European Commission

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

Independent Expert Report

Research and Innovation

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

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Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

In collaboration with

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Table of Contents

Introduction

This Impact Assessment Study had the primary objective to support and provide input to the impact assessments of the first set of 13 European Institutionalised Partnerships based on Articles 185 and 187 of the Treaty on the Functioning of the EU (TFEU) that are envisaged to be funded under the new Framework Programme for Research and Innovation, Horizon Europe.

In addition, the Impact Assessment Study team contributed to future European policymaking on the overall European Partnership landscape by means of a horizontal analysis of the coherence and efficiency in the implementation of European partnerships. The purpose of this analysis was to draw the lessons learned from the implementation of the impact assessment methodology developed for this study and to formulate recommendations for the refinement and operational design of the criteria for the selection, implementation, monitoring, evaluation and phasing-out for the three types of European Partnerships. Finally, an impact modelling exercise was conducted in order to estimate the potential for longer-term future impacts of the candidate Institutionalised European partnerships in the economic and environmental sustainability spheres.

Technopolis Group was responsible for the overall coordination of the 13 specific impact assessment studies, the development of the common methodological framework, and the delivery of the horizontal analysis. It also conducted specific analyses that were common to all studies, acting as a 'horizontal' team, in collaboration with CEPS, IPM, Nomisma, and Optimat Ltd. For the implementation of the individual impact assessment studies, Technopolis Group collaborated with organisations that are key experts in specific fields covered by the candidate Institutionalised European Partnerships. These partner organisations were Aecom, Idate, Steer, Think, and Trinomics. Cambridge Econometrics took charge of the impact modelling exercise.

The Impact Assessment Study was conducted between July 2019 and January 2020. The 13 Impact Assessment Studies were conducted simultaneously, based upon a common methodological framework in order to maximise consistency and efficiency. The meta-framework reflected the Better Regulation Guidelines and operationalised the selection criteria for European Partnerships set out in the Horizon Europe Regulation. The 'Horizontal analysis of efficiency and coherence of implementation' was conducted in the same time period, building upon the information available on the 44 envisaged European Partnerships landscape as in May 2019, complemented with information on five envisaged European Partnerships as decided by the European Commission in October and November 2019.

This final report contains the reports of all individual impact assessment studies and the 'horizontal' analyses. It is structured in two parts, reflecting the two strands of analysis:

PART I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

1. Overarching context to the impact assessment studies

This report sets out the overall policy context and methodological framework underlying the impact assessment studies for the candidate Institutionalised European Partnerships. It describes the changes in approach to the public-private and public-public partnerships under Horizon Europe compared to the previous EU Framework Programmes. An example is the requirement that all envisaged European Partnerships be implemented as either co-programmed, co-funded or institutionalised. The impact assessment studies will consider these three scenarios as the different options to be assessed, in compliance with the Better Regulation guidelines and against the functionalities that the candidate partnerships are expected to fulfil. The report describes the common methodological framework to assess the envisaged initiatives accordingly. The report also presents the landscape of European Partnerships at the level of Horizon Europe Pillar 2 clusters, which lay the grounds for all of the impact assessment studies except the candidate Institutionalised European Partnership for Innovative SMEs.

2. EU-Africa Global Health Candidate Institutionalised European Partnership

This initiative focuses on research and innovation in the area of infectious diseases, with a particular focus on sub-Saharan Africa. It will address the challenges of a sustained high burden of infectious diseases in Africa, as well as the (re)emergence of infectious diseases worldwide. Its objectives will thus be to contribute to a reduction of the burden of infectious diseases in sub-Saharan Africa and to the control of (re)emerging infectious diseases globally. It will do so through investments in relevant research and innovation actions, as well as by supporting the further development of essential research capacity in Africa. The study concluded that an Institutionalised Partnership under Art. 187 of the TFEU is the preferred option for the implementation of this initiative.

3. Candidate Institutionalised European Partnership on Innovative Health

This initiative focuses on supporting innovation for health and care within the EU. It will address the EU-wide challenges raised by inefficient translation of scientific knowledge for use in health and care, insufficient innovative products reaching health and care services and threats to the competitiveness of the health industry. Its main objectives are to create an EU-wide health R&I ecosystem that facilitates translation of scientific knowledge into innovations; foster the development of safe, effective, patient-centred and cost-effective innovations that respond to strategic unmet public health needs currently not served by industry; and drive cross-sectoral health innovation for a globally competitive European health industry. The study concluded that an Institutionalised Partnership based on Article 187 of the Treaty on the Functioning of the EU (TFEU) is the preferred option for the implementation of this initiative.

4. Candidate Institutionalised European Partnership in High Performance Computing

The initiative focuses on coordinating efforts and resources in order to deploy a European HPC infrastructure together with a competitive innovation ecosystem in terms of technologies, applications, and skills. It will address the challenges raised by underinvestment, the lack of coordination between the EU and MS, fragmentation of instruments, technological dependency on non-EU suppliers, unmet scientific demand, and weaknesses in the endogenous HPC supply chain. The initiative has as its main objectives to enhance EU research in terms of HPC and related applications, continued support for the competitiveness EU HPC industry, and fostering digital autonomy in order to ensure long-term support for the European HPC ecosystem as a whole. The study concluded that an Institutionalised Partnership is the preferred option for the implementation of this initiative as it maximises benefits in comparison to the other available policy options.

5. Candidate Institutionalised European Partnership in Key Digital Technologies

This initiative focusses on enhancing the research, innovation and business value creation of European electronics value chains in key strategic market segments in a sustainable manner to achieve technological sovereignty and ultimately make European businesses and citizens best equipped for the digital age. It will address the risks of Europe losing the lead in critical industries and services and emerging KDTs. It will also tackle Europe’s limited control over digital technologies that are critical for EU industry and citizens. It has as main objectives to strengthen KDTs which are critical for the competitive position of key European industries in the global markets, to establish European leadership in emerging technologies with high socioeconomic potential and to secure Europe’s technological sovereignty to maintain a strong and globally competitive presence in KDTs. The study concluded that the Institutionalised Partnership is the preferred option for the implementation of this initiative.

6. Candidate Institutionalised European Partnership in Smart Networks and Services

This initiative focuses on the development of future networks infrastructure and the associated services. This includes bringing communication networks beyond 5G and toward 6G capabilities, but also the development of the Internet of Things and Edge Computing technologies. It will address the challenges raised by Europe delay in the deployment of network infrastructure and failure to fully benefit from the full potential of digitalisation. It has as main objective to ensure European technological sovereignty in future smart networks and digital services, to strengthen the uptake of digital solutions, and to foster the development of digital innovation that answers to European needs and that are well aligned with societal needs. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

7. Candidate Institutionalised European Partnership in Metrology

This initiative focuses on metrology - that is the science of measurement and the provision of the technical infrastructure that underpins accurate and robust measurements throughout society; measurements that underpin all domains of science and technology and enable fair and open trade and support innovations and the design and implementation of policy and regulations. It will address challenges in the fragmentation of national metrology systems across Europe and the need to meet ever-increasing demands on metrology infrastructure to support the measurement needs of emerging technologies and important policy domains in climate, environment, energy and health. The main objective of the initiative is to establish a sustainable coordinated world-class metrology system in Europe that will increase and accelerate the development and deployment of innovations and contribute to the design and implementation of policy, regulation and standards. The study concluded that an A185 Institutionalised Partnership is the preferred option for the implementation of this initiative.

8. Candidate Institutionalised European Partnership on Transforming Europe's Rail System

This initiative focuses on the development of a pan-European approach to research and innovation in the rail sector. It will address the challenges raised by the lack of alignment of research and innovation with the needs of a competitive rail transport industry and the consequent failure of the European rail network to make its full contribution to European societal objectives. It will also strengthen the competitiveness of the European rail supply industry in global markets. Accordingly, the objectives of the initiative are to ensure a more market-focused approach to research and innovation, improving the competitiveness and modal share of the rail industry and enhancing its contribution to environmental sustainability as well as economic and social development across the European Union. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

9. Candidate Institutionalised European Partnership for Integrated Air Traffic Management

This initiative focuses on the modernisation of the Air Traffic Management in Europe - an essential enabler of safe and efficient air transport and a cornerstone of the European Union's society and economy. The proposed initiative will address the challenges raised by an outdated Air Traffic Management system with a non-optimised performance. The current system needs to be transformed to enable exploitation of emerging digital technologies and to accommodate new forms of air vehicle including drones. The objective is therefore to harmonise European Air Traffic Management system based on high levels of digitalisation, automation and connectivity whilst strengthening air transport, drone and ATM markets competitiveness and achieving environmental, performance and mobility goals. This would create €1,800b benefits to the EU economy if the current initiative can be built on and accelerated. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

10. Candidate Institutionalised European Partnership on Clean Aviation

This imitative focuses on further aeronautical research and innovation to improve technology leading to more environmentally efficient aviation equipment. It will address the challenges raised by the growing ecological footprint of aviation and the challenges and barriers faced by the aviation industry towards climate neutrality. It will also strengthen the competitiveness of the European aeronautical industry in global markets. Accordingly, the objectives of the initiative are to ensure that aviation reaches climate neutrality and that other environmental impacts are reduced significantly by 2050, maintain the leadership and competitiveness of the European aeronautics industry and ensure safe, secure and efficient air transport of passengers and goods. The Impact Assessment study assessed the options for implementation that would allow for an optimal attainment of these objectives. The study concluded that an institutionalised partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

11. Candidate Institutionalised European Partnership on Clean Hydrogen

The report assesses the impact of potential initiatives to support, through research and innovation, the growth and development of clean hydrogen, among which an Institutionalised European Partnership is one of the options assessed. The existing challenges for clean hydrogen include the limited high-level scientific capacity and fragmented research activities, the insufficient deployment of hydrogen applications, and consequently weaker EU scientific and industrial value chains. Environmental, health and mobility pressures are also driving the need for cleaner hydrogen generation, deployment and use. An initiative for clean hydrogen must have as a main objective the strengthening and integration of EU scientific capacities, to support the creation, capitalisation and sharing of knowledge. This is necessary to accelerate the development and improvement of advanced clean hydrogen applications, the market entry of innovative competitive clean solutions, to strengthen the competitiveness of the EU clean hydrogen value chains (and notably the SMEs within them), and to develop the hydrogen-based solutions necessary to reach climate neutrality in the EU by 2050. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

12. Candidate Institutionalised European Partnership on Safe and Automated Road Transport

This initiative focuses on Connected, Cooperative and Automated Mobility: the use of connected and automated vehicles to create more user-centred, all-inclusive mobility, while also increasing safety, reducing congestion and contributing to decarbonisation. With current road traffic collisions and negative local and global environmental impacts not reducing quickly enough, it will address the challenges raised by the current fragmentation of research across the field, and the threat to European competitiveness if the research agenda does not advance quickly enough. The initiative will focus on strengthening EU scientific capacity and economic competitiveness in the field of CCAM, whilst contributing to wider societal benefits including improved road safety, less environmental impact, and improved accessibility to mobility. The study concluded that a co-programmed partnership is the preferred option for the implementation of this initiative.

13. Candidate Institutionalised European Partnership for a Circular Bio-based Europe

This initiative focuses on intensifying research and innovation allowing to replace, where possible, non-renewable fossil and mineral resources with biomass and waste for the production of renewable products and nutrients, in order to drive forward sustainable and climate-neutral solutions that accelerate the transition to a healthy planet and respect planetary boundaries. It will address the challenges raised by the fact that the EU economy does not operate within planetary boundaries, is not sufficiently circular and is predominantly fossil based. It will also address the insufficient research and innovation (R&I) capacity and cross-sectoral transfer of knowledge and bio-based solutions, as well as risks posed to the European bio-based industry's global competitiveness. The study concluded that Institutionalised European Partnership based upon Article 187 TFEU is the preferred option for the implementation of this initiative.

14. Candidate Institutionalised European Partnership for Innovative SMEs

The initiative is envisaged as a continuation of the Eurostars 2 programme which is managed by the Eureka network. The initiative focuses on international collaborative R&D of innovative companies, facilitated through a network of national funding organisations as included in the Eureka network. The funded projects are bottom-up and involve small numbers of project partners. The candidate partnership addresses a niche issue namely limited opportunities for international bottom-up collaboration. The partnership provides thus an opportunity for SMEs for international R&D collaboration but does not address specific technological, social, or environmental challenges. Its main objective is to improve the competitiveness of European SMEs through collaborative funding. The study concluded that a co-funded partnership is the preferred option for the implementation of this initiative.

PART II. Horizontal studies

1. Horizontal Analysis of Efficiency and Coherence in Implementation

The focus of this report is on the coherence and efficiency in the current European Partnership landscape under Horizon Europe and the potential to enhance efficiency in the European Partnerships' implementation.

European Partnerships are geared towards playing a pivotal role in tackling the complex economic and societal challenges that constitute the R&I priorities of the Horizon Europe Pillar II and are in a unique position to address transformational failures. Multiple potential interconnections and synergies exist between the candidate European Partnerships within the clusters, but few are visible across the clusters.

As for the improvement of the efficiency in implementation of institutionalised partnerships under Art. 187, potential efficiency and effectiveness gains could be achieved with enhanced collaboration. An option for a common back-office sharing operational implementation activities is worth exploring further through a detailed feasibility study in order to assess whether efficiency gains can be made. Ideally this would be co-designed as a common Partnership approach, leading to a win-win situation for all partners.

2. Impact Modelling of the Candidate Institutionalised European Partnerships

This report presents the results of the use of a macroeconomic model to assess the economic and environmental impacts of the preferred options identified in the individual 13 impact assessment studies. The model used is E3ME. It includes explicit representation for each EU Member State with a detailed sectoral disaggregation.

The impact modelling estimated the impacts of the envisaged initiatives at an aggregated as well as individual level. In total, 14 macroeconomic models have been run, one per reviewed initiative with a time horizon of 2035 and one that combines all initiatives with a time horizon of 2050. The results of each of these models were compared with those of a baseline scenario, which corresponds to a situation where the initiatives would be funded through regular Horizon Europe calls rather than European Partnerships.

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Part II. Horizontal Studies

2. Impact Modelling of the Candidate Institutionalised European Partnerships

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This impact modelling exercise was conducted by Cambridge Econometrics with the support of Technopolis Group and the impact assessment study teams in the period October 2019 – February 2020.

The report is structured as follows:

- Chapter 1 sets out the background to the study
- In Chapter 2, the basic specifications and dimensions are set out
- The modelling of R&D within E3ME is explained in Chapter 3
- Chapter 4 covers the descriptive model specification for the Horizon Europe baseline
- Chapter 5 sets out the scope of the exercise
- In Chapter 6 we describe the modelling assumptions
- Chapter 7 provides the technical model specification for the Horizon Europe baseline
- In Chapter 8 the scenario design is set out
- Chapter 9 covers the management costs of Horizon Europe
- Chapter 10 provides the results of the impact modelling, for all the initiatives combined and each initiative individually

Table of Contents

List of Figures

List of Tables

1 Background to the project

The proposal for the future EU research and innovation (R&D) programme, Horizon Europe, was adopted in June 2018. EC (2018b) presents the highlights of the Horizon Europe plan, which will run from 2021 to 2027. EC (2018c) provides a detailed impact assessment of Horizon Europe, the 9th Framework Programme. One of the strategic priorities of Horizon Europe is to support the development of a new generation of research and innovation partnerships in Europe.

DG RTD commissioned the *"Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe"*. A consortium, led by Technopolis, won this contract. CE has been subcontracted to complete macroeconomic modelling of envisaged partnerships. This impact assessment study will form part of the evidence base for deciding the best form of implementation to use to achieve the objectives set for the candidate Institutionalised European Partnerships under Horizon Europe. The budgets of the initiatives are not known, since they firstly depend on the adoption of the Multiannual Financial Framework of the European Union, and the budget of Horizon Europe therein.

The **impact assessment for Horizon Europe** included macroeconomic modelling using three models, namely: NEMESIS, RHOMOLO, and QUEST. The QUEST and RHOMOLO (Christensen, 2018) results were produced by DG ECFIN and DG JRC, respectively. The modelling completed using NEMESIS is fully documented in EC (2018d).

The scenarios using QUEST and RHOMOLO modelled the continuation of H2020, against a baseline of no Framework Programme. The modelling using NEMESIS was more detailed, assessing scenarios across budget, management, and design options.

2 Basic specification, dimensions, etc.

In this report, the E3ME macroeconomic model was used to assess the preferred scenarios following the completion of the thematic assessments for each of the 13 initiatives under review.[1] E3ME is a global model that includes explicit representation of each EU Member State. It has a detailed sectoral disaggregation. E3ME solves on an annual basis up to the year 2050. We assess a time horizon of 2035 for the individual initiatives and 2050 for the combined initiatives.

The preferred option can be either: traditional calls (i.e., the baseline, implying no partnership), Co-funded European Partnership, Co-programmed European Partnership, Institutionalised European Partnership (Article 185 or 187).

In total there are 14 model runs, one for each of the 13 initiatives under review, and one that combines the initiatives. These model runs are compared to a baseline case in which the funding allocated to partnerships is instead used for "regular" Horizon 2020 activities (traditional calls).

All the scenarios will be limited in complexity in order to respect the timeline presented below, and to ease interpretation of results.

3 Modelling R&D within E3ME

E3ME is top-down in design, as a whole-economy model, although it is linked to the bottom-up Future Technology Transformation (FTT) energy sub-models for key sectors (power generation, road transport, heating and steel). The treatment of R&D and

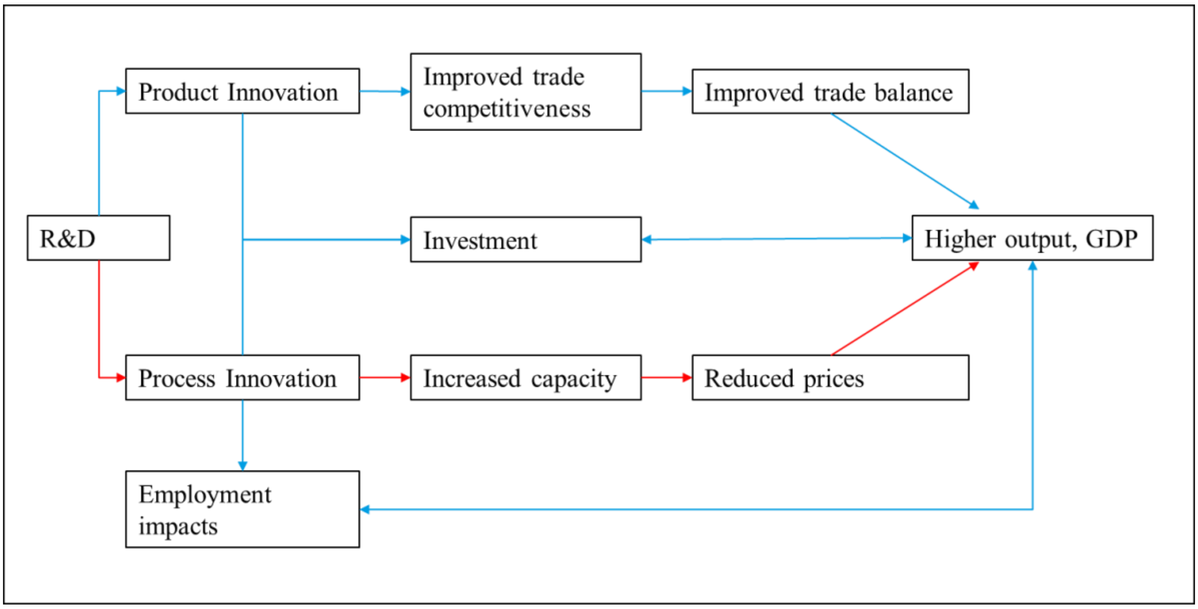
[1] https://www.e3me.com/

innovation relevant to this study is the implicit treatment through technology indices. Figure 1 shows the main linkages in the E3ME modelling framework.

R&D expenditure feeds into the model's technology indices, which are labelled as product and process innovation in the figure. These indices in turn impact on other model variables. In the figure, process innovation is shown with the red arrows, whereas product innovation is shown through the blue arrows. The exceptions are the links through investment and employment, which may result from either product or process innovation, and are also impacted by other economic developments.

It should be noted that the figure is a reduced form of the complex relationships within the E3ME model.

Figure 1: Innovation in the E3ME model



Note: Process innovation is shown with red arrows, product innovation is shown with blue arrows.

3.1 *Process Innovation*

Higher levels of R&D expenditure lead to process innovation, which improves efficiency in production. These efficiency gains boost the level of potential production supply in the economy (i.e., capacity), leading to lower prices that in turn boost demand. Final consumers respond, boosting the level of output and GDP.

3.2 *Product Innovation*

Improvements to the quality of products can also have positive impacts, but here the channel is more through the level of aggregate demand. Better products will be more competitive in international markets and therefore higher R&D expenditure can lead to improvements in the trade balance and GDP.

These effects can also be to some extent self-perpetuating, but they face limits in that improvements to the trade balance can only boost GDP while there is spare capacity in the economy (e.g., unemployed workers).

The sectors that will benefit the most from product innovation are the manufacturing sectors that export their goods to a global market. There is also scope for exporting services sectors to benefit.

3.3 Direct Investment Effects

Higher R&D expenditure may lead to higher investment because the creation of new capital equipment (that either produces better goods, or the same goods at lower cost) could lead to higher levels of investment.

3.4 Direct Employment Effects

In E3ME, the technology indices also feed into the employment equations. The sign may be positive or negative, depending on whether the technology is labour-saving or labour-augmenting. At macro level, the effects in different sectors may cancel out.

3.5 Spillover Effects

The spillover effects in this model specification use work developed under the H2020 project MONROE (Modelling of the Research and Innovation Policies). Under MONROE, the innovation specification of E3ME was substantially improved, including the estimation and inclusion of spillover effects. The spillover matrices were estimated using patent data and citations. See Cambridge Econometrics (2019).

The model specification is not the same as under MONROE:

- This study only includes domestic spillover effects, not international;
- R&D expenditure is exogenous in E3ME in this study. Differences in R&D expenditure, from baseline, are determined by the exogenous scenario inputs. A positive effect on private sector R&D expenditure, in moving to partnerships, is included as an impact pathway.

3.6 Model Disaggregation

The E3ME model is one of the most disaggregated macroeconomic modelling tools currently in operation, with 70 sectors defined. The technology indices are calculated on a sector level. All the effects detailed above operate at the sectoral level, for each Member State.

3.7 Formulation of Key Variables

The main technology indices in E3ME are measured as accumulations:

$$CAPS_t = K_t + 0.9 \times CAPS_{t_{-1}} \;;$$

$$KNOS_t = RD_t + 0.9 \times KNOS_{t_{-1}} \;.$$

The capital and knowledge stocks ($CAPS$ and $KNOS$) at time t are equal to the previous year's stock minus a 10% depreciation rate, plus the current year's additions to the stock (K being the investment proxied by gross fixed capital formation, RD being recorded R&D expenditure).[2]

The econometric equations are estimated and solved by sector. The signs of the coefficients are restricted so that they do not produce counter-intuitive results.[3] The parameter estimates are otherwise derived from the time-series historical data.

[2] See Cambridge Econometrics (2019). Note that the baseline knowledge obsolescence rate in the NEMESIS model in European Commission (2018d) is 15%.

[3] "E3ME has a complete specification of the long-term solution in the form of an estimated equation which has long-term restrictions imposed on its parameters. Economic theory, for example theories of endogenous growth, informs the specification of the long-term equations and hence properties of the model; dynamic equations which embody these long-term properties are estimated by econometric methods to allow the

3.8 "Applied" versus "Basic" R&D

There is no explicit distinction in E3ME by type of R&D expenditure. For each sector, all R&D expenditure is aggregated. The econometric parameters are estimated at sectoral level, however. The relationships in the model, therefore, will implicitly capture the relative effects of applied and basic R&D, where different sectors focus on different types of research.

For the purposes of being consistent with the EC (2018d) impact pathways, the values of additional R&D in this study are calculated as a function of EU level "applied" and "basic" funding. "Basic" is defined at TRL 1-3. "Applied" is 4-9.[4] Study teams provided an estimate of the "applied" share of funding, see Appendix B.

3.9 Energy Demand Effects

E3ME models technology and R&D effects in energy demand, broadly, in two distinct ways: 1) dedicated sector-level technology diffusion models; and 2) technology indices in the energy demand equations. The methodology in this study employs the second of these.

Measures of R&D expenditure and investment are included in the aggregate and disaggregate energy demand equations. These variables capture the effect of new ways of decreasing energy demand and the elimination of inefficient technologies; that is, energy saving technological progress.

4 Descriptive model specification for the baseline

The E3ME baseline used in this study is calibrated to standard European Commission projections. It is calibrated to the economic forecasts in the 2018 Ageing Report, and the energy forecasts of the 2016 PRIMES Reference Scenario. The environmental forecasts are determined by the energy forecast, and emissions coefficients calculated from historical data.

The Ageing Report and PRIMES Reference Scenario reports do not detail assumptions regarding European Union R&D expenditure. These forecasts assume continuation of current policy, however.[5] Therefore, they should be considered to include a continuation of the EU R&D programme, using 'traditional calls' of the Framework Programme. The E3ME baseline, therefore, implicitly assumes the same continuation.

The baseline assumes a continuation of the Horizon 2020 programme. The scenarios redirect this funding to the preferred form of partnerships' implementation for each

model to provide forecasts. The method utilises developments in time-series econometrics, with the specification of dynamic relationships in terms of error correction models (ECM) which allow dynamic convergence to a long-term outcome." Cambridge Econometrics (2019) p.22

[4] TRL 1 – Basic principles observed; 2 – Technology concept formulated; 3 – Experimental proof of concept. TRL 4 – Technology validated in lab; 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies); 6 – Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies); 7 – System prototype demonstration in operational environment; 8 – System complete and qualified; 9 – Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space). From the general annexes of the Horizon 2020 work programme (https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf)

[5] EC (2017) 2018 Ageing Report, p. 2: "The projections are made under a "no-policy-change" assumption. They do not aim to predict the future; they are made to illustrate what the future could be if current policies remain unchanged".

initiative (co-funded, co-programmed, institutionalised) in case the preferred option is not the baseline.

5 Scope of the Modelling Assessment

The scope of this modelling assessment is restricted to the design of EU R&D funding. EC (2018d) assesses three dimensions of potential change: management, budget, and design. Moving from regular calls to partnerships does not affect the management level or total EU R&D budget, by assumption. The starting assumptions of this exercise are:

- The Framework Programme budget is equal across all scenarios and baseline. (Note that this assumption does not imply zero net change in private sector R&D expenditure).
- The role played by the EU in support of R&D is the same for both baseline and scenarios. Member State contributions to the EU central budget do not change. That is, there is no discontinuation, decentralisation, or centralisation of research funding across the EC and the Member States.

These two assumptions map to the budget and management options in EC (2018d). This analysis focuses specifically on the marginal impacts of the design options for Horizon Europe.

6 Modelling Assumptions

The key assumptions in this analysis are:

- All Horizon Europe spending is counted as R&D, whether it is allocated to partnerships or to other projects.
- Where management costs of initiative design are higher (Institutionalised Partnerships), the costs are offset by reduced funding available within the initiative. Total EU contribution is assumed equal across scenarios. For more details see Section 9.
- The baseline H2020 R&D expenditure matches the sectoral allocation of the partnerships. For example, considering the European Metrology Partnership, it is assumed that in the baseline, funding is directed to metrology through regular calls. This is important because any sectoral shift of EU R&D funding would imply sectoral shifts in private investment (if it is assumed that direct leveraging in the baseline is greater than zero). If EU R&D is directed to the same area across scenarios, then the modelling isolates the effect of initiative design. This concentrates on additional direct leverage and avoids confounding with a sectoral shift in private investment.
- The total value of EU funding to each initiative is €1bn (2018 prices). It is noted that the actual value of funding to each initiative may be different, but a single value allows for comparison across initiatives. Further, these 13 initiatives do not represent the entire prospective budget of Horizon Europe.
- The allocation of funding by Member State follows the allocation of funds under H2020, excluding the UK. See Appendix A for data provided by DG RTD.
- The allocation of funding over the Horizon Europe years 2021-2027 follow the calculations in EC (2018d).

7 Technical model specification for the Horizon Europe baseline

To model the initiatives, 14 individual technology indices are developed: one for each of the 13 initiatives, and a catch-all index for all R&D expenditure outside the initiatives. The 14 knowledge stocks are then simply aggregated, and the aggregate index operates as the technology index, as detailed above.

The individual knowledge stocks are developed by allocating the €1bn according to

- Member State allocation in Appendix B;
- sectoral allocation given in 0;
- time horizon given in Appendix D.

The knowledge stock for each initiative also includes the value of non-EU funds which are directly crowded in. Following the methodology in EC (2018d), this is not the value leverage-ratio of EU funding, but is the net direct leverage effect on private R&D. In the baseline, this value is 15% of the "applied" share of EU funding.

The knowledge stock, therefore, does not include R&D expenditure that would occur in the absence of the EU programme. That is, any private R&D expenditure that is reallocated from a private programme into an EU programme, and is therefore not additional, is not counted in the initiative's knowledge stock. This calculation is necessary to be consistent with the impact pathways in EC (2018d).

8 Scenario Design

Firstly, it is important to understand that this modelling set-up isolates the impacts of partnership, compared to regular calls. This modelling does not repeat the assessment of continuation versus discontinuation of the Framework Programme.

EC (2018d) explains that under Horizon Europe the European Partnerships are expected to deliver "more impact" and "more openness".

The inception report details preliminary scenario inputs for each partnership, which capture impact pathways across this design axis. The scenario inputs will capture the "additionality" and "directionality" effects which each partnership delivers. It is important to note that these model inputs would assume implicitly that the initiatives are successful.

The scenario inputs detailed in the inception report identify the expected economic, energy, and environmental impacts of the initiatives. The basic assumption is that the efficacy of the initiatives would vary across partnership options and traditional calls. The desired modelling inputs would capture these differences.

For example, take the European Partnership on Circular bio-based Europe. The expected effects of a successful initiative are a shift in the value of supply-chains from extractive sectors, to recycling and to agriculture. This would be modelled by adjusting the input-output coefficients in E3ME.[6] The scenario inputs should be the *additional* supply-chain value shifts from the traditional calls (baseline) to the preferred option (scenario). It may be judged that the initiative would achieve a 2% shift via traditional calls, but 3% if a co-programmed partnership was formed.

The study teams have been unable, in most cases, to identify estimates consistent with this approach. Given the lack of input data for scenarios, it was necessary to pursue an adjusted methodology. The adjusted methodology is to model the "more impact" and

[6] See EC (2018a) for details of how circular economy policies can be represented in macroeconomic models.

"more openness" design axes, using a similar mechanism as EC (2018d). This methodology uses the R&D specification in E3ME, detailed in Section 3. The two axes (more impact and more openness) are modelled through six selected impact pathways. Those pathways are described below, and the options attached to them in Appendix B. The magnitude of effect for each pathway follows the magnitudes in European Commission (2018d).

More impact:

- Higher economic performance: This pathway captures a reinforcement of the performance of EU funding, compared to national funding. A "virtual R&D" value is added to the initiative knowledge stock to capture this effect. A "virtual R&D" value is added for the baseline to measure the assumed increased efficacy of EU traditional calls, over national funding programmes. The baseline value in EU funding is 15% more effective than standard (national) R&D expenditure. The 'low' option for pathway is the same as the baseline; 'low' assumes that the effectiveness of EU funding is equal under traditional calls and partnership.

- Lower knowledge obsolescence: This pathway captures the effect of the focusing on breakthrough innovations. In the baseline, the knowledge stock depreciates at 10% per annum.

- Stronger complementarities with other innovative assets: This pathway captures the propensity for breakthrough innovations to increase investments in innovative assets. In E3ME, the relevant mechanism is that the knowledge stock is an explanatory variable in the investment decision equation. Additional "virtual R&D" is added in the investment decision. The value is calculated as a multiplicative factor of all additional R&D in the scenario.

- Higher direct leverage of private R&D spending: This pathway captures the increase in private sector investment in R&D in the relevant sector/s. This effect is only applicable to the 'applied' share of EU funding. The 'low' option for pathway is the same as the baseline; 'low' assumes that the direct leverage effect is equal under traditional calls and partnership.

More openness:

- Higher complementarities with national support to R&D: This pathway captures the idea of complementarities between EU and national R&D. In E3ME, this is modelled as a shift in national spending from wider government investment to R&D investment. The rate of increased national support is a function of "basic" EU funding.

- Stronger knowledge diffusion: This pathway captures the potential of options designed to facilitate knowledge diffusion. In E3ME, the higher spillovers are added as "virtual R&D" to the knowledge stock. The additional spillovers are calculated as a multiplicative increase of baseline coefficients. The additional spillover applied to all additional R&D in the scenario; that is, including higher economic performance virtual R&D etc.

The assumptions for the six impact pathways listed above were decided in consultation with the study teams for each initiative. The options for each impact pathway to be selected by the study teams are taken from EC (2018d) and range from "low" through "mid" to "high impact" (the option "None", assuming no impact, is also included). The options and their quantified translation into the model are described in Appendix B.

Table 1 below details the decisions for each initiative, based on the responses of the study teams and on to the 13 study teams' final reports of the *Impact Assessment Study for the candidates Institutionalised European Partnership*. In this work, a single scenario is modelled for each initiative, using these central assumptions for each initiative.

Table 1: Input assumptions for the impact pathways from the study teams

	Partnership	Higher economic performance	Lower knowledge obsolescence	Stronger complementarity with other innovative assets	Higher direct leverage effect on private R&D	Higher complementarities with national support to R&D	Stronger knowledge diffusion	Applied share
1	Global Health	Low	High	Low	Low	Mid	High	0.85
2	Innovative Health	Mid	High	High	Low	Mid	Mid	0.85
3	Digital Tech	High	Mid	High	High	Mid	Mid	0.65
4	Smart Networks	High	Mid	High	High	Mid	Mid	0.65
5	EuroHPC	High	Low	Low	Mid	Low	High	1.00
6	Rail System	High	Mid	High	Mid	None	High	0.65
7	Air Traffic	High	Mid	High	High	Low	Mid	0.8
8	Clean Aviation	High	None	High	Mid	Low	None	0.65
9	Automated Road	Mid	Mid	Mid	Mid	Mid	Mid	0.65
10	Circular Bio	High	Mid	High	High	Mid	Mid	0.75
11	Hydrogen	High	High	High	High	Mid	High	0.65
12	Metrology	Mid	High	High	Mid	High	High	0.8
13	SMEs	Mid	Low	High	High	None	Low	1.00

Note: Low/Mid/High corresponds to the options for the six impact pathways described in Table 2 in Appendix A. Higher economic performance: effectiveness of EU funding relative to standard (national) R&D expenditure (in %); Lower knowledge obsolescence: depreciation of the knowledge stock (in %); Stronger complementarity with other innovative assets: additional R&D in scenario (in %); Higher direct leverage effect on private R&D: increase in private sector investment in R&D, Higher complementarities with national support to R&D: increase in national support to R&D investment (in %); Stronger knowledge diffusion: increase of the knowledge stock (in %).

The impact pathways operate, in most cases, by developing “virtual R&D” values. The term “virtual R&D” is used to identify the variable which is used to capture the higher efficacy of R&D funding under partnerships. The “virtual R&D” has the exact same impact as actual R&D expenditure in terms of contributing to the technology index; ”virtual R&D” therefore affects the same model mechanisms as “actual” R&D. It is additive to the “actual” R&D expenditure. The equation for the knowledge stock, including “virtual R&D” (VRD) is:

$$KNOS_t = RD_t + VRD_t + 0.9 \times KNOS_{t_{-1}} \ .$$

The "virtual R&D" differs from actual R&D in that:

- It represents no increase in demand for real resources in R&D. Therefore, there is no cost attached.
- It represents increased efficacy of given spending, not an increase in real spending, and therefore does not enter the national accounts or contribute to GDP.

9 Management costs of Horizon Europe

Cost modelling of the baseline and partnership options was carried out in the parent study to this work. The cost modelling shows that the management costs of partnerships are substantially greater than baseline "traditional calls". The implication of the higher management costs is that, for a given value of EU funding, less funds are available for "actual" R&D.

In this modelling work, difference in management costs are not explicitly taken into account. The impact pathways used, and range of scenario values, were taken from the EC (2018d) study, which did not discuss the issue of management costs. It is assumed that the scenario values used take into account the redirection of some funds under partnership to management.

10 Results

Results are all presented for the "EU27", i.e., the EU28 minus the UK.

In a first sub-section, estimated impacts on financial, R&D and environmental indicators for the 13 initiatives combined are discussed. Then the specific results are discussed by initiative.[7]

10.1 All the initiatives combined

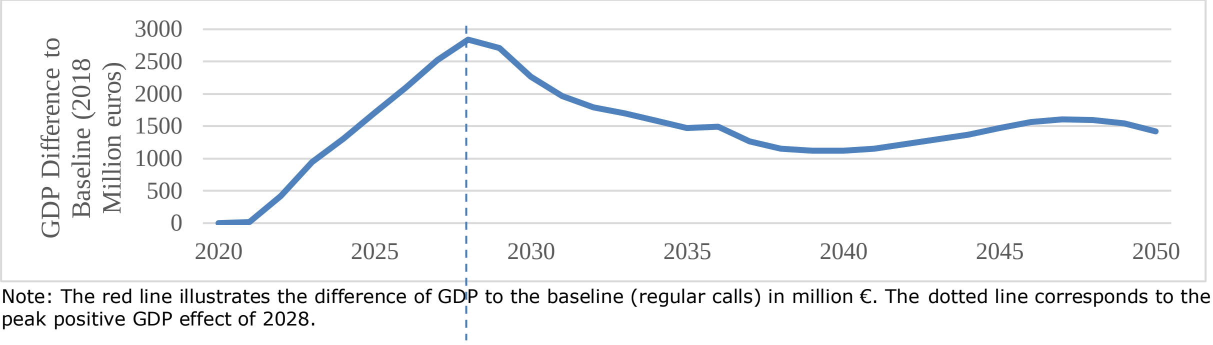
The impacts on countries' GDP, total employments and investments are positive throughout the projection period (from 2021 to 2050). Both indicators follow a similar time path: increasingly positive effects throughout the Horizon Europe programme, followed by a regression to baseline (moderate for both GDP and employment).

Figure 2,Figure 3 Figure 4, below, illustrate the indicators difference to the baseline (traditional calls).

The peak positive GDP effect is in 2028, at €2.84bn, 0.018% higher than baseline EU27 GDP, the peak employment effect is in 2029, at 26.7 thousand jobs, 0.013% higher than baseline EU27 employment and the peak investment effect is also in 2029, at €1,45bn, 0.035% higher than baseline EU27 investment.

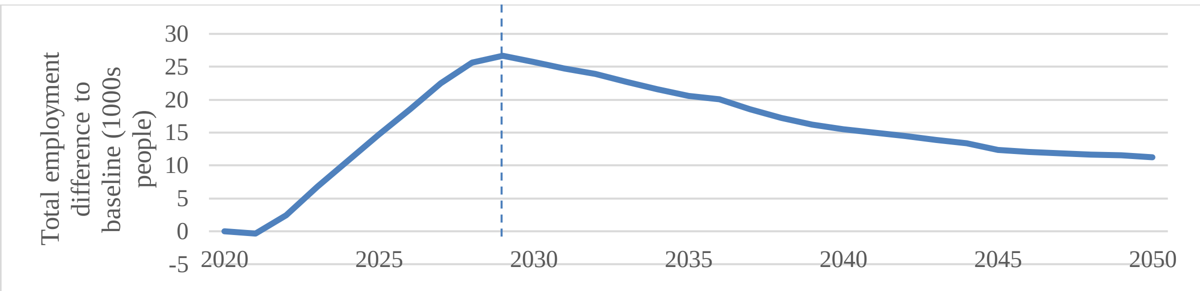
[7] Table 21 in Appendix H also provides an overview of the results for the year 2030 (around the peak of most impacts and coinciding with the final year of Horizon Europe) by initiative and for the 13 initiatives combined.

Figure 2: GDP Difference to Baseline in Combined Scenario (EU27)



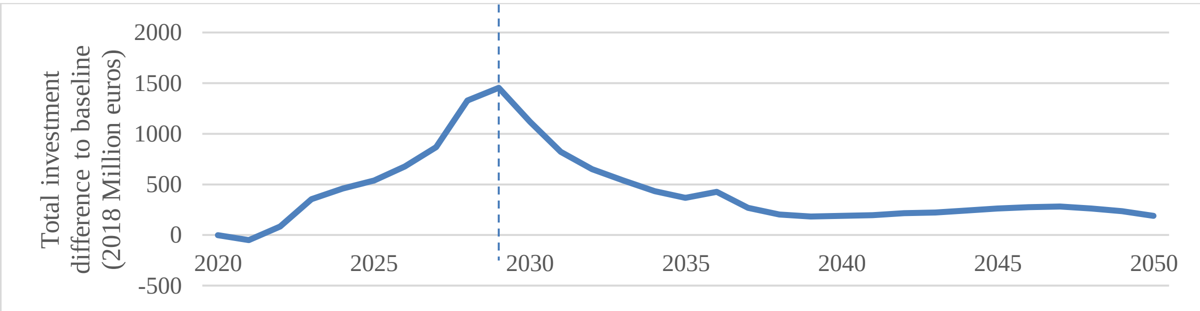
Note: The red line illustrates the difference of GDP to the baseline (regular calls) in million €. The dotted line corresponds to the peak positive GDP effect of 2028.

Figure 3: Employment Difference to Baseline in Combine Scenario (EU27)



Note: The red line illustrates the difference of total employment to the baseline (regular calls) in thousands. The dotted line corresponds to the peak positive employment effect of 2029.

Figure 4: Employment Difference to Baseline in Combine Scenario (EU27)



Note: The red line illustrates the difference of total investment to the baseline (regular calls) in thousands. The dotted line corresponds to the peak positive investment effect of 2029.

Figure 5,Figure 6 and Figure 7, below, show respectively the GDP, employment and investment difference to baseline (in millions € and thousands respectively) stacked for the 13 initiatives.[8]

Most of the GDP impacts peaks in 2028 (for 7 out of 13 initiatives) with the highest impact (in magnitude) for the ATM initiative, followed by Circular Bio and Clean Hydrogen. Global Health and Innovative Health are the two initiatives associated with the lowest countries' GDP impact.

Most of the employment impacts also peaks in 2028 (for 6 out of 13 initiatives), but the highest impact (in magnitude) is measured in 2031 for the Smart Network and Services initiative, followed by Euro HPC peaking in Clean Aviation, both peaking in 2028. The only initiative with a delayed employment impact is ATM with a positive difference to baseline

[8] Additionally, the individual difference to baseline are shown in Figure 36, Figure 37 and Figure 38 in Appendix G

from 2028 onwards. Similar to the GDP results, Global Health and Innovative Health are the two initiatives associated with the lowest countries' employment impact.

A similar narrative applies to the investment impacts, with most impacts peaking in 2029 (for 9 out of 13 initiatives). The highest impact (in magnitude) is measured in 2031 for the Clean Hydrogen initiative, followed by the Smart Network and Services initiative. Similar to the previously discussed GDP and employment results, Global Health and Innovative Health are the two initiatives associated with the lowest countries' investment impact.

Figure 5: Stacked GDP Difference to Baseline by Initiative

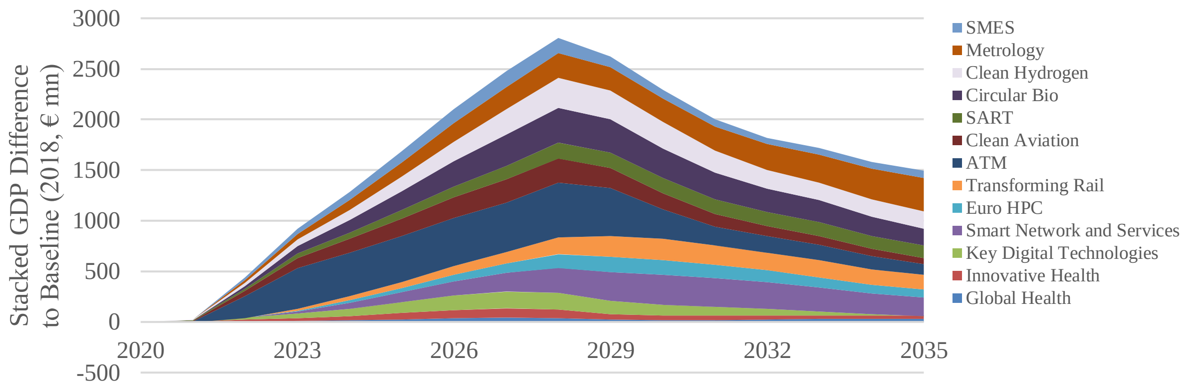


Figure 6: Stacked Employment Difference to Baseline by Initiative

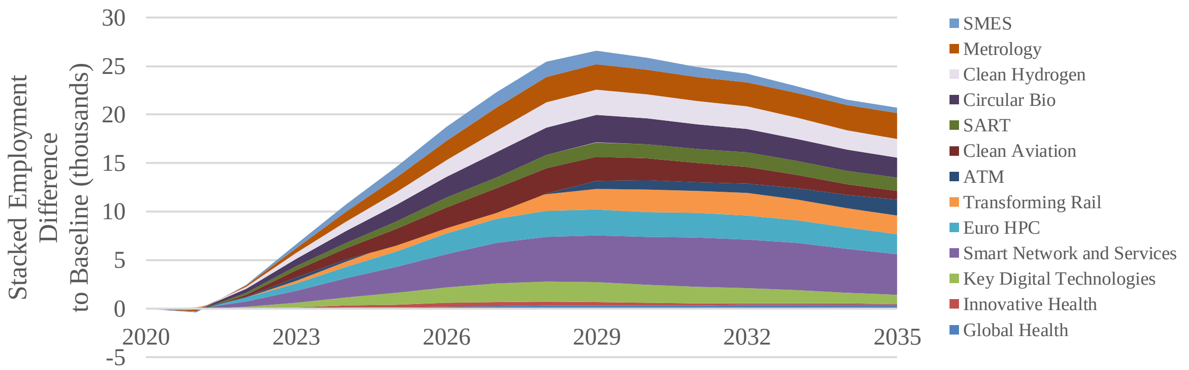
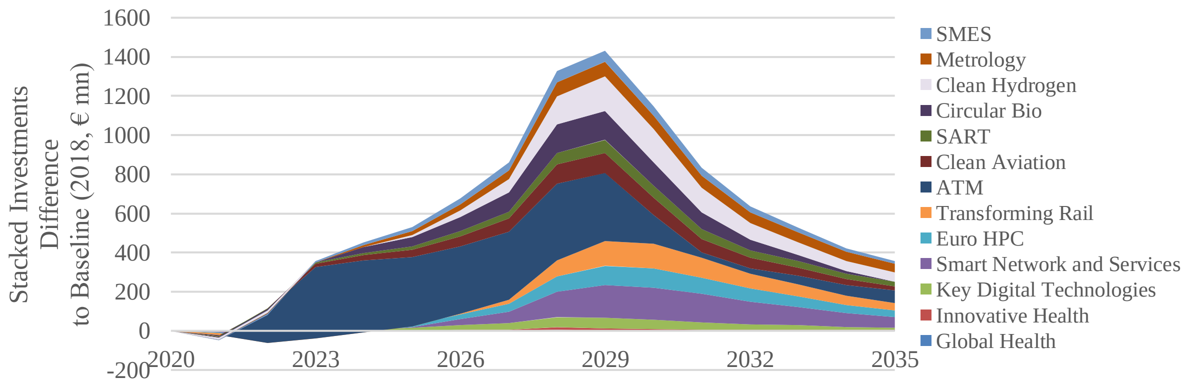


Figure 7: Stacked Investments Difference to Baseline by Initiative



The most important driver of positive socio-economic effects in the short to medium term is investment. Investment is directly and positively impacted by an increase of R&D expenditure (annual R&D expenditure counts as an input in the investment equation, its increase therefore acts directly in increasing investment through the impact pathways described in section 3). In the GDP peak year of 2028 additional investment accounts for approximately 48% of the increase in GDP.

However, from 2030, the additional investment decreases in magnitude because the rate of growth in new products slows. As a result, investment is stimulated most during the lifetime of Horizon Europe.

An increase in external exports contributes substantially to positive socio-economic results in the short to medium term. In 2028, higher external exports account for approximately 17% of the GDP increase.[9] The most important sectors for higher external exports are pharmaceuticals, chemicals, electrical equipment, and machinery and equipment not elsewhere classified (n.e.c).

The long-run increase in GDP is dominated by consumer expenditure: indeed, approximately 68% of the estimated increase in GDP in 2050 is attributable to higher consumer expenditure. It is a consequence of the increase in employment during Horizon Europe, following investment and trade stimuli, which persists beyond 2030, increasing aggregate real incomes and in turn increasing consumer expenditure.

Whilst aggregate employment is greater than baseline throughout the forecast, there are mixed employment effects at sectoral level. In some sectors, labour intensity decreases following increases in the knowledge stock.

Employment effects peak in 2029 and regress to the baseline steadily until 2050. GDP results are less stable; GDP effects peak in 2028, regress to baseline until 2040, and then increase again. The time path of GDP is the result of declining positive external trade and investment benefits after 2028, coupled with positive consumer expenditure effects persisting and increasing into the medium-long term.

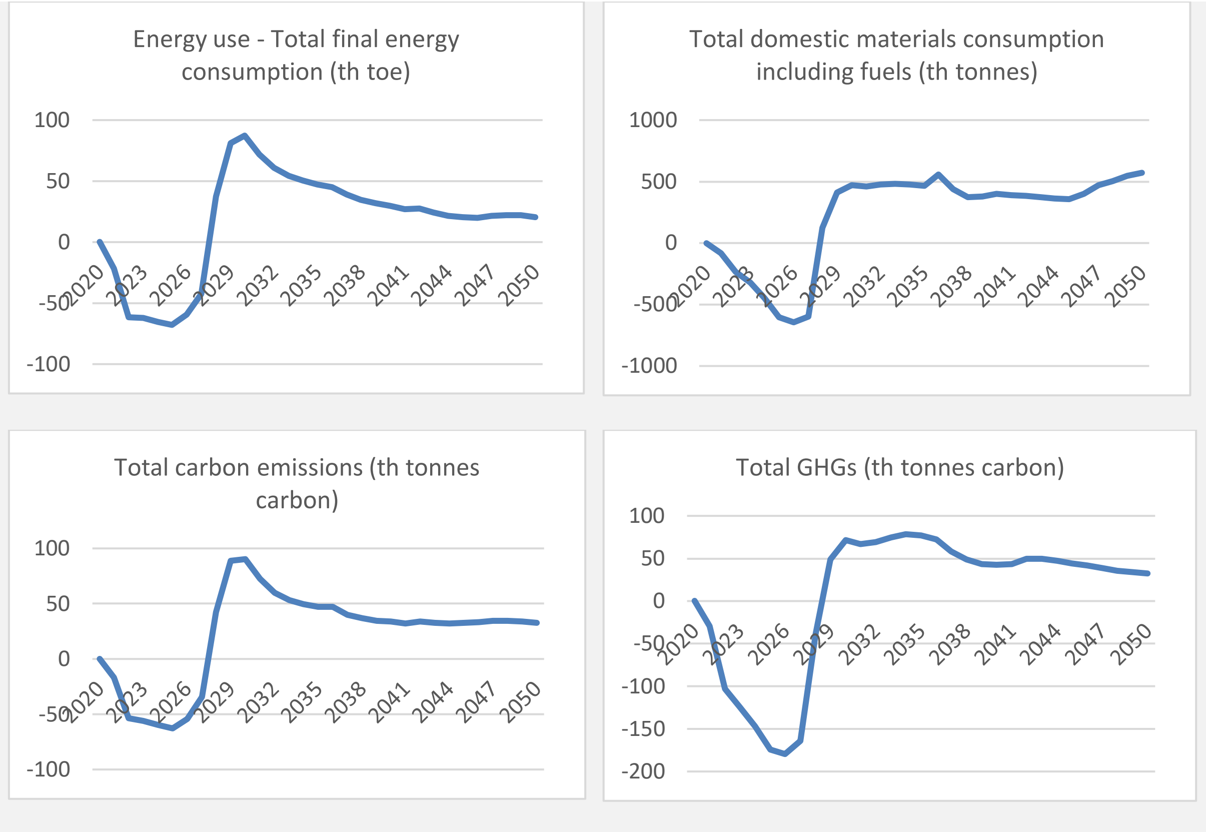
There are limited effects in the energy-environment results in the scenario. Total final energy consumption (TFEC), carbon emissions, and domestic material consumption (DMC) decrease in the short-medium term, following the higher effective R&D of the scenario. However, in the longer term, the higher level of economic activity dominates: there is a moderate increase in TFEC, carbon emissions, and DMC from 2028. Compared to the baseline, by 2050 the EU27 GDP is 0.007% higher, TFEC is 0.003% higher, carbon emissions are 0.007% higher, and DMC is 0.004% higher. Whilst negligible, it is also noted that the energy and carbon intensity of GDP decreases, rather than increases, compared to baseline.

Across energy demand, carbon emissions, and material consumption, the effect of higher economic activity more than outweighs the impacts of technological progress, in the years after 2030. The scenario results yield a relative decoupling of economic activity and environment impacts in the medium-long term, but not an absolute decoupling. The effect is minimal, however. The pattern of final energy consumption change is very similar across all sectors of the economy. In the years of Horizon Europe funding, the energy efficiency improvements result in an absolute reduction in energy demand. In the years after, the increase in economic activity outweighs the energy efficiency improvements, and energy demand increases compared to baseline. More specifically, the impact on the four energy-environmental indicators are S shaped, first dropping until 2027 (2028 for total GHG emissions), then significantly increasing for the consumption of domestic materials (including fuels) and returning to baseline for the three remaining indicators (Total final energy consumption, Carbon emissions and Total GHG emissions) from 2035 onwards.

Figure 8, below, illustrates the impacts on Energy Use, Total Carbon Emissions, Total Domestic Materials Consumption and Total GHGs.

[9] Annual R&D expenditure and the knowledge stock feed directly into the trade equations in E3ME, capturing the capacity of R&D to improve competitiveness.

Figure 8: Energy Use, Total Carbon Emissions, Total Domestic Materials Consumption and Total GHGs Difference for the 13 initiatives combines (Combine Scenarios, EU27)



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

Moreover, it is informative to compare the value of the E3ME results to the NEMESIS results presented in EC (2018d). The comparable work is Chapter 6 in EC (2018d), "Beyond the management and the budget: the "Design" Options.".

- The magnitude of EU funding in the NEMESIS scenarios is greater than in the E3ME modelling, by approximately five times: the NEMESIS scenario is €70bn (2014 prices), whereas the E3ME scenario is €13 bn (2018 prices), for all 13 initiatives combined.

- The NEMESIS modelling considers low and high scenarios, whereas the E3ME modelling provides a single scenario for each initiative, using assumptions informed by the individual initiative and choice of partnership. The NEMESIS modelling gives peak GDP increases in low and high scenarios of approximately 0.04% and 0.1% respectively. The NEMESIS modelling gives peak employment changes in low and high scenarios of 27 and 67 thousand (approximately) respectively.

- If the above effects are adjusted for the magnitude of R&D funding, the results from the E3ME modelling are comparable those from the NEMESIS work. The peak GDP increase of 0.018% is comparable to the higher end of the NEMESIS estimate. The peak employment change of 26.7 thousand is greater than the higher end of the NEMESIS estimate.

- The most striking difference between the E3ME and NEMESIS results is the time path of effects.[10] In E3ME, the positive effects in the scenario are increasing to 2030 and reduce

[10] The differences in the timing of impacts is a function of the differing dynamics in the two models.

slightly after the Horizon Europe programme concludes. In contrast, GDP and employment gains in NEMESIS do not peak until 2040.

10.2 Initiative 1 – EU-Africa Global Health Partnership

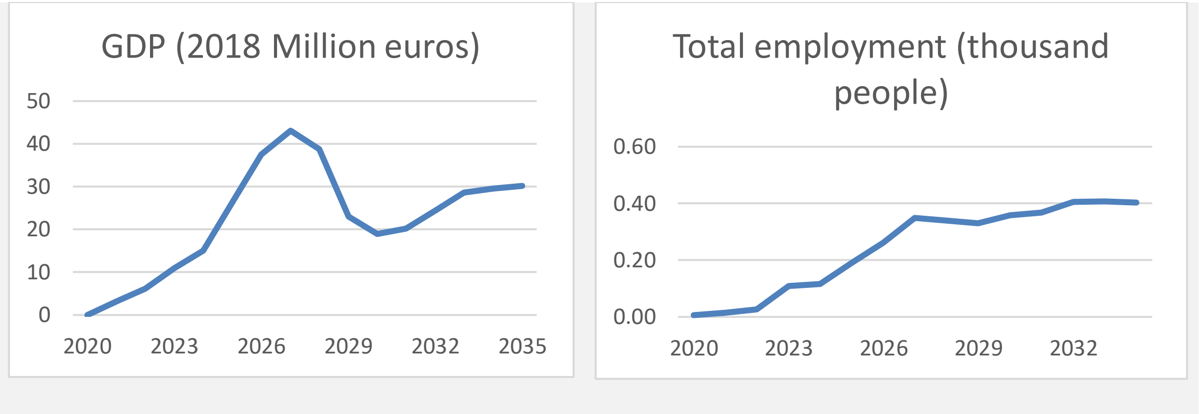
GDP and employment results are positive throughout the projection period to 2035, with GDP increasing throughout the Horizon Europe programme and peaking in 2027, whereas employment impacts increase throughout the period to 2034.

However, the magnitude of positive socio-economic effects is small. The peak GDP increase is €43 million, and the employment increase peaks at approximately 400 jobs.

The three main drivers of increased GDP are:

- Increased external exports (exports to outside the EU) of pharmaceuticals, implying an increase in competitiveness of EU exports. This dominates positive effects during the years 2021-2029.
- Higher employment in pharmaceuticals leads to increased real consumer incomes and increased consumer expenditure.
- The largest identified knowledge spillover effect is to the chemicals sector, with as result an increase in extra-EU exports in this sector.

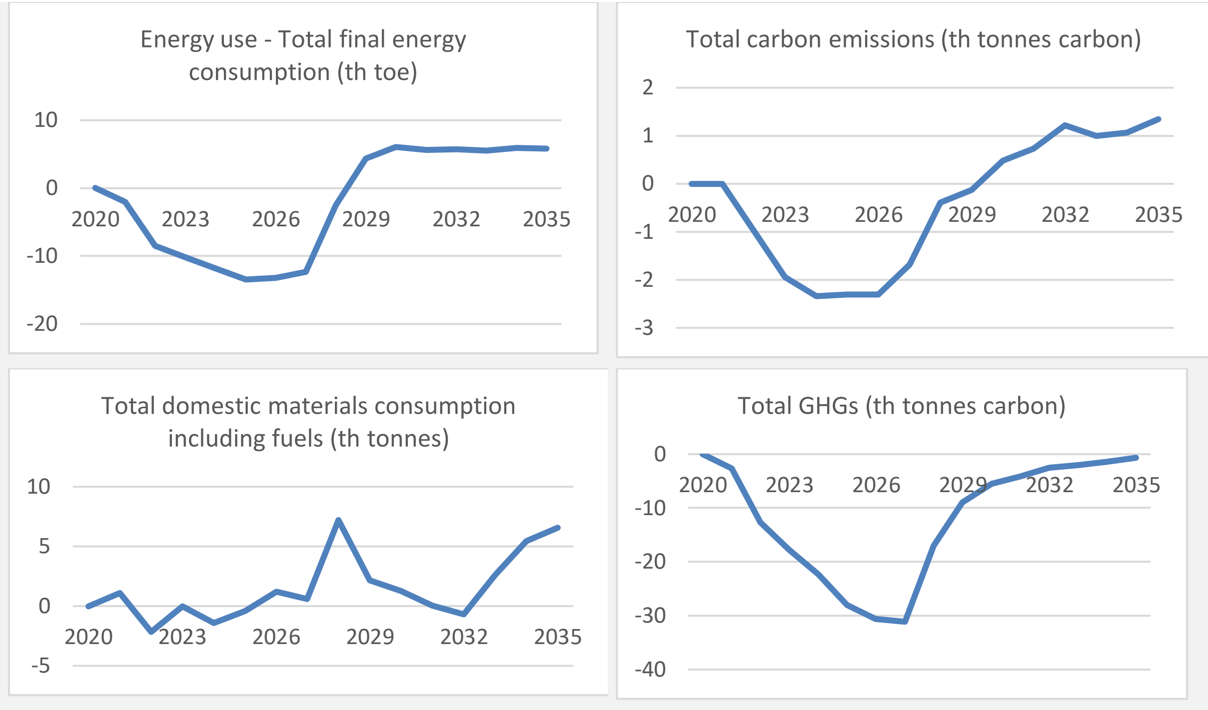
Figure 9: Difference to Baseline of Socio-Economic Indicators for the EU-Africa Global Health Partnership



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2030 with the exception of domestic materials consumption that revolves around the baseline with a peak positive difference to baseline in 2028 (at 7.9 thousand tonnes). TFEC and carbon emissions are lower than baseline until 2030 and 2029, respectively. The peak decrease in TFEC and carbon emissions are 1.7 thousand tonnes of oil equivalent (ktoe), and 2.3 thousand tonnes of carbon, respectively. The GHG emissions are lower than baseline throughout the entire analysis period, however returning to baseline by 2035. These results are driven by higher effective R&D in the pharmaceuticals and chemicals sectors.

Figure 10: Difference to Baseline of Energy-Environmental Indicators for the EU-Africa Global Health Partnership



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

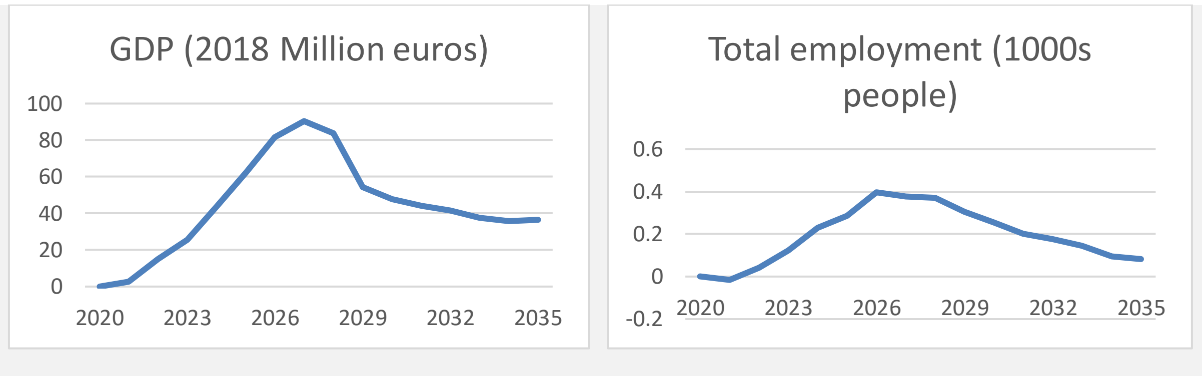
10.3 Initiative 2 – European Partnership on Innovative Health

GDP and employment results are positive throughout the projection period, with a positive effect on GDP peaking at €90 million in 2027 and an increase in employment peaking at 400 jobs in 2026.

The two main drivers of increased GDP are:

- Increased external exports (exports to outside the EU) of pharmaceuticals implying an increase in competitiveness of EU exports. This dominates positive effects during the years 2021-2029.
- Higher employment in pharmaceuticals and computer services, which leads to increased real consumer incomes and consumer expenditure.

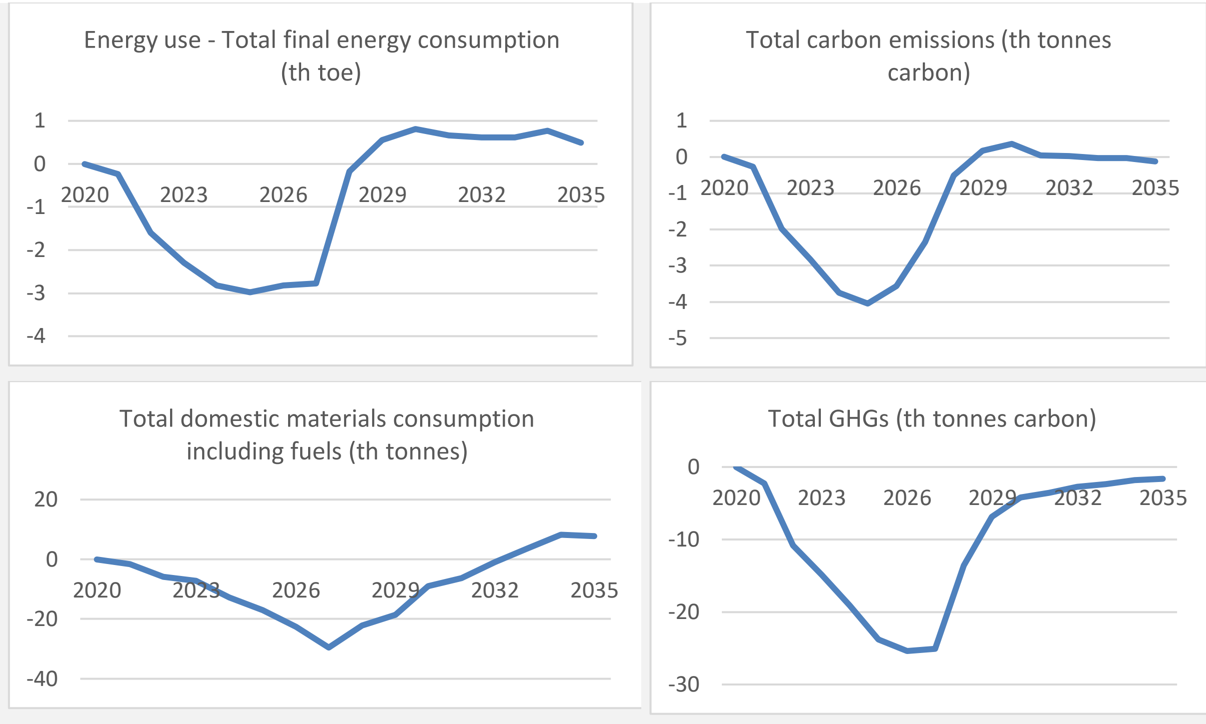
Figure 11: Difference to Baseline of Socio-Economic Indicators for the Innovative Health initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2028. TFEC and carbon emissions are lower than baseline until 2028. The peak decrease in TFEC and carbon emissions are 2.9 thousand tonnes of oil equivalent (ktoe), and 4 thousand tonnes of carbon, respectively. The GHG emissions are lower than baseline throughout the entire analysis period, however returning to baseline by 2035. Domestic materials consumption is lower than baseline from 2021 to 2032 and are increasing over the baseline thereafter.

Figure 12: Difference to Baseline of Energy-Environmental Indicators for the Innovative Health initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.4 Initiative 3 – European Partnership for Key Digital Technologies

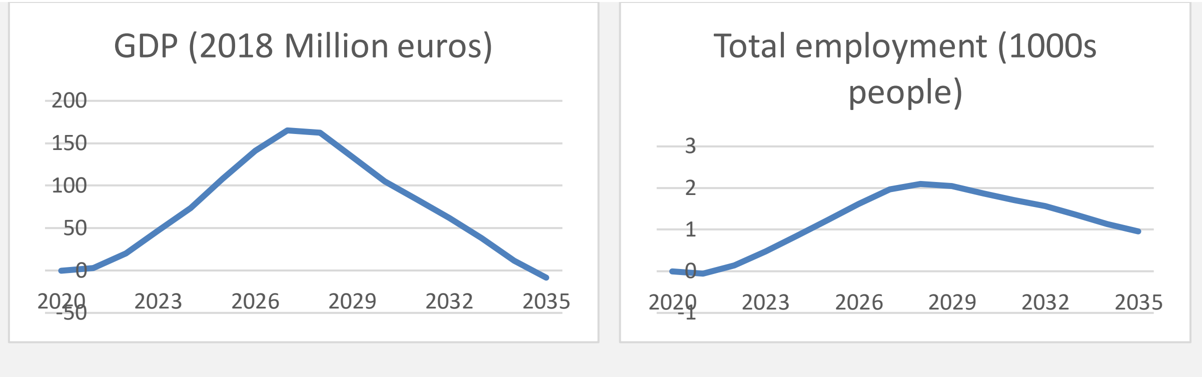
Socio-economic results are positive throughout most of the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2027 and 2028, respectively. After this peak, the improvements over baseline fade. By 2035, employment results are still positive, but GDP is marginally lower.

The GDP increase to baseline peaks at €165 million in 2027, and the employment increase to baseline peaks at 2,100 jobs in 2028.

The three main drivers of increased GDP are:

- Increased external exports in manufacturing sectors including machinery, electrical equipment, and electronics.
- Investment increases across numerous sectors of the economy, across both manufacturing and services. This follows from diverse network in the initiative.
- Increased employment and therefore consumer expenditure. For this initiative, employment increases are concentrated in the services sectors.

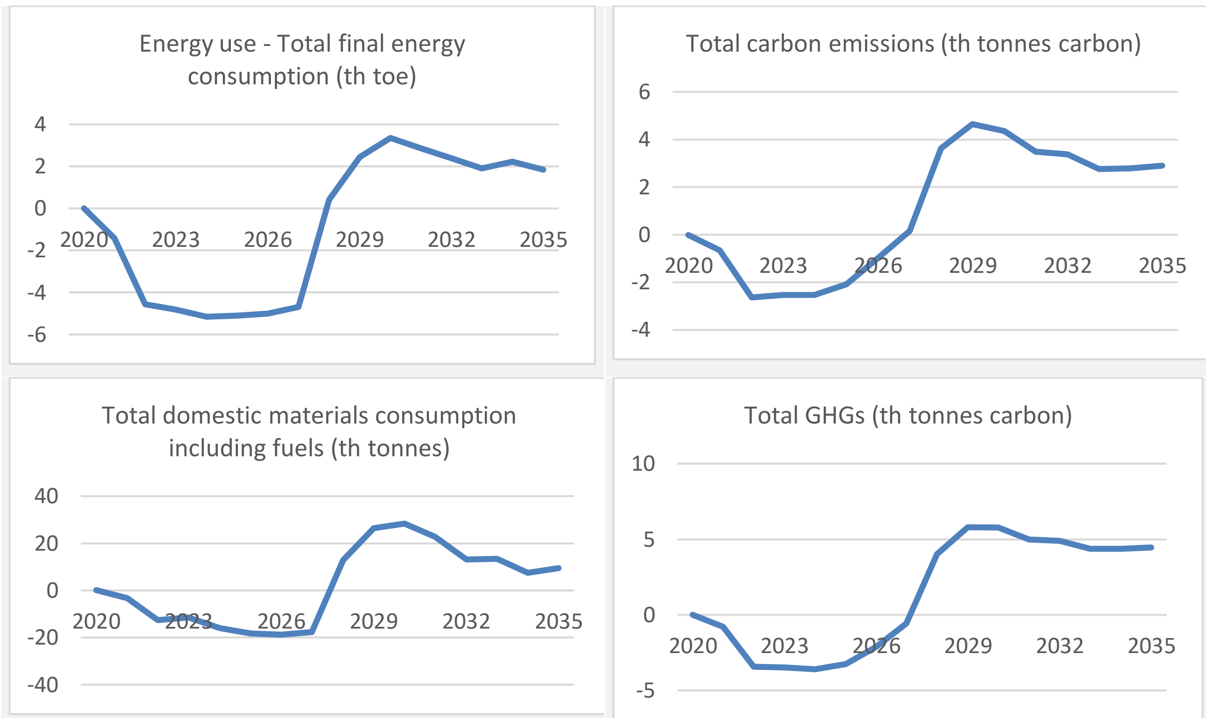
Figure 13: Difference to Baseline of Socio-Economic Indicators for the Key Digital Technologies Initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2027, from that year onwards all four indicators (TFC, TCE, DMC and GHG emissions) are higher than baseline. The peak decrease in TFEC and carbon emissions are 3.5 thousand tonnes of oil equivalent (ktoe), and 2.6 thousand tonnes of carbon, respectively.

Figure 14: Difference to Baseline of Energy-Environmental Indicators for the Key Digital Technologies Initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.5 Initiative 4 – European Partnership for Smart Networks and Services

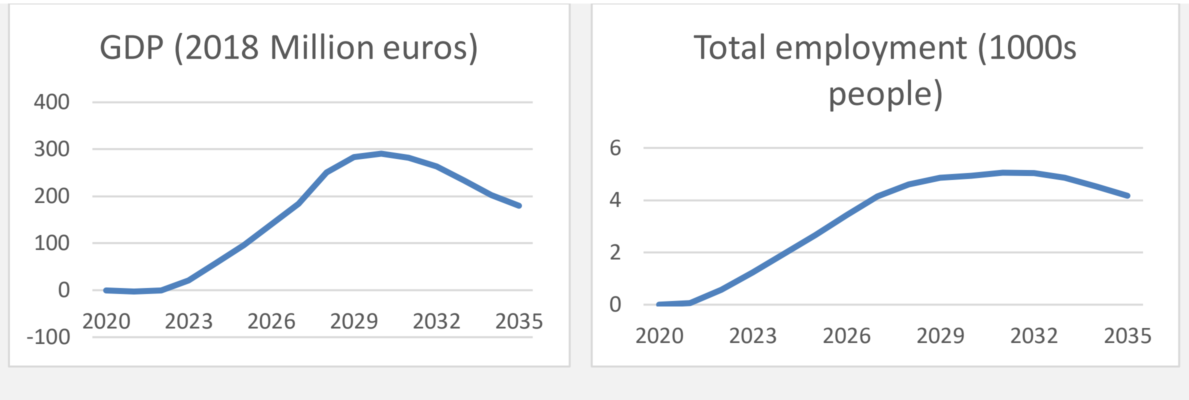
Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2030 and 2031, respectively.

The GDP increase peaks at €290 million in 2030 and the employment increase peaks at 5,000 jobs in 2031.

The three main drivers of increased GDP are:

- Investment first and foremost. Investment increases across most sectors in the economy. This follows from investment in the digital transformation across the economy. Investment increases are strongest in the service sectors.
- Employment following the increase in investment.
- Employment increases in service sectors (same sectors in which investment is stimulated).

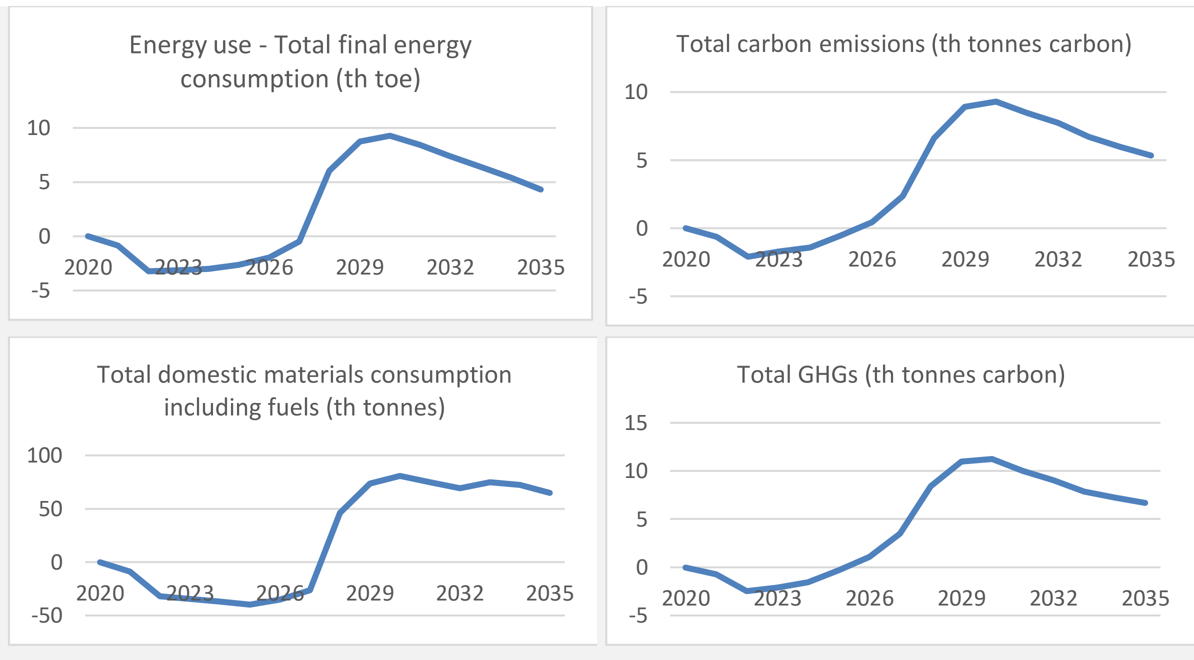
Figure 15: Difference to Baseline of Socio-Economic Indicators for the Smart Networks and Services Initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2027, from that year onwards all four indicators (TFC, TCE, DMC and GHG emissions) are higher than baseline. The peak decrease in TFEC and carbon emissions are 3.2 thousand tonnes of oil equivalent (ktoe), and 2.1 thousand tonnes of carbon, respectively.

Figure 16: Difference to Baseline of Energy-Environmental Indicators for the Smart Networks and Services Initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.6 Initiative 5 – EuroHPC Partnership

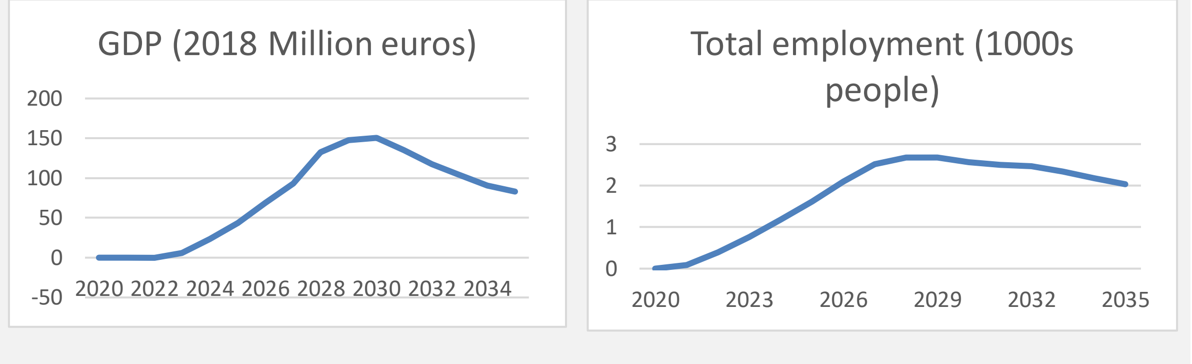
Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2030 and 2028, respectively.

The GDP increase peaks at €151 million in 2030 and the employment increases peak at 2,700 additional jobs in 2028.

The two main drivers of increased GDP are:

- Investment, which increases in NACE 62, and many service sectors that are more minor participants in the initiative. This widespread increase in investment reflects the applicability of HPC across services.
- Employment in the key sectors of the initiative, and across service sectors. Increased employment leads to higher real incomes and expenditure.

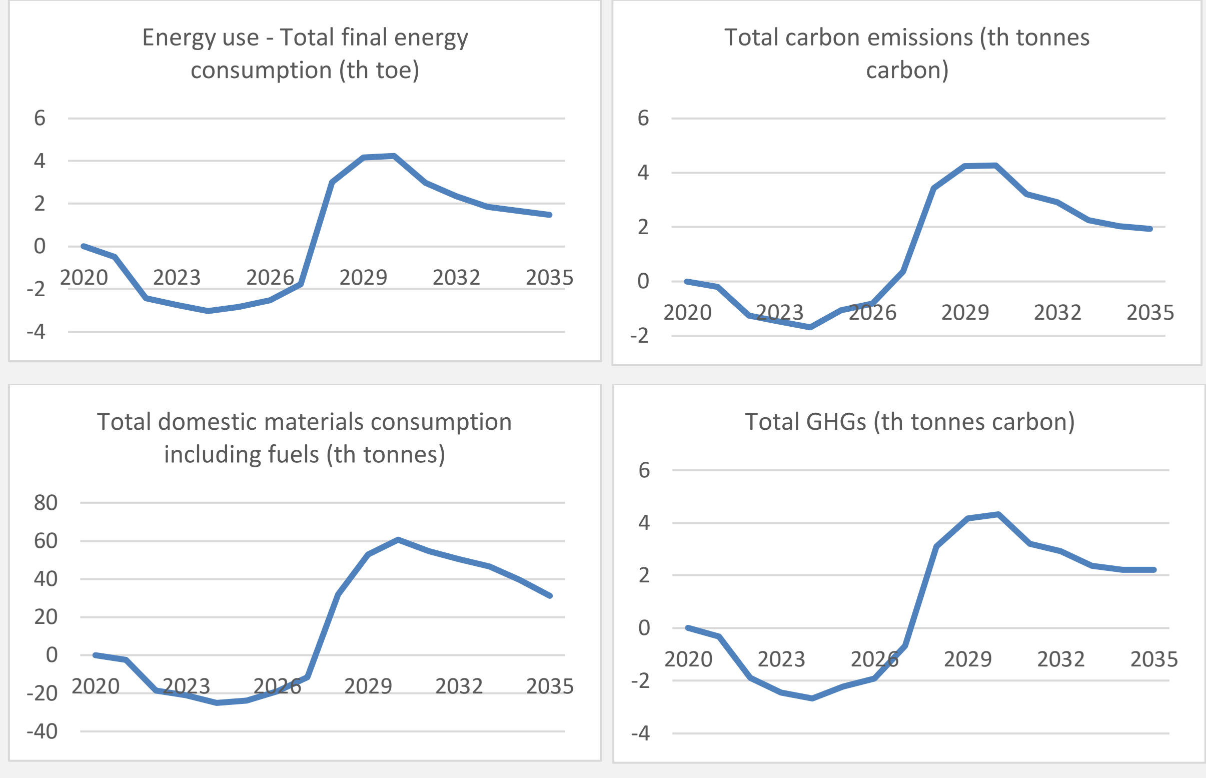
Figure 17: Difference to Baseline of Socio-Economic Indicators for the EuroHPC Partnserhip



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2027, from that year onwards all four indicators (TFC, TCE, DMC and GHG emissions) are higher than baseline. TFEC and carbon emissions are lower than baseline until 2028 and 2027, respectively. The peak decrease in TFEC and carbon emissions are 3 thousand tonnes of oil equivalent (ktoe), and 1.7 thousand tonnes of carbon, respectively.

Figure 18: Difference to Baseline of Energy-Environmental Indicators for the EuroHPC Partnserhip



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

The scenario models the €1 bn of Horizon Europe funding allocated to classic R&D over the period 2021-2029 following the same time allocation of the other 12 initiatives (see Appendix D). That is, the scenario does not explicitly model the procurement of super-computers at the beginning of the initiative but focuses on the use of this capital over the period to 2029.

10.7 Initiative 6 – European Partnership for Transforming Europe's Rail System

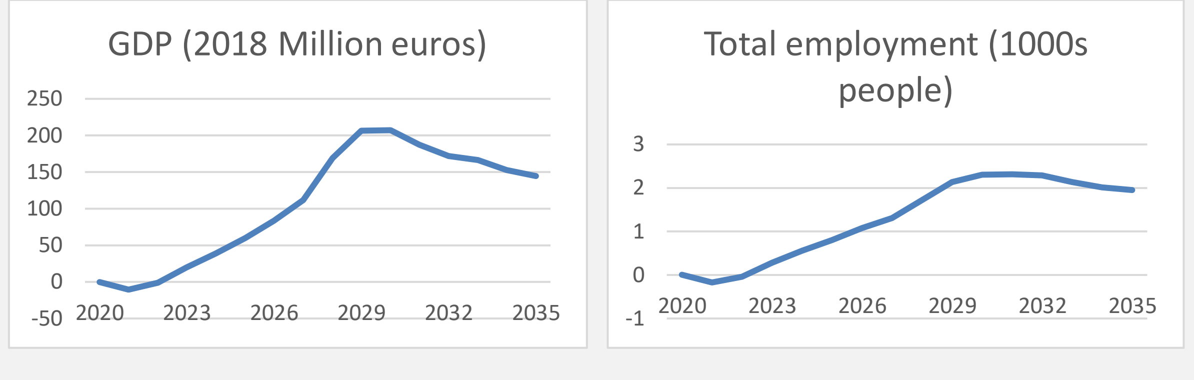
Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2030.

The GDP increase peaks at €207 million in 2030 and the employment increases peak at 2,300 jobs in 2030.

The three main drivers of increased GDP are:

- In the years, to 2027, an improvement in the net external trade position of key manufacturing sectors: other transport equipment, electrical equipment, machinery and equipment n.e.c. and other manufacturing. This improvement in the net trade position follows increased competitiveness given the more effective R&D.
- Investment in land transport and construction. These sectors are key to the delivery of the transformed rail system.
- Employment increases across manufacturing and service. The strongest is in construction.

Figure 19: Difference to Baseline of Socio-Economic Indicators for the Transforming Rail Partnserhip



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

Labour-replacing technology is not a focus of this initiative; the only mention in the study team's report is more automated loading of rail freight, to increase competitiveness. Initial modelling suggested strong decreases in employment in land transport, but these modelling dynamics were adjusted given the R&D focus of the initiative.

The energy and environmental dynamics of this initiative are not well captured in this impact pathway scenario. The energy and environment aspects are substantially more detailed in the second modelling scenario of Transforming Rail provided in Appendix E.

10.8 Initiative 7 – European Partnership for Integrated Air Traffic Management

GDP results are positive throughout the forecast period. The time path is an increasing improvement in GDP to 2028 and reducing improvement thereafter. The GDP increase peaks at €539 million in 2028.

The GDP results show much lower increases from baseline from 2029 onwards. By 2035, the increase is only €108 million because the increase in investment subsides. Overall, it is new knowledge creation that stimulates investment, meaning that the effects are strong only during the period of Horizon Europe funding, from 2021 to 2029.

The magnitude of the peak GDP increase is greater than any of the other initiatives. This is driven by the strong investment response in NACE 52, warehousing and support activities for transportation, which receives over half of the R&D funding in this intiative. The strength of investment response follows from the econometric relationships estimated in the model.

The time path of aggregate employment is more complex. There is some decrease until 2028. The peak decrease is 700 jobs in 2027. From 2028 onwards, employment increases, to a peak in 2035 of 1,700.

The employment response in NACE 52 is heterogenous across Member States, depending on the estimated parameters in E3ME. This leads to the somewhat non-intuitive time path of employment.

The decrease in employment to 2027 is dominated by reduced employment in NACE 52 in a few Member States. A justification for this is that the study team's report does state that the next generation of air traffic management systems will be more automated. As Section 3.4 (Direct Employment Effects) in the report notes, the direct employment effects of R&D may be positive or negative depending on whether it is predominately labour-augmenting or labour-replacing.

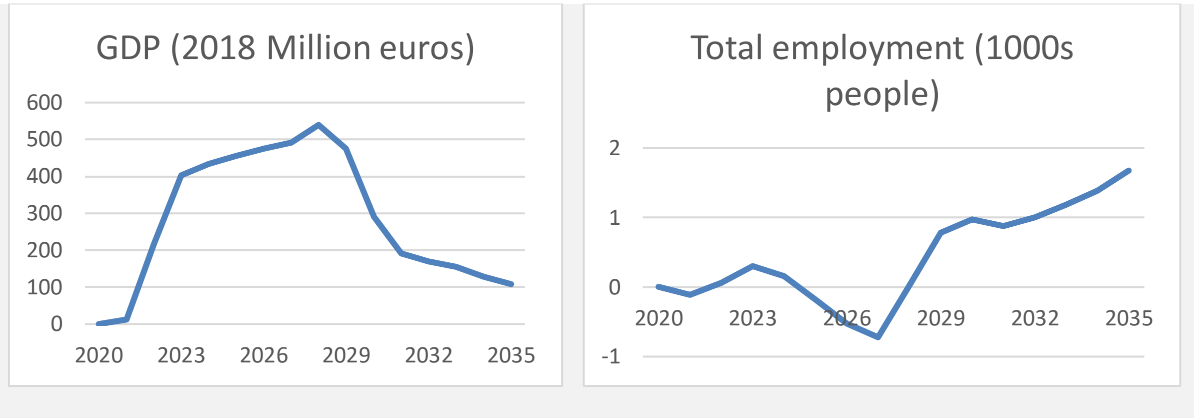
From 2031, EU27 employment in NACE 52 is higher than baseline; increases in employment in the Member States with positive impacts in NACE 52 outweigh reductions in other Member States.

Net employment impacts in other sectors are positive throughout the forecast, to 2032. The increase in employment is driven by investment demand in NACE 52. Employment increases throughout the forecast in computer, optical, and electronic manufacturing, the other sector involved in the initiative.

The main drivers of increased GDP are:

- By far the dominant economic impact is investment in NACE 52.
- Investment in NACE 52 creates employment across many sectors, most notably construction.

Figure 20: Difference to Baseline of Socio-Economic Indicators for the Integrated Air Traffic Management Initiative

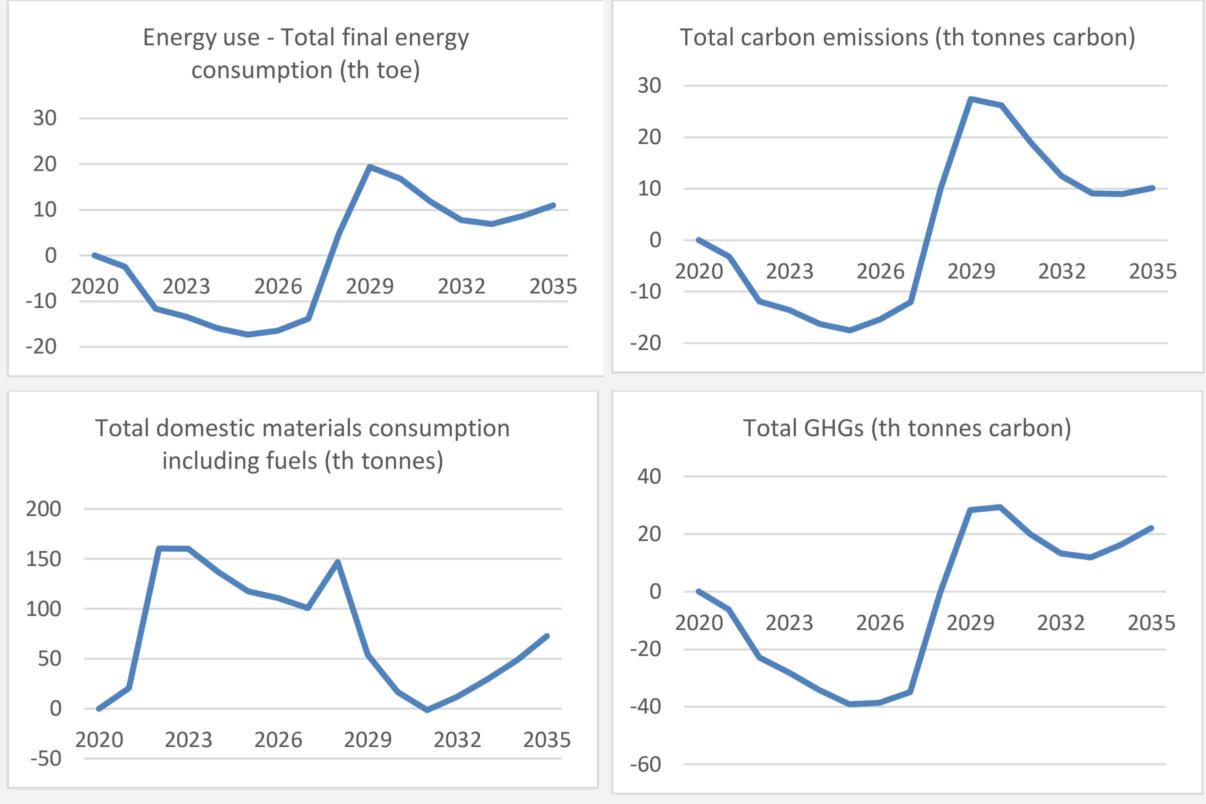


Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The net external trade position improves throughout the period to 2035. External imports of NACE 52 decrease substantially. External exports increase across many manufacturing sectors including computer optical and electronic manufacturing; electrical equipment; and machinery and equipment n.e.c.

The impacts on countries’ energy consumption, carbon and GHG emissions are positive until 2027 (2028 for the GHG emissions), whereas domestic material consumption lies over baseline throughout the entire period, peaking already in 2022. The peak decrease in TFEC and carbon emissions are 17.3 thousand tonnes of oil equivalent (ktoe), and 17.5 thousand tonnes of carbon, respectively.

Figure 21: Difference to Baseline of Energy-Environmental Indicators for the Integrated Air Traffic Management Initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.9 Initiative 8 – European Partnership on Clean Aviation

Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2028.

The GDP increase peaks at €240 million in 2028. The employment increases peak at 2,600 jobs in 2028.

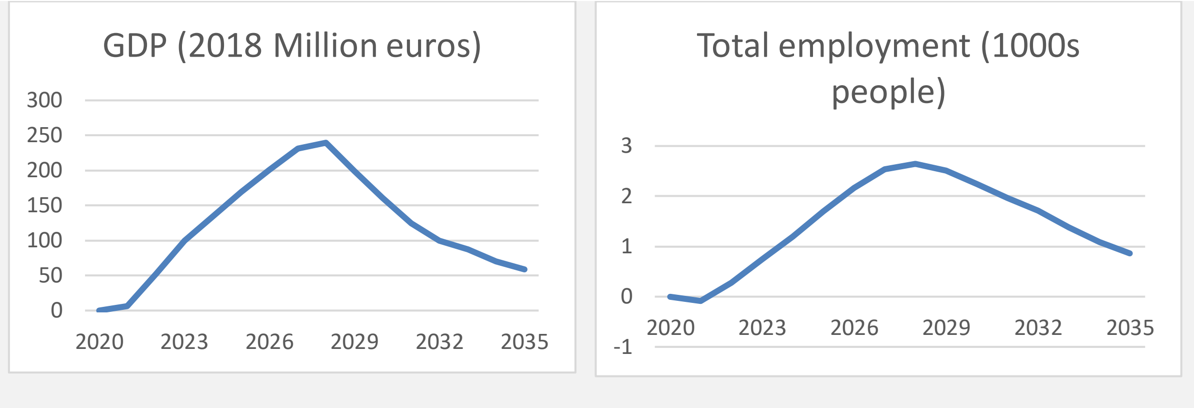
The positive results decrease substantially from 2029, and GDP is only €59 million higher than in the baseline in 2035. Employment is only 900 jobs higher than in the baseline by 2035. The reason is that investment is the most important driver of GDP and employment, and this is strongest during the years of Horizon Europe.

The main drivers of increased GDP are:

- Investment in key sectors of the initiative, including warehousing and support activities for transportation; and air transport. Investment also increases across many service sectors.
- Increases in employment following investment demand.
- Increase in employment in several service sectors which are involved in the initiative. These are mostly in NACE M 'professional, scientific, and technical activities' and NACE N 'administrative and support service activities'.

The net external trade position improves throughout the period to 2028. External exports increase across many manufacturing sectors including machinery and equipment n.e.c., other transport equipment, and electrical equipment.

Figure 22: Difference to Baseline of Socio-Economic Indicators for the Clean Aviation Initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The energy and environmental dynamics of this initiative are not well captured in this impact pathways scenario. The energy and environment aspects are more detailed in the second modelling scenario of Clean Aviation provided in Appendix F.

10.10 Initiative 9 – European Partnership for Safe and Automated Road Transport

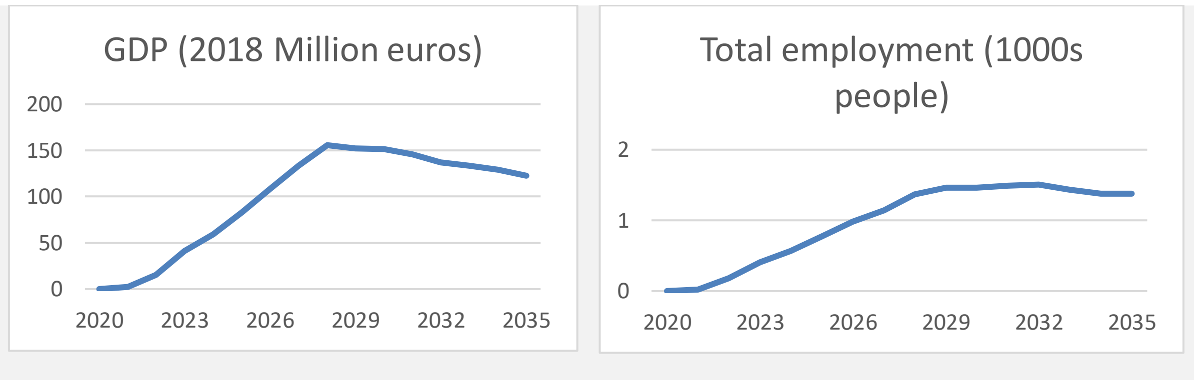
Socio-economic results are positive throughout the forecast period. The GDP increase peaks at €156 million in 2028. Employment increases peak at 1,500 jobs in 2032. The positive results are largely sustained to 2035. GDP and employment are still €122 million and 1,400 higher than in the baseline by 2035.

The main drivers of increased GDP are:

- Investment in key sectors of the initiative, including warehousing and support activities for transportation; and land transport. Investment also increases across many service sectors.
- Increases in employment following investment demand.
- Increase in employment in several service sectors which are involved in the initiative. These are mostly in NACE M 'professional, scientific, and technical activities' and NACE N 'administrative and support service activities'.

The net external trade position improves throughout the forecast period, but particularly strongly until 2028. External exports increase across many manufacturing sectors including motor vehicles; machinery and equipment n.e.c.; and electrical equipment.

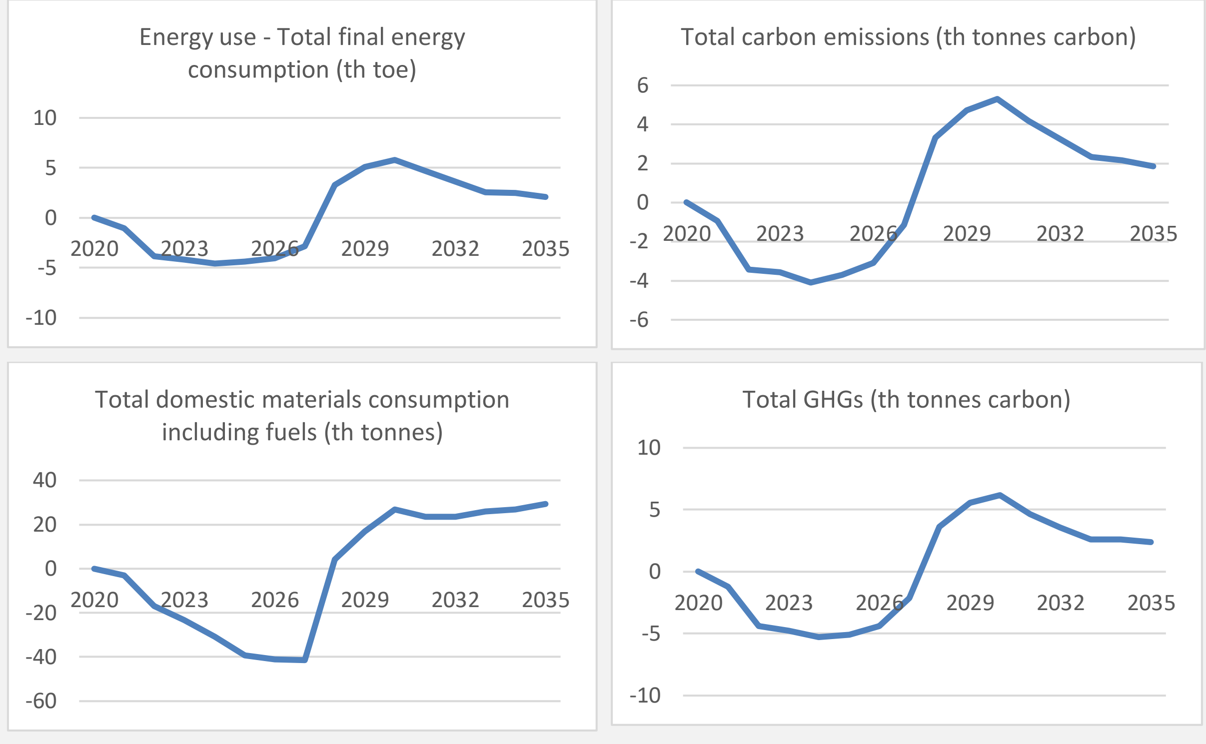
Figure 23: Difference to Baseline of Energy-Environmental Indicators for the Safe Automated Road Transport Initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2027. The peak decrease in TFEC and carbon emissions are 4.5 thousand tonnes of oil equivalent (ktoe), and 4.1 thousand tonnes of carbon, respectively.

Figure 24: Difference to Baseline of Energy-Environmental Indicators for the Safe Automated Road Transport Initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.11 Initiative 10 – European Partnership on Circular bio-based Europe

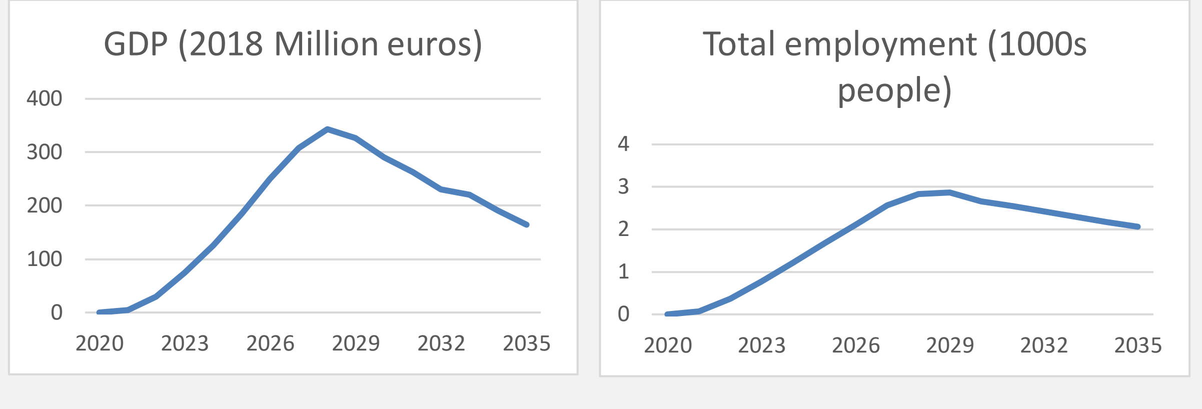
Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2028 and 2029, respectively.

The GDP increase peaks at €343 million in 2028. Employment increases peak at 2,900 additional jobs in 2029.

The main drivers of increased GDP are:

- Increase in employment in several service sectors which are involved in the initiative. These are mostly in NACE M 'professional, scientific, and technical activities' and NACE N 'administrative and support service activities'.
- Aggregate employment in the primary sectors decreases over the period. This indicates some decrease in labour intensity following technological progress.
- Improvement in the net external trade position. This is attributable to an increase in external exports in the chemicals sector, agriculture, and the pharmaceuticals sector.
- Investment increases across the economy. The R&D funding allocation is widespread across primary, secondary and tertiary sectors. There are investment responses across all three.

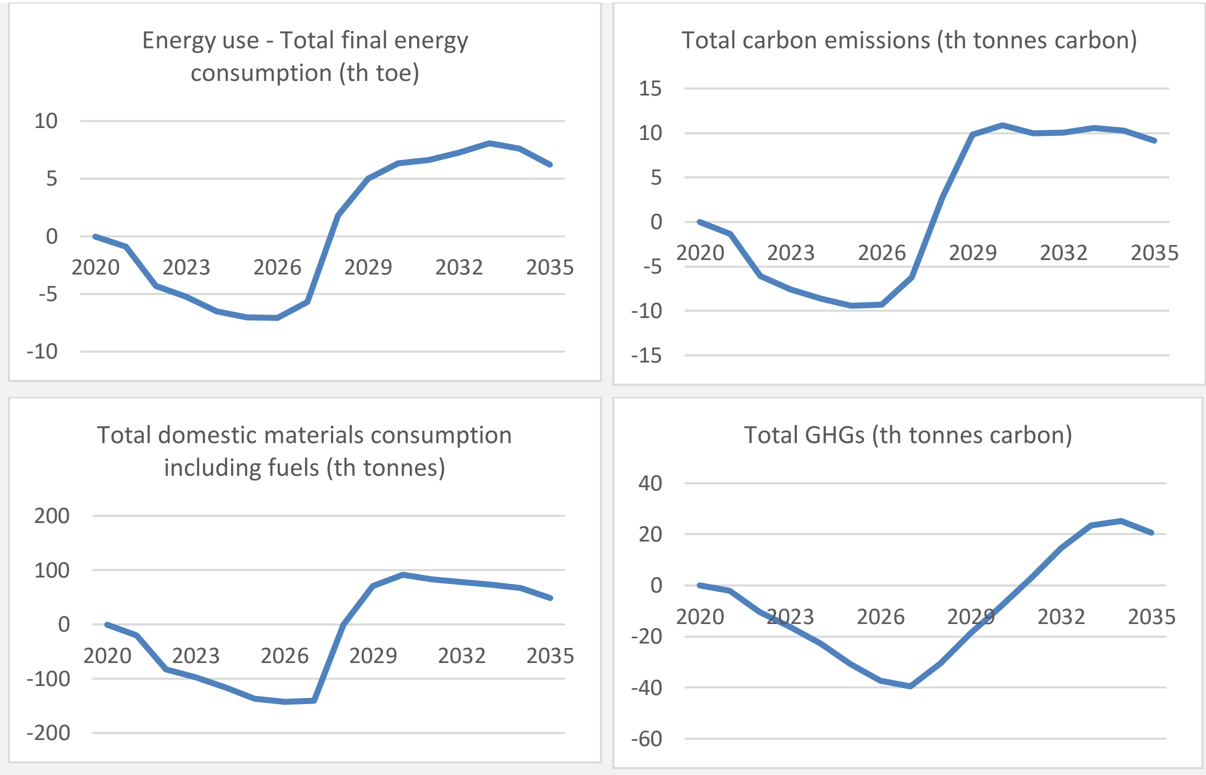
Figure 25: Difference to Baseline of Socio-Economic Indicators for the European Partnership on Circular bio-based Europe



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2028. From 2028 onwards, TFEC, TCE and DMC are above baseline. The impact on GHG emissions is positive for a longer time period (up to 2031). The peak decrease in TFEC and carbon emissions are 7 thousand tonnes of oil equivalent (ktoe), and 9.4 thousand tonnes of carbon, respectively.

Figure 26 Difference to Baseline of Energy-Environmental Indicators for the European Partnership on Circular bio-based Europe



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.12 Initiative 11 – European Partnership Clean Hydrogen

The most important sectors for this initiative are manufacture of electrical equipment (NACE 27); manufacture of machinery and equipment n.e.c. (NACE 28); and land transport and transport via pipelines (NACE 49).

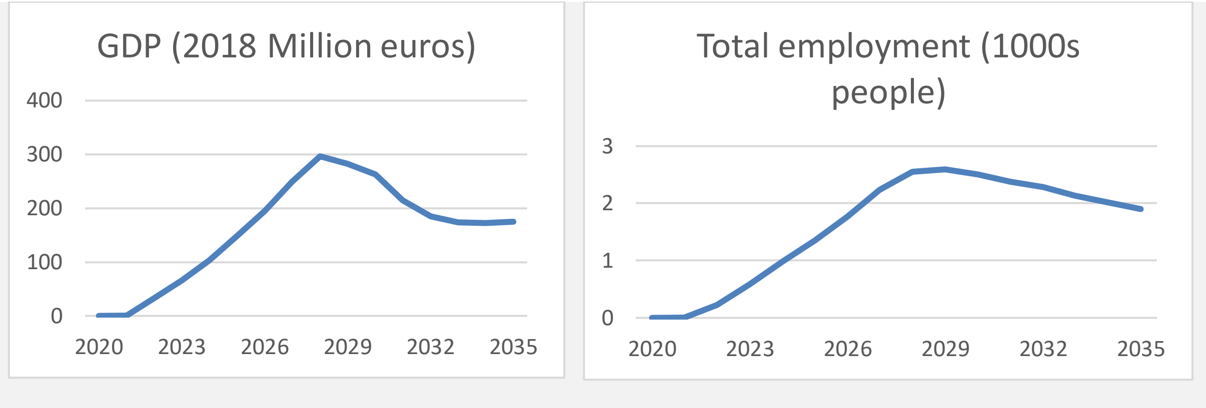
Socio-economic results are positive throughout the forecast period. The time path is an increasing improvement in GDP and employment over baseline to 2028 and 2029, respectively.

The GDP increase peaks at €297 million in 2028. The employment increases peak at 2,600 jobs in 2029.

The main drivers of increased GDP are:

- Investment in the land transport sector, which has the strongest stimulus effect to 2030.
- Increase in employment in several service sectors which are involved in the initiative. These are mostly in NACE M 'professional, scientific, and technical activities' and NACE N 'administrative and support service activities'.
- The net external trade position improves strongly until 2028. External exports increase across key manufacturing sectors including: electrical equipment; machinery and equipment n.e.c,; and chemicals.

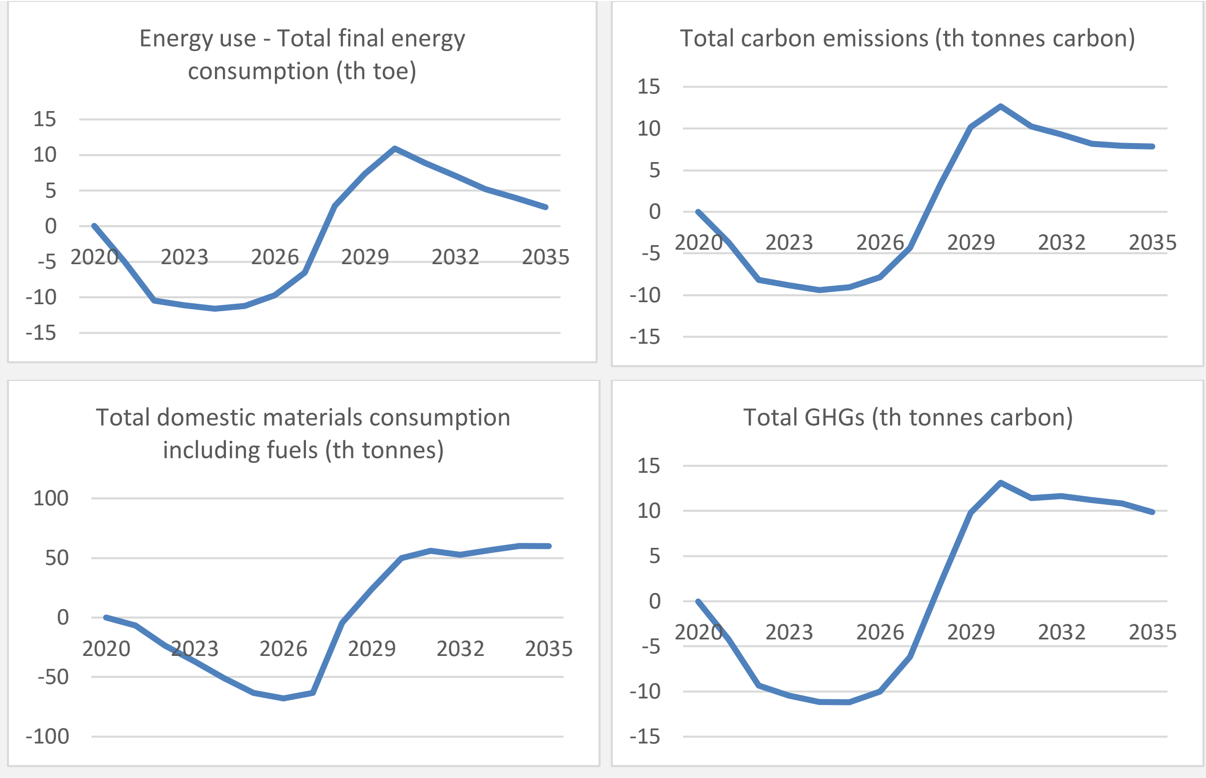
Figure 27: Difference to Baseline of Socio-Economic Indicators for the European Partnership Clean Hydrogen



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2028. Thereafter all indicators remain above the baseline, with TFEC returning to baseline by 2035. The peak decrease in TFEC and carbon emissions are 11.6 thousand tonnes of oil equivalent (ktoe), and 9.3 thousand tonnes of carbon, respectively.

Figure 28: Difference to Baseline of Energy-Environmental Indicators for the European Partnership Clean Hydrogen



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.13 Initiative 12 – European Metrology Partnership

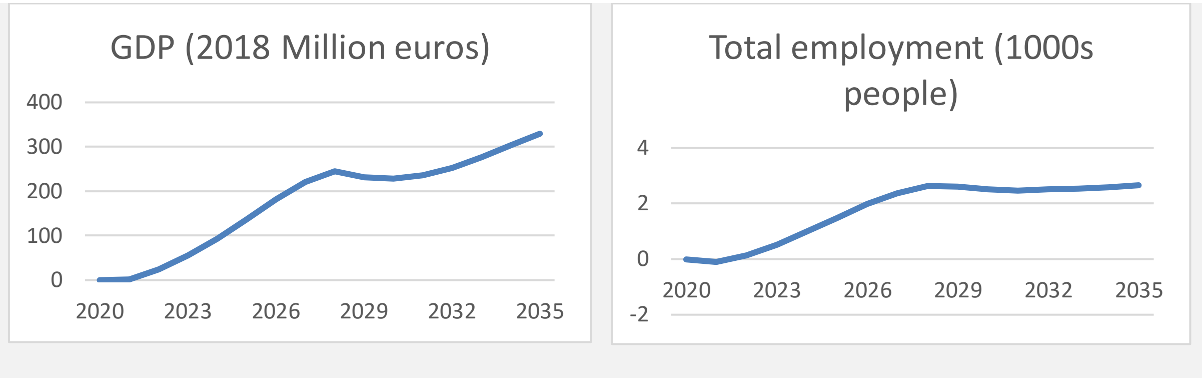
Socio-economic results are positive throughout the projection period. In contrast to all other initiatives, impacts increase throughout the period to 2035, for both GDP and employment.

The GDP increase peaks at €329 million in 2035. The employment increases peak at 2,700 additional jobs in 2035.

The main drivers of increased GDP are:

- Investment is an important driver, especially in the years to 2029. Investment increases across most sectors of the economy.
- Consumption is the dominant effect in the longer term. This follows from employment increases across most sectors of the economy. The largest increases are in the services sectors.
- The net external trade position improves throughout the forecast. External exports increase across key manufacturing sectors including pharmaceuticals; machinery and equipment n.e.c.; electrical equipment; and chemicals. External imports decrease in a number of services including travel agency tours; postal and courier activities; and advertising.

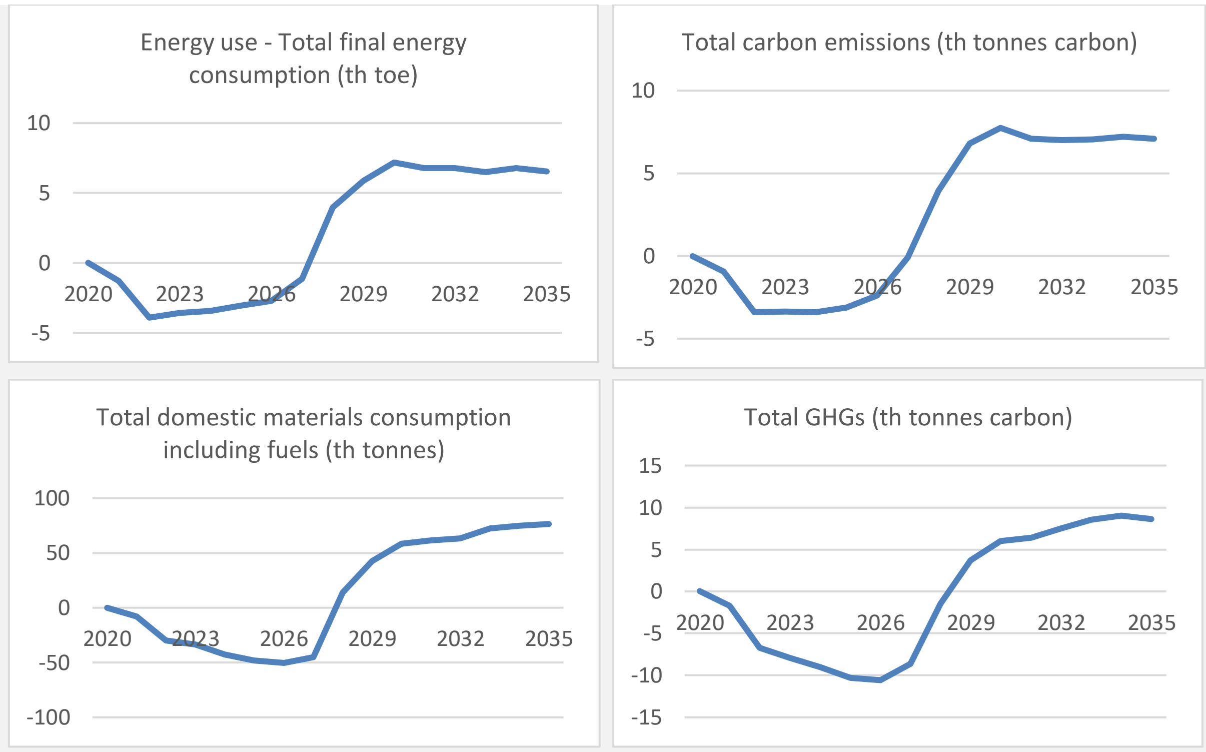
Figure 29: Difference to Baseline of Socio-Economic Indicators for the European Metrology Partnership



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are positive throughout the years to 2027 for both TCE and TFEC. The positive impact on GHG emissions lasts up to 2029. The peak decrease in TFEC and carbon emissions are 3.9 thousand tonnes of oil equivalent (ktoe), and 3.4 thousand tonnes of carbon, respectively.

Figure 30; Difference to Baseline of Energy-Environmental Indicators for the European Metrology Partnership



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

10.14 Initiative 13 – European Partnership for Innovative SMEs

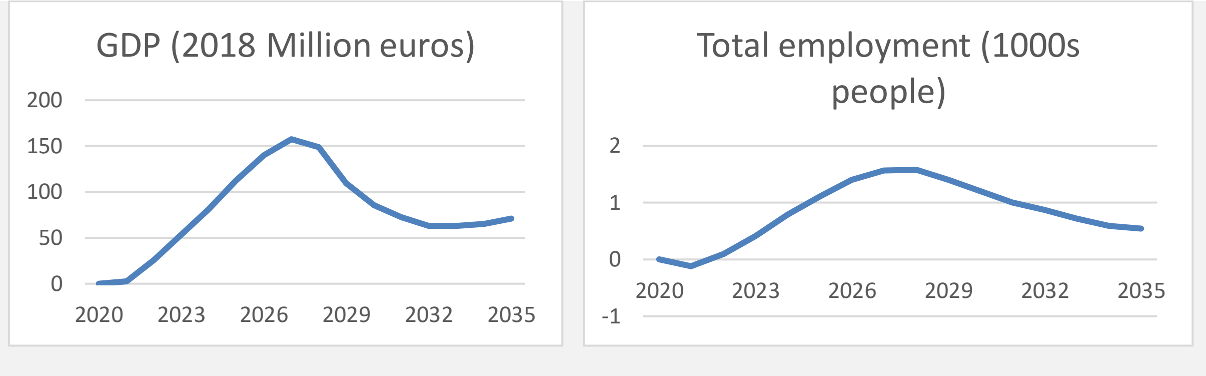
Socio-economic results are positive throughout the projection period. The time path is an increasing improvement in GDP and employment over baseline to 2027 and 2028, respectively.

The GDP increase peaks at €157 million in 2028. The employment increases peak at 1,600 jobs in 2028.

The main drivers of increased GDP are:

- The net external trade position improves throughout the projection period. External exports increase across key manufacturing sectors including pharmaceuticals; machinery and equipment n.e.c.; electrical equipment; and chemicals. External imports decrease in several services including telecommunications; postal and courier activities; and advertising.
- Increases in employment across most manufacturing and service sectors. Higher employment leads to higher consumer expenditure.
- Investment increases across the economy, particularly in services.

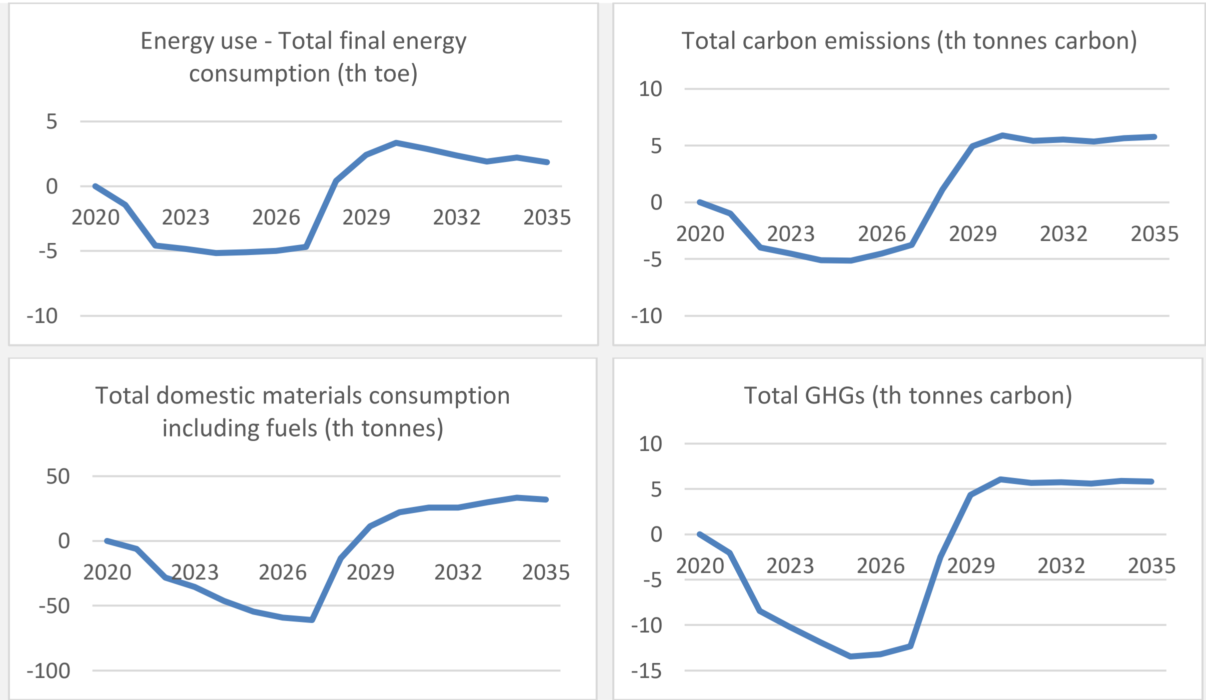
Figure 31: Difference to Baseline of Socio-Economic Indicators for the Innovative SME initiative



Note: The lines illustrate the difference of GDP and total employment to baseline (traditional calls) in € mn and thousand respectively.

The environmental results are mostly positive throughout the years to 2029. The peak decrease in TFEC and carbon emissions are 5.1 thousand tonnes of oil equivalent (ktoe), and 5.1 thousand tonnes of carbon, respectively.

Figure 32: Difference to Baseline of Energy-Environmental Indicators for the Innovative SME initiative



Note: The lines illustrate the difference of energy use, total carbon emissions, total domestic materials consumption and total GHGs to the baseline (regular calls) in thousands toe, thousands of tonnes carbon; thousands of tonnes and thousands of tonnes carbon respectively.

Appendix A References

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Christensen, M. (2018). Assessing the regional socio-economic impact of the European R&D programme. JRC Working Papers on Territorial Modelling and Analysis No. 05/2018, European Commission, Seville, 2018, JRC114347.[12]

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European Commission (2018c) 'Impact assessment of the 9th EU framework programme for research and innovation'.[16]

European Commission (2018d) 'Support for assessment of socioeconomic and environmental impacts (SEEI) of European R&D programme: the case of Horizon Europe'.[17]

Eurostat (2014) 'Manual on measuring Research and Development in ESA 2010'.[18]

[11] https://www.monroeproject.eu/wp-content/uploads/2019/05/D4.4.2-Technical-description-of-the-RI-module-of-E3ME-model.pdf

[12] https://ec.europa.eu/jrc/sites/jrcsh/files/jrc114347.pdf

[13] https://ec.europa.eu/info/sites/info/files/economy-finance/ip065_en.pdf

[14] https://circulareconomy.europa.eu/platform/sites/default/files/ec_2018_-_impacts_of_circular_economy_policies_on_the_labour_market.pdf

[15] https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-research-innovation_en.pdf

[16] https://publications.europa.eu/en/publication-detail/-/publication/00d78651-a037-11e8-99ee-01aa75ed71a1/language-en/format-PDF/source-77975709

[17] https://op.europa.eu/en/publication-detail/-/publication/2374ca1a-9f70-11e8-99ee-01aa75ed71a1/language-en/format-PDF

[18] https://eur-lex.europa.eu/resource.html?uri=cellar:cb11eb82-663b-4358-89ff-032ea811d2b4.0001.01/DOC_1&format=PDF

Appendix B Input assumptions

Modelling assumptions on for the impact pathways have been formulated based on the European Commission (2018d) report and insights from the study teams. The six impact pathways and their assumed impact on countries' R&D aggregate are detailed in Table 2, below. The range of options' values are taken from European Commission (2018d).

Table 2: Impact pathways

	Higher economic performance	Lower knowledge obsolescence	Stronger complementarities with other innovative assets	Higher direct leverage of private R&D spending	Higher complementarities with national support to R&D	Stronger knowledge diffusion
Baseline	15%	10%	0%	15%	0%	0%
None	15%	10%	0%	-	0%	0%
Low	-	9,5%	5%	15%	5%	5%
Mid	17,5%	9,25%	7,5%	17,5%	7,5%	7,5%
High	20%	9%	10%	20%	10%	10%

Note: (1) more effective (EU funding) than standard (national) R&D expenditure, (2) depreciation of the knowledge stock, (3) additional effect of R&D in investment decision in scenario, (4) increase in private sector investment in R&D, (5) increase in national support to R&D investment, (6) increase of the knowledge stock.

The country-level allocation of the EC funded R&D expenditure is calculated based on the historical allocation of Horizon 2020 funding. Data on the historical expenditures has been provided to CE by DG RTD. The allocation excluding the UK was used (illustrated by Figure 33).

Table 3 Historical national allocation of EC funding to Member States for Horizon 2020

Country name	Country code	Share of total EC contribution received	Share of total EC contribution received without UK
		%, Horizon 2020 observed data	%, used for Horizon Europe
Austria	AT	2.9%	3.3%
Belgium	BE	5.5%	6.2%
Bulgaria	BG	0.2%	0.3%
Cyprus	CY	0.3%	0.4%
Czech Republic	CZ	0.9%	1.0%
Germany	DE	17.4%	19.7%
Denmark	DK	2.9%	3.2%
Estonia	EN	0.3%	0.3%
Greece	EL	2.6%	2.9%

Country name	Country code	Share of total EC contribution received	Share of total EC contribution received without UK
		%, Horizon 2020 observed data	%, used for Horizon Europe
Spain	ES	9.2%	10.4%
Finland	FI	2.1%	2.3%
France	FR	15.5%	17.5%
Croatia	HR	0.2%	0.2%
Hungary	HU	0.5%	0.6%
Ireland	IE	1.7%	1.9%
Italy	IT	9.1%	10.2%
Lithuania	LT	0.1%	0.2%
Luxembourg	LX	0.3%	0.3%
Latvia	LV	0.1%	0.2%
Malta	MT	0.0%	0.0%
The Netherlands	NL	8.7%	9.8%
Poland	PL	1.2%	1.4%
Portugal	PT	1.6%	1.8%
Romania	RO	0.5%	0.5%
Sweden	SW	4.0%	4.6%
Slovenia	SI	0.5%	0.5%
Slovakia	SK	0.2%	0.2%
The United-Kingdom	UK	11.6%	(omitted)
EU	EU	100.0%	100.0%

Figure 33: Historical national allocation of EC funding to Member States for Horizon 2020 (incl. UK, in %)

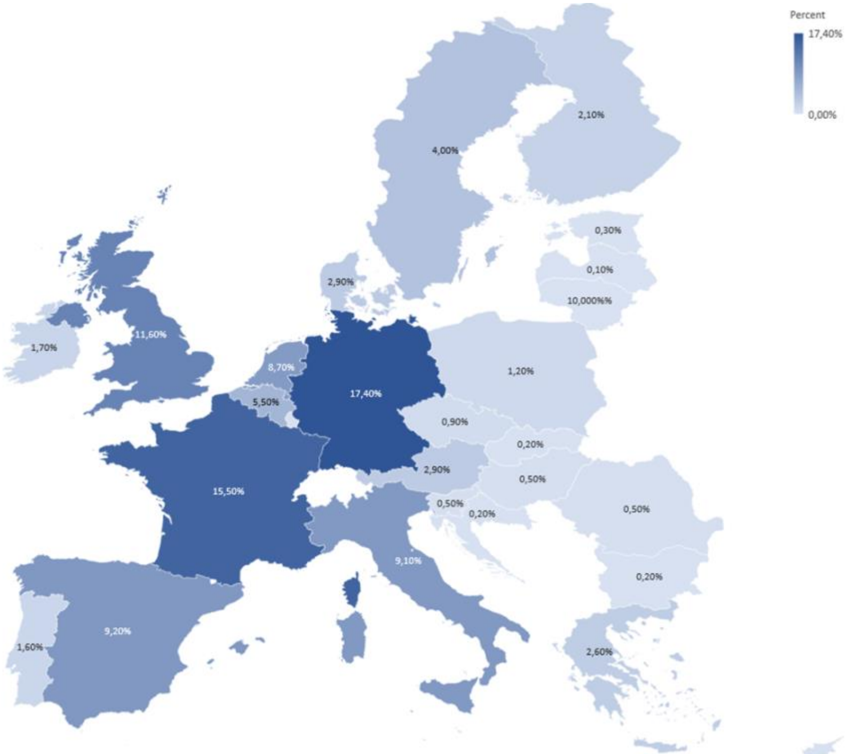


Figure 34: Historical national allocation of EC funding to Member States for Horizon 2020 (excl. UK, in%)

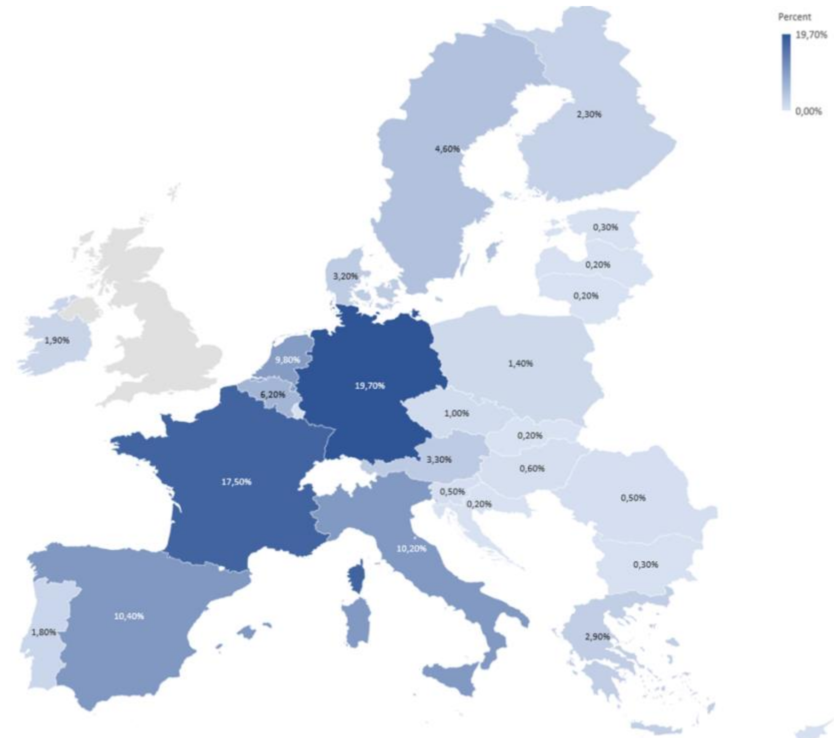


Table 4: Historical national allocation of EC funding to Member States for Horizon 2020

Country name	Country code	Share of total EC contribution received	Share of total EC contribution received without UK
		%, Horizon 2020 observed data	%, used for Horizon Europe
Austria	AT	2.9%	3.3%
Belgium	BE	5.5%	6.2%
Bulgaria	BG	0.2%	0.3%
Cyprus	CY	0.3%	0.4%
Czech Republic	CZ	0.9%	1.0%
Germany	DE	17.4%	19.7%
Denmark	DK	2.9%	3.2%
Estonia	EN	0.3%	0.3%
Greece	EL	2.6%	2.9%
Spain	ES	9.2%	10.4%
Finland	FI	2.1%	2.3%
France	FR	15.5%	17.5%
Croatia	HR	0.2%	0.2%
Hungary	HU	0.5%	0.6%
Ireland	IE	1.7%	1.9%
Italy	IT	9.1%	10.2%
Lithuania	LT	0.1%	0.2%
Luxembourg	LX	0.3%	0.3%
Latvia	LV	0.1%	0.2%
Malta	MT	0.0%	0.0%
The Netherlands	NL	8.7%	9.8%
Poland	PL	1.2%	1.4%
Portugal	PT	1.6%	1.8%
Romania	RO	0.5%	0.5%
Sweden	SW	4.0%	4.6%
Slovenia	SI	0.5%	0.5%
Slovakia	SK	0.2%	0.2%
The United-Kingdom	UK	11.6%	(omitted)
EU	EU	100.0%	100.0%

Appendix C NACE allocation of R&D Investment for each partnership

To determine the NACE allocation for each partnership the eCORDA sectoral allocation data on existing joint undertakings was used as a guide.[19] The eCORDA source provides information of the sector of the project participants of each partnership financed from EC contributions. This information was supplemented by the expert insights of the study teams which modified the eCORDA allocation for some of the partnerships. In absence of available eCORDA data for any given partnership, information provided by the study teams or the sectoral distribution of R&D investment in the E3ME model was used as a proxy. The NACE allocation of funding is assumed to be the same over the forecast horizon.

To focus on the industry specialisation of the partnership, the shares of education and R&D sectors have been set to zero in the modelling and their shares has been distributed proportionally among the other key sectors for each partnership.

The section below shows the key NACE sectors identified for each partnership and their share from the partnership's R&D, based on the eCORDA data and study team insights.

C.1 EU-Africa Global Health Partnership

There was no available eCORDA NACE allocation for this partnership, therefore the allocation of the investment was determined by the study team.

For the initiative EU-Africa Global Health, it is assumed that all R&D expenditure is allocated to the pharmaceuticals (NACE 21) sector.

Table 5: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	100.0%

C.2 European Partnership on Innovative Health

The NACE allocation for the European Innovative Health partnership was determined by CE in consultation with the study team. It was advised not to use the NACE allocation of the IMI2 partnership. The NACE sectors shows in Table 6 have been identified as the key industries for R&D investment in NACE sector 'human health activities'. The share of those sectors was calculated based on product-level input-output tables by Eurostat.[20] The current sectoral allocation reflects that the purpose of the Innovative Health partnership is to link drugs, devices and software, the latter provided by health informatics and other digital companies.

For the initiative Innovative Health R&D, approximately 50% of expenditure is allocated to pharmaceuticals (NACE 21). Other sectors that receive R&D expenditure include other manufacturing (NACE 32); manufacture of computer, electronic and optical products electronics (NACE 26); and information service activities (NACE 63).

[19] See "Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe - Horizontal analysis of efficiency and coherence of implementation", Final Report, Technopolis Group, European Commission, 2020.

[20] Eurostat (2020). Symmetric input-output table at basic prices (product by product) [naio_10_cp1700]. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=naio_10_cp1700&lang=en

Table 6: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	53.3%
32	Other manufacturing	22.7%
26	Manufacture of computer, electronic and optical products	13.9%
63	Information service activities	10.1%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.3 European Partnership for Key Digital Technologies

The NACE division for the Key Digital Technologies partnership is calculated based on then eCORDA data, but it has been modified based on the insight of the study team. The share of NACE 62computer programming, consultancy and related activities sector has been doubled to reflect its importance, while other sectors have been scaled back proportionally.

For Key Digital Technologies, the R&D expenditure is relatively diffuse and spans manufacturing and services. Of particular importance are manufacture of computer, electronics and optical products (NACE 26); computer programming, consultancy and related activities (NACE 62); and manufacture of machinery and equipment n.e.c. (NACE 28).

Table 7: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
26	Manufacture of computer, electronic and optical products	30.2%
72	Scientific research and development	30.0%
85	Education	10.0%
62	Computer programming, consultancy and related activities	10.0%
28	Manufacture of machinery and equipment n.e.c.	7.8%
71	Architectural and engineering activities; technical testing and analysis	2.7%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.4 European Partnership for Smart Networks and Services

For the Smart Networks and Services partnership, the eCORDA data has been used as the basis of the NACE division. Based on the suggestion of the study team the share of 'vertical industries' using 5G technologies for their digital transformation has been increased at the expense of the 'computer programming, consultancy and related activities' sector. The shares have been increased proportionally to their existing shares for the automotive and manufacturing industries and in a lesser extent health, energy and transport.

For the initiative Smart Networks, R&D expenditure is relatively diffuse. Involvement in the initiative includes 'vertical industries' using 5G technologies for their digital transformation. R&D expenditure spans manufacturing and services. Of particular importance are telecommunications (NACE 61); manufacture of computer, electronic and optical products (NACE 26); and computer programming, consultancy and related activities (NACE 62).

Table 8: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
85	Education	22.7%
72	Scientific research and development	22.6%
61	Telecommunications	11.8%
26	Manufacture of computer, electronic and optical products	10.2%
62	Computer programming, consultancy and related activities	10.2%
71	Architectural and engineering activities; technical testing and analysis	3.5%
82	Office administrative, office support and other business support activities	2.7%
46	Wholesale trade, except of motor vehicles and motorcycles	2.7%
94	Activities of membership organisations	2.3%
70	Activities of head offices; management consultancy activities	2.2%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.5 EuroHPC Partnership

For the EuroHPC partnership the eCORDA allocation has been used without modification.

R&D allocation is concentrated in computer programming, consultancy and related activities (NACE 62), which receives over 50% of the total spending. Other important sectors include architectural and engineering activities (NACE 71); and wholesale trade, except of motor vehicles and motorcycles (NACE 46).

Table 9: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
62	Computer programming, consultancy and related activities	53.7%
71	Architectural and engineering activities; technical testing and analysis	11.9%
46	Wholesale trade, except of motor vehicles and motorcycles	9.6%
82	Office administrative, office support and other business support activities	6.8%
26	Manufacture of computer, electronic and optical products	4.3%
47	Retail trade, except of motor vehicles and motorcycles	2.9%
72	Scientific research and development	2.7%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.6 European Partnership for Transforming Europe's Rail System

For the European Partnership for transforming Europe's rail system the eCORDA allocation has been used without modification.

The most important sectors for this initiative are manufacture of other transport equipment (NACE 30); architectural and engineering activities (NACE 71); and other manufacturing (NACE 32).

Table 10: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
30	Manufacture of other transport equipment	20.1%
85	Education	12.9%
72	Scientific research and development	11.5%
71	Architectural and engineering activities; technical testing and analysis	10.3%

NACE2 code	NACE2 Name	R&D share (%)
32	Other manufacturing	6.4%
62	Computer programming, consultancy and related activities	5.7%
41	Construction of buildings	5.5%
49	Land transport and transport via pipelines	5.4%
28	Manufacture of machinery and equipment n.e.c.	3.9%
26	Manufacture of computer, electronic and optical products	3.5%
70	Activities of head offices; management consultancy activities	2.6%
94 to 96	Other service activities	2.2%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.7 European Partnership for Integrated Air Traffic Management

For the European Partnership for Integrated Air Traffic Management the study team identified the key sectors; air transportation service providers and airborne and ground industry for the air traffic related manufacturing. The share between these was estimated from the eCORDA data.

R&D is allocated between warehousing and support activities for transportation (NACE 52) (includes service providers, e.g., ASNP and airports); and manufacture of computer, electronic and optical products (NACE 26) (airborne and ground industry).

Table 11: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
52	Warehousing and support activities for transportation	51.3%
26	Manufacture of computer, electronic and optical products	48.7%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.8 European Partnership on Clean Aviation

For the European Partnership on Clean Aviation the eCORDA allocation has been used with some modifications suggested by the study team, to reflect better the actual sectoral disaggregation observed.

The most important sectors for this initiative are manufacture of other transport equipment (NACE 30); manufacture of computer, electronic and optical products (NACE 26); and computer programming, consultancy and related activities (NACE 62).

Table 12: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE 2 Name	R&D share (%)
30	Manufacture of other transport equipment	14.3%
26	Manufacture of computer, electronic and optical products	14.0%
72	Scientific research and development	12.0%
62	Computer programming, consultancy and related activities	8.4%
28	Manufacture of machinery and equipment n.e.c.	7.6%
85	Education	7.0%
71	Architectural and engineering activities; technical testing and analysis	6.8%
27	Manufacture of electrical equipment	4.0%
70	Activities of head offices; management consultancy activities	3.4%
29	Manufacture of motor vehicles, trailers and semi-trailers	3.2%
94	Activities of membership organisations	2.4%
74	Other professional, scientific and technical activities	1.8%
61	Telecommunications	1.6%
52	Warehousing and support activities for transportation	1.6%
20	Manufacture of chemicals and chemical products	1.5%
49	Land transport and transport via pipelines	1.3%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.9 European Partnership for Safe and Automated Road Transport

For the European Partnership for Safe and Automated Road Transport the eCORDA allocation has been used without modification (for the CCAT Road joint undertaking).

The most important sectors for this initiative are manufacture of motor vehicles, trailers and semi-trailers (NACE 29); computer programming, consultancy and related activities (NACE 62); and architectural and engineering activities; technical testing and analysis (NACE 71).

Table 13: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
72	Scientific research and development	28.3%
85	Education	16.9%
29	Manufacture of motor vehicles, trailers and semi-trailers	14.5%
62	Computer programming, consultancy and related activities	8.7%
71	Architectural and engineering activities; technical testing and analysis	6.3%
26	Manufacture of computer, electronic and optical products	5.3%
28	Manufacture of machinery and equipment n.e.c.	2.4%
61	Telecommunications	2.1%
70	Activities of head offices; management consultancy activities	2.1%
84	Public administration and defence; compulsory social security	1.4%
49	Land transport and transport via pipelines	1.2%
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	1.1%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.10 European Partnership on Circular bio-based Europe

For the European Partnership on Circular bio-based Europe the eCORDA NACE division was used as a basis, but the share of the NACE 19 "manufacture of coke and refined petroleum products" has been increased based on consultation with the study team. The share of other sectors has been decreased proportionally.

The most important sectors for this initiative are manufacture of chemicals and chemical products (NACE 20); wholesale trade, except of motor vehicles and motorcycles (NACE 46); manufacture of food products (NACE 10); and manufacture of coke and refined petroleum products (NACE 19).

Table 14: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE2 Name	R&D share (%)
72	Scientific research and development	26.2%
20	Manufacture of chemicals and chemical products	21.7%
85	Education	11.5%
46	Wholesale trade, except of motor vehicles and motorcycles	7.0%
10	Manufacture of food products	5.2%
19	Manufacture of coke and refined petroleum products	5.2%
74	Other professional, scientific and technical activities	3.5%
71	Architectural and engineering activities; technical testing and analysis	3.3%
17	Manufacture of paper and paper products	2.6%
70	Activities of head offices; management consultancy activities	1.8%
94	Activities of membership organisations	1.5%
22	Manufacture of rubber and plastic products	1.0%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.11 European Partnership Clean Hydrogen

For the European Partnership Clean Hydrogen, the eCORDA allocation has been used as a guide and was modified considering study team insights. The adjustments were minimal, the largest allocating 3% of total to NACE 42 "civil engineering".

The decision for the sectoral allocation of R&D funding under Metrology is driven by the fact that metrology is a general-purpose technology. R&D funding is split proportionally, within each Member State, to the latest historical data (2016) in E3ME for sectoral R&D expenditure. This initiative, therefore, has the most widespread coverage.

Table 15: NACE sectors accounting for at least 90% of the R&D investment together

NACE2 code	NACE 2 Name	R&D share (%)
72	Scientific research and development	18.1%
27	Manufacture of electrical equipment	15.4%
28	Manufacture of machinery and equipment n.e.c.	9.4%
85	Education	7.6%
49	Land transport and transport via pipelines	7.1%
84	Public administration & defence; social security	5.3%
71	Architectural and engineering activities; technical testing and analysis	4.1%
29	Manufacture of motor vehicles, trailers and semi-trailers	3.8%
42	Civil engineering	3.0%
70	Activities of head offices; management consultancy activities	2.7%
35	Electricity, gas, steam and air conditioning supply	2.6%
74	Other professional, scientific and technical activities	2.3%
20	Manufacture of chemicals and chemical products	2.0%
64	Financial service activities, except insurance and pension funding	1.7%
47	Retail trade, except of motor vehicles and motorcycles	1.7%
94	Activities of membership organisations	1.6%
24	Manufacture of basic metals	1.3%

NACE2 code	NACE 2 Name	R&D share (%)
26	Manufacture of computer, electronic and optical products	1.3%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.12 European Metrology Partnership

For the European Metrology partnership, the sectoral R&D division reflects the 2016 E3ME R&D investment shares. This decision reflects the fact that metrology is a general-purpose-technology.

Table 16: E3ME sectors accounting for at least 90% of the R&D investment together

E3ME Sector EU	Share
22 Motor vehicles	17.5%
19 Computer, optical & electronic	12.1%
21 Other machinery & equipment	8.2%
14 Pharmaceuticals	7.8%
43 Computer programming, info services	6.7%
23 Other transport equipment	5.1%
13 Other chemicals	4.9%
20 Electrical equipment	4.0%
49 Legal, account, & consulting services	3.6%
50 Architectural & engineering	2.5%
15 Rubber & plastic products	2.0%
18 Fabricated metal prods	1.8%
47 Real estate	1.7%
40 Publishing activities	1.7%
32 Wholesale excl. motor vehicles	1.5%
44 Financial services	1.4%
24 Furniture; other manufacturing	1.3%

E3ME Sector EU	Share
7 Food, drink & tobacco	1.3%
42 Telecommunications	1.3%
33 Retail excluding motor vehicles	1.2%
25 Repair & installation machinery	1.1%
17 Basic metals	1.1%
31 Wholesale/retail motor vehicles	0.8%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

C.13 European Partnership for Innovative SMEs

For the European Partnership for innovative SMEs the NACE division reflects the 2016 E3ME R&D investment shares. Based on advice from the study team, all sectors in the following NACE sections have been excluded from the R&D investment: A, B, D, E, I, K, L, N, O, P, Q, R, S, T, U.

For SMEs, R&D funding is split proportionally, within each Member State, to the latest historical data (2016) in E3ME for sectoral R&D expenditure. The only sectors included however, are NACE sections C, F, G, H, J, and M.

R&D is therefore focused on motor vehicles, electronics, machinery equipment, pharmaceuticals, computer services, other transport equipment and chemicals.

Table 17: E3ME sectors accounting for at least 90% of the R&D investment together

E3ME Sector EU	Share
22 Motor vehicles	18.9%
19 Computer, optical & electronic	13.1%
21 Other machinery & equipment	8.9%
14 Pharmaceuticals	8.4%
43 Computer programming, info services	7.2%
23 Other transport equipment	5.5%
13 Other chemicals	5.3%
20 Electrical equipment	4.3%
49 Legal, account, & consulting services	3.9%

E3ME Sector EU	Share
50 Architectural & engineering	2.7%
15 Rubber & plastic products	2.1%
18 Fabricated metal prods	2.0%
40 Publishing activities	1.8%
32 Wholesale excl. motor vehicles	1.6%
24 Furniture; other manufacturing	1.4%
7 Food, drink & tobacco	1.4%
42 Telecommunications	1.4%

Note: For more details and the full list of sectors see IP of RP Baseline Methodology Annex - NACE allocation.xlsx

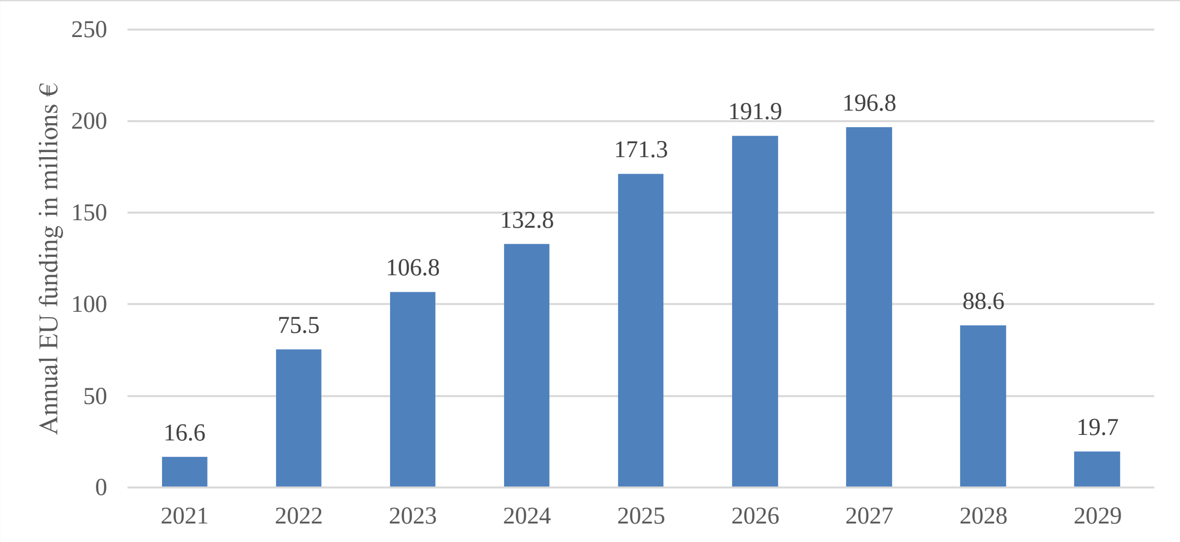
Appendix D Horizon Europe Expenditure Assumptions

The allocation of EU funding over the Horizon Europe funding period is derived from EC (2018d). The same proportional allocation over the period 2021-2029 has been used. See Table 2 in EC (2018d).

Table 18: EU funding for each initiative in Horizon Europe

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029
Millions € (2018 prices)	16.6	75.5	106.8	132.8	171.3	191.9	196.8	88.6	19.7

Figure 35 Annual EU funding for each initiative in Horizon Europe



Appendix E Impact Modelling: Transforming EU's Rail System

E.1 Scenario Design

The impact modelling for this project assessed thirteen individual initiatives. The methodology for the main modelling relied on the impact pathways developed in the original Horizon Europe Impact Assessment. This methodology was pursued because there was inadequate data to carry out the methodology detailed in the original scope of work. The Transforming Rail team, however, were able to develop inputs consistent with the original scope of work.

This scenario models the transformation of the EU's rail transport system, following the decision of an Article 187 partnership. The baseline for the work is traditional calls. . The scenario models a substantial increase in the use of rail for both passenger and freight transport, at the expense of road and air transport.

The scenario has been modelled using the inputs provided by the study team, which include the extent of the additional rail use (in passenger and freight kms) and the assumed cost savings accompanying the transition (reinvested and passed onto service operations) compared to the baseline scenario for the full forecast horizon. The goal of the modelling was to assess the changes in energy use and emissions by the transport sector as well as the economic impacts based on the proposed substantial transformation in the rail sector.

E.2 Study Team Input Data

The scenario compared to the baseline is establishing an institutionalised partnership for implementing a long-term strategy for rail-related R&I (which has been identified as a preferred option compared to a co-programmed partnership). The following input variables have been provided by the study team:

Table 19: Input variables used for the modelling provided by the study teams for baseline and scenario in terms of annual values by EU member states

Variable	Unit	Timeframe
Total operating cost savings	€ million (nominal)	2021-2050
Total operating cost savings passed onto service operations	€ million (nominal)	2021-2050
Total operating cost savings reinvested into the railway	€ million (nominal)	2021-2050
Total rail passenger kilometres (PKMs) (incl. additional)	billion PKMs	2011-2050
Additional rail passenger kilometres	billion PKMs	2021-2050
Total rail freight kilometres (incl. additional)	billion PKMs	2011-2050
Additional rail freight kilometres	billion PKMs	2022-2050

Note: The inputs have been provided for EU member states except for Cyprus and Malta, which do not have a rail network.

The scenario inputs assume substantial operating cost savings which relies on the modelling assumption of 50% reduction in life cycle costs (which is the Shift2Rail key performance indicator target) and the 75% take-up (study team estimate, based on conversations and interviews). By assumption, the reduction in life cycle costs are used in equal part for: 1) reinvestment in the rail network; and 2) passed onto service operations as reduction in prices.

The shift to rail use in terms of additional passenger and freight kilometres reflect a substantial change in the transport sector compared to the current PRIMES 2016 estimates, which serve as baseline for the E3ME and the study team's modelling.

Additional rail freight and passenger kilometres in the scenario were compensated by a matching decrease in the use of other modes of transport. Rail freight is assumed to substitute road freight within the EU. Rail passenger activity assumed to substitute road and air passenger transport within the EU. The compensating decrease in passenger kilometres was split between road and air transport based on their passenger kilometre shares in the PRIMES 2016 data over the forecast period in each member state. Note that for the compensatory decrease in activity only counts with intra-EU air transport and does not consider maritime transport, as a replacement of rail freight.

E.3 Scenario Design

The scenario includes two of the impact pathways used in the main impact modelling work (presented in section 3), namely:

- higher direct leverage of private R&D spending
- higher complementarities with national support to R&D

It is considered that the scenario inputs in Table 19, above, capture the effects otherwise modelled by the omitted four pathways.

The key mechanisms in the scenario are:

- Investment in the rail network.
- Reduction in the cost of rail transport for passenger and freight.
- An increase in consumer expenditure on rail transport.
- A decrease in consumer expenditure on air transport, purchase of vehicles, and petrol/diesel.
- Increased demand for power generation, given rail's demand for electricity.
- Reduction in demand for middle distillates, dominated by reduction in passenger road travel.
- Reduction in imports of manufactured fuels.

E.4 Results

Results are all presented for the 'EU27', the EU28 minus the UK.

Socio-economic results are positive throughout the forecast period. The peak GDP increase is 2031 at €28 billion. Employment increase peaks at 150 thousand in 2031.

The dominant economic driver is investment in the rail network. In 2030, the investment is equal to approximately 69% of the GDP increase over baseline. By 2050, it is equal to approximately 60%.

By 2050, the increase in consumer expenditure is equal to approximately 45% of the increase in GDP over baseline. The increase in consumer expenditure results from economy wide reductions in prices (given reduced costs of passenger and freight rail) and from the employment created from the investment stimulus.

The shift in modes of transport from road and air to rail changes the total energy demand of the economy and the use of different fuel types. Total energy use decreases because rail transport is more energy efficient, per passenger kilometre.

- Total final energy use is lower than the baseline in the scenario over the full forecast timeframe. It is 0.84% below the baseline value by 2050, for the EU 27, which means a 6700 thousand tonnes of oil equivalent (ktoe) reduction. This moderate net effect comes from an increase in energy use by the rail sector and a decrease in the road and air transport sectors.

- Total fuel use for energy is increasing in the rail sector quite substantially and reaches a 19.5% higher level in the scenario as in the baseline for the EU 27.

- The total energy use of the road transport sector is 3.6% lower than baseline by 2050. Total final energy use of the air transport sector is 0.6% lower than baseline in 2050, for the EU 27.

- Across fuel types, the greatest reduction in final use is middle distillates. Consumption of middle distillates is 2.5% lower in the scenario as in the baseline by 2050 for the EU27, which means almost a 5900 ktoe reduction.

Reduction in total final energy consumption, and fuel switching fuel types results in a substantial reduction in emissions in the economy. While the overall transport volume is unchanged, total EU27 CO_2 emissions are 0.5% lower than baseline by 2050.

Appendix F Impact Modelling: European Partnership on Clean Aviation

F.1 Scenario Design

The impact modelling for this project assessed thirteen individual initiatives. The methodology for the main modelling relied on the impact pathways developed in the original Horizon Europe Impact Assessment. This methodology was pursued because there was inadequate data to carry out the methodology detailed in the original scope of work. The Clean Aviation team, however, were able to develop inputs consistent with the original scope of work.

F.2 Study Team Input Data

The Clean Aviation team modelled the development of the aviation market under a baseline of traditional calls, a co-programmed partnership, and Article 187 partnership. The scenario modelled is the Article 187 partnership, compared to baseline of tradition calls. In short, the objective of the Clean Aviation partnership is to achieve climate neutrality of aviation. This modelling work focuses on the decarbonisation potential of the partnership; the scenarios focus on increasing use of sustainable aviation fuel (SAF).

The variables used in the E3ME modelling are detailed in Table 20. The substitution of kerosene to SAF follows from the objective of the partnership. The investment in airport infrastructure is included, to take account of investment required for implementation of new fuelling systems.

Table 20: Input variables used for the E3ME modelling, provided by the study team

Variable	Unit	Timeframe
Investment in airport infrastructure	€ million (real)	2021-2050
Share of kerosene in fuel use[21]	%	2021-2050
Share of SAF in fuel use	%	2021-2050
Share of 'hybrid' in fuel use (SAF & kerosene)	%	2021-2050
Relative costs of SAF and kerosene	Ratio	2021-2050

F.3 Scenario Design

The scenario in E3ME models a substitution of fuel use to SAF, over the period 2025-2050. Additional investment in airport infrastructure is required over the period 2030-2050 to accommodate this shift in fuelling requirements. By 2050, the European aviation sector achieves a 6.1% shift to SAF.

The scenario includes two of the impact pathways used in the main impact modelling work, namely:

[21] This is derived by differencing the fuel use results in the study team's data, between Article 187 and base case. The E3ME modelling uses PRIMES 2016 Reference Scenario, which does not include the kerosene tax applied in the study team's data.

- higher direct leverage of private R&D spending;
- higher complementarities with national support to R&D.

It is considered that the scenario inputs in Table 20, above, capture the effects otherwise modelled by the omitted four pathways.

The key mechanisms in the scenario are:

- Fuel switching leading to reduction in CO_2 emissions in the aviation sector.
- Fuel switching leading to reduction in imports of kerosene.
- Investment stimulus in airport infrastructure.
- Increase (relatively small) of prices in air transport, given increased cost of fuels and funding infrastructure investment.

F.4 Results

Results are all presented for the 'EU27', the EU28 minus the UK.

Socio-economic results are positive throughout the forecast period. The peak GDP increase is 2047 at €2.3 billion. Employment increase peaks at 10.8 thousand in 2035. Employment remains 9.8 thousand higher than baseline by 2050.

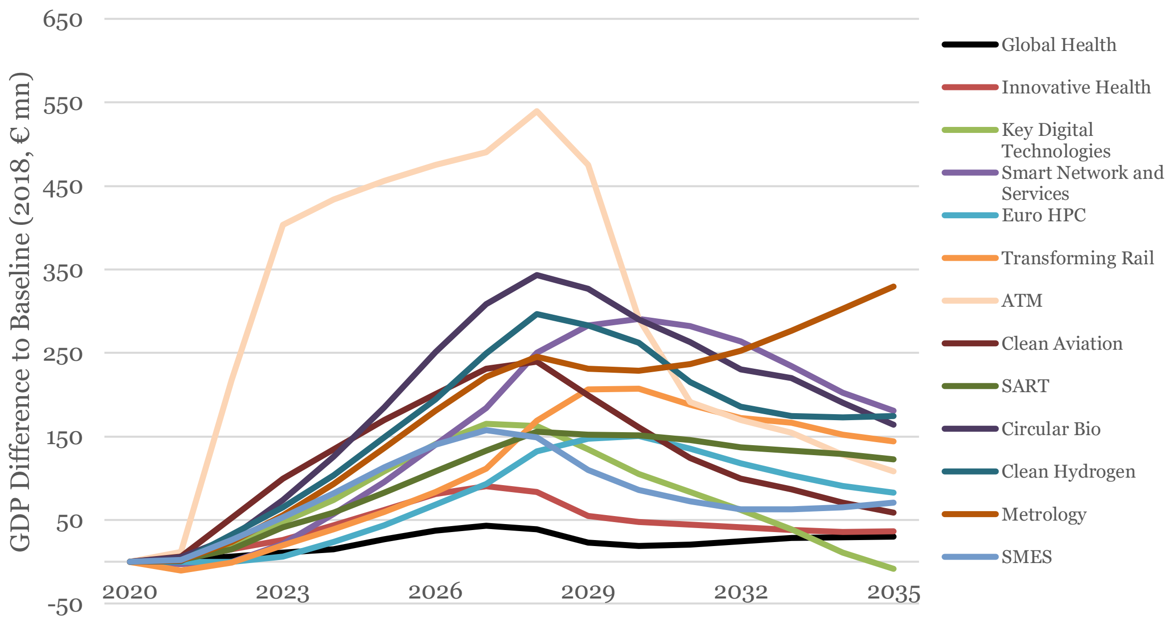
The dominant economic driver is investment, specifically in support activities to aviation. In 2050, the economy-wide additional investment (scenario input and induced effects) is equal to approximately 78% of the GDP increase over baseline.

The other important economic effect is a reduction in external imports (outside the EU28) of kerosene. In 2050, the value of kerosene imports is €800 million lower than baseline.

Total CO_2 emissions of the EU aviation sector decrease by over 6% by 2050.

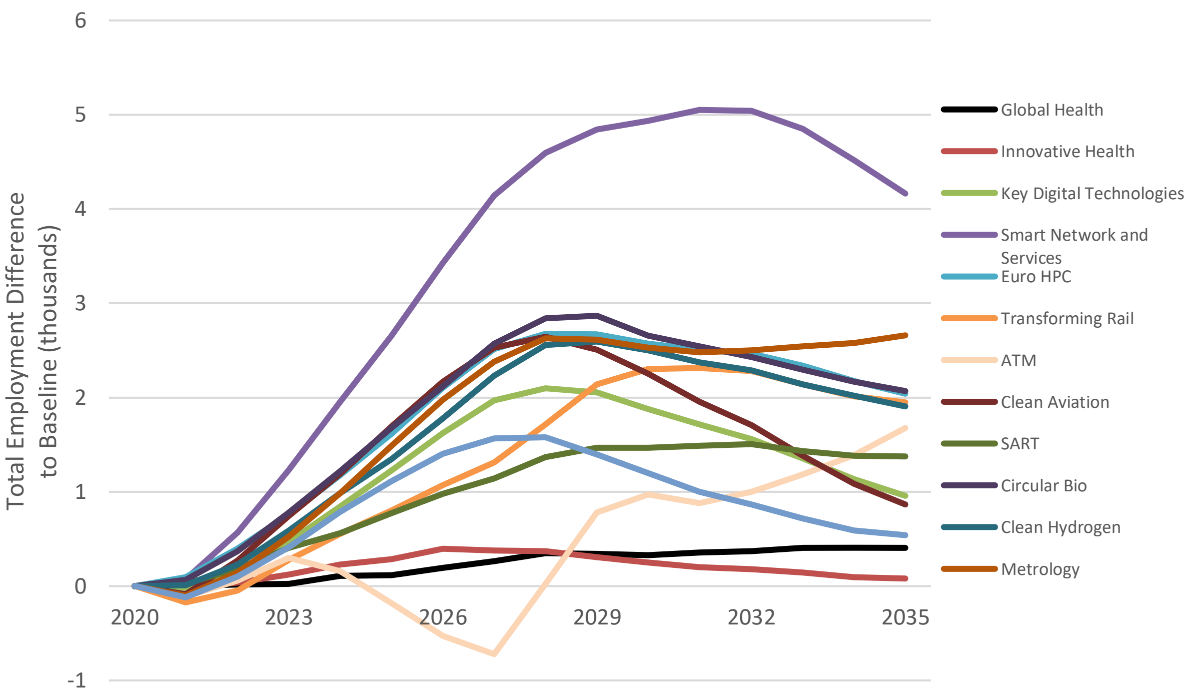
Appendix G GDP, Employment and Investment Difference to Baseline by Initiative

Figure 36 GDP Difference to Baseline by Initiative



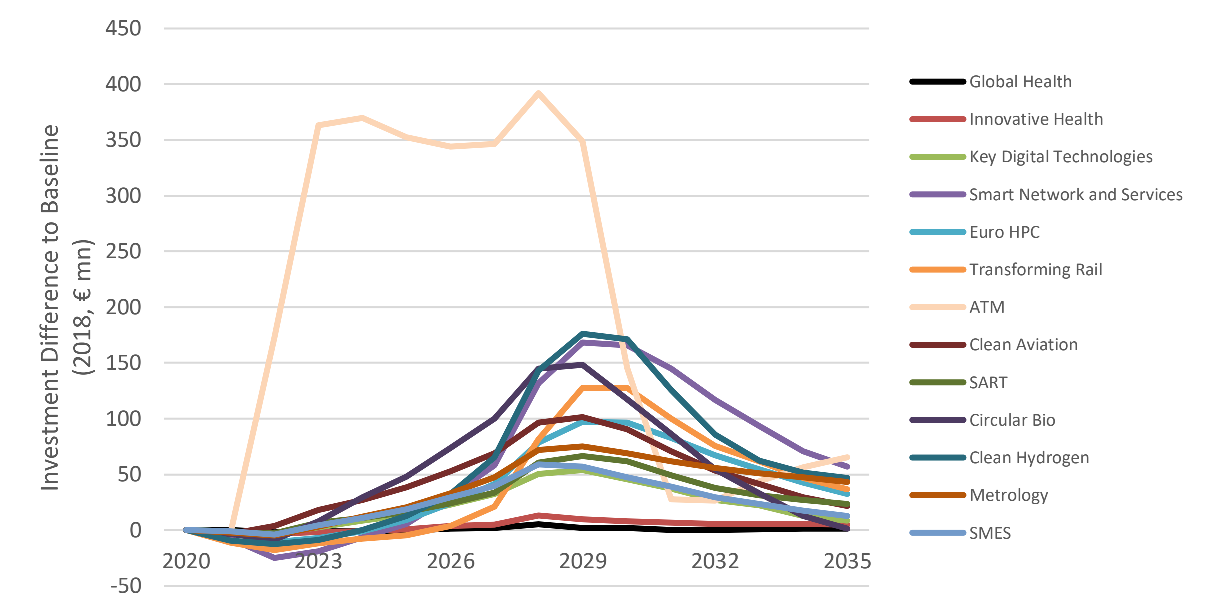
Note: The lines illustrate the difference of total employment to the baseline (regular calls) in thousands for each 13 initiatives.

Figure 37 Employment Difference to Baseline by Initiative



Note: The lines illustrate the difference of total employment to the baseline (regular calls) in thousands for each 13 initiatives.

Figure 38 Investment Difference to Baseline by Initiative



Note: The lines illustrate the difference of total employment to the baseline (regular calls) in thousands for each 13 initiatives.

Appendix H 2030 results for the 13 initiatives combined and by initiative

In the year 2030 — coinciding with the majority of peak indicator's impacts by initiative and also corresponding to the end of EU funding to the programme — four of the highest indicator impact (in magnitude, out of 11 indicators) are measured for the Integrated Air Traffic Management initiative (highest increase of GDP, TFEC, TCE and GHG emissions to Baseline). Largest employment increase is seen for the Smart Networks and Services initiative (4,9 thousand) as well as total consumption (12911 million €). The initiative with the highest investment difference to baseline is Clean Hydrogen which is also associated with the largest impact on EU-external imports (58 million €). Four of the lowest impact on countries' indicators are measured for the Global Health initiative (GDP, Investment and EU-external exports) and three for the Innovative Health initiative (Employment, Carbon Emissions and DMC).

Table 21 Difference to Baseline in 2030 by initiative and for the 13 initiatives combined

2030 results - absolute difference from "Traditional calls"	**Global Health**	**Innovative Health**	**Digital Tech**	**Smart Networks**	**EuroHPC**	**Rail System**	**Air Traffic**	**Clean Aviation**	**Automated Road**	**Circular Bio**	**Hydrogen**	**Metrology**	**SMEs**	**Combined**
GDP (2018 Million euros)	18,9	47,7	105,3	290,6	150,5	207,1	290,8	160,4	151,2	290,2	262,2	228,6	85,8	2269,1
Total employment (1000s people)	0,3	0,2	1,8	4,9	2,5	2,3	0,9	2,2	1,4	2,6	2,5	2,5	1,2	25,7
Total investment (2018 Million euros)	1,7	8	45,7	165,8	96,7	127,4	145,3	90,3	61,5	117,6	171	68,9	47,6	1120
Total consumption (2018 Million euros)	10,9	20,6	38,2	129,1	53,8	93	11	72,2	84,7	127,1	111,8	88,9	0,8	855,9
Total external exports (2018 Million euros)	4,0	8,2	6,7	13,7	9,9	7,4	12,1	10,3	9,9	56,9	22,1	11	9,8	177,5
Total external imports (2018 Million euros)	-0,1	-5,4	-5,4	23	10,9	24,8	-27,5	35,2	9,9	14,5	58	-30,5	-12,9	92,9
Total net external trade (2018 Million euros)	4,1	13,6	12,1	-9,2	-1	-17,4	39,6	-24,9	0,00	42,4	-35,8	41,5	22,8	84,6

2030 results - absolute difference from "Traditional calls"	Global Health	Innovative Health	Digital Tech	Smart Networks	EuroHPC	Rail System	Air Traffic	Clean Aviation	Automated Road	Circular Bio	Hydrogen	Metrology	SMEs	Combined
Energy use - Total final energy consumption (th toe)	-0,1	0,8	3,9	9,2	4,2	7,6	16,8	10	5,8	6,3	10,9	7,1	3,3	87,3
Total carbon emissions (th tonnes carbon)	0,4	0,3	4,3	9,3	4,2	7,4	26,1	6,1	5,3	10,8	12,6	7,7	5,9	90,3
Total domestic materials consumption including fuels (th tonnes)	1,2	-9	28,3	80,7	60,6	53,1	16,9	44,2	26,8	91,3	49,8	58,1	21,9	470,4
Total GHGs (th tonnes carbon)	-5,5	-4,1	5,7	11,2	4,3	7,5	29,3	9,8	6,1	-8,2	13,1	5,9	6	71,6

Note: The red-coloured figures correspond to the highest impact measured for 2030 by indicator. The blue-coloured figures correspond to the lowest impact measured for 2030 by indicator.

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