The RHOMOLO and FIDELIO interim evaluation of the impact of Horizon Europe

Casas, Pablo and Christou, Tryfonas and Ferreira, Valeria and García Rodríguez, Abián and Lazarou, Nicholas Joseph and Pedauga, Luis Enrique and Rueda Cantuche, José Manuel and Bernard, Hannah and Volpe, Roberto and Neicu, Daniel and Salotti, Simone

European Commission, Joint Research Centre Seville, European Commission, Directorate-General for Research and Innovation

6 May 2025

The RHOMOLO and FIDELIO interim evaluation of the impact of Horizon Europe

Pablo Casas[1], Tryfonas Christou[1], Valeria Ferreira[1], Abián García Rodríguez[1], Nicholas Lazarou[1], Luis Pedauga[1], José Manuel Rueda-Cantuche[1], Hannah Bernard[2], Roberto Volpe[2], Daniel Neicu[2] and Simone Salotti[1]

1. *European Commission, Joint Research Centre (JRC) Seville, Spain*
2. *European Commission, DG Research & Innovation, Brussels, Belgium*

Abstract. This paper presents a macroeconomic evaluation of the impact of the Horizon Europe Framework Programme for Research and Innovation, for which projects have been signed between 2021 and 1 July 2024, using the general equilibrium models RHOMOLO (Regional Holistic Model) and FIDELIO (Fully Interregional Dynamic Econometric Long-term Input-Output). The RHOMOLO model simulations suggest that the GDP gains in 2024 for the European Union would be up to 0.10% compared to GDP in 2020. The GDP gains are also expected to be significant in the medium term, with a cumulative GDP multiplier of more than 4, ten years after the end of the injection. The impact then gradually diminishes due to the obsolescence of the new knowledge and innovations generated by the policy intervention. The model results also show significant interregional spillovers in some, but not all, countries of the European Union. The FIDELIO model is used to disaggregate the impact of Horizon Europe funds on EU R&D expenditure and by sector, complementing the analysis of the RHOMOLO model. The results indicate that the positive effects on innovation gains, with business investment contributing to substantial GDP gains after the four-year intervention period, are mainly directed towards business R&D in manufacturing. Within manufacturing, the most important sub-sectors are the manufacture of machinery and equipment; computer, electronic and optical products; motor vehicles, trailers and semi-trailers; and fabricated metal products.

Keywords: innovation policy, regional growth, industry impact, general equilibrium.

JEL Codes: C68, O30, R13.

Acknowledgments: We thank Milena Isakovic Suni and Julia Lorenz for valuable comments. All remaining errors are our own.

Disclaimer: The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

1. Introduction

Public intervention in research and development (R&D) is generally based on the link between research, innovation and economic growth (Mansfield, 1972). Due to market failures (Arrow, 1962), private companies underinvest in research and development (R&D), so that socially optimal innovative activity is not achieved, which hinders economic growth. More recent economic theory views innovation as a system that requires public intervention to address systemic challenges rather than market failures (see Neicu, 2016 for a discussion).

Against this background, European research and innovation policy has addressed these challenges from both a market failure and a systemic perspective. There are currently three main systemic challenges facing research and innovation (R&I) in Europe: an under-utilised R&I ecosystem, a technological gap with other world regions, and a persistent R&I divide between and within Member States (European Commission, 2024a).

Supporting research and innovation at European level has a number of advantages over national or regional support. These range from a larger scale of support through pooling of resources, increased collaboration across borders and sectors, addressing European rather than local challenges, stimulating EU-wide competition for funding, avoiding duplication of effort, and setting common standards and regulations (Mitra et al., 2024).

Since 1984, nine successive EU Framework Programmes for research and innovation have invested in European researchers, universities, research centres and companies, focusing on scientific excellence and collaboration. Horizon Europe[1] is the EU's ninth Framework Programme funding R&I, with a budget of €93.5 billion for the period 2021-2027. It aims to strengthen the scientific and technological base in Europe and foster its competitiveness, to deliver on strategic policy priorities and contribute to tackling global challenges.

To this end, Horizon Europe supports projects in basic research, applied research and development and innovation activities. The former is mainly supported through the Excellent Science pillar ('Pillar I'), which includes the European Research Council and Marie Sklodowska-Curie actions. Applied research and development is mainly funded through collaborative actions under the Global Challenges and European Industrial Competitiveness pillar ('Pillar II'), which includes European Partnerships and EU Missions. The third pillar of the programme - Innovative Europe - includes, in particular, the European Innovation Council, which aims to support deep-tech start-ups from basic research to the market introduction of their innovations and their subsequent scaling up. Finally, there are cross-pillar schemes to promote programme participation and scientific excellence in countries with low R&I performance ('widening' countries).

To achieve its expected impact, Horizon Europe provides competitive research funding for both bottom-up "blue sky" research and innovation projects and top-down collaborative projects involving large consortia from across Europe. It funds more ambitious projects involving larger consortia working together across countries and sectors. It also creates synergies that individual countries cannot achieve, while reducing redundant efforts at country or regional level (Mitra et al., 2024). By investing in basic research, the programme is expected to generate significant long-term productivity gains (Nelson, 1959; Arrow, 1962; Rosenberg, 1990). In addition, the funding of applied research and blended finance - through the EIC - is expected to bring disruptive innovations to the European market.

[1] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

The European R&I Framework Programmes have attracted the attention of academics and researchers who have studied aspects such as their impact on innovation (Veugelers et al., 2015) and GDP growth (Pollex and Lenschow, 2018), as well as what motivates institutions to participate in the programmes (Enger, 2018). In addition, the European Commission regularly evaluates the impact of the R&I Framework Programmes ex-ante, mid-term and ex-post in order to provide transparent evidence that feeds into the EU policy cycle. Based on these evaluations, improvements are made to the programmes in each budget cycle, which currently lasts seven years.

This paper presents an interim assessment of the macroeconomic impact of Horizon Europe projects signed between 2021 and 1 July 2024, using the spatially dynamic computable general equilibrium (CGE) model RHOMOLO (Lecca et al., 2020) and the general equilibrium model FIDELIO (Rocchi et al., 2025, Rocchi et al., 2019). The main results of this analysis are presented in the official interim evaluation of Horizon Europe (European Commission, 2025), which contains results obtained with the two models mentioned above.

The RHOMOLO analysis builds on the ex-post macroeconomic assessment of the previous Framework Programme, Horizon 2020, carried out with the same model documented by Christou et al. (2024).[2] The RHOMOLO model is calibrated using 2017 data for all the NUTS-2 regions of the European Union (EU27), structured in an interregional set of social accounting matrices (SAMs) and organised into ten NACE Rev. 2 economic sectors. The data are constructed following the procedure outlined by García Rodríguez et al. (2023).

The FIDELIO model is calibrated using 2015 data based on official statistics from Eurostat's FIGARO, with a breakdown of 64 NACE industries and covering 45 countries (EU 27 Member States, its main 18 EU trading partners, and an aggregate region of RoW).

RHOMOLO and FIDELIO are general equilibrium models. As such, in addition to the direct effects of the policy in terms of monetary injections and contributions collected to finance the policy, they are able to track the indirect and induced effects across all agents, regions (in the case of RHOMOLO), and countries (in the case of FIDELIO), and by sectors of the economy with different levels of disaggregation in each model. Using two different models to conduct an impact assessment increases the robustness of the results, as compatible and comparable results suggest that they are not sensitive to the specific modelling approach used. If two models with different structures and assumptions produce similar results, this increases confidence in the validity of the results. This approach also allows for triangulation of results, providing a more comprehensive understanding of the potential impact of Horizon Europe. The complementary nature of the two models is particularly valuable, as one provides highly disaggregated geographical data (at NUTS 2 level) and the other provides detailed sectoral data (at country level). By combining these perspectives, the regional and sectoral distribution of impacts can be better understood, providing a more complete picture of the potential impacts of Horizon Europe. This in turn can provide policy makers and stakeholders with a more nuanced and informative basis for decision making.

According to the RHOMOLO simulations reported here, there are positive impacts on GDP during the policy implementation phase. At the peak of the impact, in 2024, GDP gains will be 0.10% higher than the EU GDP in 2020. The GDP gains are also expected to be significant after the end of the four years of intervention simulated here, due to the positive supply-side effects of the interventions on productivity and on private and public capital stocks. The effects will gradually diminish due to the gradual obsolescence of the new knowledge and innovation generated by the policy intervention.

[2] See also European Commission (2024).

The FIDELIO results also suggest that GDP increases steadily throughout the policy implementation period. Moreover, the analysis suggests that the positive effects on innovation gains, with investments in the BERD sector contributing to substantial GDP gains, are mainly directed towards business R&D in the manufacturing sector. Within manufacturing, the most important subsectors are the manufacture of machinery and equipment (NACE code C28), the manufacture of computer, electronic and optical products (C26), the manufacture of motor vehicles (C29) and the manufacture of fabricated metal products (C25).

The paper is structured as follows: Section 2 briefly discusses the data (provided by the Directorate-General for Research and Innovation - DG RTD). Section 3 illustrates the strategy used to carry out the assessment. Section 4 presents the results of the modelling simulations and section 5 concludes.

2. The data

This assessment deals with the investments made under the Horizon Europe programme between 2021 and 2024. The data related to these investments have been provided by DG RTD in monetary terms by NUTS 2 region and by year and refer to the projects signed before 1 July 2024 (source: Common Research Data Warehouse – CORDA).

The total amount of Horizon Europe funding at the reference date of the analysis is about €33,626 million in current prices (equivalent to almost €30,225 million in 2020 prices), which is slightly more than one third of the total budget of the programme, as the analysis is limited to the first three and a half years of the programming period and only considers EU Member States. 3% of these funds were granted through contracts signed in 2021, 46% in 2022, 41% in 2023 and 10% in the first half of 2024. As the data were extracted on 1 July 2024, more than 2,400 projects were signed in the remaining part of the year, but these are not part of the analysis.

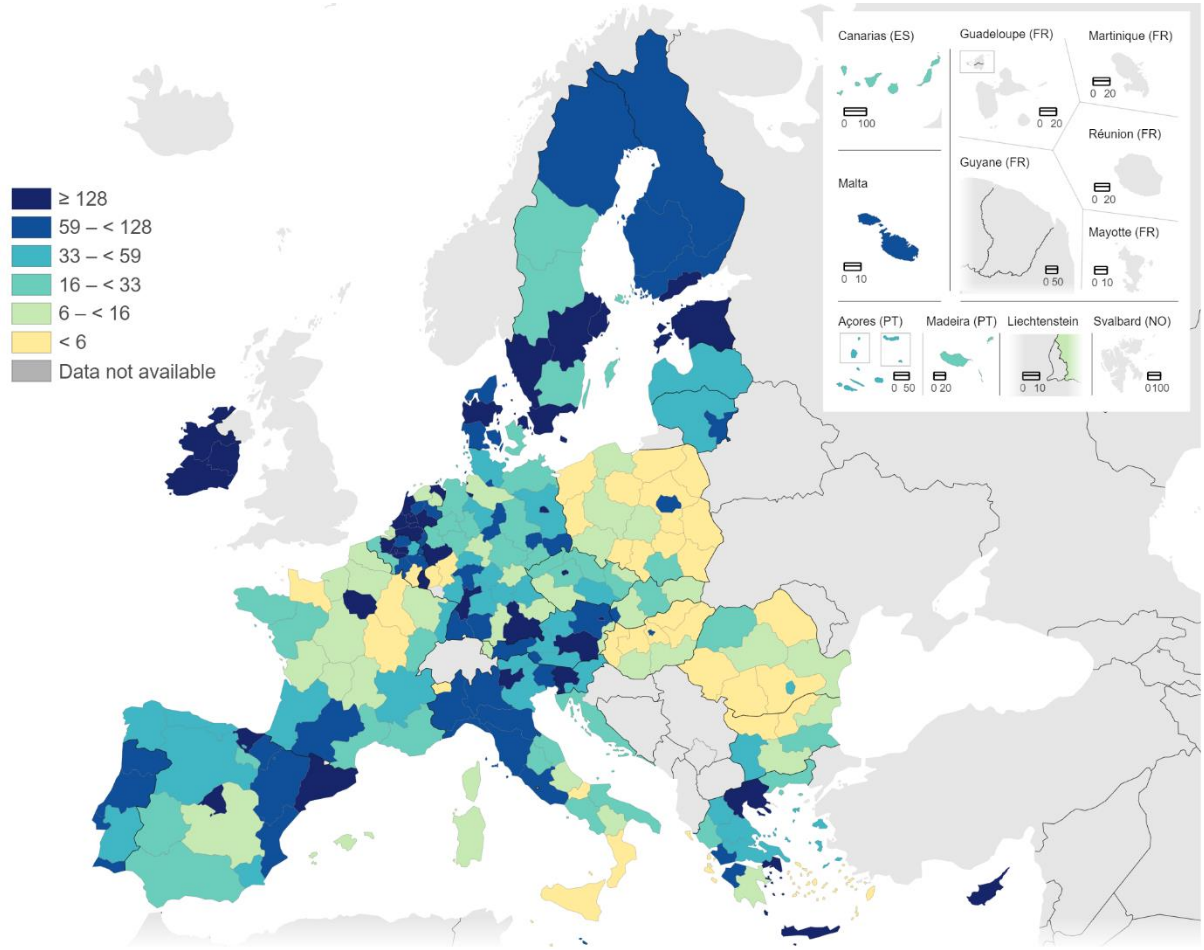
More than half of the funding (56%, €19.0 billion in real prices) was allocated to applied R&D projects under Pillar II. Around a quarter went to basic research (27%, €9.2 billion). The remaining €5.9 billion (17%) is mainly innovation funding under the EIC, the European Institute of Innovation and Technology (EIT) and other similar schemes. The vast majority of funding is in the form of grants, with reimbursement rates typically between 70% and 100% of total project costs. However, the total also includes €1.2 billion of equity investments from the EIC Fund, one of Horizon Europe's funds specifically targeted at start-ups with scale-up potential. These investments represent 3.7% of all Horizon Europe funding at the reporting date.

Figure 2.1 shows the distribution of total per capita funding (in euro) by NUTS2 region (over the entire period 2021-2024) used in the RHOMOLO analysis. Larger amounts of funding per capita (indicated by darker colours) are mostly concentrated in Central Europe, with amounts exceeding €128 per capita. The least well-funded regions (less than €6 per capita) are mainly located in the Member States identified in Horizon Europe as 'widening Europe', such as Poland, Romania and Bulgaria - although some areas of France, Italy and Germany also show similar results. Conversely, among the widening countries, regions in the Baltic States, Portugal, Greece and especially Cyprus and Slovenia receive more R&I funding per capita than the EU median. Overall, widening member states will receive 14% of Horizon Europe funding between 2021 and 2024, an increase in their participation compared to Horizon 2020 (9%).

In addition, most capital city regions are characterised by a relatively high level of funding per capita. This is particularly pronounced in the widening countries (such as the Czech Republic, Hungary, Poland), but is also visible in several other countries (e.g. France).

Funding per region is broadly correlated with national expenditure on R&D and with the number of scientists and engineers employed in the area. However, even after weighting for these well-known regional disparities, some regions receive relatively more funding (such as the Brussels region, northern Italy, Greece) and others less, especially in some enlargement countries such as Poland and Romania, where the number of scientists and engineers employed is relatively higher (see Table 2.1).

Figure 2.1: Territorial distribution of the Horizon Europe (2021-2024) funds per capita (in euro)



Source: European Commission's DG RTD (Horizon Europe funds) and Eurostat (population). Note: class breaks refer to quantiles.

Table 2.1: Top-5 and bottom-5 EU 27 NUTS 2 regions by Horizon Europe funding (2021-2024) by number of scientists and engineers (2023)

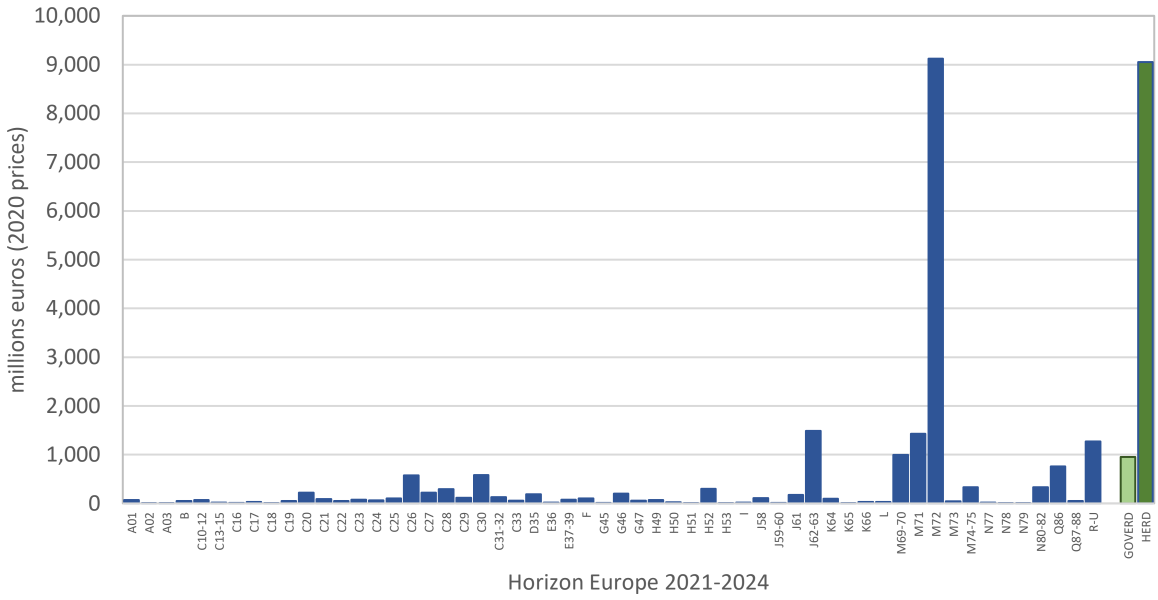
Top-5		*Bottom-5*	
Region	*Value (EUR)*	*Region*	*Value (EUR)*
Brussels Capital Region (BE)	15 593	Lubuskie (PL)=	12.0
Prov. Vlaams-Brabant (BE)	11 580	Mazowiecki regionalny (PL)	13.5
Trento (IT)	9993	Świętokrzyskie (PL)	22.1
Kriti (EL)	8993	Opolskie (PL)	35.0
Wien (AT)	4996	Sud – Muntenia (RO)	35.0

Source: European Commission's DG RTD (Horizon Europe funds) and Eurostat (table: hrst_st_rcat). EU funding is expressed in nominal terms.

Figure 2.2 shows the distribution of total funding by NACE industrial sector (over the entire period 2021-2024) used in the FIDELIO analysis (data in euro). At industry level, Horizon Europe funds are most important for scientific research and development and education, health services, computer programming, consultancy and related activities, manufacture of other transport equipment and manufacture of computer, electronic and optical products.

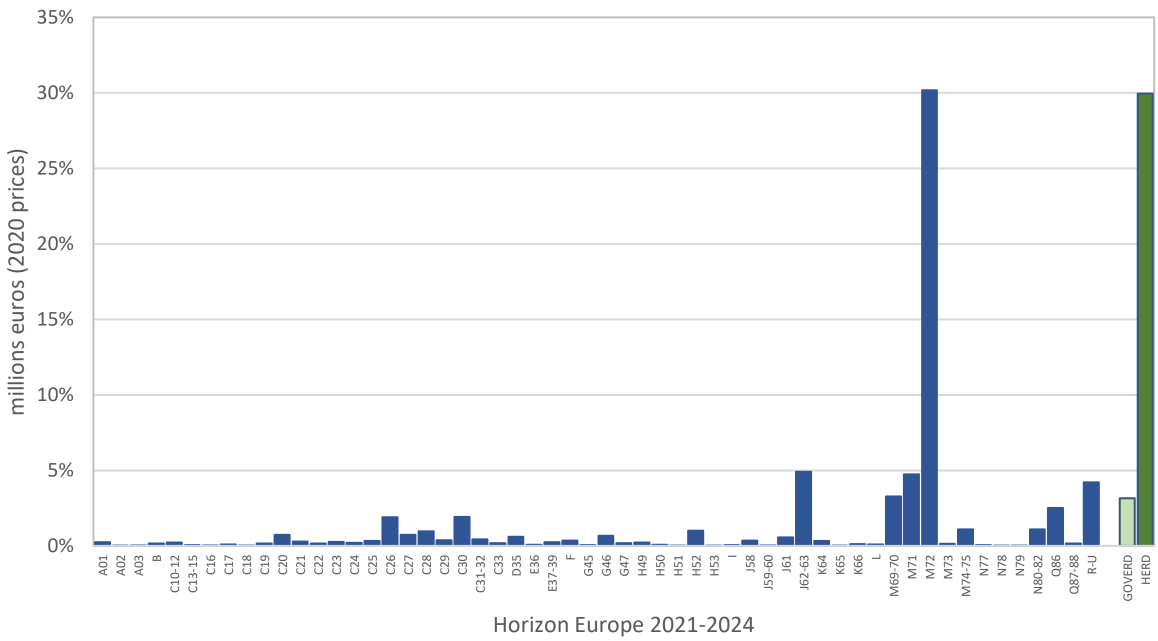
The economic impact in a region, country or industry will be correlated with the amount of money spent in each area or in industry. However, the effects are not always linear. Interregional spillovers and indirect or induced effects of the shocks require the use of a general equilibrium framework to better understand the impact of the policy.

Figure 2.2: Industry distribution of the Horizon Europe (2021-2024) funds in million euros



Source: European Commission's DG RTD.

Figure 2.3: Industry distribution of the Horizon Europe (2021-2024) funds as a proportion of the total



Source: European Commission's DG RTD.

3. The modelling strategy

3.1 The RHOMOLO model in a nutshell

RHOMOLO is a spatial dynamic CGE model, whose full mathematical description can be found in Lecca et al. (2018). The version of the model used for this assessment covers 235 NUTS 2 regions of the EU. Each region is composed of ten economic sectors operating under monopolistic competition (with the exception of agriculture and public services, which operate under perfect competition due the lack of data on the number of firms for these sectors – see Table 3.1). Regional goods are produced by combining labour and capital with domestic and imported intermediate inputs. Public capital enters the production function as an unpaid factor.

Final goods are consumed by households, the government and investors. The representative household in each region supplies labour of three skill types, consumes goods and services and saves part of its income. The government collects taxes, purchases public consumption goods, invests in the economy and transfers resources to the various agents in the economy. Goods and services can either be sold within the domestic economy or exported to other regions. Trade between regions is associated with a set of bilateral regional transport costs based on the Persyn et al. (2022) model. The RHOMOLO model incorporates imperfect competition in the labour market and allows for unemployment. Wage formation is assumed to follow a wage curve specification as in Blanchflower and Oswald (1995), which implies that lower unemployment increases workers' bargaining power and thus real wages.

There are two types of capital in the model: sector-specific private capital and public capital. The latter is accumulated by the government through public investment, and it is considered an unpaid factor of production freely available to firms in all sectors within each region (Barro, 1990, and Baxter and King, 1993). Public capital is subject to congestion (Fisher and Turnovsky, 1998), so its efficiency declines as production increases, and the elasticity of output to public capital is set to 0.08, in line with the findings by Bom and Lightart, 2014 (and also in line with the modelling choices made by Pfeiffer et al., 2021, using the QUEST model). Sector-specific private capital is accumulated by private investors. The investment-capital ratio is a function of the rate of return on capital and the user cost of capital, allowing the capital stock to reach its desired level smoothly over time.

R&D expenditure is modelled as private investment. Therefore, R&I expenditure generates demand for capital goods. In addition, R&I expenditure leads to the accumulation of an intangible knowledge capital stock, which has a positive effect on total factor productivity (TFP). Public spending to support R&I is introduced into the model as a reduction in the user cost of capital, which in turn generates an increase in private investment. The impact of R&I spending on TFP through the accumulated stock of knowledge capital is captured by a set of regional elasticities, ranging between 0.01 and 0.04, that are positively related to regional research and development (R&D) intensity (see, for example, Männasoo et al., 2018). The intuition is that firms in regions that already spend a lot on R&D signal their pre-existing capacity to generate value from innovation activities.

Expectations are assumed to be myopic and the model is solved sequentially, with stocks being updated at the start of each period. For this particular exercise, capital mobility within the EU was assumed, but no labour mobility.

Table 3.1 RHOMOLO economic sectors

Code	NACE Rev.2
A	Agriculture, forestry and fishing
B-E	Industry (except construction)
C	Manufacturing
F	Construction
G-I	Wholesale and retail trade, transport, accommodation and food service activities
J	Information and communication
K_L	Financial and insurance activities, real estate activities
M_N	Professional, scientific and technical activities; administrative and support service activities
O-Q	Public administration, defence, education, human health and social work activities
R-U	Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies

3.2 The RHOMOLO simulation strategy

The strategy adopted here is based on the Horizon 2020 assessment mentioned above (Christou et al., 2024), as well as on a separate modelling analysis also included in the H2020 ex-post evaluation (European Commission, 2024b), using the NEMESIS macroeconomic model.[3] Firstly, it is estimated that 30% of the funding are allocated to basic research and 70% to applied research.[4]

In RHOMOLO, basic research funding is simulated via an increase in public investment, which leads to a temporary increase in the public capital stock of the regions (which depreciates at a rate of 5% per year). Due to the role of public capital in the production function, in addition to the demand-side effect of increased (public) investment, this increases the productivity of firms.

It is assumed that the applied research funds reduce the user cost of capital, leading to an increase in private investment. This is a demand-side effect that also leads to a temporary increase in the private capital stock (which depreciates at an annual rate of 15%). Based on the NEMESIS assumption regarding leverage, the change in the user cost of capital is calibrated so that the European applied research funds crowd in additional private investment (+15%). It is also assumed that this R&I investment leads to an increase in TFP, subject to an annual depreciation rate of 5% and with an elasticity that depends on the R&D intensity, as explained above.

Based on the evidence provided by Mitra et al. (2024), and to be consistent with the NEMESIS analysis, we increase the output elasticity of the additional public capital accumulated thanks to the Horizon Europe funds by 15%, and we also increase the TFP elasticity of private investment by 15% to account for the added value of EU-level investments in R&I that lead to enhanced synergies, economies of scale and scope and increased cooperation between institutions.

Finally, it is assumed that the policy is financed by lump-sum transfers. In order to mimic the financing of the EU budget, regional contributions are proportional to the GDP weight of each region in the EU GDP. In other words, a region does not necessarily have to finance the policy with a contribution equal to the amount of Horizon Europe earmarked for the region itself, but instead the contribution depends

[3] For information on NEMESIS, see https://www.erasme-team.eu/en/the-nemesis-model/.
[4] The estimation is based on an analysis of the types of grants provided by Horizon Europe. Grants under the Horizon Europe Pillar I (including the European Research Council and Marie Sklodowska-Curie Actions) are considered basic research, while Pillar II collaborative projects and Pillar III (including the European Innovation Council) are considered applied research.

on the share of EU GDP generated in the region (and the distribution of funds presented in section 2 above).

3.3 The FIDELIO model in a nutshell

FIDELIO is a Multi-sector Dynamic General Equilibrium economic model, designed for policy impact assessment and evaluation, providing industrial-, country-, and time-specific simulations (Rocchi et al., 2025, Rocchi et al., 2019). The model compares counterfactual and baseline equilibriums to assess interaction effects between economic agents.

The version of the model used for this assessment covers 64 economic sectors (see table 3.2) and 45 countries (EU27 Member States, the EU's 18 main trading partners, and an aggregate region of the RoW). This allows the analysis of Europe-wide policies at the Member State level, as well as the analysis of growth, environmental and innovation policies linked to specific commodities or industries. The model's capacity to analyse diverse national contexts enables it to demonstrate how a policy can influence trade balances, relative prices, and comparative advantage in the international trade arena.

To produce, firms use four production factors: capital, labour, energy intermediates, and non-energy intermediates or materials. From the production processes, firms pay the cost of the other factors of production (labour and capital) to households and to the government. Goods and services can either be sold within the domestic economy or exported to other regions. Households receive their income through wages, a share of the gross operating surplus, property income and the governmental and non-governmental transfers. Household income, net of taxes and social security contributions, is used to consume or to save.

The government raises its revenue from five main sources: operating surplus that goes to the government, production taxes, taxes less subsidies on products, social security contributions and taxes on household income. This revenue is then used to finance the government interest, the government capital formation, the government transfers to the households, and the government consumption that is another component of the total demand. The budget balance is calculated as the difference between government revenues and expenses, and it determines the variation in public debt.

FIDELIO is based on the widely accepted dynamic input-output model discussed in Okuyama (2017) and Miller & Blair (2022), in which some of the most important properties of endogenous growth theory are included (innovation and knowledge spillovers) to simulate the potential effect of R&D subsidies on economic growth (Los, 2001; Dietzenbacher & Los, 2002). In this sense, two types of economic effects are expected. The first effect refers to the rippling effect throughout the economy brought about by spending on R&I. This is called the Keynesian multiplier effect and occurs with spending on any type of product. The second effect is the increase in productivity due to technical progress and only occurs through spending on R&D. This is called the return on R&D.

In dynamic econometric input-output models (or temporary input-output systems) such as FIDELIO, the allocation of inputs to the R&D process would be reflected in increased levels of future output of economic sectors from one period to another. That is, incremental changes in direct input coefficients, productivity growth and changes of R&D capital-output intensities. The Keynesian multiplier effect is modelled as an increase in R&D spending. The Horizon Europe funding leads to an increase in R&D activities in the sectors that receive funding. The sectoral R&D activities are embodied by all the industries as secondary production of "Scientific research and development services" (CPA M72) on the supply side. The production of CPA M72 increases according to the allocation of Horizon Europe funding by country and by industry.

Table 3.2 List of NACE Rev. 2 industries in FIDELIO

NACE A*64	NACE A*64 Name
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10T12	Manufacture of food products, beverages and tobacco products
C13T15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37T39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation; food and beverage service activities
J58	Publishing activities
J59_60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting
J61	Telecommunications
J62_63	Computer programming, consultancy and related activities; information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L	Real estate activities
M69_70	Legal and accounting activities; activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74_75	Other professional, scientific and technical activities; veterinary activities
N77	Rental and leasing activities
N78	Employment activities
N79	Travel agency, tour operator reservation service and related activities
N80T82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities
O84	Public administration and defence; compulsory social security
P85	Education
Q86	Human health activities
Q87_88	Social work activities
R90T92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
R93	Sports activities and amusement and recreation activities
S94	Activities of membership organisations
S95	Repair of computers and personal and household goods
S96	Other personal service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organisations and bodies

3.4 The FIDELIO simulation strategy

The FIDELIO model simulates the impact of R&D funding programs on the economy by incorporating R&D expenditures as secondary activities within various industries. These R&D activities, conducted alongside the main production activities, contribute to the overall advancement and innovation.

In the FIDELIO model, R&D investments affect productivity in two stages of effects, capturing both short and longer-term economic impacts.

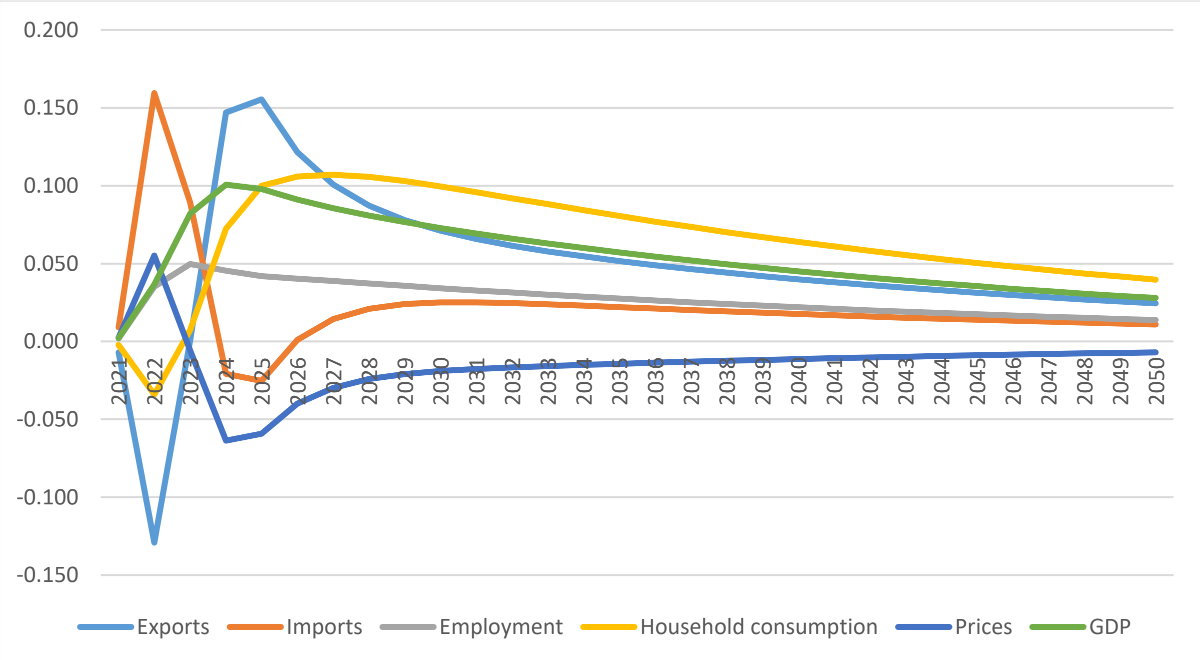
The first-order effect operates as a Keynesian multiplier: increasing R&D spending—such as that funded by the Horizon Europe —boost R&D activity and stimulates the economy growth, similar to other forms of public expenditure. At this stage, the model follows a sequential approach where industries determine their current R&D inputs based on their previous output levels (driven by their respective R&D returns) and the production functions prevailing in the R&D sector. This process results in the current levels of output, R&D activity, employment, and final demand, setting the stage for the second-order effect.

The second-order effect reflects the gains in capital productivity resulting from technological progress, specifically the return from R&D investments. This is estimated econometrically at country and sectoral level by measuring the increase in value added coming from the first-order effects. Following Los (2001), the model assumes that today's R&D expenditure decisions shape future production functions and investment patterns (see Rocchi et al., 2025). Thus, the additional value added by country and sector is incorporated into the investment trajectory as a future expenditure in R&D. Consequently, R&D funds, which are considered exogenous to the short-run decision process, can be fed into the system and long-term effects of parameter changes can be studied.

4. The RHOMOLO modelling results

Figure 4.1 shows the simulated impact of Horizon Europe 2021-2024 investments at EU level from 2021 to 2050, on six key macroeconomic variables: exports, imports, employment, household consumption, prices, and GDP. The figures shown are percentage deviations from the initial equilibrium, expressed as a percentage of EU GDP in 2020. Note that all results are in real terms.

Figure 4.1: Horizon Europe (2021-2024) impact over time on selected macroeconomic variables (EU27)



Source: RHOMOLO simulations.

GDP increases steadily over the implementation period, peaking at +0.10% in 2024. It then gradually declines as the simulated monetary injection ends, the increased private and public capital stocks depreciate and the temporary increase in TFP fades. In 2050, the residual effects of the policy are relatively small, as GDP is 0.03% above its initial level. The policy injection also leads to improvements in employment, whose impact peaks at +0.05% in 2023, amounting to about 94,600 persons (the total number of persons employed in the EU in 2020 was around 190 million).

The other variables presented in Figure 4.1 show that the Horizon Europe injections lead to an initial deterioration in the EU's trade balance with the rest of the world, as imports increase and exports decrease in the early years of the simulation. This is due to the initial increase in demand caused by the policy injection and the subsequent increase in prices (measured here by the changes in the GDP deflator). Competitiveness then improves, leading to a fall in the price level, with a positive impact on exports and hence on the trade balance.

Table 4.1 below shows the percentage deviations from baseline for some key macroeconomic variables in selected years (with an annual frequency during the implementation period and then at larger intervals to show the legacy effects of the policy), including the GDP multiplier. This multiplier is obtained as the cumulative change in GDP divided by the size of the policy shock and can be read as the amount of euros of GDP created for each euro invested in the policy. It increases over time as the impact on GDP is positive throughout the simulation period, while the policy shocks only last for the first 4 years.

The multiplier is close to 1 in the last year of policy implementation and is above 2 at the end of the programming period in 2027. It continues to increase thanks to the supply-side effects of the policy and is above 4 ten years after the end of the cash injection, in 2034, suggesting substantial macroeconomic returns from the policy.

Table 4.1: Horizon Europe (2021-2024) impact in selected years on a selection of macroeconomic variables (EU27)

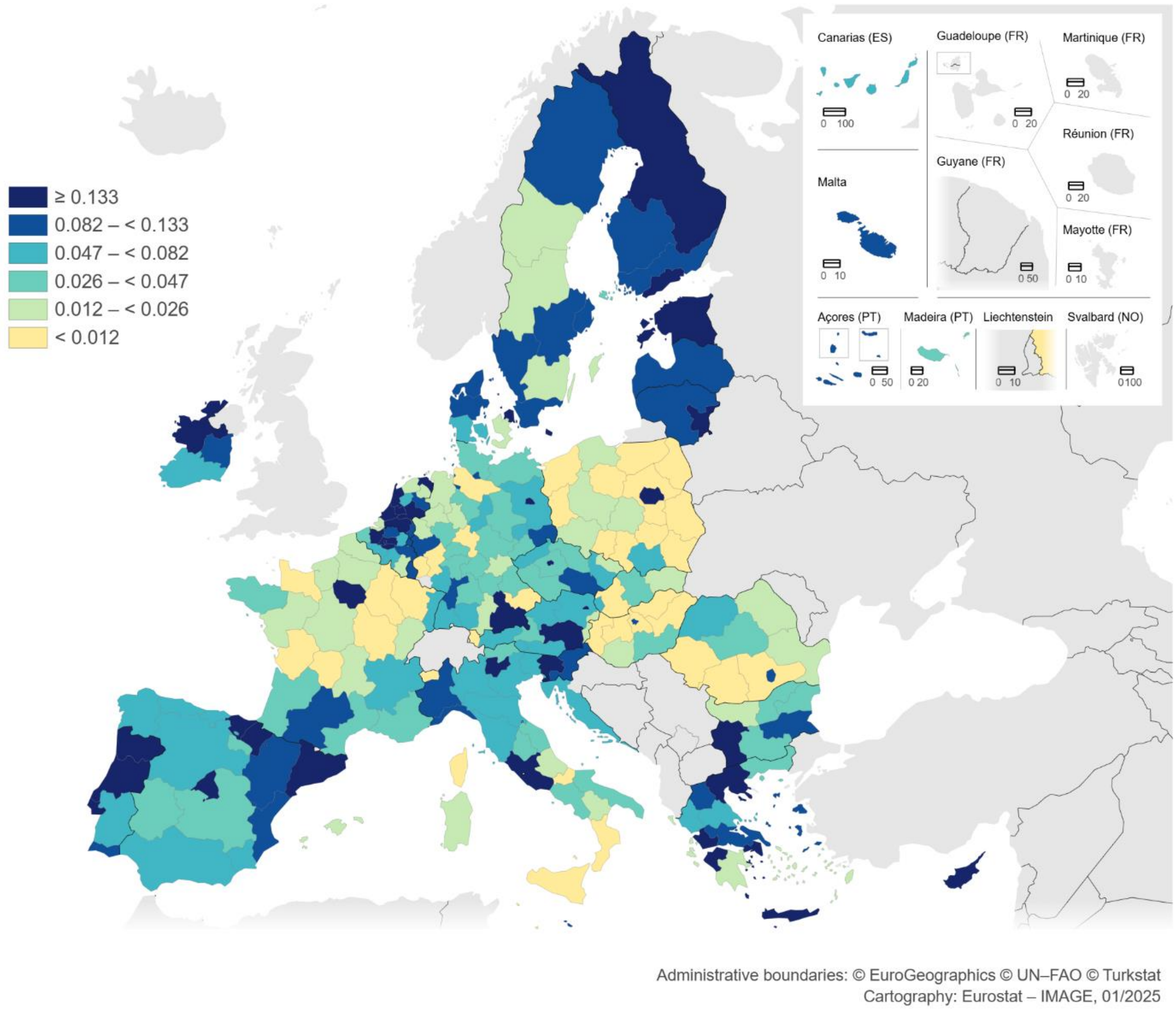
	2021	2022	2023	2024	2025	2026	2027	2030	2034	2040	2044	2050
GDP change (% w.r.t. 2020 GDP)	0.002	0.037	0.082	0.101	0.098	0.091	0.086	0.073	0.060	0.045	0.037	0.028
GDP change (mn €, 2020 prices)	300.2	4962.3	11149.2	13670.3	13301.7	12366.9	11614.8	9894.8	8149.3	6122.0	5055.6	3786.4
GDP multiplier	0.343	0.342	0.6	0.995	1.435	1.845	2.229	3.264	4.425	5.798	6.518	7.369
Exports change (% w.r.t. 2020 exports)	-0.005	-0.100	0.017	0.137	0.141	0.109	0.090	0.063	0.049	0.036	0.029	0.022
Imports change (% w.r.t. 2020 imports)	0.007	0.125	0.062	-0.028	-0.028	-0.003	0.009	0.020	0.018	0.014	0.012	0.009
Employment change (% w.r.t. 2020 employment)	0.002	0.035	0.050	0.046	0.042	0.040	0.039	0.034	0.028	0.022	0.018	0.013
Employment change (thousand persons)	3.3	66.8	94.3	86.7	79.8	76.8	73.8	64.8	54.2	42.2	34.6	25.6
Horizon Europe contribution (mn €, 2020 prices)	874.3	14496.7	11959.4	2894.4								
Crowding-in of the applied research funds (mn €, 2020 prices)	2.4	517.0	934.4	1237.1								

Source: RHOMOLO simulations (and DG RTD for the Horizon Europe contribution).

Private investment over the four years of the policy increases by a total of €23,848 million in 2020 prices, i.e. 13% more than the Horizon Europe funding for applied research (70% of the total, i.e. €21,157 million in 2020 prices), as assumed to be consistent with the NEMESIS analysis, as explained in the previous section.

The advantage of using a spatial dynamic model is that results can be obtained for the different territories targeted by the policy. Figure 2.1 shows the territorial distribution of the Horizon Europe funds (2021-2024) and it is expected that the GDP impact reflects this distribution, especially in the short term. In the longer term, there are spill-over effects, which could be either positive (due to synergies between regional economic systems) or negative (due to increased competitiveness in regions that benefit more from the policy at the expense of other regions). Figures 4.2 - 4.4 show the territorial distribution of the GDP impact of the policy injections, expressed as percentage deviations with respect to 2020 GDP (hypothetical scenario without the policy) in the following years: 2024, 2030, and 2050, respectively.[5]

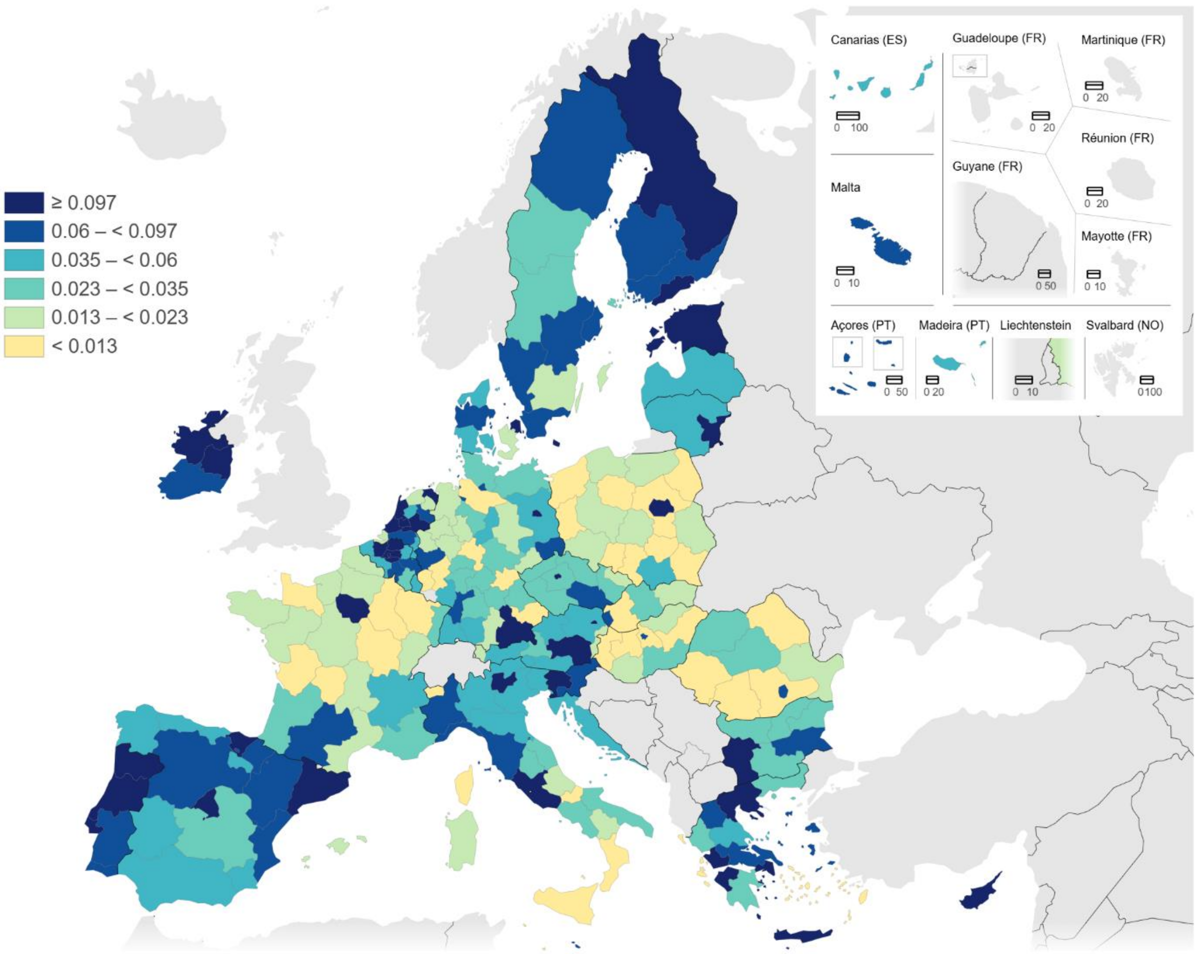
Figure 4.2 Territorial distribution of the GDP impact of the Horizon Europe funds (2021-2024) in 2024 (expressed as % deviations from 2020 GDP)



Source: RHOMOLO simulations. Data are grouped into quantiles.

[5] Caution should be exercised when comparing the maps between different years, as the level of impact varies between the maps and the colour presentation can be misleading, making direct visual comparisons difficult and potentially leading to misinterpretations of the evolution of the impact of the policy over time.

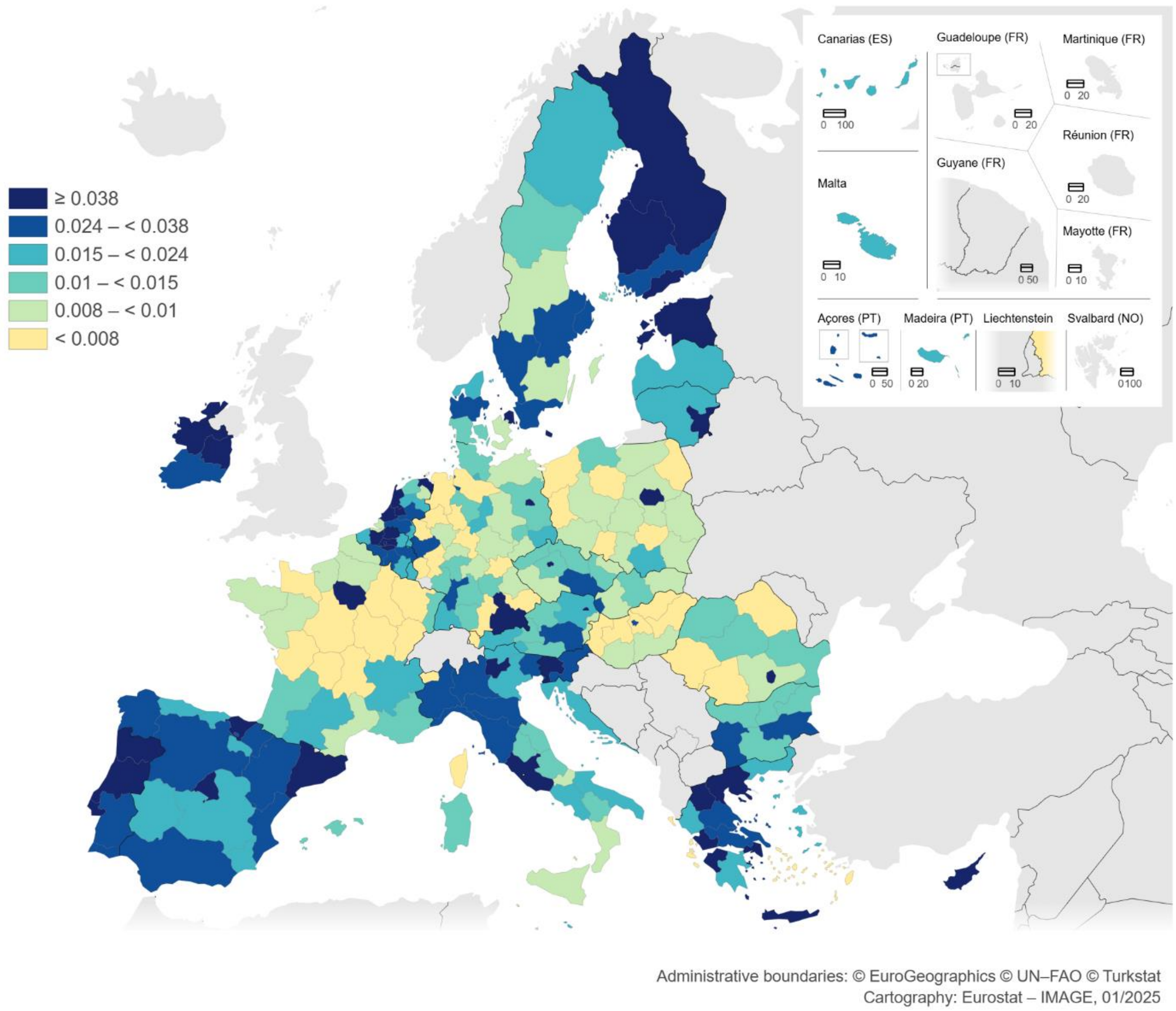
Figure 4.3 Territorial distribution of the GDP impact of the Horizon Europe funds (2021-2024) in 2030 (expressed as % deviations from 2020 GDP)



Administrative boundaries: © EuroGeographics © UN–FAO © Turkstat
Cartography: Eurostat – IMAGE, 01/2025

Source: RHOMOLO simulations. Data are grouped into quantiles.

Figure 4.4 Territorial distribution of the GDP impact of the Horizon Europe funds (2021-2024) in 2050 (expressed as % deviations from 2020 GDP)



Source: RHOMOLO simulations. Data are grouped into quantiles.

The impact on GDP in 2024 (Figure 4.2) is stronger in the regions receiving more Horizon Europe funding. For example, the macroeconomic impact of the policy is relatively high in the Scandinavian regions, Central Europe and the Iberian Peninsula. Moreover, in most countries the capital regions benefit more than the other regions, which is particularly evident in countries such as Poland, the Czech Republic, Slovakia, Hungary, Bulgaria, and Romania. Regions receiving more Horizon Europe funding relative to their number of scientists and engineers (see Table 2.1) also benefit from high macroeconomic impacts. In some cases, this is combined with the 'capital city effect' (Brussels, Wien).

Over time, in countries such as Spain, Italy, France, Germany and Poland, the effects gradually spill over to regions receiving relatively less Horizon Europe funding (2021-2024) – see Figures 4.3 and 4.4. However, this does not seem to be the case in all EU countries, as the effects remain mostly concentrated in the richest regions, which are also the capital regions in Hungary, Bulgaria and Romania. This last finding is not entirely surprising: Barbero et al. (2024) found that investments in the capital regions show little spillover to the peripheral regions, because the trade flows of the richest regions are mostly with regions abroad and therefore investments there do not stimulate production in the neighbouring regions of the same country. The diffusion of knowledge between beneficiary regions is also facilitated by the important cross-border collaboration in Horizon Europe projects. 81% of Horizon Europe funding is allocated to collaborative projects led by consortia of several partners from different countries (an average of 16 partners for Pillar II projects), including from enlargement Member States. By establishing or strengthening collaborations with leading research organisations, these projects contribute to the dissemination of knowledge across Member States and increase the impact of R&I funding and the European Research Area (European Commission, 2025).

Overall, the magnitude of the impact decreases across the board, due to the temporary nature of the investments (from 2021 to 2024) and the assumed depreciation rates of the temporarily increased private and public capital stocks, as well as the decay rate of the TFP improvements.

5. The FIDELIO modelling results

The EU-wide GDP impacts obtained with the FIDELIO model are consistent with those obtained with RHOMOLO presented above. Therefore, this section focuses on additional results that take advantage of the sectoral detail available with the FIDELIO model.

Figure 5.1 shows the simulated impact of Horizon Europe 2021-2024 investments on EU GDP from 2021 to 2050, estimated ex ante by the FIDELIO model. The impact of Horizon Europe funding on the EU GDP can be broken down by institutional sector and by industry (NACE codes). The split for various institutional sectors and selected industries is presented in Table 5.1. The figures shown are percentage deviations from the initial steady state, which is a hypothetical scenario in which no European R&D investments are introduced into the economy (refer to Annex A for detailed contributions from all industries).

Within the EU, most of the simulated impact of Horizon Europe is directed towards the business sector (BERD), with a contribution to the overall GDP impact of 68.5% in 2023. It is followed by the higher education sector (HERD) with 28.1%, which indicates that the impact on GOVERD is relatively small (3.5%). The relative contribution of the BERD sector increases over time, and from 2027 onwards, almost all of the residual GDP impact is to be attributed to BERD.

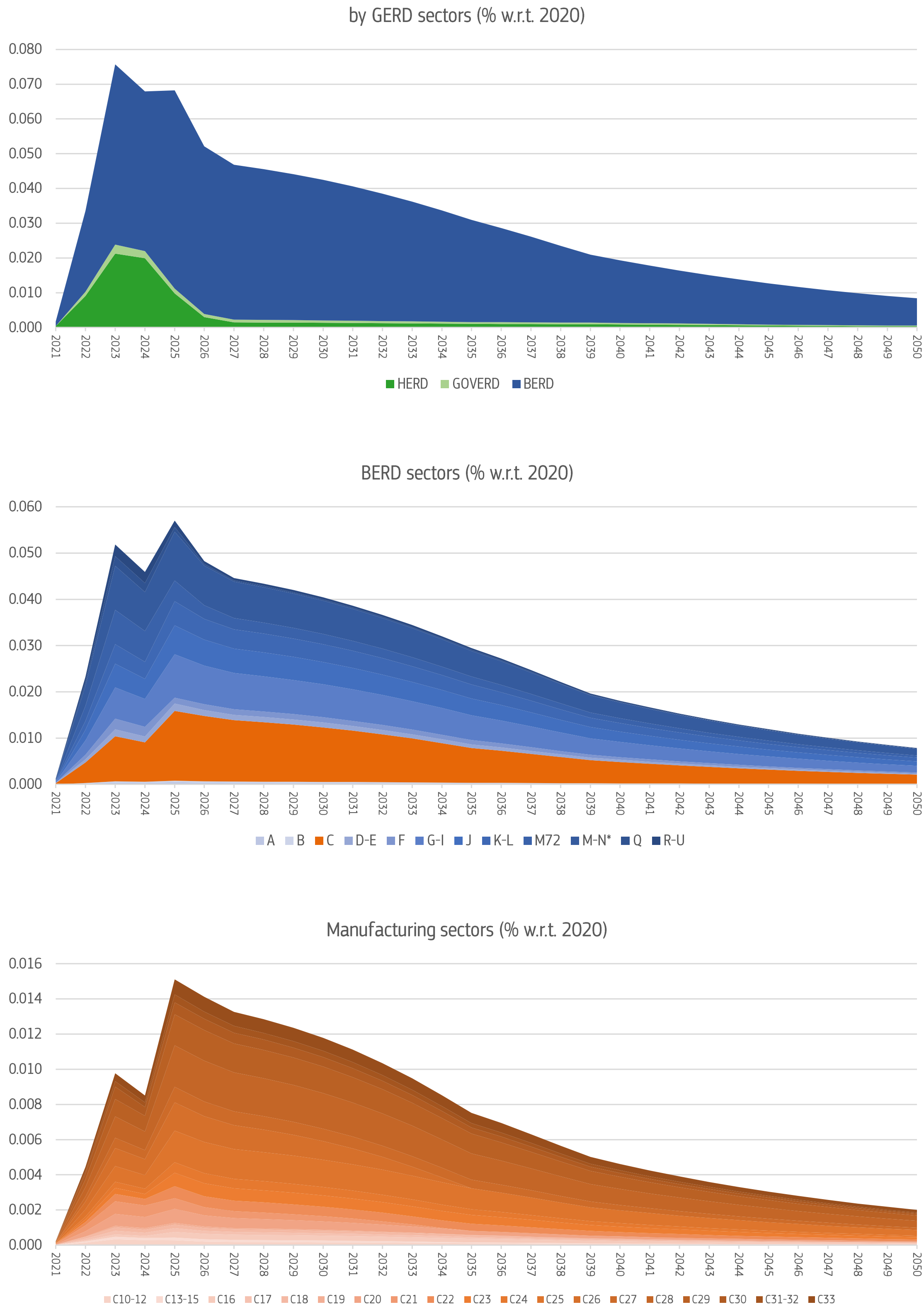
The GDP impact on HERD fluctuates the most over time. During the time of the intervention (2021-2024), it accounts for a significant share of the total GDP change (between 21.2% and 29.3%), but it drops considerably once the intervention finishes, with values between 3.1% and 4.7% for the period 2027-2050. However, the intervention is assumed to end only within the context of the modelling approach – which focuses on the R&D investment between 2021 and 2024, while in practice EU investment in R&D is expected to continue over time without interruption

Table 5.1 Horizon Europe (2021-2024) impact over time on GDP impact (EU27) by GERD sectors and industries

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2040	2045	2050
GDP change contribution (%) by GERD sectors	**GERD**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	GOVERD	2.9	3.7	3.5	3.1	2.1	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	2.3	2.2	2.3
	HERD	21.2	27.0	28.1	29.3	14.3	5.7	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.3	3.3	4.5	4.3	4.7
	BERD	75.9	69.3	68.5	67.6	83.6	92.6	95.2	95.2	95.2	95.2	95.2	95.2	95.1	95.1	95.0	93.2	93.5	93.0
Business sector R&D (BERD) change contribution (%) by NACE A*10	**BERD**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	A	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5
	B	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
	C	17.7	19.1	18.9	18.5	26.5	29.3	29.7	29.6	29.4	29.1	28.8	28.2	27.5	26.6	25.6	25.6	25.6	25.6
	D-E	2.3	2.8	2.8	2.8	2.8	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	F	3.9	4.4	4.4	4.6	2.2	2.6	2.7	2.8	2.8	2.8	2.8	2.9	3.0	3.1	3.2	3.2	3.2	3.2
	G-I	14.8	13.2	13.1	13.1	16.5	17.3	17.5	17.5	17.6	17.6	17.7	17.8	17.9	18.0	18.2	18.2	18.2	18.2
	J	7.5	10.0	9.9	9.5	11.0	11.7	11.9	11.9	11.9	11.9	12.0	12.0	12.1	12.2	12.3	12.3	12.3	12.3
	K-L	7.3	8.2	8.1	8.0	9.2	9.3	9.3	9.4	9.4	9.5	9.6	9.7	9.8	10.0	10.3	10.3	10.3	10.3
	M72	8.9	14.0	14.3	14.5	7.8	6.1	5.5	5.5	5.5	5.5	5.6	5.6	5.7	5.8	5.9	5.9	5.9	5.9
	M-N*	23.5	18.6	18.3	18.4	18.6	17.7	17.6	17.7	17.7	17.8	17.9	18.1	18.3	18.5	18.9	18.9	18.9	18.9
	Q	3.4	3.7	4.1	4.3	1.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8
	R-U	9.6	4.8	4.9	5.2	2.4	1.3	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3
Manufacturing change contribution (%) by Manufacturing	**Manufacturing**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	C10-12	3.3	3.4	3.4	3.4	1.8	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	C13-15	1.2	1.5	1.4	1.4	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
	C16	1.3	1.4	1.4	1.4	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.5	2.6	2.7	2.9	2.9	2.9	2.9
	C17	1.7	2.1	2.1	2.1	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	C18	1.9	2.0	2.1	2.1	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4
	C19	0.8	0.7	0.8	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2
	C20	6.8	6.7	6.9	7.4	5.3	4.5	4.3	4.2	4.2	4.1	4.0	3.9	3.7	3.5	3.1	3.1	3.1	3.1
	C21	15.4	7.4	7.3	7.7	4.0	3.2	3.0	2.9	2.7	2.5	2.2	1.8	1.2	0.3	0.0	0.0	0.0	0.0
	C22	3.8	4.2	4.3	4.3	4.5	4.4	4.5	4.5	4.5	4.6	4.6	4.8	4.9	5.1	5.3	5.3	5.3	5.3
	C23	2.7	3.5	3.5	3.5	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.7	6.0	6.3	6.7	6.7	6.7	6.7
	C24	3.8	3.6	3.5	3.5	3.9	4.0	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.3	4.3	4.3	4.3
	C25	9.2	9.2	9.1	9.1	11.9	12.6	12.8	12.9	13.0	13.2	13.4	13.8	14.3	15.0	15.8	15.8	15.8	15.8
	C26	7.8	10.1	10.4	10.7	10.7	10.4	10.3	10.0	9.6	9.0	8.2	7.0	5.4	3.2	0.0	0.0	0.0	0.0
	C27	6.3	6.1	6.1	6.0	5.8	5.9	5.9	5.9	5.9	6.0	6.1	6.1	6.3	6.4	6.6	6.6	6.6	6.6
	C28	13.6	12.4	12.3	12.4	15.6	16.5	16.7	16.8	17.0	17.2	17.4	17.8	18.3	19.0	19.8	19.8	19.8	19.8
	C29	8.8	9.7	10.1	10.5	11.7	12.3	12.4	12.5	12.6	12.8	13.0	13.3	13.7	14.2	14.9	14.9	14.9	14.9
	C30	4.7	8.0	7.2	5.9	4.5	4.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7
	C31-32	2.7	3.2	3.2	3.1	3.0	2.9	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.2	3.3	3.3	3.3	3.3
	C33	4.1	4.8	4.7	4.6	5.7	6.0	6.1	6.1	6.2	6.3	6.4	6.6	6.9	7.3	7.8	7.8	7.8	7.8

Source: FIDELIO simulations. Note: M-N* refers to all the industries in M and N, excluding M72.

Figure 5.1 Horizon Europe (2021-2024) impact on EU27 GDP (% w.r.t. baseline)



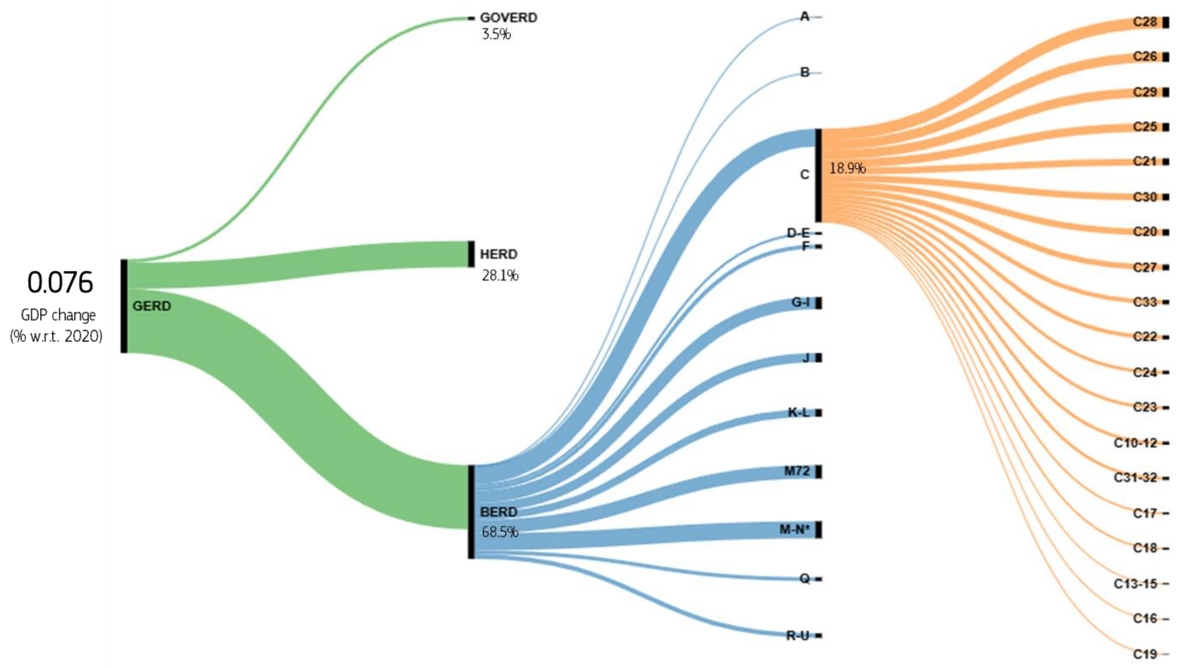
Source: FIDELIO simulations. Note: M-N* refers to all the industries in M and N, excluding M72.

As shown in Table 5.2 and Figure 5.2, the impact of Horizon Europe funds on the EU can be further broken down by industry NACE codes. Figure 5.2 shows the impact on BERD by industry (Sankey diagram). The impact on the manufacturing sector (C) stands out. In 2023 it accounts for 18.9% of the total impact on BERD. Within manufacturing, the most important subsectors are the manufacture of machinery and equipment (C28), the manufacture of computer, electronic and optical products (C26), the manufacture of motor vehicles (C29) and the manufacture of fabricated metal products (C25). Professional, scientific and technical activities (M) is also a sector that contributes to the overall GDP impact, mainly driven by the sub-sector Scientific research and development (M72), which alone accounts for 14.3% of the BERD impact. In the long term, impact projections for 2030 show similar trends, with BERD receiving 95.2% of GERD and an increased impact on manufacturing (29.1%), particularly in industries C25, C28 and C29. While the relative contribution to GDP impact increases over time for these manufacturing sectors, the contribution of scientific research and development peaks during the intervention period. This can partly be explained by the modelling assumptions, which assigns all basic research activities to sector M72. In addition, BERD can generate significant spillover effects. These spillover effects can have long-term benefits for the economy, as they can lead to the creation of new clusters, networks, and ecosystems that can drive innovation and growth. In contrast, HERD generates more indirect and intangible benefits, including advancements in knowledge, improved education and training, and broader societal benefits, which are often more challenging to quantify. The distinct return profiles of BERD and HERD are reflected in their respective rates of return on investment, with BERD typically producing higher returns. This suggests that allocating resources to BERD may lead to higher long-term returns, whereas the benefits of HERD may be more diffuse and slower to materialize.

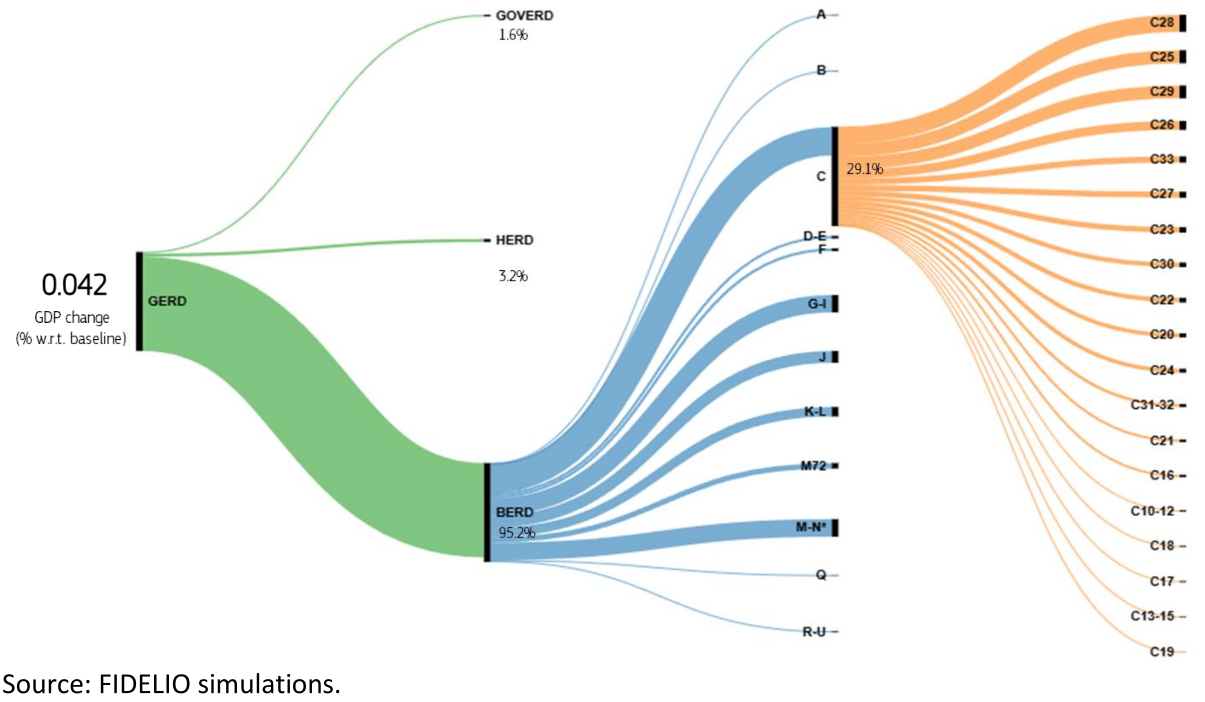
Concrete examples of the impact generated by the manufacturing sector are illustrated by the economic outcomes of the Joint Undertakings (JU) – public-private partnerships co-funded by Horizon Europe – and their contribution to EU’s global leadership and resilience in key technologies. For example, under sub-sector C28, the Clean Hydrogen JU was instrumental in advancing electrolyser technology and scaling up capacity. The Chips JU contributed to the impact of sub-sector C26, by strengthening the European electronic components and systems (ECS) industry by driving innovation and advances in semiconductor manufacturing, and improving the resilience of its technology value chains (European Commission, 2025).

Figure 5.2 Horizon Europe impact on EU27, by institutional sector and industry.

Year: 2023



Year: 2030



Source: FIDELIO simulations.

The sectoral distribution of the GDP impact of Horizon Europe funding varies significantly across countries. Annex B presents an illustration of such distribution in 2023 and in 2030 by institutional sector and industry for selected EU countries – Germany, France, Belgium, the Netherlands, Italy, Spain- taking into account that these are the countries receiving a higher amount of funds.

FIDELIO estimates a strongest GDP increase in the short run for Netherlands. However, in the longer run, Spain and Italy are estimated to be the countries with the highest positive GDP effects. In 2023, the proportion on impact observed for BERD ranged between 61% in Belgium to 85% in France; however, in 2030, for all six countries over 90% of all observed GDP impact is observed on BERD.

The distribution of the effects within the business sector is more distinct between countries. In **Germany** (Figure B.1 in Annex B), the impact on the manufacturing sectors (C) stands out, primarily due to the sub-sectors of the Manufacture of motor vehicles, trailers and semi-trailers (C29), the Manufacture of machinery and equipment (C28), the Manufacture of computer, electronic and optical products (C26), and the Manufacture of fabricated metal products (C25).

In **France** (Figure B.2), a higher proportion of the GDP impact is attributed to the M72 sector (scientific research and development). Manufacturing plays a significant less important role than in Germany, representing less than 20% of total GDP change in 2030 (against almost 50% in Germany). The strongest manufacturing sectors are also different between 2023 and 2030, with Manufacture of fabricated metal products (C25) gaining in importance over Repair and installation of machinery and equipment (C33).

Belgium (Figure B.3) and the **Netherlands** (Figure B.5) both show higher estimated short-term impact from scientific research and development sectors and, in the case of Belgium, Manufacture of pharmaceuticals (C21). However, over time, in both countries other manufacturing sectors increase in importance, such as manufacturing of machinery and equipment (C28). Both countries also show a strong impact from the HERD sector in the short-term, which drops in the longer-term affecting the overall GDP impact.

In **Italy** (Figure B.4) and **Spain** (Figure B.6) as well, most of the GDP impact is driven by sectors other than manufacturing, with similar sectors standing out both in the short and in the longer-term, such as Manufacture of fabricated metal products (C25, both countries), Manufacture of machinery and equipment (C28, mostly Italy), and Manufacture of motor vehicles, trailers, and semi-trailers (C29, primarily Spain).

6. Conclusions

This document presents the results of simulations carried out with the spatial dynamic CGE models RHOMOLO and FIDELIO, using data on the R&I projects signed under Horizon Europe between 1 January 2021 and 1 July 2024. This analysis is carried out in the mark of the interim assessment of the policy. However, the results should not be interpreted as a way of measuring the actual macroeconomic impact of the Horizon Europe interventions, as they are based on assumptions regarding both the modelling setup and the simulation strategy used to simulate the impact of the investments, i.e. the economic channels activated by them. General equilibrium models, in addition to the direct effects of the policy in terms of cash injections and contributions levied to finance the policy, are able to track the indirect and induced effects across all agents, regions and sectors of the economy.

According to the RHOMOLO analysis, at the EU level, the policy is able to generate almost one euro of GDP for every euro spent through Horizon Europe already at the end of the four years of simulated financial injections. Given the supply-side effects of the interventions on productivity and the capital stock of the economy, the GDP multiplier increases over time and is above 4 in 2034, i.e. ten years after the end of the simulated policy investments. In the very long run (2050), GDP is still above its pre-policy level. In addition to presenting the macroeconomic impact of the Horizon Europe interventions at EU level on GDP, multipliers, employment, trade balance, consumption and prices, we have shown the territorial distribution of the GDP impact over time up to 2050. The RHOMOLO simulations suggest that the policy has a significant macroeconomic impact, with significant inter-regional spillovers in some, but not all, EU countries.

The impact analysis of Horizon Europe using the FIDELIO model demonstrates a positive effect on the European economy, particularly in the manufacturing sector. In particular, simulations results indicate that the positive effects on innovations gains, in the BERD sector investments contribute to substantial GDP gains following the conclusion of the four-year intervention period. The impact is primarily directed towards business R&D in the manufacturing sector, with the top benefiting sectors being machinery and equipment, computer, electronic, and optical products, motor vehicles, trailers, and semi-trailers, and fabricated metal products.

It is worth mentioning some limitations of the analysis. First, this is a scenario analysis, so all results are obtained by perturbing an initial equilibrium and do not reflect the actual economic outcomes that occurred during the period analysed. The results presented here assume that all funds allocated through Horizon Europe are used efficiently and activate the economic channels used in the model to simulate their impact. It is also assumed in terms of timing that the funds start to have an impact on the economy as soon as the projects are signed, but it is realistic to expect delays in the use of funds with respect to the date of project signature. The distinction between basic and applied research can be considered as a strong assumption, in particular due to its homogeneity across EU regions. Finally, the results are inevitably affected by the parameterisation of the shocks used to simulate the impact of the policy (including the elasticity used to govern the changes in TFP brought about by the Horizon Europe investments or the output elasticity of public capital). We limit the uncertainty of our results by using values that are consistent with the existing literature on the subject.

References

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In *The Rate and Direction of Inventive Activity* (R. Nelson, pp. 219–236). Princeton, NJ: Princeton University Press.

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

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

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

Blanchflower, D.G., and Oswald, A.J. (1995). An introduction to the wage curve. *Journal of Economic Perspectives* 9(3), 153-167. DOI: 10.1257/jep.9.3.153

Bom, P. R., and Ligthart, J. E., (2014). What have we learned from three decades of research on the productivity of public capital? *Journal of Economic Surveys* 28(5), 889-916. https://doi.org/10.1111/joes.12037

Christou, T., Crucitti, F., García-Rodríguez, A., Lazarou, N.J., and Salotti, S. (2024). The RHOMOLO ex-post assessment of the 2014-2020 European research and innovation funding programme (Horizon 2020). JRC Working Papers on Territorial Modelling and Analysis No. 01/2024, European Commission, Seville, JRC133690.

Dietzenbacher, E., & Los, B. (2002). Externalities of R&D expenditures. *Economic Systems Research*, *14*(4), 407-425.

Enger, S.G. (2018). Closed clubs: Network centrality and participation in Horizon 2020. *Science and Public Policy* 45(6), 884-896.

European Commission, Directorate-General for Research and Innovation. Science, research and innovation performance of the EU (2024a). A competitive Europe for a sustainable future, Publications Office of the European Union, 2024.

European Commission (2024b). REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL: Ex-post evaluation of Horizon 2020, the EU Framework Programme for Research and Innovation. SWD(2024) 29 final. Brussels, 29.1.2024.

European Commission (2025). Interim evaluation of the Horizon Europe Framework Programme for research and innovation (2021-2024). SWD(2025) 110 final. Brussles, 30.4.2025.

Fisher, W.H., and Turnovsky, S.J. (1998). Public investment, congestion, and private capital accumulation. *The Economic Journal* 108(447), 399-413. https://doi.org/10.1111/1468-0297.00294

García-Rodríguez, A., Lazarou, N., Mandras, G., Salotti, S., Thissen, M., and Kalvelagen, E. (2023). A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset. JRC Working Papers on Territorial Modelling and Analysis no. 01/2023, JRC132883.

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

Lecca, P., Christensen, M., Conte, A., Mandras, G., and Salotti, S. (2020). Upward pressure on wages and the interregional trade spillover effects under demand-side shocks. *Papers in Regional Science* 99(1), 165-182. https://doi.org/10.1111/pirs.12472

Los, B. (2001). Endogenous growth and structural change in a dynamic input-output model. *Economic Systems Research*, *13*(1), 3-34.

Mansfield, E. (1972). Contribution of R&D to Economic Growth in the United States. *Science*, 175(4021), 477–486.

Miller, R. E., & Blair, P. D. (2022). *Input-output analysis: foundations and extensions*. Cambridge university press.

Männasoo, K., Hein, H., and Ruubel, R. (2018). The contributions of human capital, R&D spending and convergence to total factor productivity growth. *Regional Studies* 52(12), 1598-1611. DOI: 10.1080/00343404.2018.1445848

Mazzucato, M. (2018). Mission-oriented research & innovation in the European Union. Publications office of the European Union, Luxembourg.808

Mitra, A., Canton, E., Ravet, J., and Steeman, J.T. (2024). The added value of European investments in research and innovation. Policy brief, Directorate-General for Research and Innovation, doi: 10.2777/682623

Neicu, D. (2016). Learning how to behave. An analysis of the behavioural changes induced by public support for R&D. University of Leuven, Belgium.

Nelson, R. R. (1959). The simple economics of basic scientific research. *The Journal of Political Economy*, 67(3), 297–306.

Okuyama, Y. (2017). Dynamic input–output analysis. In *Handbook of input–output analysis* (pp. 464-484). Edward Elgar Publishing.

Persyn, D., Díaz-Lanchas, J., and Barbero, J. (2022). Estimating distance and road transport costs between and within European Union regions. *Transport Policy* 124, 33-42. https://doi.org/10.1016/j.tranpol.2020.04.006

Pfeiffer, P., Varga, J., and in 't Veld, J., (2021). Quantifying spillovers of Next Generation EU investment. European Economy Discussion Papers no. 144, July.

Pollex, J., and Lenschow, A. (2018). Surrendering to growth? The European Union's goals for research and technology in the Horizon 2020 framework. Journal of Cleaner Production 197(2), 1863-1871.

Rocchi, P., Reynès, F., Hu, J., Pedauga, L., Cai, M., Boonman, H., Rueda Cantuche, J.M. (2025). FIDELIO 4 manual: Equations and data sources, JRC Technical Report (forthcoming).

Rocchi, P., Salotti, S., Reynès, F., Hu, J., Bulavskaya, T., Rueda Cantuche, J.M., Valderas Jaramillo, J.M., Velázquez Afonso, A., Amores, A.F., Corsatea, T. (2019). FIDELIO 3 manual: Equations and data sources, EUR 29620 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-98872-1, doi:10.2760/219417, JRC115308.

Rosenberg, N. (1990). Why do firms do basic research (with their own money)? *Research Policy*, 19(2), 165–174.

Veugelers, R., Cincera, M., Frietsch, R., Rammer, C., Schubert, T., Pelle, A., Montalvo, C., and Leijten, J. (2015). The impact of Horizon 2020 on innovation in Europe. *Intereconomics* 50(1), 4-30.

Annex A

EU27 GDP change contribution (%) by GERD and NACE sectors 2021-2050

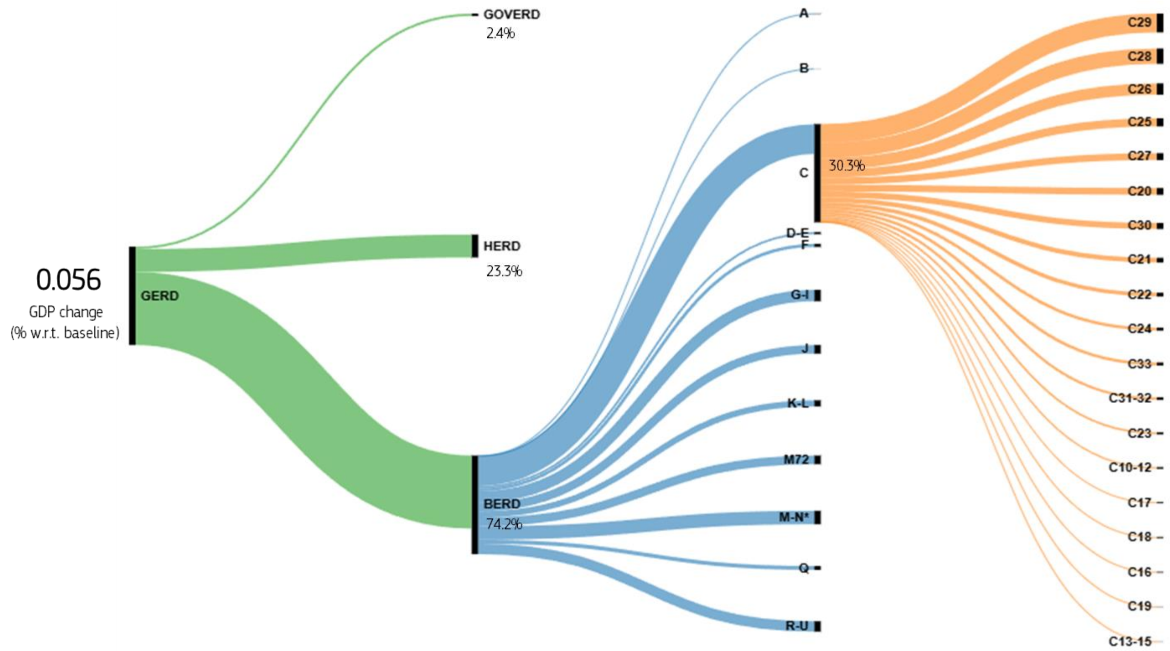
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2040	2045	2050
GERD	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
GOVERD	2.9	3.7	3.5	3.1	2.1	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	2.3	2.2	2.3
HERD	21.2	27.0	28.1	29.3	14.3	5.7	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.3	3.3	4.5	4.3	4.7
BERD	75.9	69.3	68.5	67.6	83.6	92.6	95.2	95.2	95.2	95.2	95.2	95.2	95.1	95.1	95.0	93.2	93.5	93.0
A01	0.39	0.40	0.39	0.38	0.45	0.44	0.43	0.42	0.41	0.39	0.37	0.34	0.30	0.25	0.18	0.18	0.18	0.18
A02	0.09	0.12	0.11	0.11	0.21	0.26	0.27	0.27	0.27	0.27	0.27	0.28	0.28	0.28	0.29	0.29	0.29	0.29
A03	0.06	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
B	0.29	0.31	0.31	0.31	0.47	0.53	0.56	0.56	0.57	0.58	0.59	0.60	0.61	0.63	0.65	0.63	0.64	0.63
C10-12	0.45	0.45	0.44	0.42	0.40	0.39	0.39	0.39	0.38	0.38	0.38	0.37	0.36	0.35	0.34	0.34	0.34	0.33
C13-15	0.17	0.19	0.19	0.18	0.23	0.24	0.24	0.24	0.24	0.24	0.23	0.22	0.21	0.19	0.16	0.16	0.16	0.16
C16	0.17	0.18	0.18	0.18	0.47	0.60	0.63	0.64	0.64	0.64	0.65	0.66	0.67	0.68	0.70	0.69	0.69	0.69
C17	0.23	0.28	0.27	0.26	0.31	0.33	0.34	0.34	0.33	0.33	0.33	0.32	0.31	0.30	0.28	0.28	0.28	0.28
C18	0.26	0.27	0.27	0.27	0.31	0.32	0.33	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.33
C19	0.10	0.10	0.11	0.12	0.14	0.14	0.14	0.14	0.13	0.12	0.11	0.10	0.08	0.06	0.04	0.04	0.04	0.04
C20	0.91	0.89	0.89	0.93	1.16	1.23	1.21	1.19	1.17	1.14	1.10	1.04	0.97	0.88	0.76	0.75	0.75	0.74
C21	2.07	0.98	0.94	0.97	0.90	0.87	0.84	0.81	0.76	0.69	0.60	0.47	0.31	0.09	0.00	0.00	0.00	0.00
C22	0.51	0.56	0.55	0.54	0.99	1.20	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.29	1.29	1.27	1.27	1.26
C23	0.36	0.46	0.45	0.43	1.12	1.41	1.50	1.51	1.51	1.52	1.53	1.54	1.57	1.60	1.63	1.60	1.61	1.60
C24	0.51	0.47	0.46	0.44	0.87	1.08	1.14	1.13	1.13	1.12	1.11	1.10	1.08	1.06	1.04	1.02	1.02	1.01
C25	1.24	1.22	1.18	1.14	2.64	3.41	3.61	3.62	3.64	3.65	3.67	3.70	3.74	3.78	3.85	3.77	3.79	3.77
C26	1.05	1.34	1.35	1.34	2.36	2.83	2.90	2.81	2.68	2.49	2.23	1.88	1.42	0.80	0.00	0.00	0.00	0.00
C27	0.84	0.81	0.79	0.76	1.29	1.59	1.67	1.67	1.66	1.66	1.66	1.65	1.64	1.62	1.60	1.57	1.57	1.56
C28	1.83	1.64	1.59	1.55	3.45	4.47	4.74	4.75	4.75	4.76	4.77	4.78	4.79	4.80	4.81	4.72	4.73	4.71
C29	1.19	1.29	1.31	1.32	2.59	3.34	3.52	3.53	3.54	3.55	3.56	3.57	3.58	3.60	3.63	3.56	3.57	3.55
C30	0.64	1.05	0.93	0.74	1.01	1.22	1.29	1.29	1.28	1.27	1.26	1.24	1.22	1.18	1.14	1.12	1.12	1.12
C31-32	0.36	0.42	0.41	0.39	0.66	0.79	0.83	0.83	0.83	0.83	0.83	0.83	0.82	0.82	0.81	0.79	0.79	0.79
C33	0.56	0.64	0.61	0.57	1.25	1.62	1.72	1.73	1.73	1.75	1.76	1.78	1.81	1.85	1.90	1.86	1.87	1.86
D35	1.13	1.32	1.32	1.32	1.54	1.59	1.61	1.61	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.57	1.57	1.56
E36	0.15	0.16	0.16	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
E37-39	0.46	0.49	0.46	0.43	0.60	0.67	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.68	0.68	0.68
F	2.98	3.02	3.03	3.08	1.83	2.42	2.61	2.62	2.64	2.66	2.70	2.75	2.82	2.92	3.06	3.00	3.01	2.99
G45	0.83	0.74	0.71	0.68	1.30	1.64	1.73	1.73	1.74	1.75	1.76	1.78	1.81	1.84	1.89	1.85	1.86	1.85
G46	4.00	3.70	3.58	3.47	6.04	7.27	7.61	7.63	7.64	7.67	7.69	7.72	7.76	7.81	7.87	7.72	7.74	7.70
G47	1.04	1.15	1.12	1.09	1.80	2.11	2.20	2.22	2.23	2.25	2.29	2.33	2.38	2.46	2.56	2.52	2.52	2.51
H49	1.43	1.35	1.31	1.28	1.81	2.04	2.10	2.10	2.09	2.08	2.07	2.05	2.04	2.01	1.99	1.95	1.95	1.94
H50	0.06	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.08	0.07	0.07	0.05	0.04	0.02	0.00	0.00	0.00	0.00
H51	0.12	0.11	0.11	0.11	0.13	0.13	0.13	0.13	0.12	0.12	0.11	0.10	0.08	0.07	0.04	0.04	0.04	0.04
H52	2.93	1.19	1.24	1.34	1.57	1.61	1.67	1.67	1.67	1.66	1.66	1.65	1.63	1.62	1.59	1.56	1.56	1.55
H53	0.31	0.30	0.30	0.30	0.35	0.38	0.39	0.39	0.39	0.39	0.40	0.40	0.40	0.41	0.41	0.40	0.40	0.40
I	0.50	0.52	0.52	0.51	0.67	0.72	0.74	0.74	0.75	0.76	0.78	0.81	0.84	0.89	0.96	0.94	0.94	0.94
J58	0.54	0.62	0.62	0.62	1.02	1.19	1.23	1.22	1.22	1.21	1.20	1.19	1.17	1.14	1.11	1.09	1.09	1.09
J59-60	0.28	0.29	0.28	0.27	0.55	0.70	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.75	0.75	0.74	0.74	0.73
J61	0.80	1.18	1.09	0.97	0.93	0.95	0.95	0.95	0.95	0.94	0.94	0.93	0.92	0.90	0.88	0.87	0.87	0.86
J62-63	4.07	4.87	4.76	4.54	6.66	8.01	8.38	8.40	8.43	8.46	8.51	8.57	8.66	8.79	8.96	8.79	8.82	8.77
K64	2.26	2.14	2.07	1.97	2.55	2.78	2.87	2.88	2.88	2.89	2.90	2.92	2.93	2.95	2.97	2.92	2.93	2.91
K65	0.30	0.24	0.24	0.24	0.29	0.32	0.32	0.33	0.33	0.33	0.34	0.34	0.35	0.36	0.37	0.36	0.36	0.36
K66	0.42	0.39	0.38	0.37	0.48	0.52	0.54	0.54	0.54	0.54	0.55	0.55	0.56	0.57	0.58	0.57	0.57	0.57
L	2.59	2.88	2.88	2.85	4.36	4.95	5.15	5.18	5.21	5.26	5.32	5.41	5.52	5.67	5.84	5.73	5.75	5.72
M69-70	5.77	4.03	3.88	3.80	4.82	5.20	5.35	5.36	5.37	5.39	5.41	5.45	5.50	5.56	5.64	5.54	5.55	5.52
M71	5.02	3.53	3.44	3.42	4.38	4.47	4.58	4.60	4.64	4.68	4.74	4.83	4.94	5.10	5.31	5.21	5.23	5.20
M72	6.73	9.69	9.80	9.78	6.54	5.68	5.24	5.24	5.25	5.28	5.30	5.34	5.40	5.47	5.58	5.47	5.49	5.46
M73	0.42	0.38	0.37	0.36	0.43	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.46
M74-75	1.29	0.92	0.88	0.86	0.79	0.71	0.69	0.69	0.70	0.70	0.70	0.70	0.71	0.71	0.72	0.71	0.71	0.71
N77	0.96	0.82	0.81	0.81	1.27	1.48	1.54	1.53	1.53	1.52	1.51	1.49	1.46	1.42	1.36	1.33	1.34	1.33
N78	1.30	1.02	1.00	0.99	1.44	1.64	1.71	1.71	1.72	1.73	1.74	1.75	1.77	1.80	1.82	1.79	1.80	1.79
N79	0.04	0.04	0.04	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
N80-82	3.06	2.16	2.12	2.13	2.32	2.34	2.36	2.36	2.37	2.38	2.40	2.42	2.44	2.48	2.53	2.48	2.49	2.47
Q86	2.43	2.37	2.55	2.68	1.35	0.68	0.55	0.56	0.56	0.56	0.57	0.58	0.60	0.62	0.65	0.63	0.64	0.63
Q87-88	0.12	0.22	0.23	0.23	0.13	0.08	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.11	0.11	0.11	0.11
R90-92	0.18	0.32	0.31	0.30	0.29	0.28	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28
R93	0.21	0.18	0.18	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17
S94	6.64	2.20	2.26	2.48	1.12	0.36	0.25	0.25	0.26	0.26	0.26	0.26	0.27	0.27	0.28	0.27	0.27	0.27
S95	0.07	0.08	0.08	0.08	0.15	0.20	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.23	0.22	0.22	0.22
S96	0.18	0.51	0.49	0.46	0.28	0.19	0.16	0.16	0.17	0.17	0.18	0.18	0.20	0.21	0.23	0.22	0.22	0.22
T	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.06	0.06	0.06	0.06

Source: FIDELIO simulations.

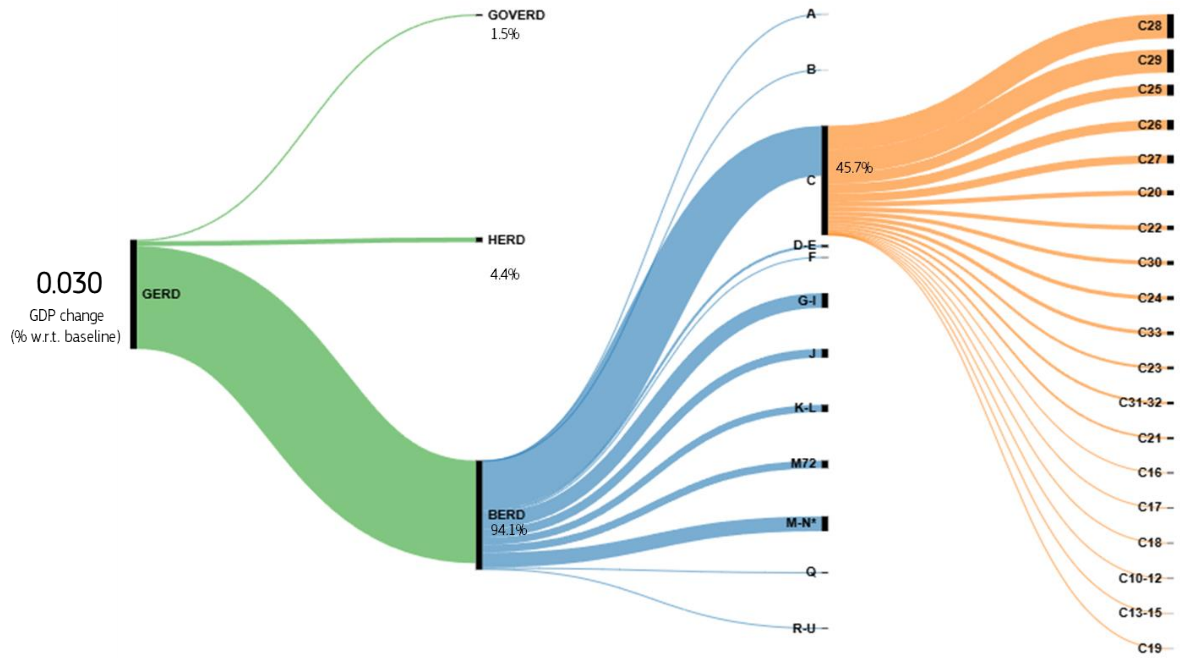
Annex B. Horizon Europe impact by country, institutional sector and industry (FIDELIO simulations)

Figure B.1: Germany

Year: 2023



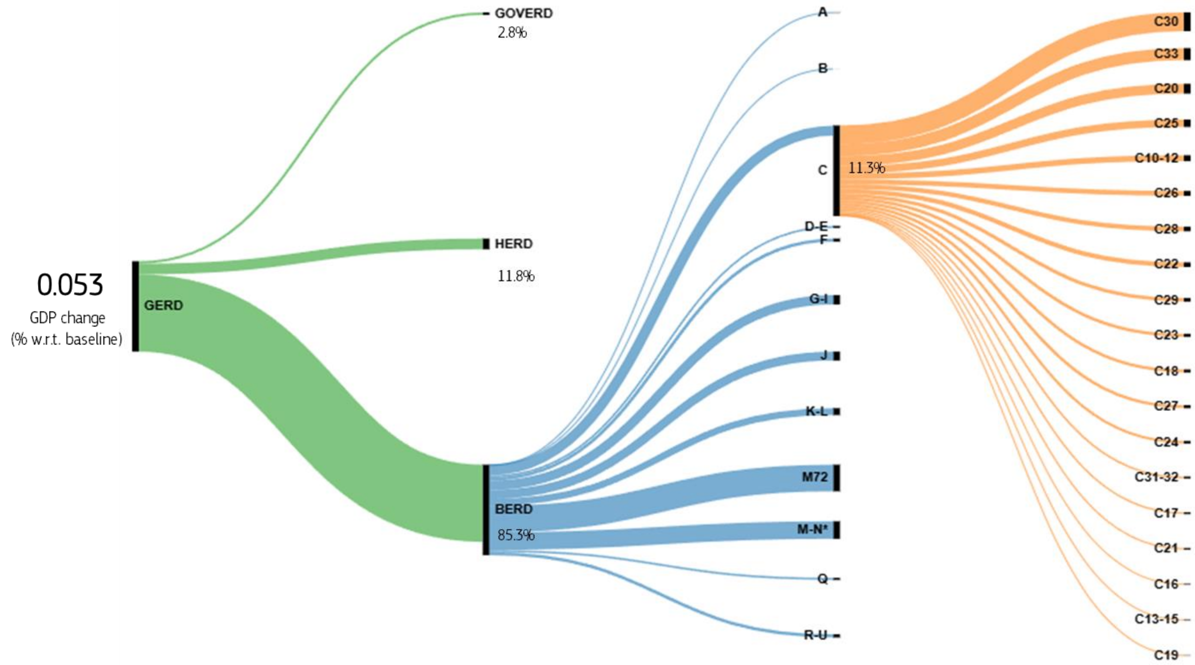
Year: 2030



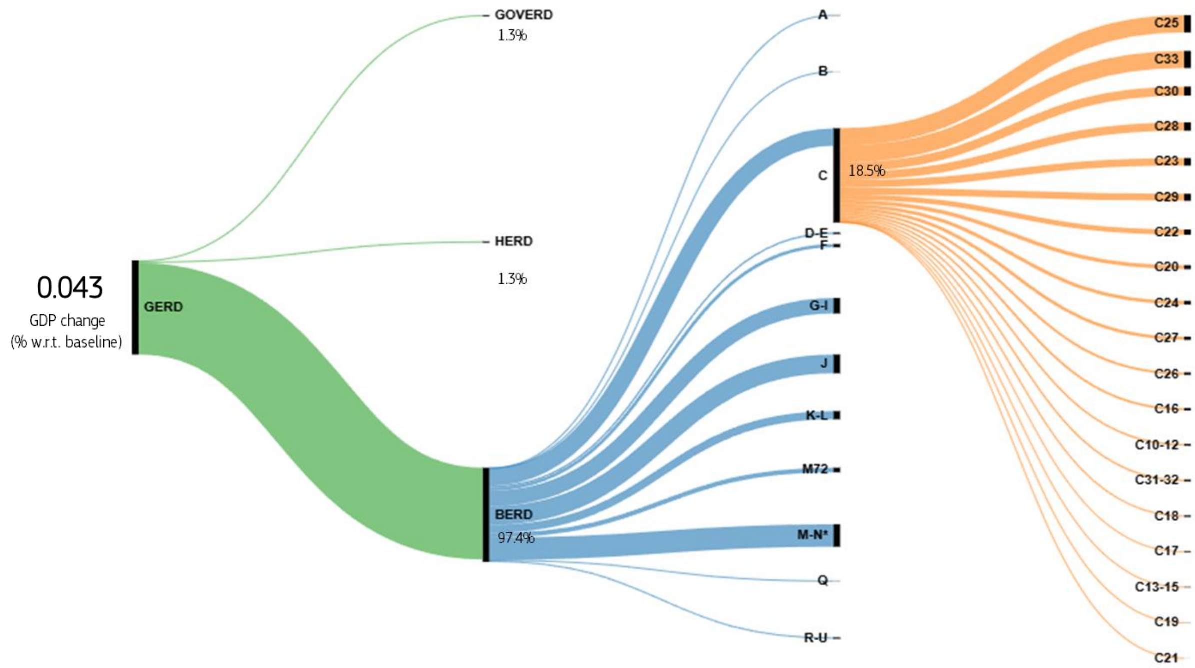
Source: FIDELIO simulations.

Figure B.2: France

Year: 2023



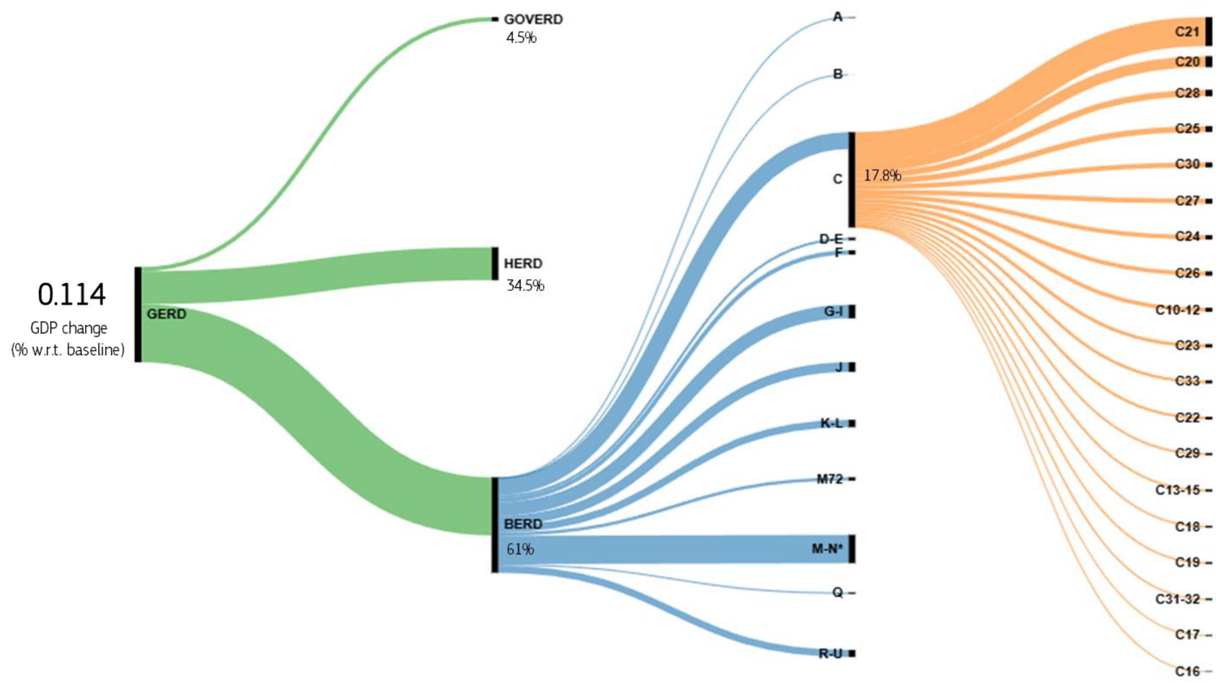
Year: 2030



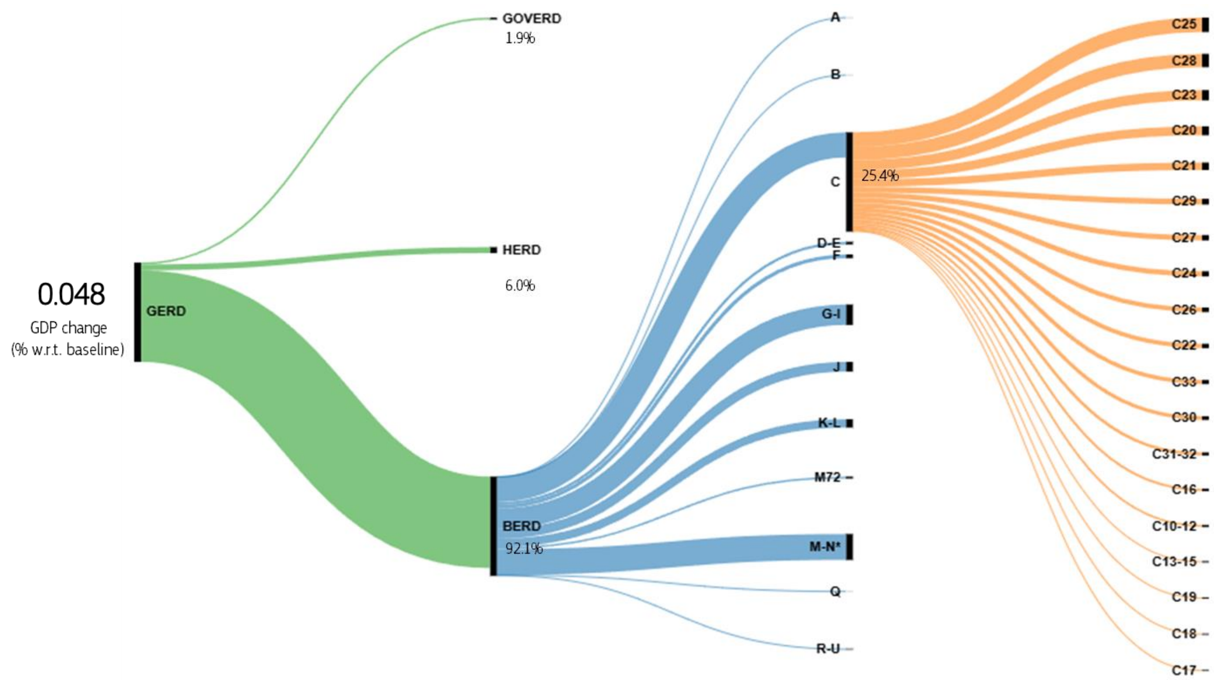
Source: FIDELIO simulations.

Figure B.3: Belgium

Year: 2023



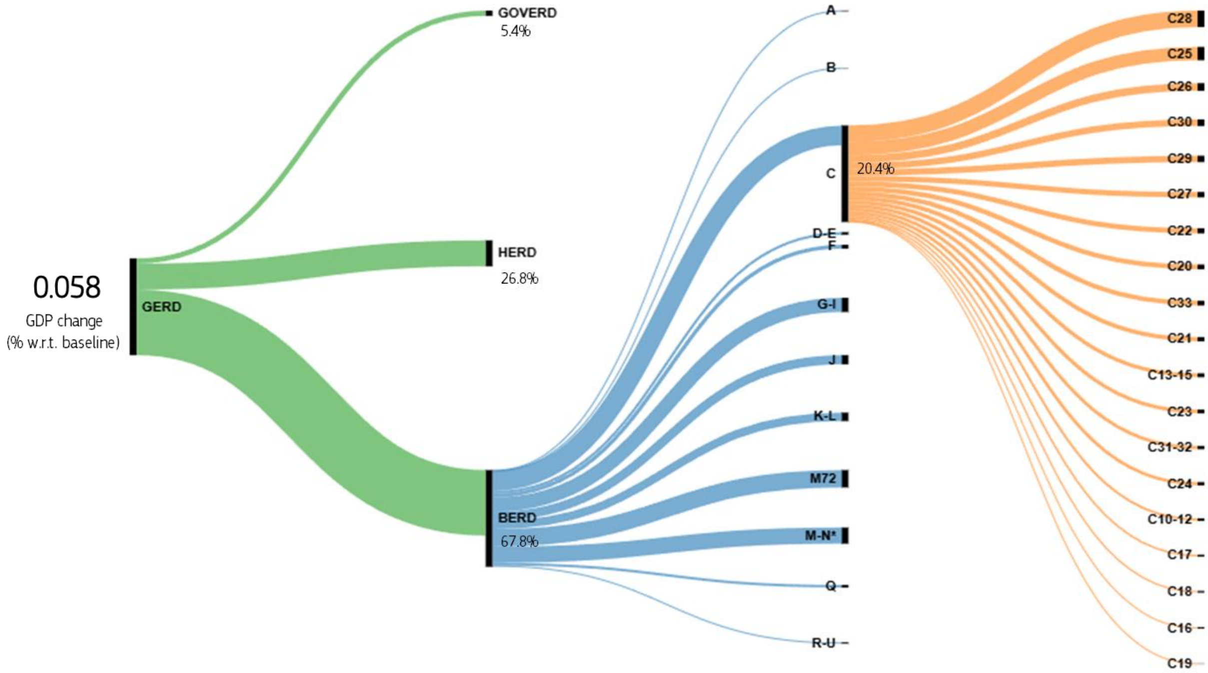
Year: 2030



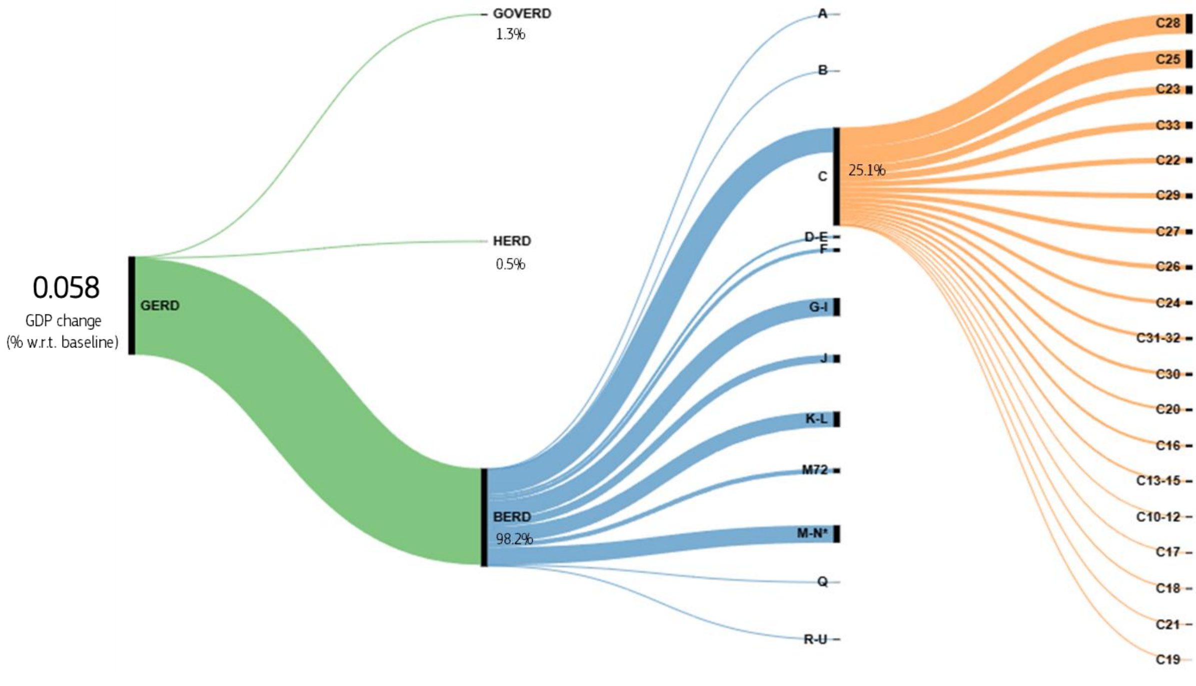
Source: FIDELIO simulations.

Figure B.4: Italy

Year: 2023



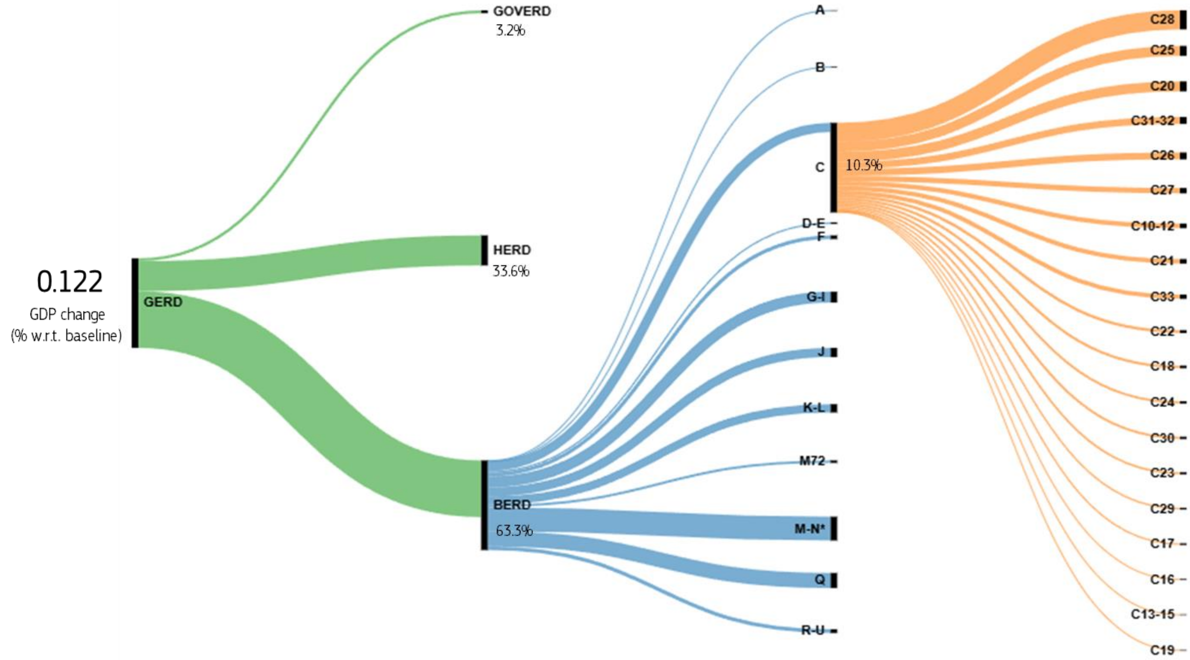
Year: 2030



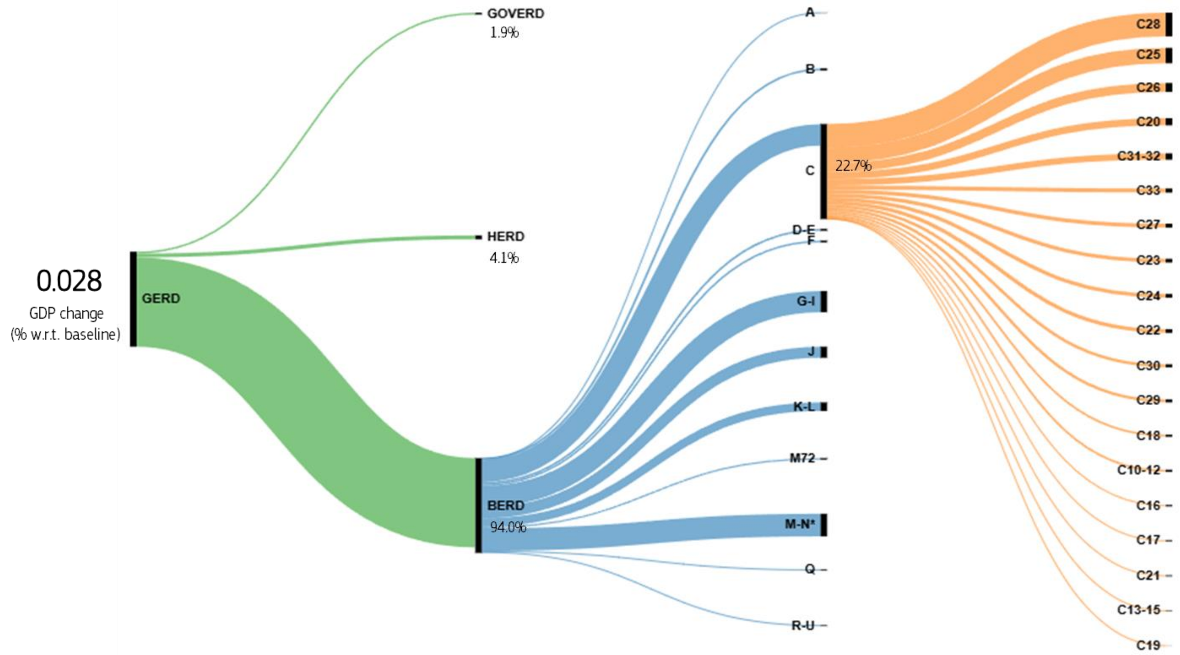
Source: FIDELIO simulations.

Figure B.5: Netherlands

Year: 2023



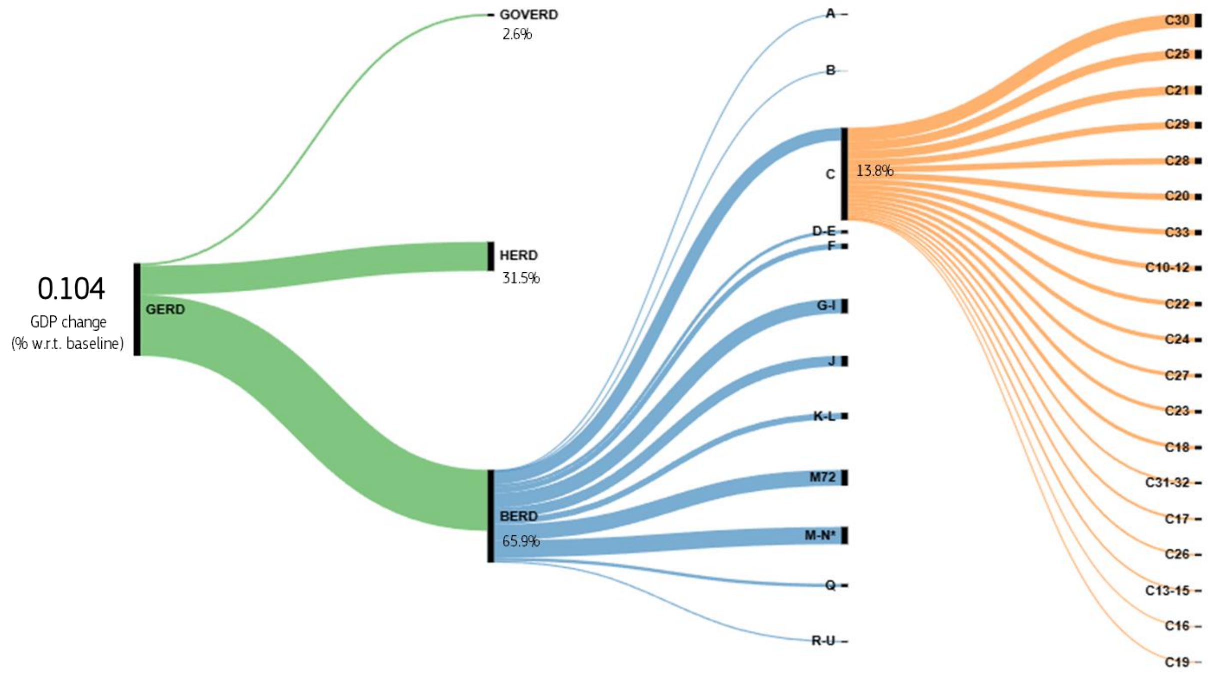
Year: 2030



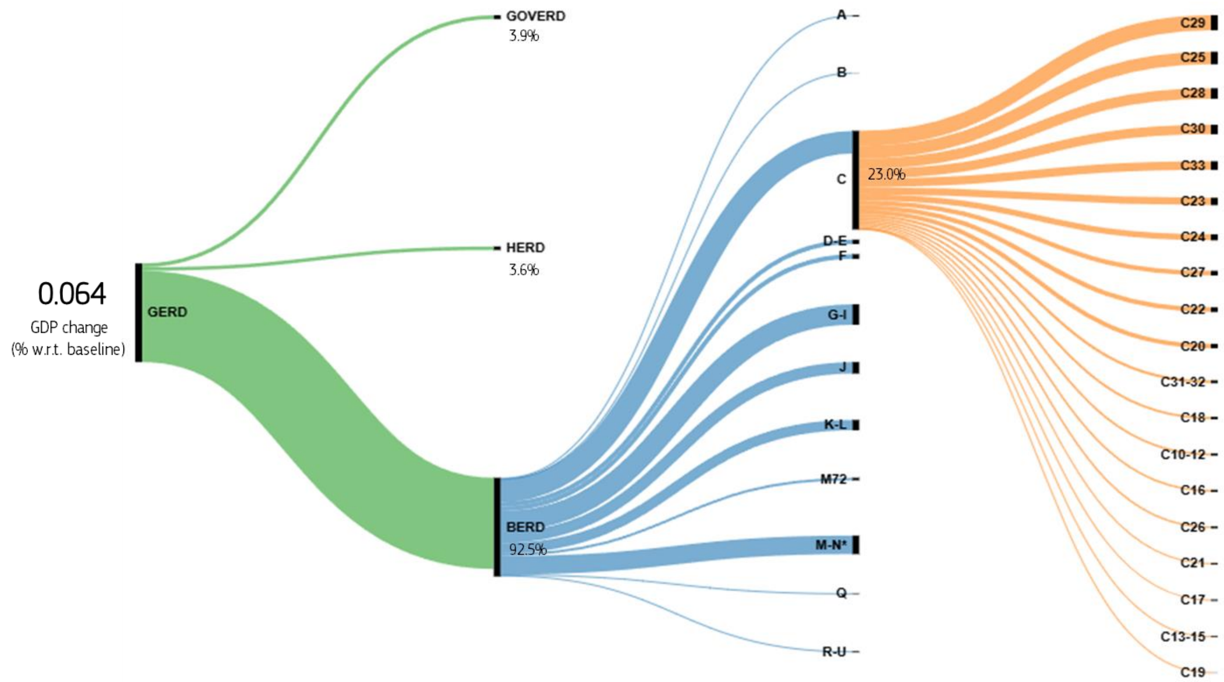
Source: FIDELIO simulations.

Figure B.6: Spain

Year: 2023



Year: 2030



Source: FIDELIO simulations.