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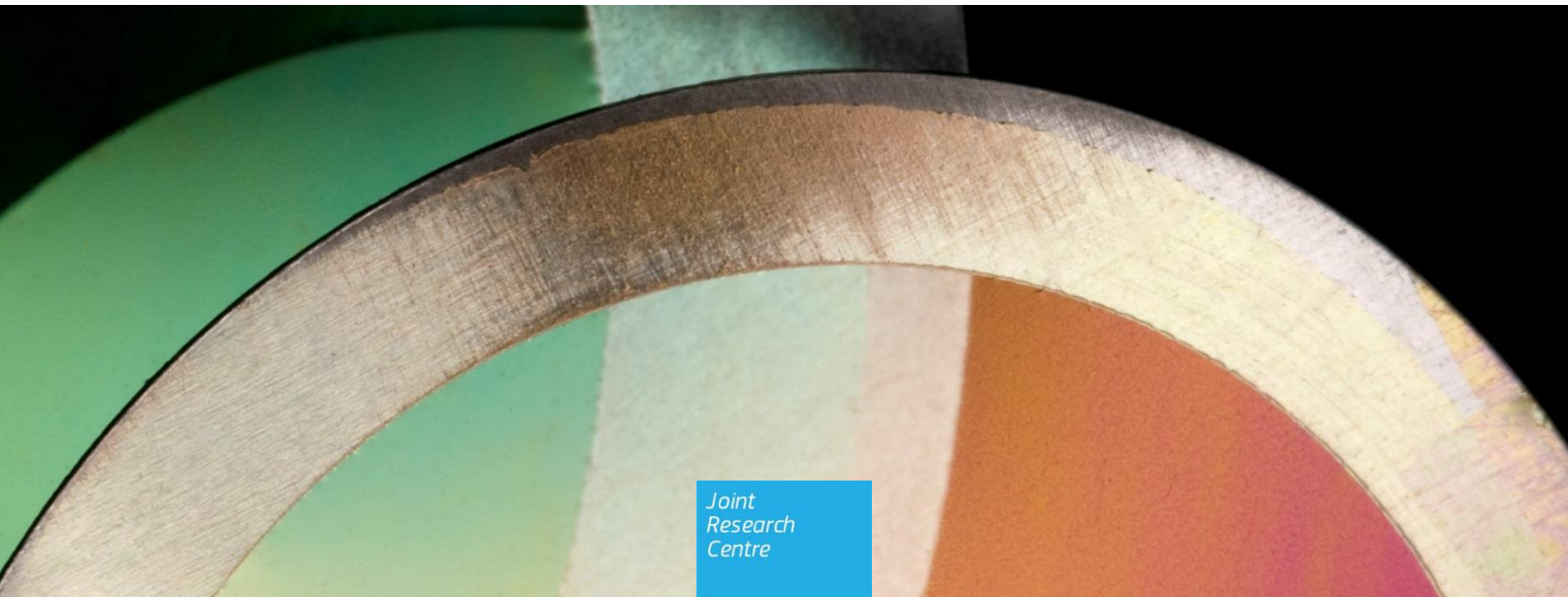

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Abstract

Structural socio-economic differences across EU regions may result in heterogeneous regional responses to changes in public spending in support to R&I. In this paper we examine the socio-economic impact at the EU aggregate level and at the regional level of alternative policy designs of the future EU R&I support programme that will be put in place after 2020. For the analysis we use the RHOMOLO spatial CGE model covering 267 EU regions. Our results indicate that public spending in support to R&I can contribute to higher aggregate GDP and employment in the EU. However, the impact of public spending in support to R&I varies considerable across regions. The R&I intensive regions benefit the most in terms of GDP and employment while other regions may suffer from a shift in public spending towards R&I support programmes.

Assessing the regional socio-economic impact of the European R&I programme

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1 Introduction

In June 2018 the European Commission put forward a proposal for Horizon Europe, the 2021-2027 EU Framework Programmes for Research and Innovation (R&I) that will be put in place after 2020.[1] In support of this work, Directorate-General for Research and Innovation (DG RTD) commissioned an ex ante impact assessment of alternative developments of the future policy design. The study was undertaken by SEURECO with the use of the macroeconomic model NEMESIS. The impact assessment examines the socio-economic impact of different policy designs at the EU aggregate level and at the national levels for all the EU Member States.

SEURECO finds that a continuation of the EU R&I programme for the years 2021-2027 could increase EU GDP in 2050 by 0.06% relative to a reference scenario in which public funds are spent on public investments (SEURECO, 2018). The socio-economic impact of the EU R&I programme varies across Member States, with the main driver of the deviations being the differences in allocations of funds in support to R&I. Substantial variations in the allocation of public funds for R&I support can be observed across EU Member States at the national level and even more so at the sub-national level. R&I activities vary largely at the sub-national level, with R&I activities clustering in some areas and leaving other areas with more modest activities. Reflecting such regional differences in R&I activities, the allocation of resources under the current Framework Programme also varies substantial across regions. A shift in policy design of the Framework Programme may, thus, shift resources across EU regions and impact differently the various regional economies. Furthermore, variations in industrial structures, infrastructures, and structural socio-economic differences across EU regions may further contribute to heterogeneous regional responses to changes in public policy in support to R&I. This calls for an impact assessment of the alternative future policy design at the sub-national level to supplement the impact assessment carried out but SEURECO.

In this paper we examine the socio-economic impact at the EU aggregate level and at the regional level of alternative policy designs of the future Framework Programme. We

[1] Horizon Europe will succeed the current Programme, Horizon 2020 which is active for the timeframe 2014-2020. The Horizon Europe proposal is accompanied by an impact assessment (European Commission, 2018) containing some of the results of the analysis presented in this Report.

examine three alternative policy designs defined in the study by SEURECO using the spatial dynamic general equilibrium model RHOMOLO. This model contains 267 regions at the NUTS2 level allowing for an assessment of how regional economies across the EU respond to a change in public spending in support to R&I.

Our results are based on two sets of simulations, the first carried out with the standard version of RHOMOLO, and the second carried out with a version of RHOMOLO in which TFP growth from knowledge creation is scaled to mirror National GDP impacts found in the NEMESIS model. Scaling of TFP in the second model version is introduced to embed the higher spillovers from R&I knowledge to productivity assumed in NEMESIS. Our results, as explained in detail in the following sections, suggest that public spending in support to R&I contributes to higher aggregate GDP and employment in the EU. We find that a continuation of the current EU R&I support programme until 2027 results in cumulative EU GDP in 2040 which is respectively 0.07% and 0.16% higher than in a reference scenario in which the public funds are spend on public investments. For the period 2021-2040, EU employment would on average be respectively 40,000 and 56,000 jobs per year higher than in the reference scenario.

The allocation of EU funds for R&I support policies varies considerable across regions leading to substantial regional variations in socio-economic impacts. As a result of continuing the EU R&I programme, regions who are large recipients of EU spending in support to R&I would experience higher TFP growth and an improvement of competitiveness leading to a rise in GDP and employment. In contrast less R&I intensive regions would suffer from a decline in cumulative GDP and employment relative to the reference scenario. These regions would attract fewer funds for R&I support and suffer from the reallocation of public spending from public investments to R&I support.

Considering alternative policy designs, we find that relocating public spending in support to R&I between national R&I support programmes and the EU R&I support programme affects GDP and employment. The regional impacts vary substantial and can be considerable higher than the impact on EU aggregates. Some regions may benefit while other lose from a given change in the spending strategy.

We find that reinforcing the EU R&I programme by centralising a third of national competitive-based project funding at the EU level would lead to cumulative EU GDP in 2040 that are respectively 0.06% and 0.25% higher than the reference scenario. In the period 2021-2040, EU employment would on average rise by between 47,000 and 102,000 jobs per year relative to the reference scenario. The diverging impact on EU GDP in the two model versions is driven by alternative assumptions concerning R&I

spillovers.[2] We find considerable variations in socio-economic impacts at the regional level. The reinforcement of the EU R&I programme results in a reallocation of public funding amongst EU regions which gives rise to heterogeneous impact on GDP and employment. Regions which experience a rise in public spending in support to R&I due to centralisation of funds at the EU level also experience an increase in GDP and employment. Reinforcing the EU R&I programme mostly benefits relative R&I intensive regions located in the Member States with lower national levels of public R&I support. In contrast R&I intensive regions in Member States characterised by high national level of R&I support suffer from a centralisation of public funds at the EU level and experience a lower rise in GDP and employment.

Decentralising the EU R&I programme and implementing it at the national level leads to a smaller rise in EU GDP and employment than the other alternative R&I support programmes considered. In 2040 cumulative EU GDP would be respectively 0.06% and 0.12% higher than in the reference scenario and EU employment in the period 2021-2040 would on average be respectively 32,000 and 34,000 jobs per year higher than the reference scenario. The lower impact on EU GDP and employment is mainly driven by an assumption in the scenario that national R&I programmes generates lower direct leverage of private R&I spending than EU funded R&I programmes. A lower rise in GDP and employment is also experienced in most EU regions.

The paper is structured as follows. Section 2 shortly presents the RHOMOLO model used for the impact assessment. Section 3 describes the policy designs considered and how they are put into model simulations. Results from the simulations on RHOMOLO are presented in section 4. Section 5 presents the results of the simulations on the model with scaled TFP. Section 6 concludes.

2 The model

RHOMOLO is a spatial dynamic general equilibrium model with new economic geography features.[3] The model includes 267 EU regions. Each region contains 10 economic sectors. A subset of these operates under monopolistic competition. The rest of the sectors operate under perfect competition. Regional goods are produced by combining labour and capital with domestic and imported intermediates, creating vertical linkages between firms.

[2] The standard version of RHOMOLO assumes a spatial variation in R&I spillover elasticities determined by regional R&D intensity. The version of RHOMOLO with TFP scaling further embeds the assumption of different R&I spillover elasticities across national and European R&I support programmes as assumed in NEMESIS

[3] A description of the most recent model version of RHOMOLO can be found in Lecca et al. (2018).

Final goods are consumed by households, government and investors. Each region is inhabited by a representative household which supply labour of three skills type, consume and save. The government levies taxes, purchases public consumption goods, conduct public investments and allocates transfers to the various agents in the economy. Goods and services either can be sold in the domestic economy or exported to other regions. Trade between regions is associated with a set of bilateral regional transportations costs. The RHOMOLO model incorporates imperfect competition in the labour market which allows for unemployment. Wage formation is assumed to follow a wage curve specification as in Blanchflower and Oswald (1995), whose implication is that lower levels of unemployment increase workers' bargaining power, thereby increasing real wages.[4]

The RHOMOLO model contains two types of capital: sector-specific private capital and public capital available to firms in all sectors within the region. Sector-specific private capital is accumulated by private investors. The investment capital ratio is a function of the rate of return to capital and the user cost of capital allowing the capital stock to reach its desired level in a smooth fashion over time. Public capital is accumulated by the government. Public capital services enters the production function as an unpaid factor of production meaning that all firms, in all sectors, enjoy the same level of public capital at no cost. The model allows for public capital to be subject to congestion (see e.g. Fisher and Turnovsky, 1998). Public capital in the model is not treated as a pure public good but is characterised by some degree of congestion. Hence, the public capital services available from the public capital stock are adjusted for congestion by aggregate production. Therefore an increase in production reduces the effective quantity of public capital stock enjoyable by all firms.

R&I expenditure is modelled as private investments. Hence, R&I spending generates demand for capital goods. In addition, R&I spending leads to accumulation of an intangible knowledge capital stock which in turn spills into an increase in TFP. Public expenditure in support for R&I is introduced into the model as a reduction in user cost of capital which in turn generates an increase in R&I investments. The impact of R&I expenditure on TFP through the accumulated knowledge capital stock is captured by a set of regional spillover elasticities which are conditional on R&D intensity within the region. Higher regional R&D intensity is associated with higher spillover from knowledge capital to TFP. The intuition is that firms in regions that are already spending much on R&D signal their pre-existing capacity to generate value from innovation activities. The R&D spillover elasticities are based on estimates by Kancs and Siliverstovs (2016).

[4] The model allows one to switch from a wage curve assumption to a Phillips curve assumption in wage formation. The current analysis is based on the wage curve assumption.

Due to the model's high dimensionality, its dynamics have to be kept relatively simple. Expectations are assumed myopic and the model is solved sequentially with stocks being upgraded at the beginning of each period. The policy scenarios are simulated on the latest version of the RHOMOLO model calibrated to the base year of 2013. The following model specifications were chosen: A subset of commodity markets operate under monopolistic competition[5]; wage setting is assumed to follow a long-run wage curve; we assume the existence of capital mobility such that regions have access to international capital markets; and private investments are determined by an investment function implying that private investments varies according to profitability.

3 Policy scenarios

In the impact assessment of the European R&I programme, SEURECO (2018) presents two sets of policy options. The first set describes four scenarios for the future EU research and innovation programme. Each of the four policy scenarios contains €70 billion of public spending. This is approximately identical to the current Horizon 2020 spending adjusted for changes in the EU budget following discontinued contributions from the UK. The scenarios are the following:

- The 'Discontinuation' scenario in which the EU R&I programme is abandoned and the resourced are spend by each Member State for public investments and national R&I support. This scenario serves as reference scenario in our analysis.
- The 'Continuation' scenario in which the EU R&I programme continues similarly to Horizon 2020 until 2027.
- The 'Centralisation' scenario where from 2021 the EU R&I programme is reinforced compared to Horizon 2020 by centralising at EU level a third of the national competitive-based project funding.
- The 'Decentralisation' scenario where the future EU R&I programme is implemented at a national level. Hence, each Member State spends a similar amount to the previous Horizon 2020 in support for national R&I activities.

The second set of policy options presented by SEURECO consists of five declinations of the 'Continuation' scenario in which the size of the budget of the future EU R&I programme varies. In this study, we limit the analysis to consider the regional impact of

[5] These are 'Mining and Utilities', 'Manufacturing', 'Construction' 'Retail and Transportation', 'Information and Communication', Financial, Insurance and Real Estate Activities' and 'Professional, Scientific and Technical Activities'.

the first set of policy options, i.e. the four scenarios 'Continuation', 'Discontinuation', 'Centralisation', and 'Decentralisation'.

For each of the four scenarios, SEURECO provided us with time series on assumed public spending on R&I support within each EU Member State and an estimate of direct leverage effect, i.e. additional R&I spending by the private sector. SUERECO differentiate between direct leverage of funding for basic research, EU funding for applied research, and national funding for national research. Based on assumed shares of funding for basic and applied research, within each of the four scenarios SEURECO provided us with a weighted average of the direct leverage effect for private investments for each of the four scenarios.

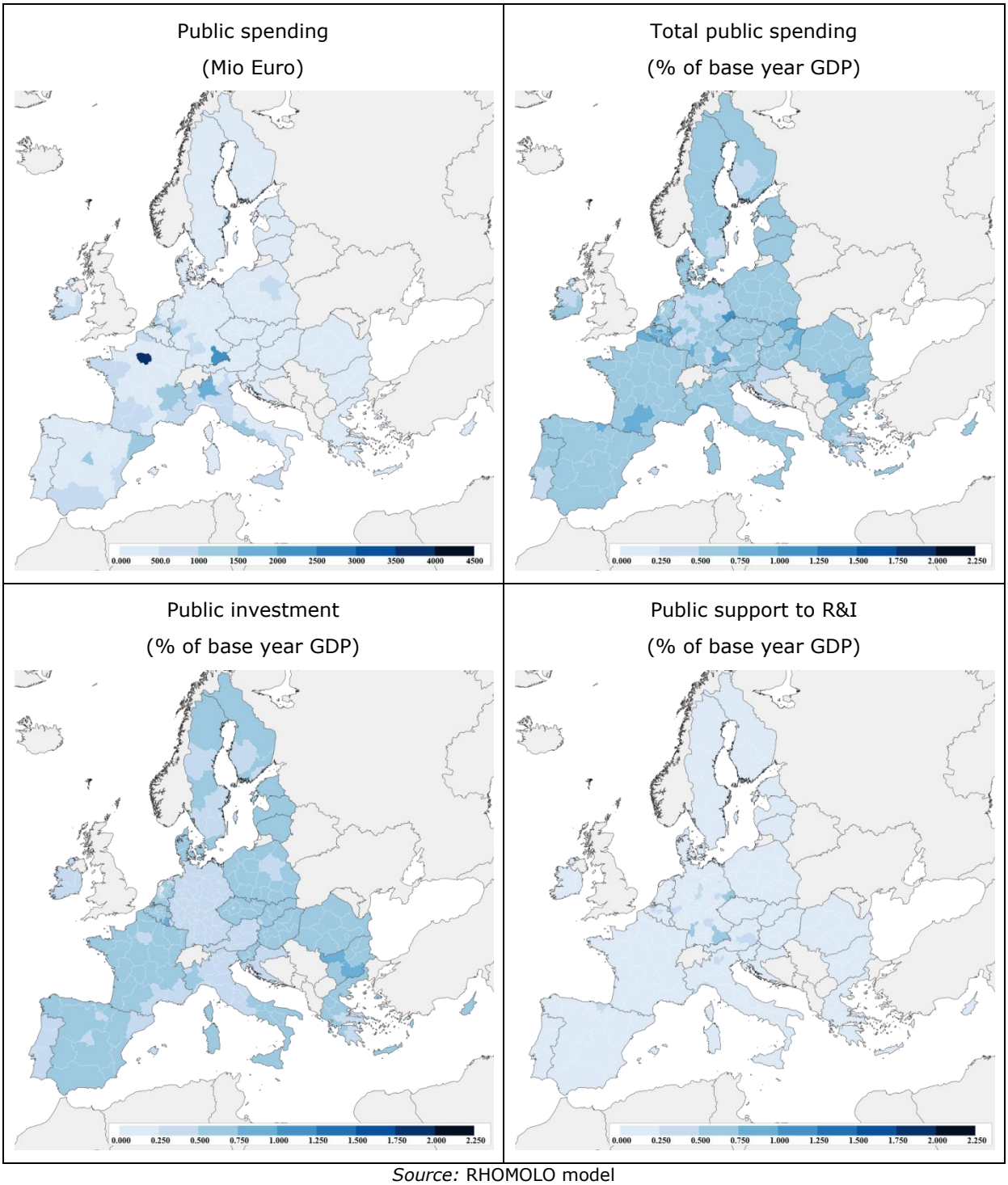
The public spending for R&I support is distributed between sectors of the economy following the sectoral allocation suggested by SEURECO.

The RHOMOLO model describes the economy at the regional NUTS2 level. Therefore, the data obtained from SEURECO is regionalised before being fed into RHOMOLO. The regionalisation of public spending data is based on observed allocation of spending across regions.

For each of the four scenarios we assumed that the €70 billion of public spending is financed by lump sum taxes with the funding shares at the national level proportional to the Member States' net budget contribution and funding shares at the within-country regional level proportional to regional GDP.

For the analysis, we use the 'Discontinuation' scenario as the reference. The 'Discontinuation' scenario assumes that the EU R&I programme is abandoned and the resources are re-allocated to Member States proportionally to their contribution to the EU budget. The funds returned to Member State are used to increase public investments and national public support to R&I. The share of public spending used for respectively public investments and national support for R&I is assumed proportional to observed spending shares. We assume the following regional allocation of public expenditures. Public investments are allocated across regions in a Member State proportionally to current regional allocation of public investments. Public support for R&I support in a Member State is allocated across regions proportional to the allocation of public support for R&I in the current Horizon 2020 Framework Programme.

Figure 1. Additional cumulative public spending allocated to regions in the reference scenario



Source: RHOMOLO model

Cumulative regional allocation of public spending in the reference scenario varies across regions as illustrated in Figure 1. The upper left panel shows the regionalised additional cumulative public spending in the reference scenario for the period 2021-2029 in million Euros.[6] We note that a few regions attract a high amount of public funds. The largest recipient of public spending is assumed to be Île de France (€3,700 million) followed by

[6] The spending programme considered runs from 2021-2027 with an assumed project length of up to three years. This implies public spending for the period 2021-2029.

Oberbayern (€2,200 million), Lombardia (€1,900 million), Rhône-Alpes (€1,500 million), Cataluña (€1,400 million) and Köln (€1,300 million).

The upper left panel shows the cumulative public spending as a proportion of regional GDP in the RHOMOLO model's base year. The additional public funds received by the regions is assumed to vary from 0.34% of base year GDP in the Italian region Provincia Autonoma di Bolzano to 1.09% of base year GDP in the Belgian region Vlaams-Brabant.

The additional €70 billion of public spending in the reference scenario is split into public investments and national public support to R&I. A total of €53 billion is assumed spend on public investments while the remaining €17 billion is assumed spend on national R&I support. The split between the two spending types varies largely across regions. For example, the Belgian region Vlaams-Brabant receives 60% of the additional public spending for public investments and 40% for public support to R&I. In contrast, Dresden receives 37% of its public funds for public investments and 63% for public support to R&I.

The lower part of Figure 1 depicts the allocation of public spending for respectively public investments and national R&I support. Regional spending on public investments varies from 0.28% of base year GDP to 0.79% of base year GDP. The figure reveals that a large variation exists in the regional allocation of public funds for national R&I support. The funding received by regions for R&I support varies from 0.00% of base year GDP to 0.67% of base year GDP. The largest receivers of funds for R&I support are R&I intensive metropolitan regions across the EU.

In the analysis, the socio-economic impact of the reference scenario is compared with the socio-economic impact of the three alternative policy scenarios; 'Continuation', 'Centralisation', and 'Decentralisation'. Each of the alternative scenarios considered in the impact assessment describes a shift in spending strategy from public investments to public support for R&I.

The 'Continuation' scenario assumes that the EU R&I programme continues similarly to Horizon 2020 until 2027. Thus, the €70 billion of public spending is allocated to the regions for R&I support through the EU R&I programme. The regionalisation of public expenditure in support for R&I is based on the regional allocation of the current Horizon 2020 Framework Programme. Hence, it is assumed that future R&I support would follow the same regional allocation as the previous spending programme.

The upper left side panel of Figure 2 shows the regional allocation of cumulative public spending under the 'Continuation' scenario. The cumulative EU spending for R&I support received by the regions is assumed to vary from 0.00% of base year GDP to 1.85% of base year GDP. As can be seen from the figure the main recipients of EU public spending for R&I support are R&I intensive metropolitan areas across the EU. The largest recipients of cumulative EU spending in percent of GDP are the Belgian Région de Bruxelles-Capitale (1.85% of base year GDP) and Prov. Vlaams-Brabant (1.70% of base year GDP). This is followed by Dresden (1.67% of base year GDP), Oberbayern (1.59% of base year GDP) and the Romanian region Bucuresti-Ilfov (1.54% of base year GDP).

The upper right side panel of Figure 2 shows the net change in public funds allocated to the regions in the 'Continuation' scenario relative to the reference scenario. The net change in cumulative public spending received by the regions varies from -0.71% of base year GDP to 1.08% of base year GDP. In the 'Continuation' scenario 66 regions experience a net rise in public funds received while 164 regions suffer a net loss of public funds.[7] The 'Continuation' scenario involves a shift in public spending strategy from public investments and national R&I support to EU programmes for public R&I support. Hence, all regions experience a decline in public investments relative to the reference scenario (as illustrated in the lower left panel of Figure 2). Likewise, all regions experience a net rise in public support for R&I (as shown in the lower right panel of Figure 2).[8] However, the most R&I intensive regions attracts a larger share of R&I support and therefore experience the largest net gain in public funding in the 'Continuation' scenario. In contrast less R&I intensive regions attract less funding for R&I support and suffer from a net decline in public funds received.

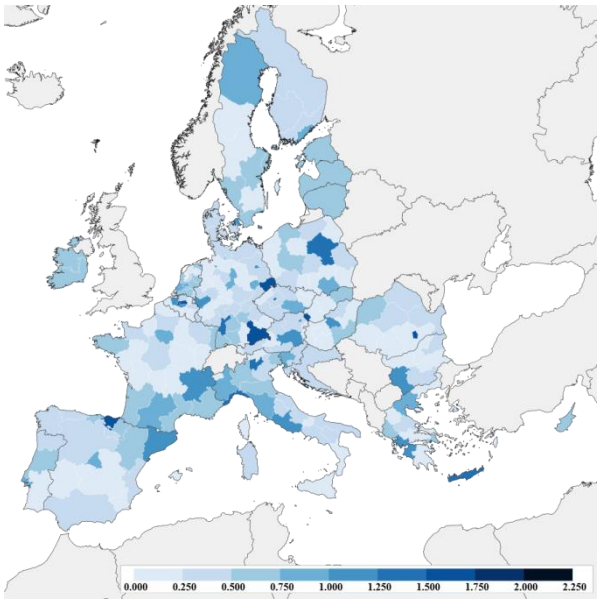
The 'Centralisation' scenario involves a shift in public spending strategy from public investments and national R&I support to EU programmes for public R&I support. Furthermore, it is assumed that the EU R&I programme after 2020 is reinforced compared to Horizon 2020 by centralising at EU level a third of the national competitive-based project funding. Hence, Member States are allocating a part of their national spending in support for R&I to the EU R&I programme. This is assumed to increase the budget for the EU R&I support programme to €133 billion.

[7] Excluding the UK reduces the number of EU regions in the RHOMOLO model to 230.
[8] The net change in public funding in support to R&I received by the regions varies from 0.00% of base year GDP to 1.50% of base year GDP.

Figure 2. Cumulative regional public spending in the Continuation scenario

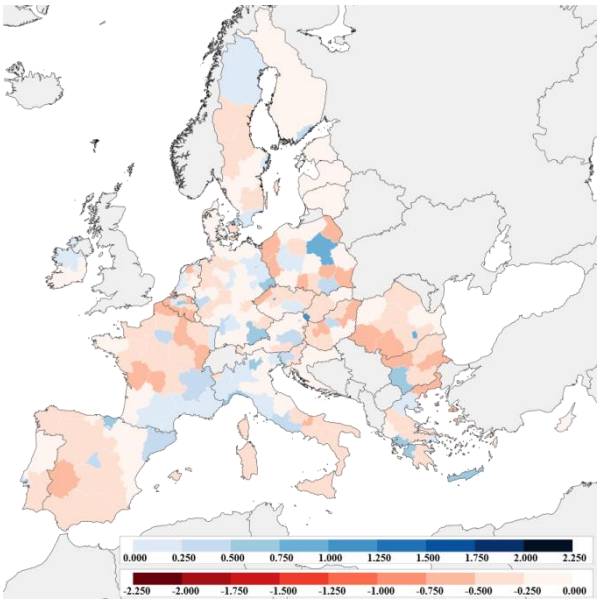
Public spending

(% of base year GDP)



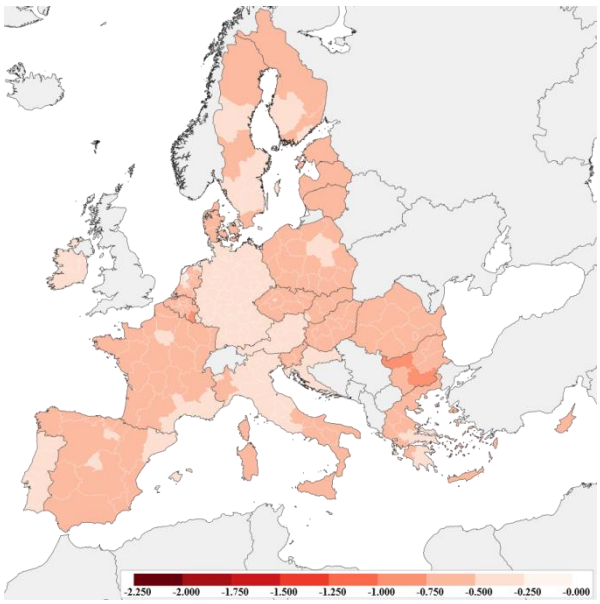
Net change in public spending

(% of base year GDP)



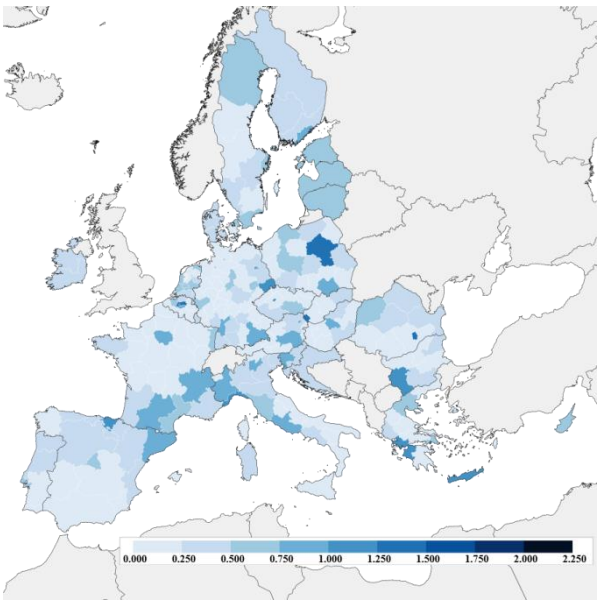
Net change in public investment

(% of base year GDP)



Net change in public support to R&I

(% of base year GDP)



Source: RHOMOLO model

As illustrated in the upper left panel of Figure 3 the main recipients of EU public spending for R&I support in the 'Centralisation' scenario remain the R&I intensive metropolitan areas across the EU. The cumulative EU spending for R&I support received by the regions is assumed to vary from 0.00% of base year GDP to 2.46% of base year GDP. The net gain in public funds received by the regions varies from -0.66% of base year GDP to 1.86% of base year GDP (as shown in the upper right panel of Figure 3).

The reinforcement of the EU R&I programme in the 'Centralisation' scenario is financed by Member States who are allocating a part of their national competitive-based spending in support for R&I to the EU R&I programme. Reinforcing the EU R&I programme in such a way results in a net transfer of public spending for R&I support from regions in Member States with relative high national competitive-based R&I support (such as Germany, Sweden, Denmark, Finland, Austria, and France) towards regions in the other Member States. This is illustrated in the left panels of Figure 3 who reveal that R&I intensive regions in Member States with more modest national competitive-based R&I spending stand to gain from the reinforcement of the EU R&I support programme as the rise in funding from EU programme outweigh the decline in national funding for R&I.

The largest recipients of cumulative EU spending for R&I support in the 'Centralisation' scenario becomes the Romanian region Bucuresti-Ilfov (2.46% of base year GDP), the Belgian Région de Bruxelles-Capitale (2.41% of base year GDP), the Belgian region Prov. Vlaams-Brabant (2.21% of base year GDP), the Slovakian region Bratislavský kraj (2.11% of base year GDP) and the Bulgarian region Yugozapaden (1.95% of base year GDP).

Although some regions lose from the reinforcement of the EU R&I programme, it should be emphasized that all regions in the 'Centralisation' scenario experience a rise in public funding for R&I support relative to the reference scenario.

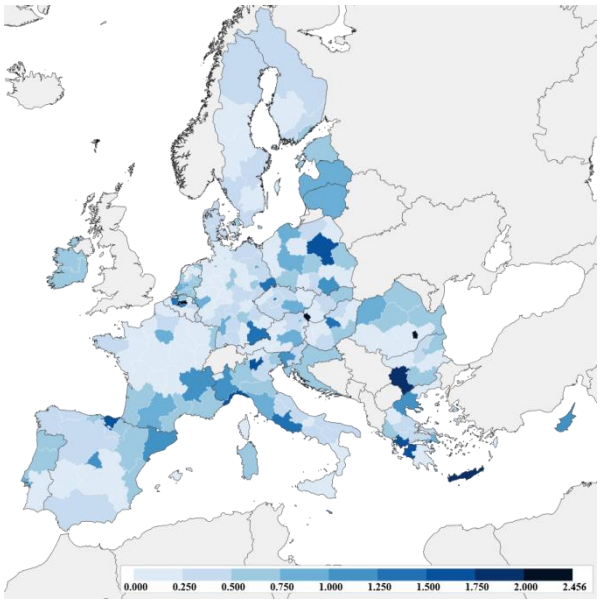
Finally, the 'Decentralisation' scenario assumes that the future EU R&I programme is implemented at the national level. Hence, each Member State spends an amount similar to what was previously spent under Horizon 2020 and allocates it to national R&I support activities. We assume that the regionalised allocation of national spending remains as under the current Horizon 2020 Framework Programme. Therefore, regionalised public spending resembles that of the 'Continuation' scenario shown in Figure 2.

In the analysis, we follow SEURECO and assume that public funding for support to R&I generates direct leverage of private R&I investments. SUERECO differentiates between direct leverage of funding for basic research, EU funding for applied research, and national funding for applied research. We follow SEURECO and assume that EU funding for support to R&I in the 'Continuation' scenario and the 'Centralisation' scenario generate an average direct leverage of private R&I investment of 9.75%. However, following assumptions on investment leverage made by SEURECO, we assumed that national R&I programmes generate less direct leverage than EU funded R&I programmes. Hence, in the 'Decentralisation' scenario public funding in support to R&I generates an average direct leverage of private R&I investment of 6.50%.

Figure 3. Cumulative regional public spending in the Centralisation scenario

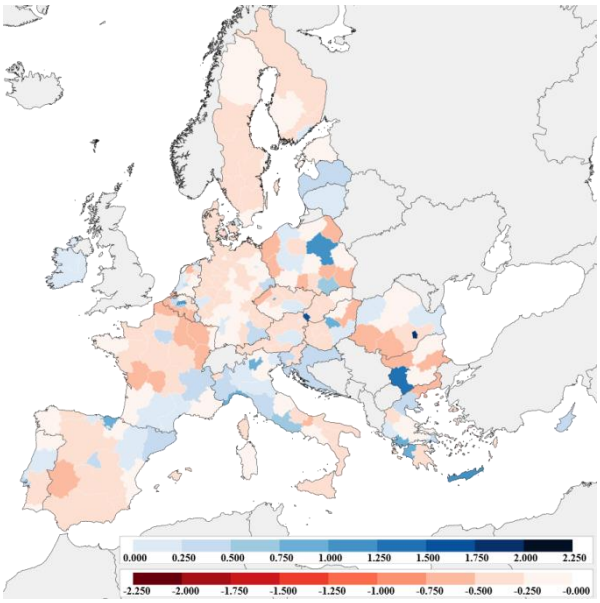
Public spending

(% of base year GDP)



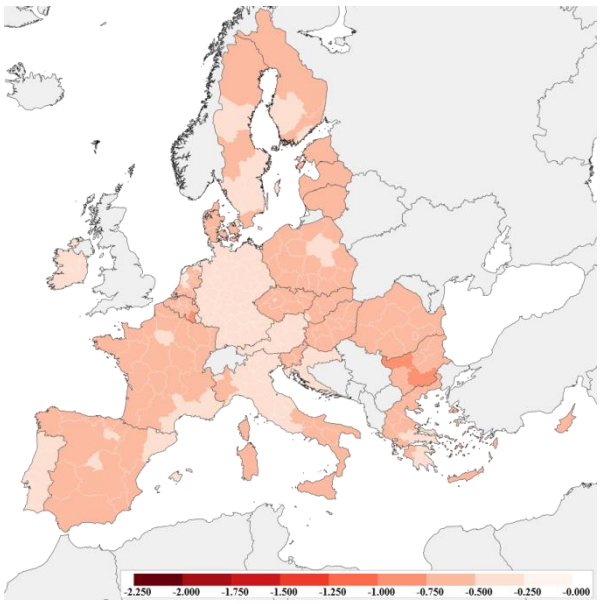
Net change in public spending

(% of base year GDP)



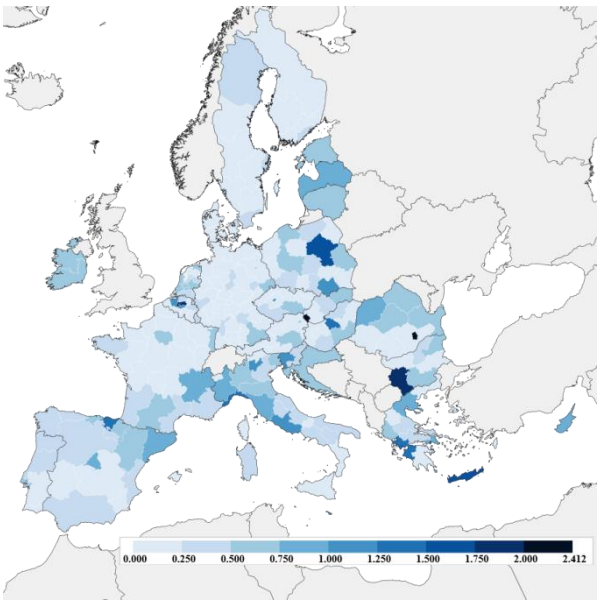
Net change in public investment

(% of base year GDP)



Net change in public support to R&I

(% of base year GDP)



Source: RHOMOLO model

4 Simulations on RHOMOLO

In this section we examine the socio-economic impact of the set of alternative spending strategies simulated on the RHOMOLO model. The results are presented as deviations from the reference scenario (the 'Discontinuation' scenario). We begin by considering the main transmissions channels of R&I spending shocks in RHOMOLO.

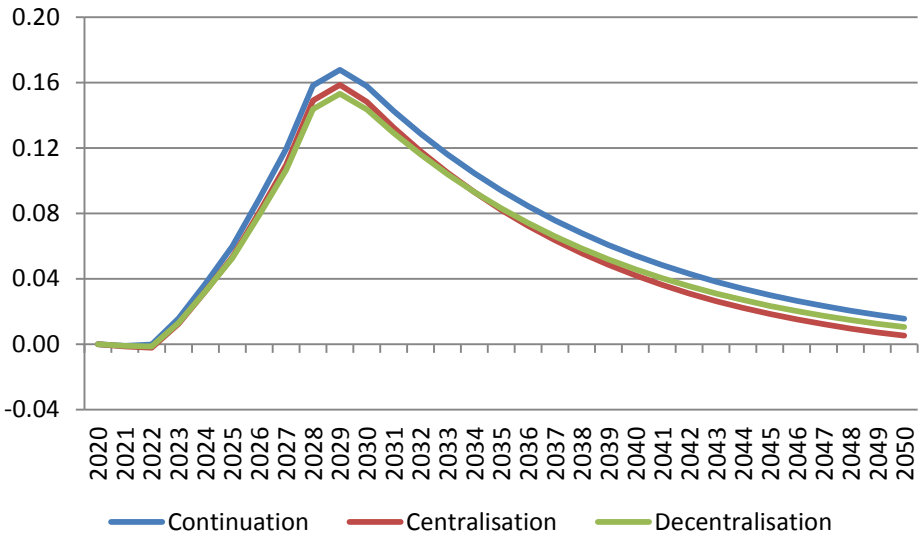
In all three alternative policy scenarios it is assumed that public funding is taken from national public investments and national support to R&I and instead are allocated to the European R&I programme (either managed at the EU level or at the national level). In RHOMOLO such a shift in spending strategy would mainly affect the economy through the two following channels: A demand channel and a productivity channel. First, consider the demand channel. The change of spending strategy results in a rise in public spending in support to R&I. This generates an increase in private R&I investments which raise private demand for capital goods. Resources are being reallocated from public investments which reduce the public demand for capital goods. How the shift in spending strategy affects the aggregate demand within a region depends on the combined effects of the decline in regional public investment and the rise in private R&I investments. Aggregate demand is also affected by the composition of inputs (material inputs and factor inputs) used in the production of the composite capital good demanded by respectively the private R&I investors and the government. This would depend on the sectors from which the material inputs are sourced, how much of these sectors' input that is produced domestically and how much that is imported, and on the share of the various domestic production factors used in the production of the capital goods. For example, a shift in investment demand towards capital goods with a higher domestic input share and a higher share of factor inputs would all else equal increase domestic production and household income.

Second, consider the productivity channel. A rise in private R&I investments leads to higher knowledge accumulation which in turn generates a rise in TFP. In contrast, lower public capital accumulation generates lower productivity growth since fewer public capital services reduces efficiency of the private production sectors in the region.

Based on the simulation results we first examine the aggregate socio-economic impact for the EU excluding the UK (for simplicity we will refer to this as EU). Figure 4 shows the change in EU GDP relative to the reference scenario for the set of alternative spending strategies. As shown in the Figure, in all scenarios there is a gradual rise in EU GDP peaking in 2029. The highest impact is recorded under the Continuation scenario, with EU GDP in 2029 being 0.17% higher than the reference scenario, and the lowest impact is associated with the Decentralisation scenario (0.15% higher than the reference scenario). The gradual rise in EU GDP is mainly caused by higher TFP growth due to

higher R&I investments. This is not offset by lower productivity due to fewer public investments. The long run GDP impact of the EU R&I programme, under any scenario, is more modest. This is mainly due to changes in TFP. For example, in the 'Continuation' scenario the EU spending programme is assumed to run until 2027 after which the public R&I support programme stops. In the RHOMOLO model an efficiency gain from the accumulated knowledge stock is assumed to depreciate. Hence, TFP gains from R&I investments made in the past gradually dies out.

Figure 4. EU GDP deviation for the set of policy options (percentage change relative to reference scenario)



Source: RHOMOLO model

Comparing the different alternative policy scenarios allow us to explore why the 'Continuation' scenario generates higher impact on EU GDP than the other scenarios. In the 'Centralisation' scenario, resources are shifted from national public investments and national R&I support towards the EU R&I support programme. In addition, a third of the national competitive based project funding is centralised at EU level. This results in a reallocation of public R&I funding to regions in Member States with low levels of national R&I support spending. The centralisation at the EU level of funding for R&I support results in a shift in R&I investments from some of the most R&I intensive regions to slightly less R&I intensive regions. In RHOMOLO, such a shift in public funding from more R&I intensive regions to slightly less R&I intensive regions results in a small reduction in TFP growth compared to the 'Continuation' scenario. This happens because the regional TFP elasticity which governs the spillover from R&I investments to TFP is positively related to regional R&I intensity.

The 'Decentralisation' scenario assumes that the future EU R&I programme is implemented at the national level. Each Member State spends an amount similar to what

was previously spent under the EU R&I programme and allocate it to national R&I support activities with an unchanged regional allocation of spending. The direct leverage of public expenditure in support to R&I is assumed to be lower for national spending programmes than for the EU spending programme. The lower direct leverage of private investments associated with national R&I support programmes slightly reduces the growth in EU GDP compared to the other R&I programmes. However, in the long term EU GDP become higher in the 'Decentralisation' scenario than in the 'Centralisation' scenario but still increases less than in the 'Continuation' scenario.

Table 1 shows the deviation in cumulative EU GDP relative to the reference scenario. The 'Continuation' scenario results in cumulative EU GDP in 2040 to become 0.07% higher than in the reference scenario. The rise in cumulative EU GDP in the 'Continuation' scenario is slightly higher than in the 'Centralisation' scenario and the 'Decentralisation' scenario. The deviation in cumulative EU GDP in 2050 is lower than in 2040 as TFP improvements caused by R&I investments made in the past are reduced at the rate of depreciation.

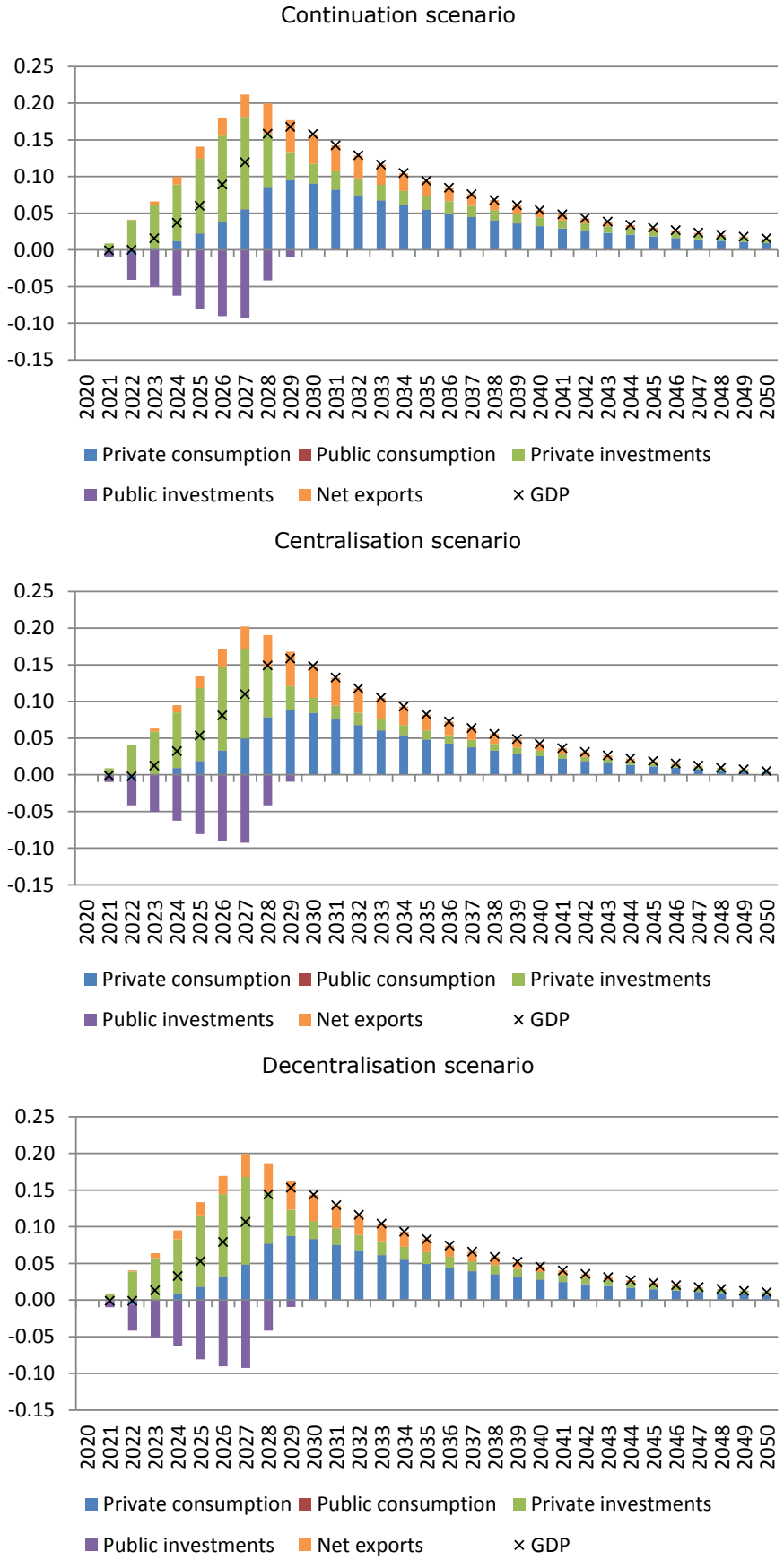
Table 1. Cumulative EU GDP deviation (percent change relative to reference scenario)

	Continuation	**Centralisation**	**Decentralisation**
Cumulative EU GDP deviation in 2030	0.063	0.058	0.056
Cumulative EU GDP deviation in 2040	0.071	0.064	0.063
Cumulative EU GDP deviation in 2050	0.056	0.048	0.049

Source: RHOMOLO model

Decomposing the deviation in EU GDP into macroeconomic aggregates allow us to examine the main drivers of GDP growth. As illustrated in Figure 5, the change in public spending strategy in the 'Continuation' scenario causes a temporary decline in public investments in the EU Member States in the period 2021-2029. Private investments rise and at first this is the main driver of the increase in EU GDP relative to the reference scenario. The change in spending strategy also leads to a rise in private household consumption and an increase in net exports. Starting from 2028, the rise in private household consumption contributes the most to the rise in EU GDP. Higher productivity growth results in an improvement of the EU trade balance, higher private investments and consumption opportunities for EU households.

Figure 5. EU GDP deviations decomposed into macroeconomic aggregates (percentage change relative to reference scenario)

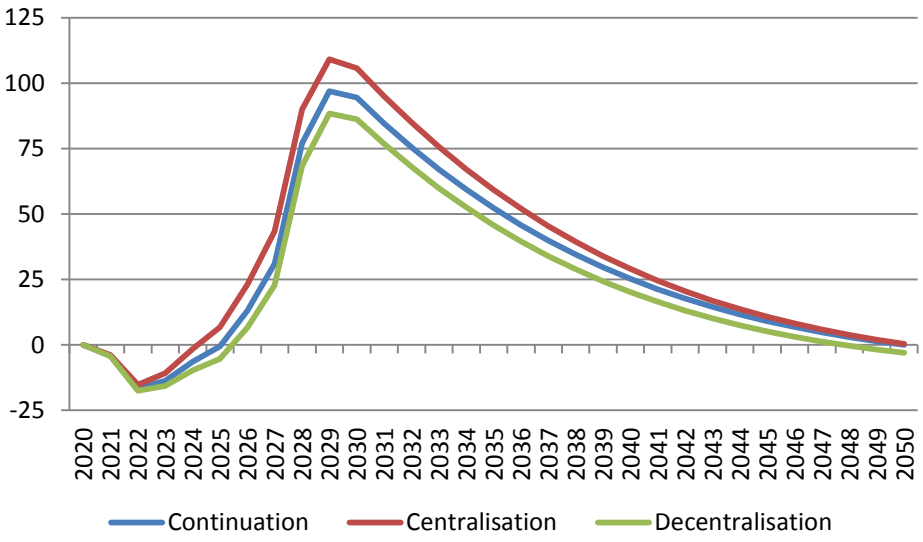


Source: RHOMOLO model

Decomposing the deviation in EU GDP into macroeconomic aggregates for the 'Centralisation' scenario and the 'Decentralisation' reveals similar effects. The rise in private investments and private household consumption is marginally lower than in the 'Continuation' scenario. In contrast, net exports become marginally higher than in the 'Continuation' scenario.

Figure 6 shows the change in EU employment relative to the reference scenario for the set of alternative policy options. The initial shift in investment demand from public investments to R&I investments leads to a small fall in employment for all scenarios considered as the production of public capital goods is more labour intensive than the production of private investment goods. The initial fall in EU employment peaks in 2022 where it for the 'Continuation' scenario is 17,000 jobs lower than in the reference scenario. The initial fall in EU employment is 15,000 jobs in the 'Centralisation' scenario and 18,000 jobs in the 'Decentralisation' scenario. However, gradually EU employment rises as a result of higher TFP growth which improves competitiveness. The EU employment is at its highest in 2029, where employment in the 'Continuation' scenario is 97,000 jobs higher than the reference scenario. EU Employment in the 'Centralisation' scenario and the 'Decentralisation' scenario is respectively 106,000 jobs and 86,000 jobs higher than the reference scenario. Long term EU employment returns to the level of the reference scenario.

Figure 6. EU employment deviation for the set of policy options (change from reference scenario, thousand jobs)



Source: RHOMOLO model

For the 'Centralisation' scenario we observe a higher impact on EU employment than for the 'Continuation scenario. Comparing the impact in terms of GDP and employment in these two scenarios we note that EU employment increases more in the 'Centralisation'

scenario whereas EU GDP increases less. The higher impact on EU employment in the 'Centralisation' scenario is the results of a reallocation of public spending for R&I support towards regions which higher unemployment rates and more labour intensive production. Thus, a relatively lower increase in value added is produced with relatively more labour inputs.

Decentralisation of public support to R&I at the national level is assumed to reduce the direct leverage of private investments which in turn reduces the impact of R&I support on EU employment. Hence, the 'Decentralisation' scenario results in a smaller rise in employment than the 'Continuation' scenario and the 'Centralisation' scenario.

Table 2 shows the deviation in average EU employment for the alternative policy scenarios considered. Comparing the scenarios shows that the 'Centralisation' scenario results in the largest increase in average EU employment relative to the reference scenario. For the period 2020-2040 the 'Centralisation' scenario results in a rise in average EU employment of 47,000 jobs per year. For the time same period, the 'Continuation' scenario results in an increase in average EU employment of 40,000 jobs per year, while the 'Decentralisation' scenario results in an increase in average EU employment of 34,000 jobs per year.

Table 2. Average EU employment deviation (thousands of jobs - difference from reference scenario)

	Continuation	Centralisation	Decentralisation
Average EU employment deviation 2020-2030	27.9	35.4	22.7
Average EU employment deviation 2020-2040	40.1	47.2	34.3
Average EU employment deviation 2020-2050	29.9	35.1	24.7

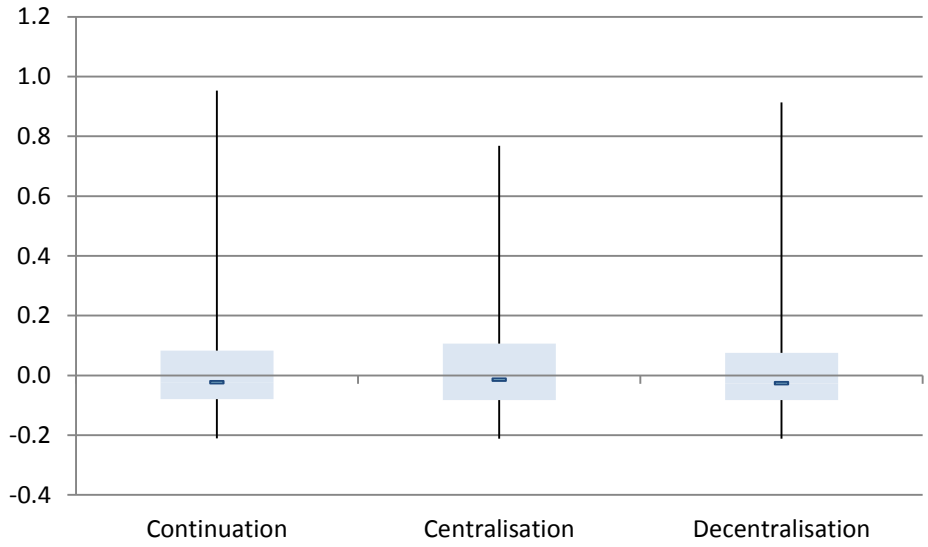
Source: RHOMOLO model

The results discussed so far have been concerned with changes in EU aggregates. However, RHOMOLO allows for an assessment of socio-economic impacts at the regional level following a change in spending strategy. The allocation of public spending varies across regions. Furthermore, regions vary in industrial structure, trade patterns and composition of production factors. Hence, regions may be impacted differently by a given policy change. Next, we therefore consider the regional economic impact of the alternative policy scenarios.

Figure 7 shows a box plot of the regional GDP impact for each of the alternative policy scenarios. The box plot illustrates the distribution of the regional deviation in cumulative GDP in 2040. The central rectangle spans the first quartile to the third quartile, with the small horizontal line inside the rectangle showing the median. The vertical line that extends from the top of the rectangle indicates the maximum value of GDP impact, and

the vertical line that extends from the bottom of the rectangle indicates the minimum value of GDP impact.

Figure 7. Distribution of cumulative regional GDP deviation in 2040 (percentage change relative to reference scenario)



Source: RHOMOLO model

Each of the three alternative policy scenarios considered results in an increase in aggregate cumulative EU GDP in 2040. However, considerable heterogeneity exists in regional GDP impact. Slightly more than half of the regions experience a fall in cumulative GDP in 2040. The decline in GDP for the median region is relatively modest. In the 'Continuation' scenario the median region suffers a decline in GDP of 0.02% relative to the Reference scenario. In the 'Centralisation' and the 'Decentralisation' scenarios, the median region suffers losses in GDP relative to the reference scenario of respectively 0.02% and 0.03%. The box plot further reveals that the distribution of regional GDP deviation is skewed in all three policy scenario. The span from the third quartile to the maximum value is higher than the span from the minimum to the first quartile. Hence, a small number of regions experience relatively large increase in cumulative GDP. To explain the regional differences, let us first consider the 'Continuation' scenario. The 'Continuation' scenario causes a shift from public investments to private R&I investments. This results in a rise in regional TFP growth and a decline in efficiency from public capital services. However, the shifts in spending are not evenly distributed across regions. Some regions experiences a net loss in public spending driven by a decline in public investments; others experience a net gain in public spending driven by a rise in EU public support to R&I. The uneven net change in allocation of public funds generates heterogeneous regional impacts on aggregate demand, productivity growth and changes in relative prices. Therefore, as a result some regions experience a decline in GDP while other regions gain.

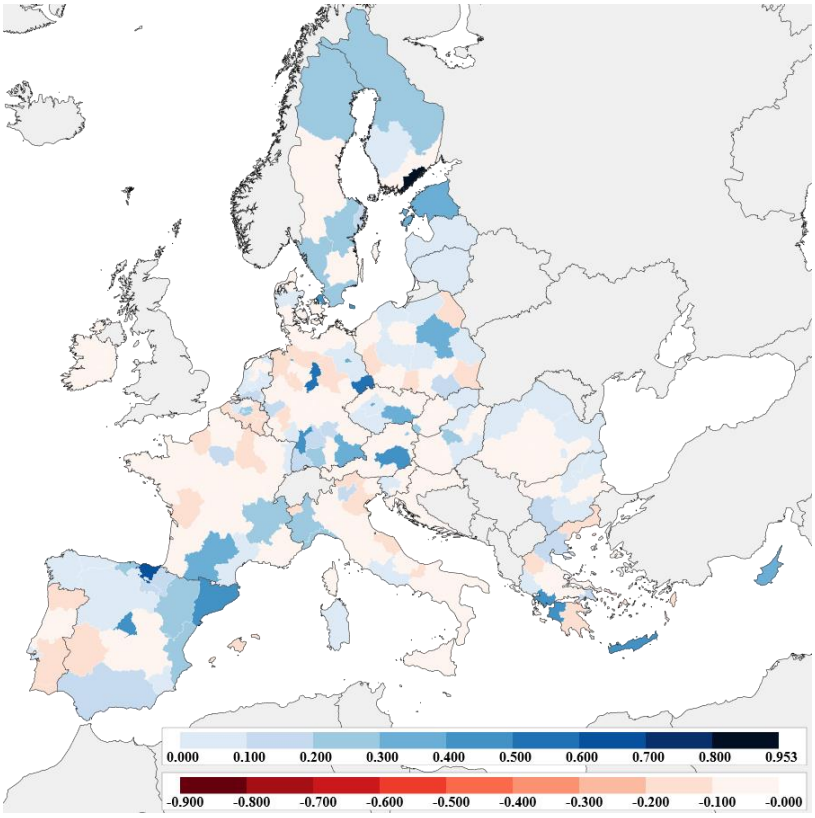
Comparing the scenarios in the Box plot reveals that a move from the 'Continuation' scenario to the other alternative R&I programmes mainly impact GDP for the regions who benefit the most from R&I support polices. In the 'Centralisation' scenario the GDP gain for the region at the third quartile is higher than for the 'Continuation' scenario whereas the maximum gain is smaller. This is caused by the net transfer of R&I funding from regions in Member States with the highest national public spending for competitive-based R&I support to regions in Member States with lower national public spending for competitive-based R&I support. In the 'Decentralisation' scenario, the GDP gain is smaller at the maximum and at the third quartile than for the 'Continuation' scenario. This is the result of lower levels of regional R&I investment generated by lower direct leverage. In contrast, a move from the 'Continuation' scenario to the other alternative policy scenarios only marginally affects the GDP impact at the first quartile and at the minimum. These regions receive less public funds for R&I support and are therefore less affected by a change in the design of the R&I programme.

Figure 8 shows the spatial distribution of cumulative regional GDP deviations in 2040 for the set of alternative policy scenarios. For the 'Continuation' scenario, we observe that the rise in cumulative GDP is more prominent in R&I intensive regions which are large recipient of public spending in support for R&I. Generally those regions would experience a boost in TFP growth and gain of competitiveness leading to an increase in GDP. In contrast, other less R&I intensive regions suffer from the shift in allocation of spending from public investments to public R&I support which results in a decline in cumulative GDP relative to the reference scenario. The change in public spending in the 'Continuation' scenario results in an increase in GDP in 97 regions and a decline in GDP in 133 regions relative to the reference scenario.

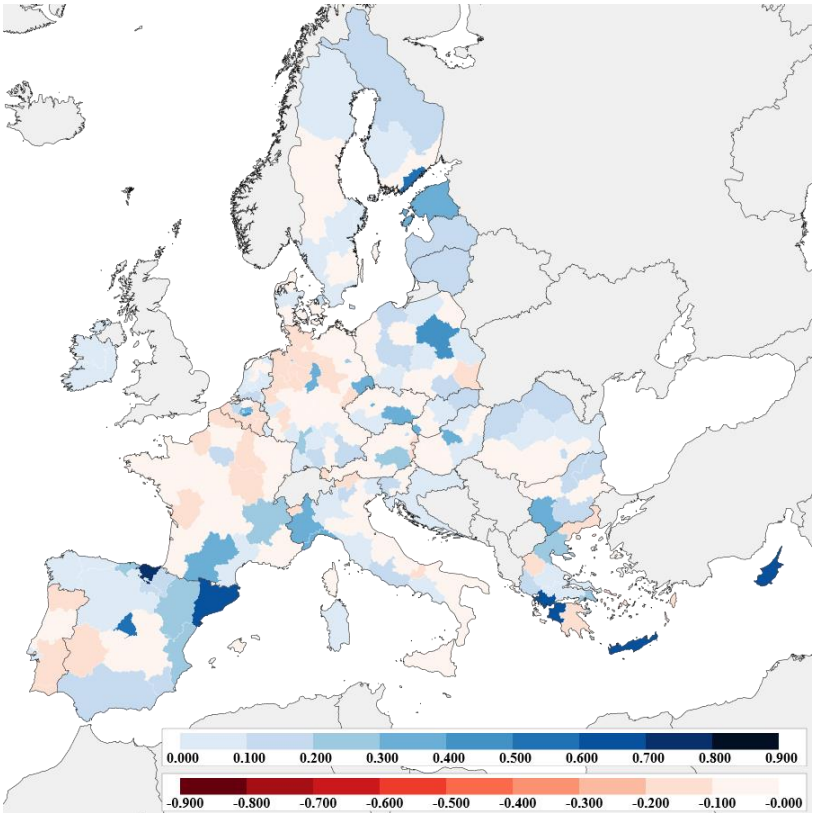
The reinforcement of the EU R&I programme in the 'Centralisation' scenario mostly benefits R&I intensive regions not located in the Member States with the highest national level of public competitive-based R&I support. A total of 108 regions experience a gain in cumulative GDP relative to the reference scenario, while 122 regions experience a decline in GDP. In the 'Decentralisation' scenario, 94 regions experience a gain in cumulative GDP in 2040 relative to the reference scenario while 136 regions experience a decline. As for the 'Continuation' scenario, the rise in GDP is most prominent in the most R&I intensive regions who are the main benefiters of public R&I support. However, the lower leverage of private R&I investments for national R&I support slightly reduced the GDP gains across regions compared to the 'Continuation' scenario.

Figure 8. Cumulative regional GDP deviation in 2040 for the set of policy options (percentage change relative to reference scenario)

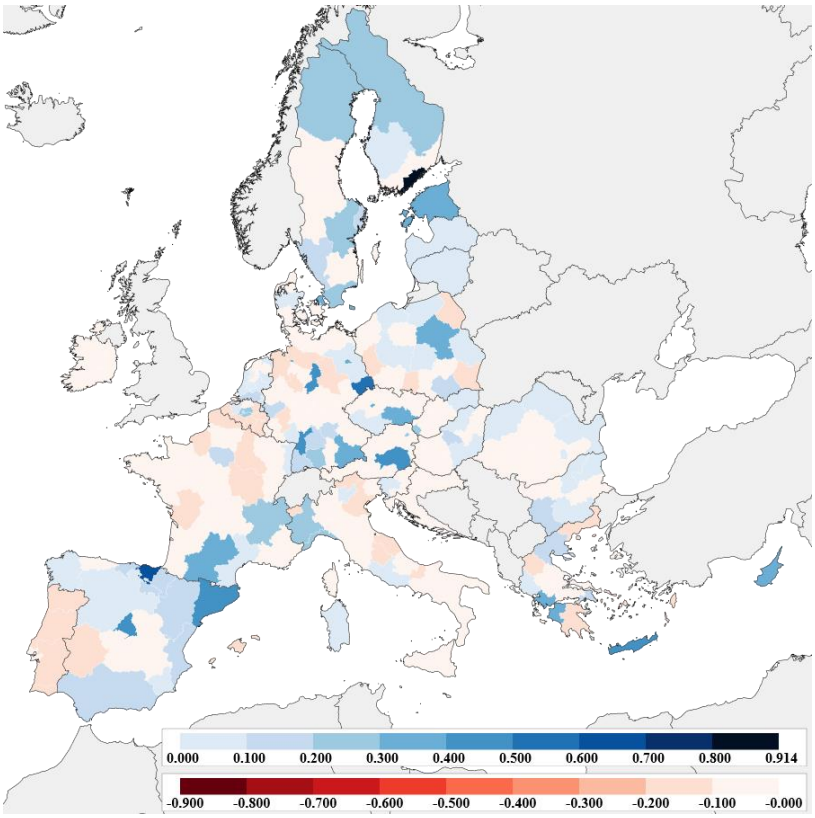
Continuation scenario



Centralisation scenario



Decentralisation scenario

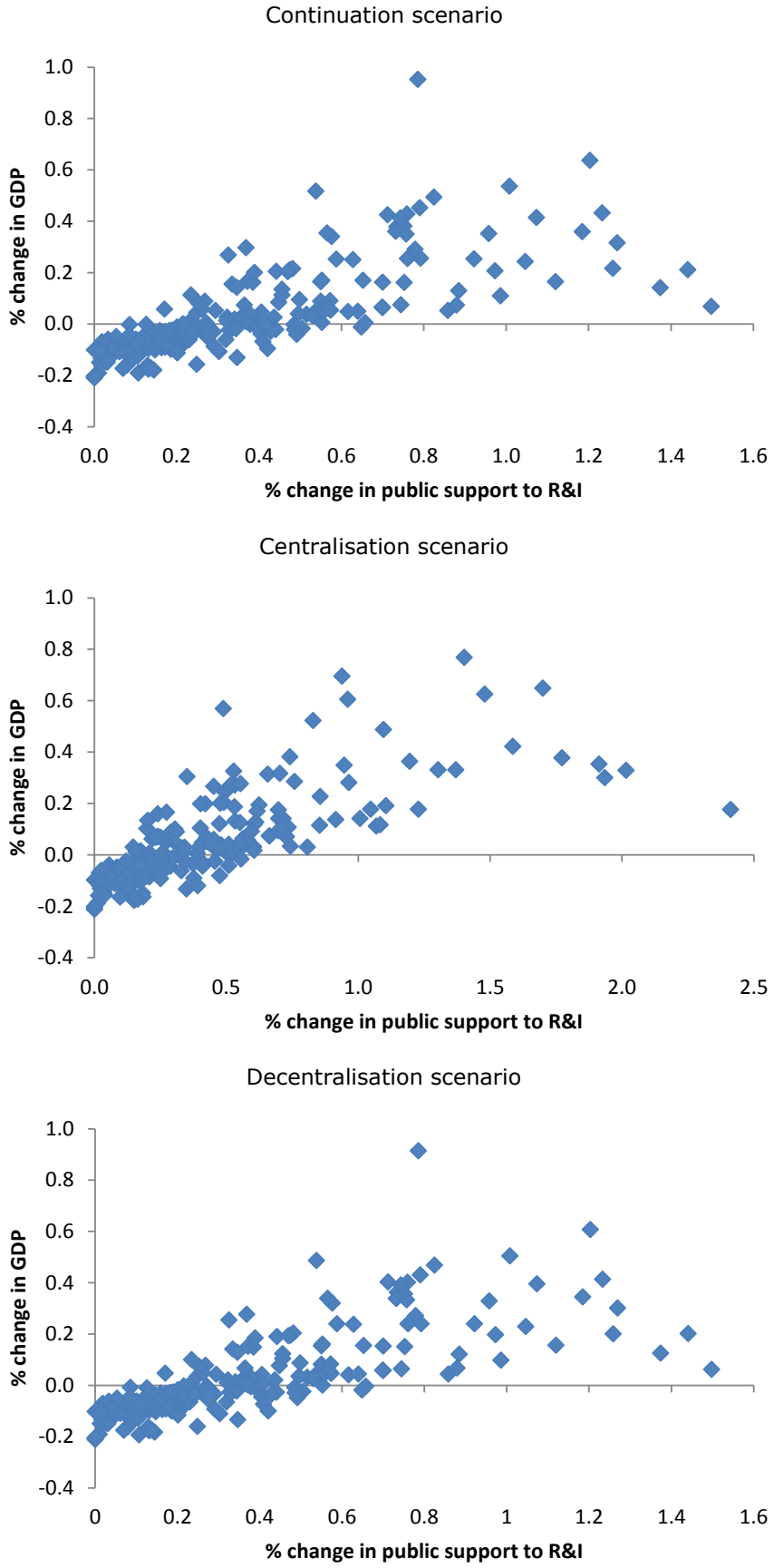


Source: RHOMOLO model

Figure 9 shows the relationship between the deviation in cumulative public spending in support to R&I and the deviation in cumulative GDP in 2040 for all EU regions. The figure reveals a positive relationship between public spending in support to R&I and the change in cumulative GDP. The regions benefitting from larger public spending in support to R&I also experiences larger rise in GDP. However, the change in GDP also depend on other regional characteristics such as R&I intensity, differences in industry structures, the mix of factor inputs and trade patterns which affects the relative change in competitiveness relative to main trading partners.

Figure 9 further reveals that regions which experience a small increase in public spending for R&I support generally also experience a small decline in cumulative GDP relative to the reference scenario. The alternative policy scenarios all concern a shift in spending from public investment to public R&I support. Hence, regions that are allocated small shares of public spending in support to R&I may experience a decline in total net public spending received. For these regions the negative impact from a decline in public investments are stronger than the positive impact from a rise in public spending for R&I support. This causes the decline in GDP.

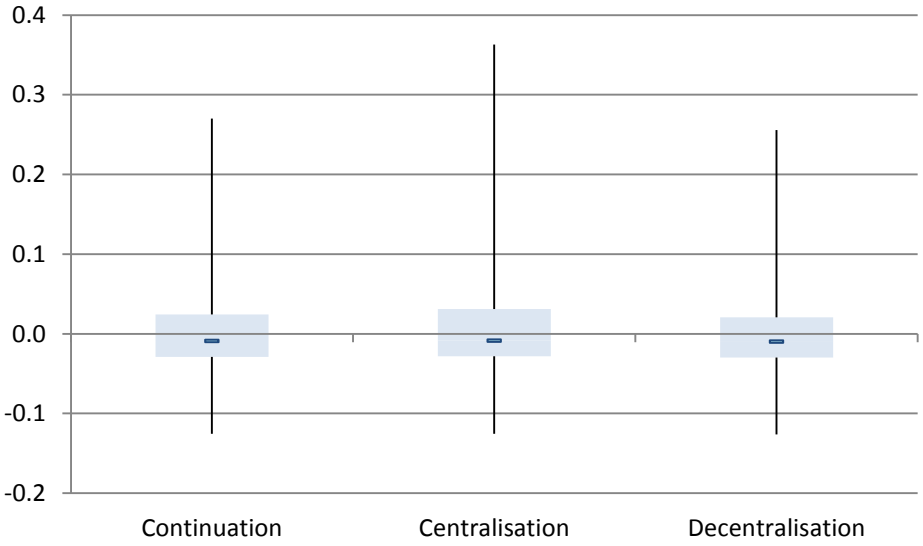
Figure 9. Relationship between the deviation of cumulative public support (EU and national) to R&I and cumulative regional GDP deviation in 2040 (percent change from reference scenario)



Source: RHOMOLO model

We next consider the regional impact on employment. Figure 10 shows a box plot of the cumulative regional impact on employment for each of the policy scenarios. The figure reveals considerable regional variations in employment impact. For all three scenarios the number of regions who suffer from a decline in cumulative employment in 2040 outnumbers the regions benefitting from an improvement in cumulative employment. Furthermore, a small number of regions experience relatively large increases in cumulative employment due to the changes in spending strategies.

Figure 10. Distribution of cumulative regional employment deviation 2020-2040 (percentage change relative to reference scenario)

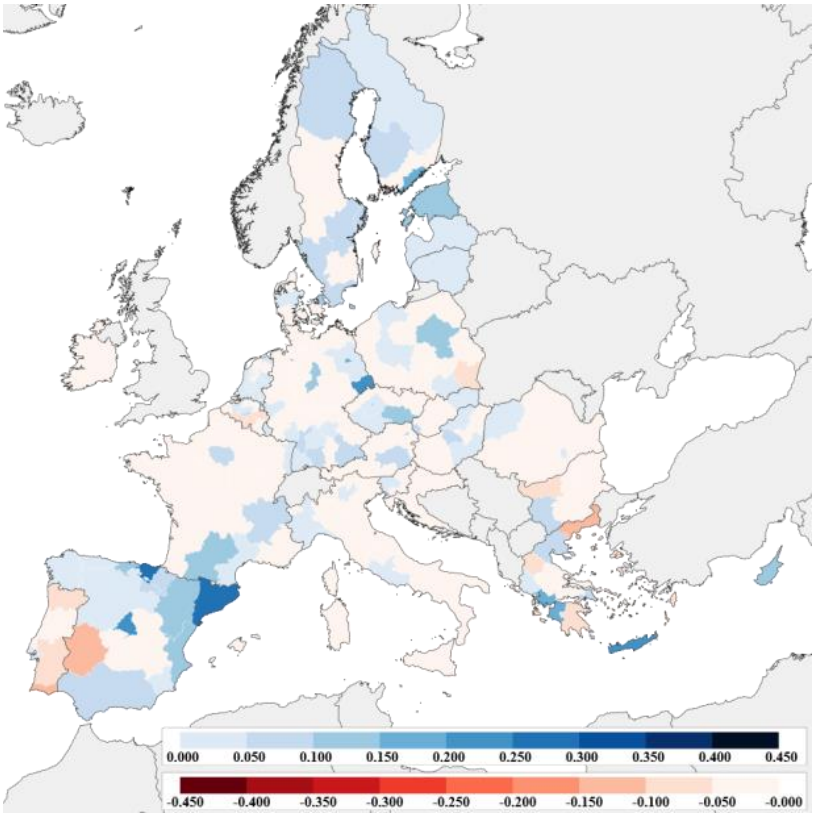


Source: RHOMOLO model

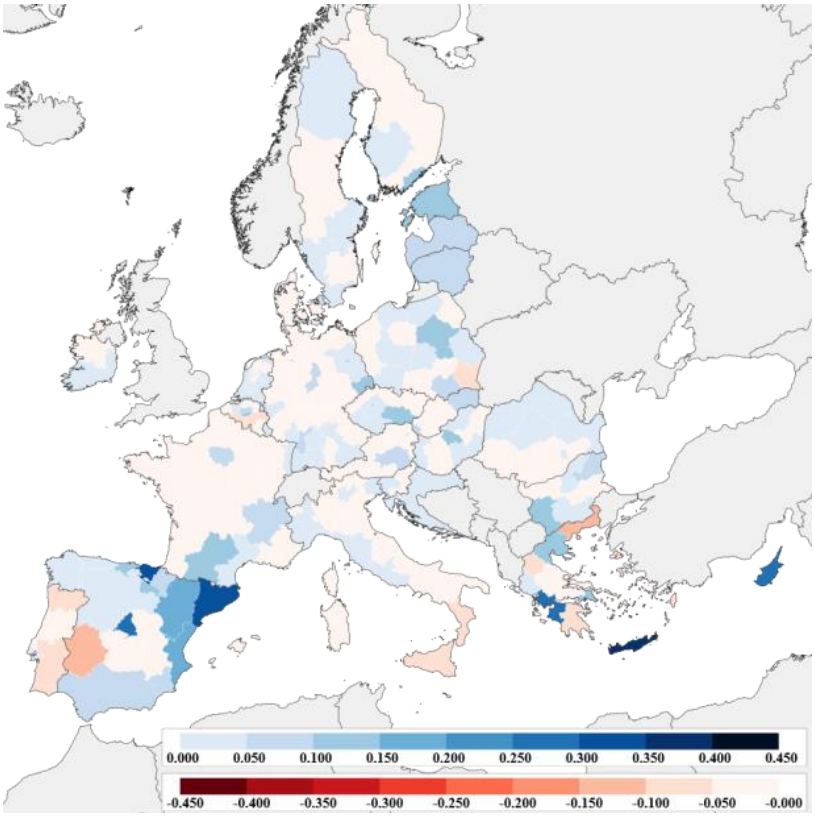
The 'Continuation' scenario results in an increase in cumulative employment in 2040 in 90 regions and a decline in employment in 140 regions. The cumulative employment deviation in 2040 varies from -0.13% to 0.27% across regions. The median region suffers a minor decline in cumulative employment (-0.01% relative to the reference scenario). The 'Centralisation' scenario results in an increase in cumulative employment in 2040 in 103 regions and a decline in employment in 127 regions. The cumulative employment deviation across regions is in the range from -0.13% to 0.36% relative to the reference scenario. The change in public spending strategy for the 'Decentralisation' scenario results in employment effects which are lower than for the 'Continuation' scenario for all quartiles. This is caused by the lower leverage of private R&I investments. In the 'Decentralisation' scenario 87 regions experience a rise in employment while 143 regions experience a decline in employment.

Figure 11. Cumulative regional employment deviation in 2040 for the set of policy options (percentage change relative to reference scenario)

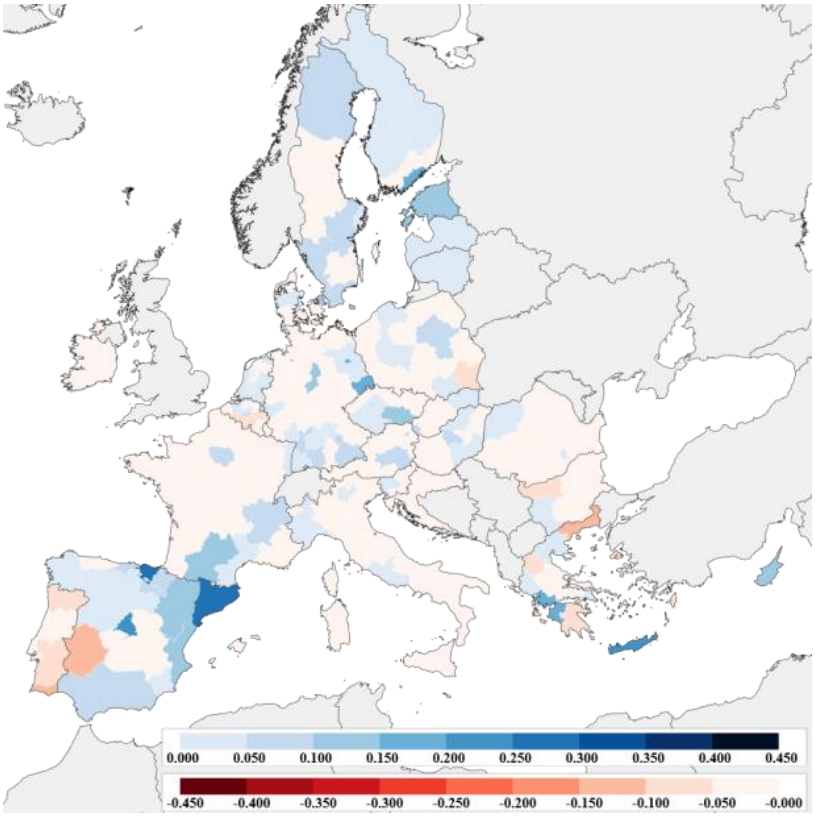
Continuation scenario



Centralisation scenario



Decentralisation scenario



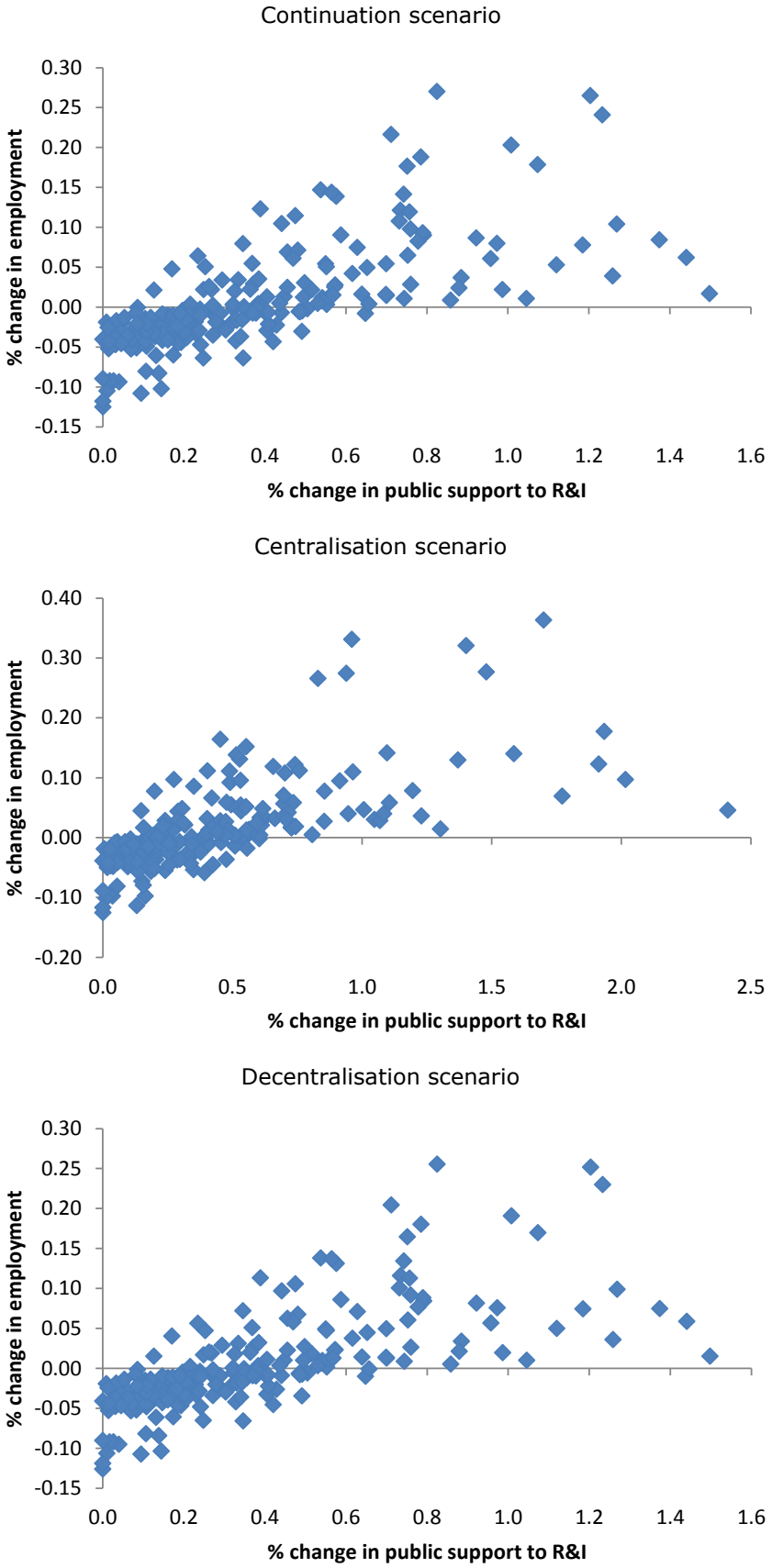
Source: RHOMOLO model

Figure 11 depicts the spatial distribution of the regional changes in cumulative employment deviation in 2040 relative to the reference scenario. The regions which experience the highest impact on employment all benefit substantially from EU funding in support to R&I and at the same time also have relative large unemployment rates which results in a high potential for employment growth.[9] The figure reveals that the reinforcement of the EU R&I programme improves employment in Sothern and Eastern Europe.

Figure 12 shows the relationship between the cumulative deviation in public spending in support to R&I and the cumulative deviation in Employment in 2040 for all the EU regions. The figure reveals a positive relationship between public spending in support to R&I and the change in cumulative employment. However, the change in employment also depend on other regional characteristics which affects the demand for labour such as differences in labour intensity in production, skills composition, regional unemployment rates, industry structures and trade patterns which affects the relative change in competitiveness relative to main trading partners.

[9] The current analysis is conducted on a model version of RHOMOLO in which net migration between regions is held constant and household labour supply is given exogenously. Hence, a rise in employment can only arise from a reduction of the unemployment rate.

Figure 12. Relationship between the deviation of cumulative public support (EU and national) to R&I and cumulative regional employment deviation in 2040 (percent change from reference scenario)



Source: RHOMOLO model

In all scenarios considered regions who gain from a large rise in public support to R&I experience a rise in cumulative employment relative to the reference scenario. In contrast, regions which experience a small rise in public support to R&I generally experience a small decline in cumulative employment relative to the reference scenario. These regions suffer from the shift in spending from public investments to R&I support as the negative impact from the loss of public investments outweighs the positive impact from the rise in public spending for R&I support. Figure 12 also illustrates how the reinforcement of the EU R&I programme in the 'Centralisation' scenario leads to considerable increases in public R&I support in some regions which as a result experience further employment gains.

5 Simulations on RHOMOLO with scaled TFP effects

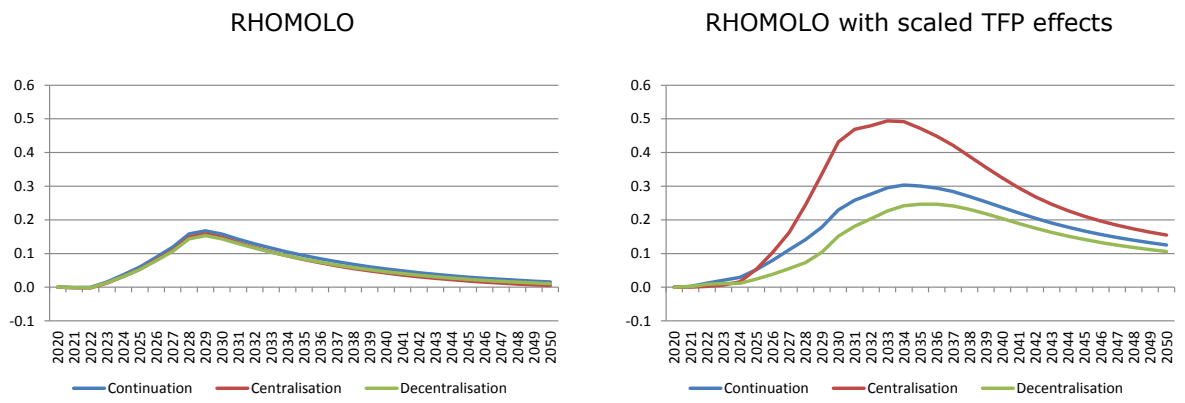
The RHOMOLO simulations presented so far indicate positive impacts from the European R&I programme on EU GDP which are of a smaller magnitude than what is found in simulations by SEURECO using the NEMESIS model. This can to a large extend be attributed to different assumptions concerning spillovers from R&I knowledge to productivity in the two models. This section presents additional results produced with a setting closer to the one assumed in the NEMESIS model. We perform a model simulation in which TFP growth from knowledge creation is scaled to replicate national GDP changes reported in the NEMESIS based impact assessment. The NEMESIS model suggests that R&I funding has a higher impact of national GDP than what is assumed in the RHOMOLO model. Adding scaling of TFP to the model simulation embeds the higher R&I spillover assumed NEMESIS and makes the deviation in EU GDP more responsive to changes in public spending for R&I support than what we observed in the RHOMOLO simulations.

Clearly, a scaling of TFP changes from knowledge creation in RHOMOLO would not solely capture differences in the size of R&I spillovers in the two models. It would also capture other differences in the models such as impacts from trade linkages, preferences of economic agents, production structures, and wage setting. This is a caveat to bear in mind when examining the outcome of the TFP scaled simulations.

Figure 13 shows the deviations in EU GDP for the set of RHOMOLO simulation and the set of alternative simulations on the model with scaled TFP. By construction, the latter simulations result in larger GDP impacts in all the policy scenarios. Under the 'Continuation' scenario, the positive impact on EU GDP reaches its peak in 2034 where it is 0.30% higher than the reference scenario. The impact on EU GDP is more persistent in

the model with scaled TFP and in 2050 EU GDP is still 0.11% higher than in the reference scenario.

Figure 13. EU GDP for the set of policy options (percentage change relative to reference scenario)



Source: RHOMOLO model

The 'Centralisation' scenario simulated on the model with scaled TFP leads to a rise in EU GDP which peaks in 2033 at 0.49% above the reference. Figure 13 shows shows that reinforcing the EU R&I programme in the 'Centralisation' scenario lowers the GDP impact relative to the 'Continuation' scenario when simulated on the RHOMOLO model but raises the GDP impact when simulated on the model with scaled TFP. The opposing GDP impacts are caused by differing assumption concerning R&I spillovers in the two model settings. RHOMOLO assumes a spatial variation in spillover from knowledge creation to TFP determined by regional R&D intensity. Therefore, reinforcing the EU programme by centralising at EU level a third of the national competitive-based project funding results in a modest slowdown in TFP growth (funding for R&I support is shifted from the most R&D intensive regions to slightly less R&I intensive region). In contrast, the NEMESIS model differentiates spillover from knowledge creation to TFP by type of R&I programme. The EU R&I programme is assumed to perform better in transforming knowledge into marketable innovation and hence leads to larger spillover from accumulated knowledge capital to TFP growth than national R&I programmes. Therefore, reinforcing the EU R&I programme results in higher TFP growth. The difference in spillover between EU funded and nationally funded R&I programmes affects the scaling of TFP and increase the impact on EU GDP for the 'Centralisation' scenario.

Under the 'Decentralisation' scenario the change in EU GDP peaks in 2036 at 0.25% higher than in the reference scenario, less than in the other scenarios. This follows from two key assumptions in the NEMESIS simulations. Firstly, the decentralisation scenario assumes that public expenditures in support to R&I at national level generates lower direct leverage of private R&I investments than spending from EU programmes in support to R&I. Secondly, R&I spending at the national level are characterised by lower

spillover from knowledge to TFP than EU funded programmes. Each of these assumptions contributes to the lower rise in EU GDP in the 'Decentralisation' scenario.

Table 3. Cumulative EU GDP deviation (percent change relative to reference scenario)

	Continuation	Centralisation	Decentralisation
Cumulative EU GDP deviation in 2030	0.067	0.105	0.037
Cumulative EU GDP deviation in 2040	0.158	0.247	0.120
Cumulative EU GDP deviation in 2050	0.157	0.229	0.124

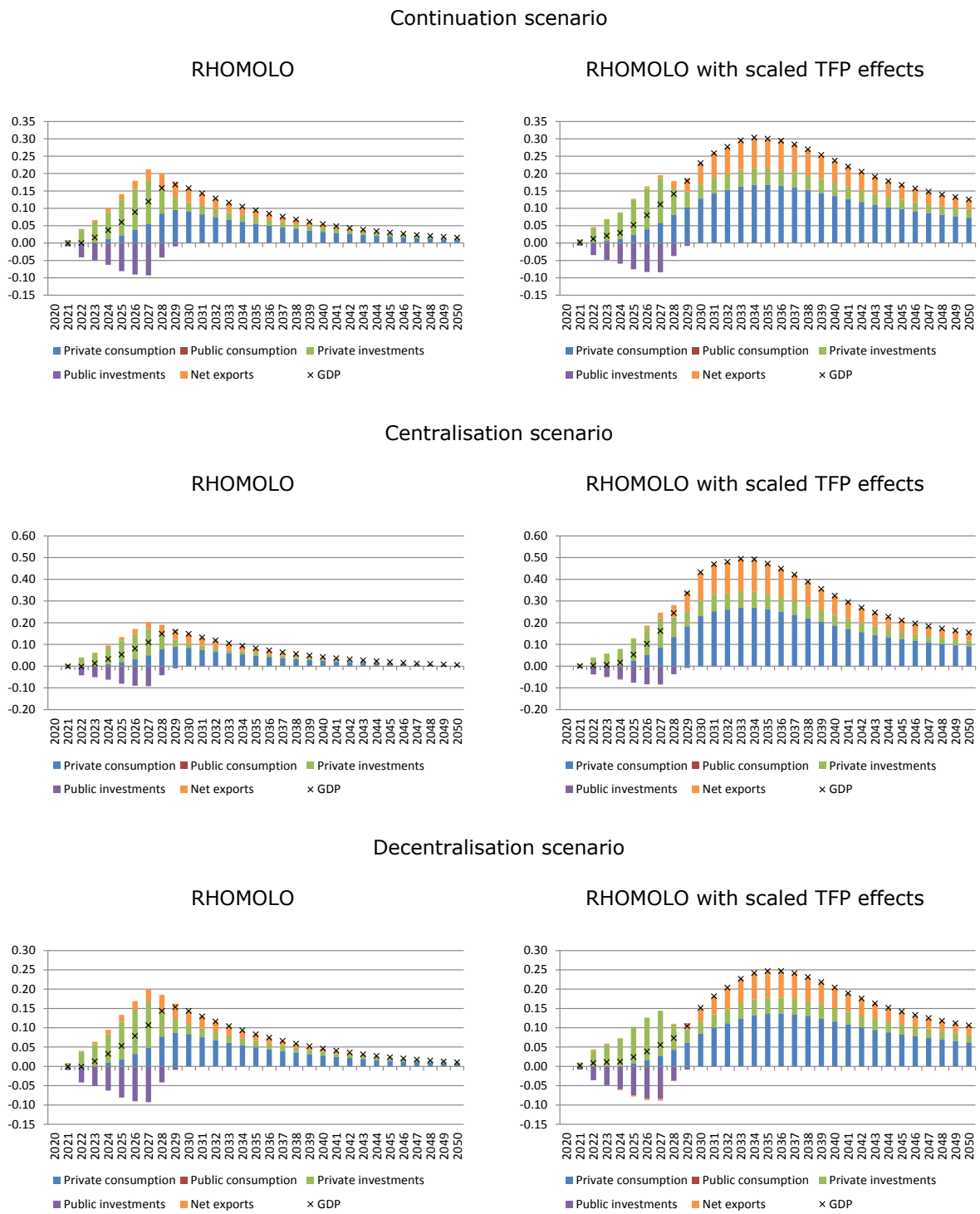
Source: RHOMOLO model

Table 3 lists the cumulative deviation in EU GDP for the set of alternative policy scenarios when simulated on the model with scaled TFP. The highest GDP impact is found for the 'Centralisation' scenario where cumulative EU GDP in 2040 is 0.25% higher than in the reference scenario. The 'Continuation' scenario leads to cumulative EU GDP in 2040 that is 0.16% higher than the reference scenario while the cumulative EU GDP in 2040 in the 'Centralisation' scenario is 0.12% higher than in the reference scenario.

Figure 14 illustrates the deviation in EU GDP relative to the reference scenario decomposed into macroeconomic aggregates. In the 'Continuation' scenario, the rise in EU GDP relative to the reference scenario is mainly driven by a rise in private consumption, private investments and net exports. The increase in these variables becomes higher and more persistent in the simulation with scaled TFP. Private consumption, private investments and net exports also contribute the most to the change in GDP in the 'Centralisation' scenario and the 'Decentralisation scenario'.

Figure 15 shows the changes in total EU employment in the two sets of simulations, with and without scaled TFP. In the latter case, under the 'Continuation' scenario there is a modest decline in EU employment which becomes 7,000 jobs lower than the reference scenario in 2022. After 2022, employment rises and from 2026 onwards it becomes higher than in the reference scenario. The rise in EU employment relative to the reference scenario peaks in 2034 where it is 108,000 jobs higher than in the reference scenario. In 2050 EU employment is 22,000 jobs higher than in the reference scenario. In comparison, the initial simulation of the 'Continuation' scenario resulted at its peak in employment gains of 97,000 jobs, with EU employment in 2050 back to the same level as the reference scenario. Thus, adding scaled TFP to the model leads to a higher and more persistent gain in EU employment.

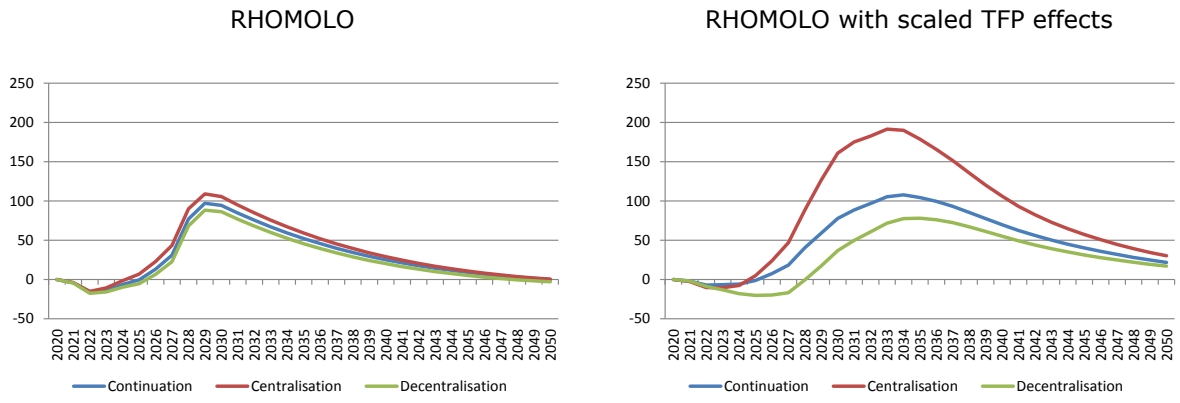
Figure 14. Change in EU GDP decomposed on macroeconomic aggregates (percentage change relative to reference scenario)



Source: RHOMOLO model

The employment effects are also higher with the new set of simulations under the 'Centralisation' scenario. In 2023 EU employment becomes 11,000 jobs lower than in the reference scenario. Then, EU employment rises and peaks in 2033 where it is 191,000 jobs higher than the reference scenario. In 2050 EU employment is 30,000 jobs higher than in the reference scenario.

Figure 15. EU total employment for the set of alternative policy scenarios (change from reference scenario, 1000 jobs)



Source: RHOMOLO model

The 'Decentralisation' scenario results in a decline in EU employment relative to the reference scenario of 20,000 jobs in 2025. EU employment then peaks in 2035 where it is 78,000 jobs higher than the reference scenario and then gradually decline. In 2050 EU employment is 17,000 jobs higher than the reference scenario. Thus, adding scaling of TFP to the model simulation reduces the potential medium term employment gains of national public R&I support. However, the change in EU employment becomes more persistent with scaled TFP in the model.

Table 4 shows the average EU employment deviation relative to the reference scenario for the simulations on the model with scaled TFP. The largest rise in EU employment is found for the 'Centralisation' scenario, with a rise in average EU employment in the period 2020-2040 of 102,000 jobs per year relative to the reference scenario. The average EU employment in the 'Continuation' scenario rises by 56,000 jobs per year, while average EU employment in the 'Decentralisation' scenario is 32,000 jobs per year higher than in the reference scenario. This marks a difference with the initial set of simulations where the highest employment effect was found under the 'Continuation' scenario. In contrast, scaled TFP leads to lower impact on EU employment for the 'Decentralisation', since the scaling of TFP reflects the assumption that a decentralisation of R&I support from the EU level to the national level reduces spillovers from R&I investments to TFP.

Table 4. Average EU employment deviation (thousands of jobs - difference from reference scenario)

	Continuation	**Centralisation**	**Decentralisation**
Average EU employment deviation 2020-2030	17.8	40.7	-4.5
Average EU employment deviation 2020-2040	56.4	101.8	32.1
Average EU employment deviation 2020-2050	51.2	87.4	32.1

Source: RHOMOLO model

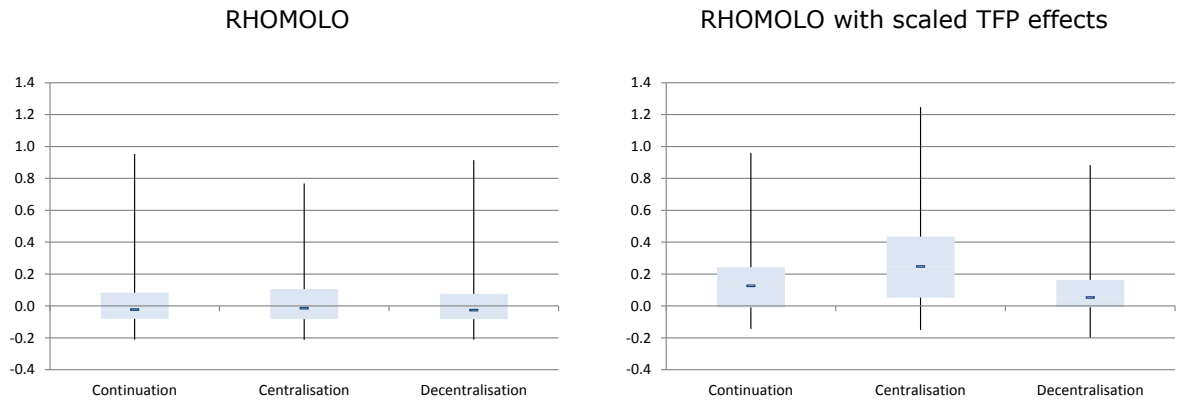
We next consider the regional socio-economic impact of the set of alternative R&I support policies. Figure 16 shows a box plot with the distribution of cumulative regional GDP impacts. Adding scaling of TFP to the model increases regional divergence of GDP impacts. The range of GDP impacts for regions from the first quartile to the third quartile is particularly affected.

Comparing the two sets of simulations in the Box plot reveals that the inclusion of scaled TFP to the model increases the impact on GDP for the median region in all alternative policy scenarios considered. The median region in the 'Continuation' scenario now experiences a gain in cumulative GDP of 0.13% relative to the reference scenario. In the 'Continuation' scenario and the 'Centralisation' scenario the gain in cumulative GDP for the median region becomes respectively 0.25% and 0.05% higher than the reference scenario.

Furthermore, most regions in the span from the first quartile to the third quartile experience a rise in GDP when TFP are scaled. In the 'Centralisation' scenario a rise in cumulative GDP is experienced by all regions in the span from the first to the third quartile when TFP is scaled.

Adding scaled TFP to the model increase the number of regions which experience a rise in cumulative GDP in 2040 from 97 regions to 167 regions in the 'Continuation', from 108 regions to 198 regions in the 'Centralisation' scenario and from 94 regions to 167 regions in the 'Decentralisation' scenario.

Figure 16. Distribution of cumulative regional GDP deviation in 2040 (percentage change relative to reference scenario)



Source: RHOMOLO model

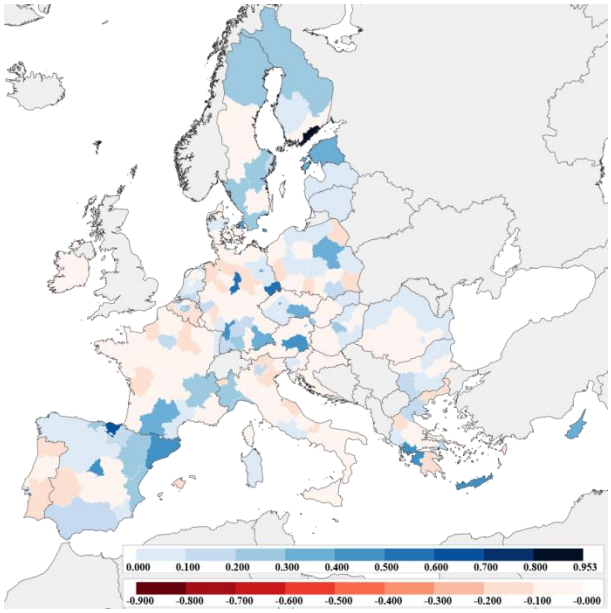
Figure 17 shows the spatial distribution of cumulative GDP deviations under the various scenarios obtained with the two sets of simulations. Adding scaled TFP to the model leads to gains in cumulative GDP relative to the reference scenario for regions across most

Member States. The largest gains in GDP can still be found amongst the most R&I intensive regions.

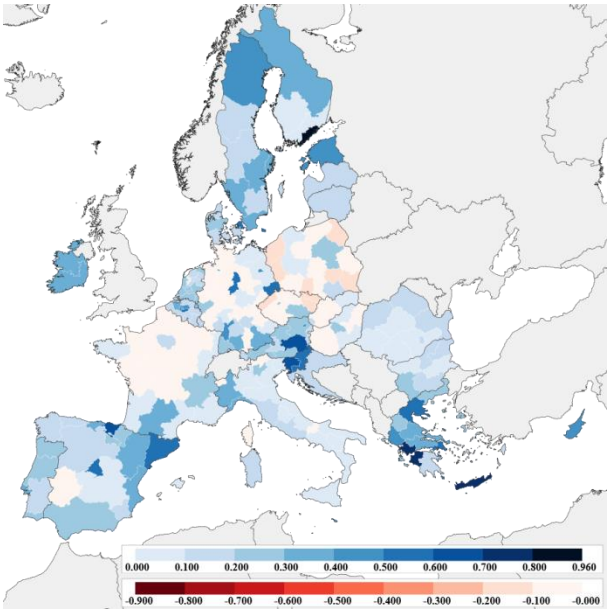
Figure 17. Cumulative regional GDP in 2040 for the set of alternative policy scenarios (percentage change relative to reference scenario)

Continuation scenario

RHOMOLO

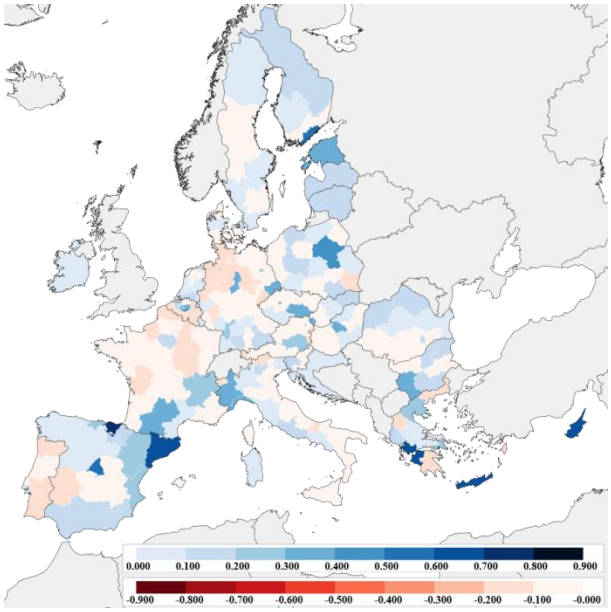


RHOMOLO with scaled TFP effects

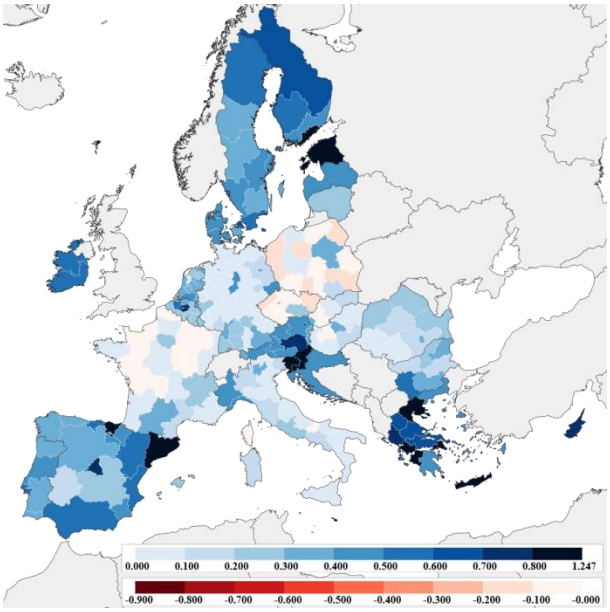


Centralisation scenario

RHOMOLO

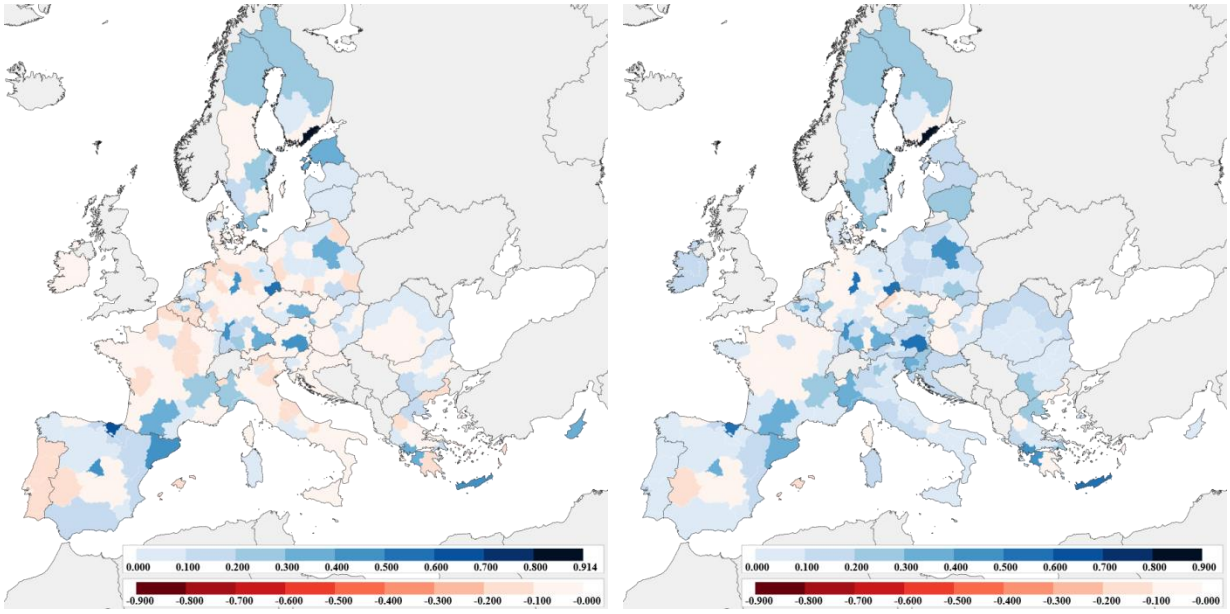


RHOMOLO with scaled TFP effects



Decentralisation scenario

RHOMOLO | RHOMOLO with scaled TFP effects



Source: RHOMOLO model

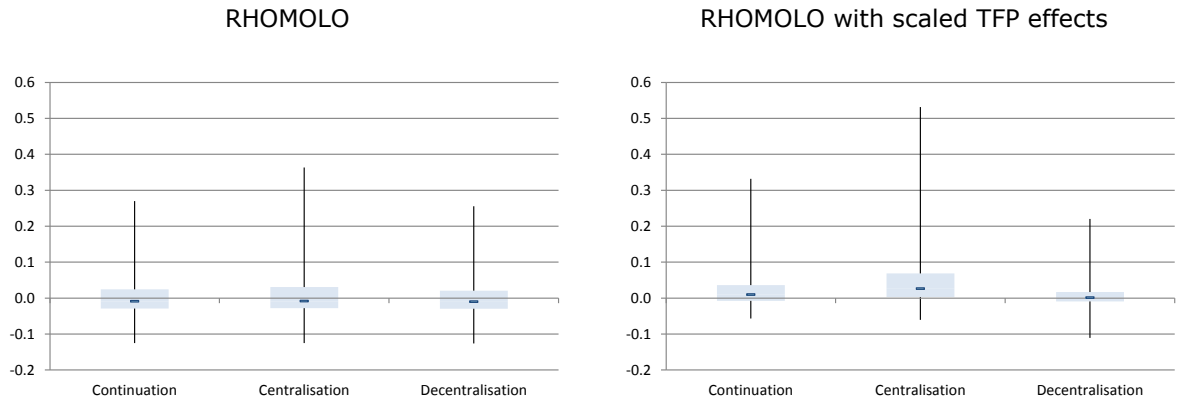
Figure 17 reveals that a reinforcement of the EU R&I programme in the 'Centralisation' scenario leads to considerable rises in regional GDP across several Member States when scaled TFP is added to the model. This is a result of the assumed higher spillovers from knowledge creation to TFP associated with the EU R&I programme. Such higher spillovers are captured by the scaling of TFP in the model. The scaling of TFP is done at the national level, hence, an upscaling of the spillovers from knowledge creation to TFP affects all regions in a given Member State. However, following a reinforcement of the EU R&I programme the largest gains in GDP can still be found in R&I intensive regions located in Member States with low national levels of public competitive-based R&I support.

Figure 18 shows in a box plot the distribution of cumulative regional employment deviation in 2040 for the set of alternative spending strategies simulated on RHOMOLO with and without scaled TFP. Adding scaled TFP to the model changes the employment deviation for the median regions from a small decline in employment to a small gain for all three alternative policy scenarios considered. Furthermore, most regions in the span from the first to the third quartile experience a gain in employment when scaled TFP is added to the model. This raises the number of regions that experience a rise in employment from 90 to 148 in the 'Continuation' scenario, from 103 regions to 179 regions in the 'Centralisation' scenario and from 87 regions to 125 regions in the 'Decentralisation' scenario.

Adding TFP scaling to the model increases the maximum employment gain experienced by the regions and reduces the minimum employment loss suffered by the regions in the 'Centralisation' scenario and the 'Centralisation' scenario. These results follow from the assumption of higher spillovers from R&I investments to TFP in the EU R&I programmes than for national R&I programmes which is embedded in the scaling of TFP in the model simulations.

In contrast, adding TFP scaling to the model for the 'Decentralisation' scenario reduces the maximum employment gain experienced by the regions and the maximum employment loss suffered by the regions. Furthermore, the span from the first to the third quartile becomes less. Thus, adding TFP scaling to the model increases the number of regions experiencing gain in employment but also reduces the gain experienced by the regions gaining the most. This reduces the impact on aggregate EU employment in the 'Decentralisation' scenario.

Figure 18. Distribution of cumulative regional employment deviation in 2040 (percentage change relative to reference scenario)



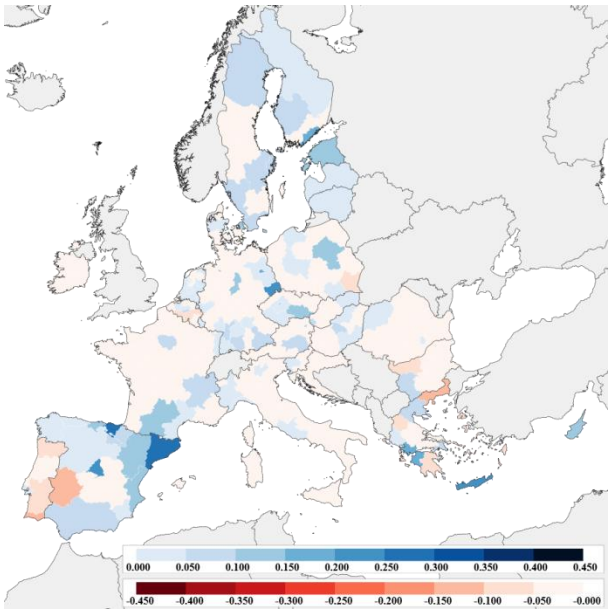
Source: RHOMOLO model

Figure 19 shows the spatial distribution of cumulative employment in 2040 for the set of alternative spending strategies simulated respectively on RHOMOLO and on the model with scaled TFP. The figure reveals that the second set of simulations increases the number of region that expereinece a gain in employement across most Member States. The largest impact on employment is experienced by regions characterised by R&I intensity and relative high unemployment rates relative to the reference scenario.

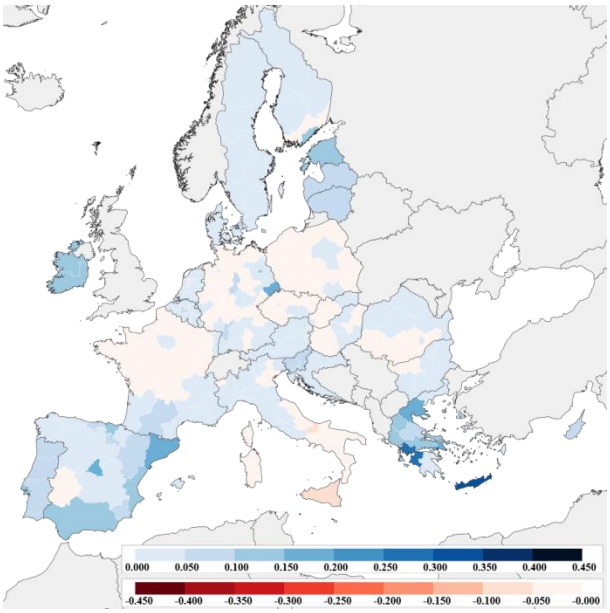
Figure 19. Cumulative regional employment in 2040 for the set of alternative policy scenarios (change from reference scenario, 1000 jobs)

Continuation scenario

RHOMOLO

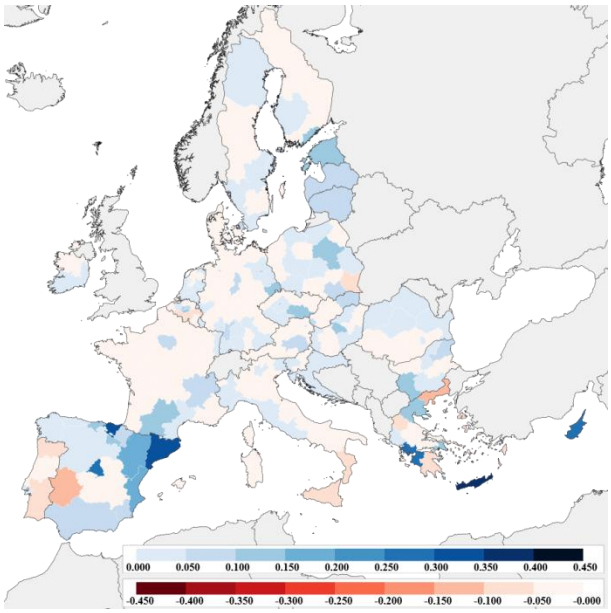


RHOMOLO with scaled TFP effects

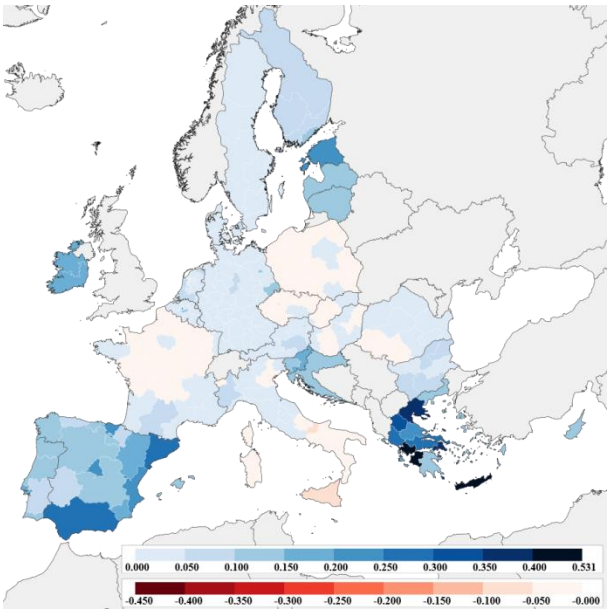


Centralisation scenario

RHOMOLO

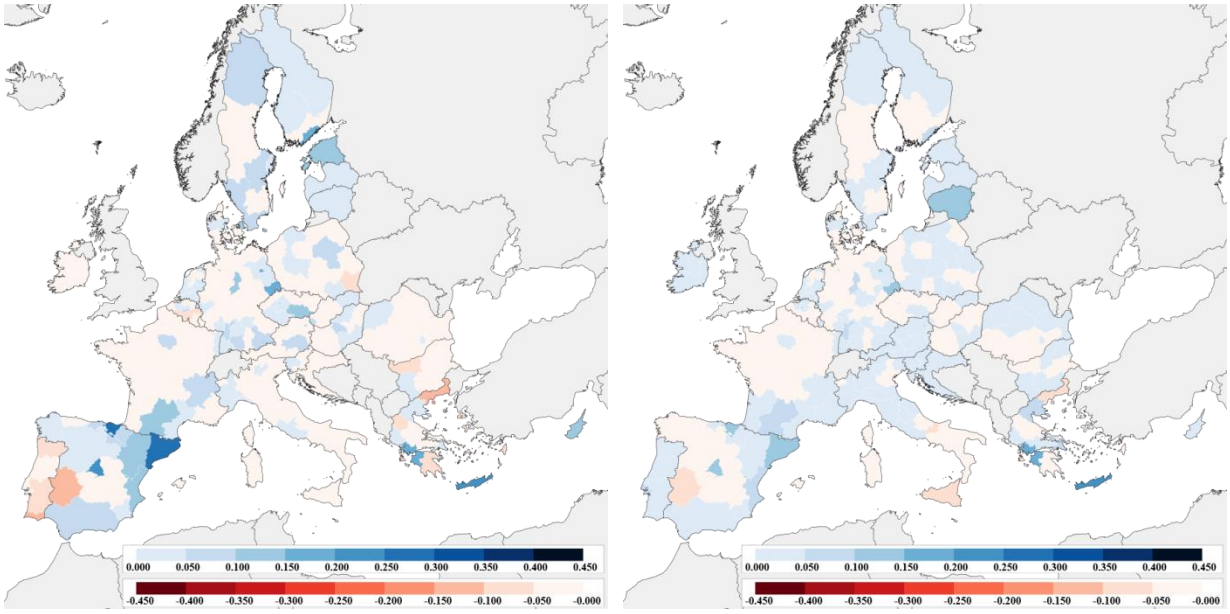


RHOMOLO with scaled TFP effects



Decentralisation scenario

RHOMOLO | RHOMOLO with scaled TFP effects



Source: RHOMOLO model

6 Summary and conclusions

We perform an ex ante assessment of the socio-economic impact of alternative policy designs for the future European R&I programme that will be put in place after 2020. The impact is evaluated both at the aggregate EU level and at the regional level. We examine three alternative policy scenarios taken from the impact assessment conducted by SEURECO for DG RTD. These are the following: the 'Continuation' scenario in which the EU R&I programme continues similar to the Horizon 2020 programme up to 2027; the 'Centralisation' scenario where the EU R&I programme is reinforced by centralising a third of national competitive-based project funding at the EU level; and the 'Decentralisation' scenario where the future EU R&I programme is implemented at a national level. The three alternative scenarios are compared to a reference scenario (the 'Discontinuation' scenario) in which the EU R&I programme is abandoned and the resources are spend by each Member State on public investments and national R&I support.

Our results are based on two sets of simulations, the first carried out with the standard version of RHOMOLO, and the second carried out with RHOMOLO but scaling TFP growth from knowledge creation according to the NEMESIS model. All simulations suggest that

the EU R&I programme contributes to GDP growth and to higher employment in the EU. However, considerable regional variations in impact emerge.

We find that a continuation of the EU R&I programme with a design similar to Horizon 2020 would lead to a rise in EU GDP and EU employment. In 2040 the cumulative EU GDP would be respectively 0.07% and 0.16% higher than in the reference scenario. For the period 2021-2040 EU employment would on average be respectively 40,000 and 56,000 jobs per year higher than in the reference scenario. A continuation of the EU R&I programme result in heterogeneous impact on GDP and employment across EU regions. Regions who are large receivers of EU spending in support to R&I would experience higher TFP growth and an improvement of competitiveness leading to a rise in GDP and employment. In contrast other regions may suffer from a shift in public spending towards higher R&I support. Regional results differ significantly between the two sets of simulations, with 60% of regions experiencing a decline in cumulative GDP and employment in the first set of simulations and 35% of the regions experiencing a decline in cumulative GDP and employment in the second set of simulations.

Reinforcing the EU R&I programme by centralising at the EU level a third of national competitive-based project funding would result in the cumulative EU GDP in 2040 to become respectively 0.06% and 0.25% higher than the reference scenario. In the period 2021-2040 EU employment would on average rise respectively 47,000 jobs and 102,000 jobs per year relative to the reference scenario. The diverging impact on EU GDP and EU employment in the two model versions is driven by alternative assumptions concerning R&I spillovers. The standard version of RHOMOLO assumes spatial variations in R&I spillover elasticities determined by regional R&D intensity. The version of RHOMOLO with TFP scaling further embeds the assumption of different R&I spillover elasticities across national and European R&I support programmes as assumed in NEMESIS. We find considerable variations in socio-economic impacts at the regional level. The reinforcement of the EU R&I programme results in a reallocation of public funding amongst EU regions which gives rise to heterogeneous impact on GDP and employment. Regions which experience a rise in public spending in support to R&I due to the reinforcement of the EU programme also experience an increase in GDP and employment. Reinforcing the EU R&I programme mostly benefit relative R&I intensive regions located in the Member States with lower national levels of public spending for R&I support. In contrast R&I intensive regions in Member States characterised by high national level of R&I support suffer from the reinforcement of the EU R&I programme and experience a worsening of GDP and employment relative to the 'Continuation' scenario.

Decentralising the EU R&I programme and implementing it at the national level also leads to a rise in EU GDP and employment relative to the reference scenario. In 2040 cumulative EU GDP would be respectively 0.06% and 0.12% higher than in the reference scenario and EU employment in the period 2021-2040 would on average be respectively 32,000 jobs and 34,000 jobs per year higher than the reference scenario. The lower impact on EU GDP and employment is mainly driven by an assumption made in the 'Decentralisation' scenario that national R&I programmes generates lower direct leverage of private R&I spending than EU funded R&I programmes. A lower rise in GDP and employment is also experienced in most EU regions.

Compared to the first set of RHOMOLO simulations, we find that adding scaling of TFP growth from knowledge creation increases the share of regions benefitting from public R&I support for each of the three policy scenarios considered. The scaling of TFP captures the higher spillovers from knowledge creation to TFP assumed in the NEMESIS model, and allowing for these in the model increases the impact of R&I support policies. However, scaling of TFP growth in RHOMOLO to replicate the changes in national GDP found in the NEMESIS simulations does not only capture differences in the size of R&I spillovers in the two models. It is also influenced by other differences in the models such as trade linkages, preferences of economic agents, production structures, and wage setting. A caveat one has to bear in mind when interpreting the outcome of the TFP scaled simulations.

In this study we find that EU R&I programmes such as Horizon Europe leads to higher cumulative EU GDP and a rise in EU employment. Horizon Europe aims to support the provision of European R&I investments through EU-wide competition and cooperation programme support. Evidence from the current Framework Programme suggests that the most R&I intensive regions are able to attract a large proportion of funding. Our simulation results suggest that the main benefiters of the EU R&I programme in terms of GDP and employment are the most R&I intensive regions. We find that up to 60% of the regions may suffer from a decline in GDP and employment following the implementation of Horizon Europe. However, it may still be the case that these regions potentially could benefit from the higher growth in their R&I intensive neighbouring regions. Firstly, Member States may use public consumption, taxation and fiscal transfers to redistribute the higher income in R&I intensive regions across all domestic regions. This could compensate households in the regions suffering from the decline in public investments. Secondly, diffusion of technologies may ensure that TFP increases in R&I intensive regions benefits neighbouring regions. In our simulation analysis productivity gains from higher knowledge creation in the R&I intensive regions spills into other regions through trade linkages. However, the model simulations do not explicitly address the effects from

diffusion of technologies across regions. Hence, interregional spillovers from TFP increases in a region may be underestimated. Thirdly, The European R&I programme is supplemented by other EU programmes which aim to strengthen economic and social cohesion. Programmes such as the European Regional Development Fund, the Cohesion fund and the European Social Fund may help address regional imbalances and promote faster dissemination and uptake of R&I results across regions. Such synergies are not examined in the impact assessment.

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