-0.01
EL	0.82	-0.37	-1.44
ES	0.60	-0.11	-0.67
FI	-0.03	0.14	-0.03
FR	0.08	-0.02	0.00
HU	1.36	1.10	-4.03
IT	0.78	-0.24	-0.19
NL	0.02	0.00	-0.01
PL	1.10	-0.31	-0.69
PT	0.66	2.72	-2.39
RO	0.30	0.18	-1.06
SE	0.02	0.03	-0.11
UK	0.47	-0.05	-0.21

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

For nearly all Member States, there is a positive impact on the lowest 10% of the GDP per capita distribution, with an average increase of +0.4%. The impact is more pronounced in the net beneficiary countries, where GDP per capita increases about 0.7% relative to the baseline, and the effect is similar in adjacent percentiles. In higher parts of the distribution, the value of the percentiles tends to decline, with some differences between net beneficiary and net contributor countries. For example, the median regions of the net contributor Member States exhibit a decline of -0.04%, while those of the net beneficiaries experience an increase of 0.36%. The richest regions of both net contributors and recipients (at the 90th percentile) experience declines of -0.8% on average. Austria notably experiences an increase of the highest 90% incomes which is the result of spillovers affecting the richest regions of the country that are generated from the net beneficiaries it trades with. Overall, the country-level evidence on the distributional effects of the policy suggest that it reduces internal regional disparities, especially in the main beneficiaries.

6. Conclusions

In this paper, we use the RHOMOLO dynamic general equilibrium model calibrated with data for all the NUTS 2 regions of the EU in order to estimate the potential impact of the 2014-2020 investments of the three main funds of cohesion policy. We assume that the policy interventions activate a number of demand- and supply-side economic transmission mechanisms, depending on the distribution of the funding across various fields of spending categories and fields of interventions.

The results of the simulations suggest that the cohesion policy interventions have positive effects on the EU economy. The EU GDP is estimated to be up to 0.4% higher by the end of the policy implementation with respect to a hypothetical scenario without the policy. In the long run, the policy investments produce positive returns, with the 20 year GDP discounted multiplier standing at 1.7. 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 generally positive even in the net contributors to the policy. This is partly due to the interregional spillovers generated by the policy by which interventions implemented in a given region also benefit to other regions in the EU, notably the ones having strong trade links with the main beneficiaries.

The GDP impacts and multipliers are substantially larger in the less developed regions of the EU which are the main target of the policy. We also show that regional disparities decrease thanks to the policy intervention, both at the EU level and within most of its Member States. We provide evidence on the cohesion impact being related to regional characteristics. In particular, the impact per euro spent is larger in regions with a strong export basis and with smaller private and public capital endowments.

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Appendix

Table A1. Correspondence between the 123 spending categories and the 6 fields of intervention

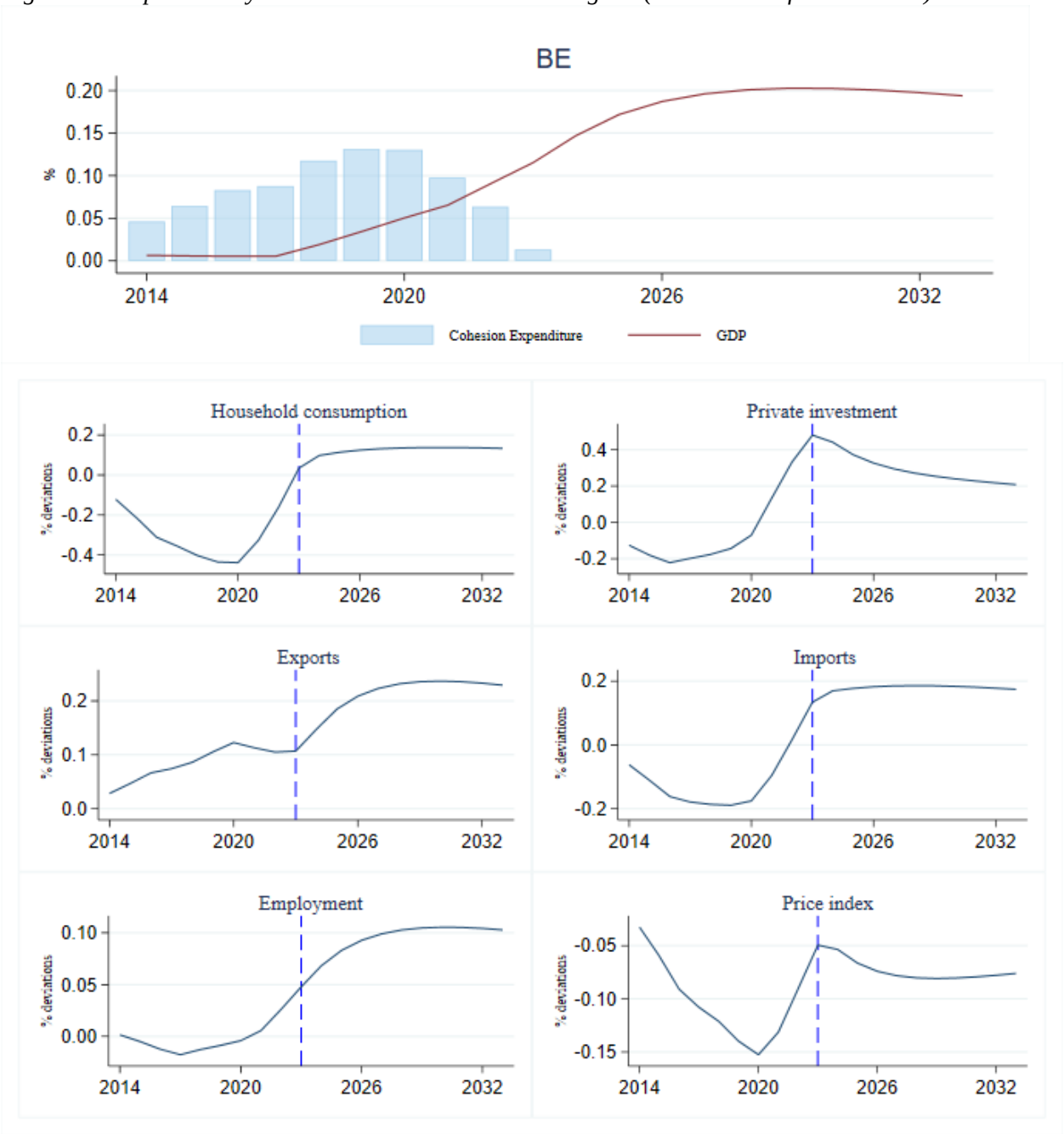
Category	Full label	Field
01	Generic productive investment in small and medium – sized enterprises ('SMEs')	AIS
02	Research and innovation processes in large enterprises	RTD
03	Productive investment in large enterprises linked to the low-carbon economy	AIS
04	Productive investment linked to the cooperation between large enterprises and SMEs for developing information and communication technology ('ICT') products and services, e-commerce and enhancing demand for ICT	RTD
05	Electricity (storage and transmission)	INFR
06	Electricity (TEN-E storage and transmission)	INFR
07	Natural gas	INFR
08	Natural gas (TEN-E)	INFR
09	Renewable energy: wind	INFR
10	Renewable energy: solar	INFR
11	Renewable energy: biomass	INFR
12	Other renewable energy (including hydroelectric, geothermal and marine energy) and renewable energy integration (including storage, power to gas and renewable hydrogen infrastructure)	INFR
13	Energy efficiency renovation of public infrastructure, demonstration projects and supporting measures	INFR
14	Energy efficiency renovation of existing housing stock, demonstration projects and supporting measures	INFR
15	Intelligent Energy Distribution Systems at medium and low voltage levels (including smart grids and ICT systems)	INFR
16	High efficiency co-generation and district heating	INFR
17	Household waste management, (including minimisation, sorting, recycling measures)	INFR
18	Household waste management, (including mechanical biological treatment, thermal treatment, incineration and landfill measures)	INFR
19	Commercial, industrial or hazardous waste management	INFR
20	Provision of water for human consumption (extraction, treatment, storage and distribution infrastructure)	INFR
21	Water management and drinking water conservation (including river basin management, water supply, specific climate change adaptation measures, district and consumer metering, charging systems and leak reduction)	INFR
22	Waste water treatment	INFR
23	Environmental measures aimed at reducing and/or avoiding greenhouse gas emissions (including treatment and storage of methane gas and composting)	INFR
24	Railways (TEN-T Core)	TRNSP
25	Railways (TEN-T comprehensive)	TRNSP
26	Other Railways	TRNSP
27	Mobile rail assets	TRNSP
28	TEN-T motorways and roads — core network (new build)	TRNSP
29	TEN-T motorways and roads — comprehensive network (new build)	TRNSP
30	Secondary road links to TEN-T road network and nodes (new build)	TRNSP
31	Other national and regional roads (new build)	TRNSP
32	Local access roads (new build)	TRNSP
33	TEN-T reconstructed or improved road	TRNSP
34	Other reconstructed or improved road (motorway, national, regional or local)	TRNSP
35	Multimodal transport (TEN-T)	TRNSP
36	Multimodal transport	TRNSP
37	Airports (TEN-T) (1)	TRNSP
38	Other airports (1)	TRNSP
39	Seaports (TEN-T)	TRNSP
40	Other seaports	TRNSP
41	Inland waterways and ports (TEN-T)	TRNSP
42	Inland waterways and ports (regional and local)	TRNSP
43	Clean urban transport infrastructure and promotion (including equipment and rolling stock)	TRNSP
44	Intelligent transport systems (including the introduction of demand management, tolling systems, IT monitoring, control and information systems)	TRNSP
45	ICT: Backbone/backhaul network	INFR
46	ICT: High-speed broadband network (access/local loop; >/= 30 Mbps)	INFR
47	ICT: Very high-speed broadband network (access/local loop; >/= 100 Mbps)	INFR
48	ICT: Other types of ICT infrastructure/large-scale computer resources/equipment (including e-infrastructure, data centres and sensors; also where embedded in other infrastructure such as research facilities, environmental and social infrastructure)	INFR
49	Education infrastructure for tertiary education	INFR
50	Education infrastructure for vocational education and training and adult learning	INFR
51	Education infrastructure for school education (primary and general secondary education)	INFR
52	Infrastructure for early childhood education and care	INFR
53	Health infrastructure	INFR
54	Housing infrastructure	INFR
55	Other social infrastructure contributing to regional and local development	INFR
56	Investment in infrastructure, capacities and equipment in SMEs directly linked to research and innovation activities	RTD
57	Investment in infrastructure, capacities and equipment in large companies directly linked to research and innovation	RTD

	activities	
58	Research and innovation infrastructure (public)	RTD
59	Research and innovation infrastructure (private, including science parks)	RTD
60	Research and innovation activities in public research centres and centres of competence including networking	RTD
61	Research and innovation activities in private research centres including networking	RTD
62	Technology transfer and university-enterprise cooperation primarily benefiting SMEs	RTD
63	Cluster support and business networks primarily benefiting SMEs	RTD
64	Research and innovation processes in SMEs (including voucher schemes, process, design, service and social innovation)	RTD
65	Research and innovation infrastructure, processes, technology transfer and cooperation in enterprises focusing on the low carbon economy and on resilience to climate change	RTD
66	Advanced support services for SMEs and groups of SMEs (including management, marketing and design services)	RTD
67	SME business development, support to entrepreneurship and incubation (including support to spin offs and spin outs)	RTD
68	Energy efficiency and demonstration projects in SMEs and supporting measures	AIS
69	Support to environmentally-friendly production processes and resource efficiency in SMEs	AIS
70	Promotion of energy efficiency in large enterprises	AIS
71	Development and promotion of enterprises specialised in providing services contributing to the low carbon economy and to resilience to climate change (including support to such services)	AIS
72	Business infrastructure for SMEs (including industrial parks and sites)	AIS
73	Support to social enterprises (SMEs)	AIS
74	Development and promotion of tourism assets in SMEs	AIS
75	Development and promotion of tourism services in or for SMEs	AIS
76	Development and promotion of cultural and creative assets in SMEs	AIS
77	Development and promotion of cultural and creative services in or for SMEs	AIS
78	e-Government services and applications (including e-Procurement, ICT measures supporting the reform of public administration, cyber-security, trust and privacy measures, e-Justice and e-Democracy)	INFR
79	Access to public sector information (including open data e-Culture, digital libraries, e-Content and e-Tourism)	INFR
80	e-Inclusion, e-Accessibility, e-Learning and e-Education services and applications, digital literacy	INFR
81	ICT solutions addressing the healthy active ageing challenge and e-Health services and applications (including e-Care and ambient assisted living)	INFR
82	ICT Services and applications for SMEs (including e-Commerce, e-Business and networked business processes), living labs, web entrepreneurs and ICT start-ups)	AIS
83	Air quality measures	INFR
84	Integrated pollution prevention and control (IPPC)	INFR
85	Protection and enhancement of biodiversity, nature protection and green infrastructure	INFR
86	Protection, restoration and sustainable use of Natura 2000 sites	INFR
87	Adaptation to climate change measures and prevention and management of climate related risks e.g. erosion, fires, flooding, storms and drought, including awareness raising, civil protection and disaster management systems and infrastructures	INFR
88	Risk prevention and management of non-climate related natural risks (i.e. earthquakes) and risks linked to human activities (e.g. technological accidents), including awareness raising, civil protection and disaster management systems and infrastructures	INFR
89	Rehabilitation of industrial sites and contaminated land	INFR
90	Cycle tracks and footpaths	TRNSP
91	Development and promotion of the tourism potential of natural areas	INFR
92	Protection, development and promotion of public tourism assets	INFR
93	Development and promotion of public tourism services	INFR
94	Protection, development and promotion of public cultural and heritage assets	INFR
95	Development and promotion of public cultural and heritage services	INFR
96	Institutional capacity of public administrations and public services related to implementation of the ERDF or actions supporting ESF institutional capacity initiatives	INFR
97	Community-led local development initiatives in urban and rural areas	INFR
98	Outermost regions: compensation of any additional costs due to accessibility deficit and territorial fragmentation	INFR
99	Outermost regions: specific action to compensate additional costs due to size market factors	INFR
100	Outermost regions: support to compensate additional costs due to climate conditions and relief difficulties	INFR
101	Cross-financing under the ERDF (support to ESF-type actions necessary for the satisfactory implementation of the ERDF part of the operation and directly linked to it)	INFR
102	Access to employment for job-seekers and inactive people, including the long-term unemployed and people far from the labour market, also through local employment initiatives and support for labour mobility	HC
103	Sustainable integration into the labour market of young people, in particular those not in employment, education or training, including young people at risk of social exclusion and young people from marginalised communities, including through the implementation of the Youth Guarantee	HC
104	Self-employment, entrepreneurship and business creation including innovative micro, small and medium sized enterprises	HC
105	Equality between men and women in all areas, including in access to employment, career progression, reconciliation of work and private life and promotion of equal pay for equal work	HC
106	Adaptation of workers, enterprises and entrepreneurs to change	HC
107	Active and healthy ageing	HC
108	Modernisation of labour market institutions, such as public and private employment services, and improving the matching of labour market needs, including throughactions that enhance transnational labour mobility as well as through mobility schemes and better cooperation between institutions and relevant stakeholders	HC
109	Active inclusion, including with a view to promoting equal opportunities and active participation, and improving	HC

	employability	
110	Socio-economic integration of marginalised communities such as the Roma	HC
111	Combating all forms of discrimination and promoting equal opportunities	HC
112	Enhancing access to affordable, sustainable and high-quality services, including health care and social services of general interest	HC
113	Promoting social entrepreneurship and vocational integration in social enterprises and the social and solidarity economy in order to facilitate access to employment	HC
114	Community-led local development strategies	HC
115	Reducing and preventing early school-leaving and promoting equal access to good quality early-childhood, primary and secondary education including formal, non-formal and informal learning pathways for reintegrating into education and training	HC
116	Improving the quality and efficiency of, and access to, tertiary and equivalent education with a view to increasing participation and attainment levels, especially for disadvantaged groups	HC
117	Enhancing equal access to lifelong learning for all age groups in formal, non-formal and informal settings, upgrading the knowledge, skills and competences of the workforce, and promoting flexible learning pathways including through career guidance and validation of acquired competences	HC
118	Improving the labour market relevance of education and training systems, facilitating the transition from education to work, and strengthening vocational education and training systems and their quality, including through mechanisms for skills anticipation, adaptation of curricula and the establishment and development of work-based learning systems, including dual learning systems and apprenticeship schemes	HC
119	Investment in institutional capacity and in the efficiency of public administrations and public services at the national, regional and local levels with a view to reforms, better regulation and good governance	HC
120	Capacity building for all stakeholders delivering education, lifelong learning, training and employment and social policies, including through sectoral and territorial pacts to mobilise for reform at the national, regional and local levels	HC
121	Preparation, implementation, monitoring and inspection	TA
122	Evaluation and studies	TA
123	Information and communication	TA

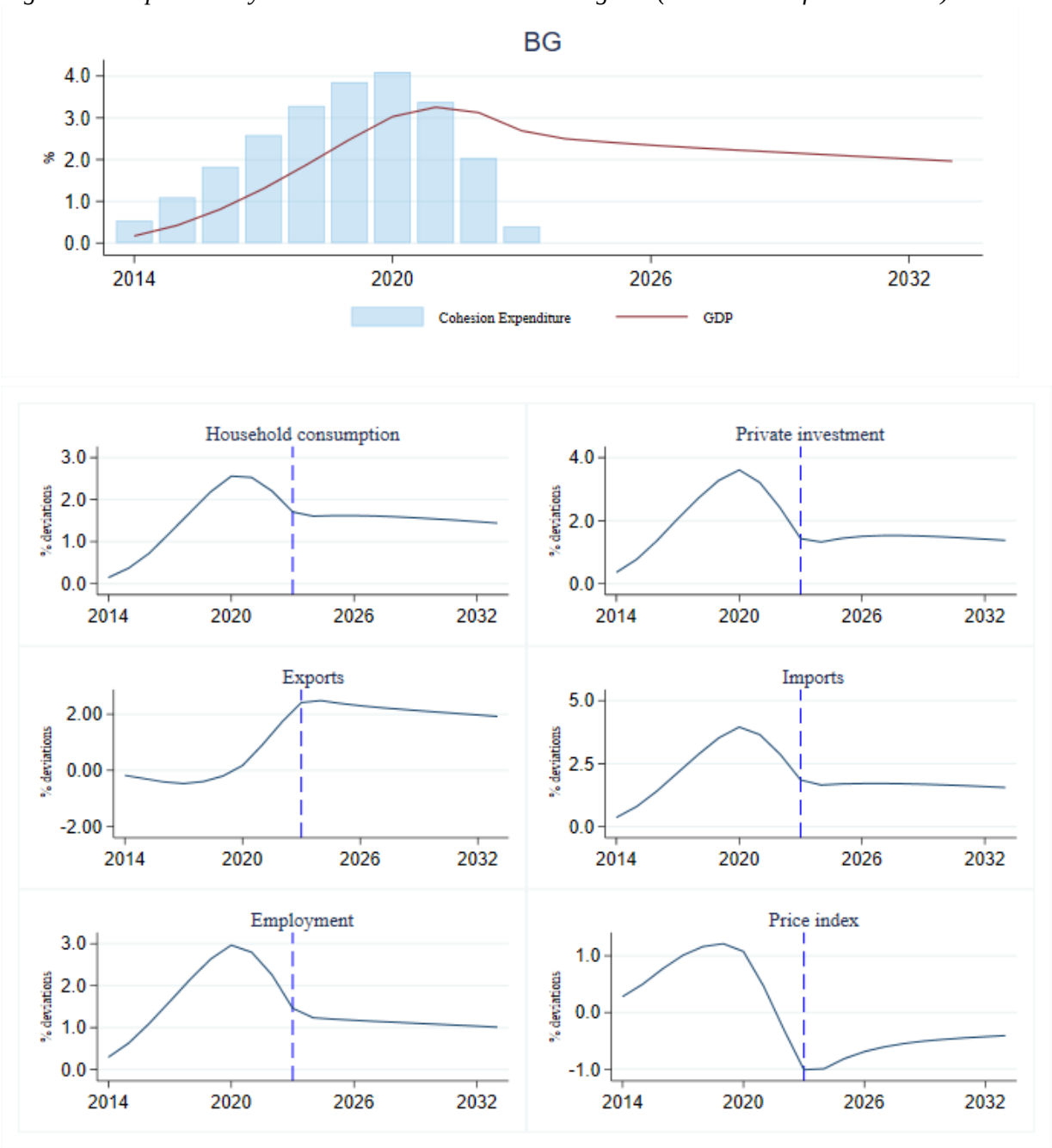
Source: European Commission and own assumptions.

Figure A2: Impact on key macroeconomic variables in Belgium (% deviations from baseline)



Source: RHOMOLO simulations. Note: the dashed vertical line indicates the end of the implementation period.

Figure A3: Impact on key macroeconomic variables in Bulgaria (% deviations from baseline)



Source: RHOMOLO simulations. Note: the dashed vertical line indicates the end of the implementation period.

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