ECONOMICS – IMPACT STUDIES

Assessing the macroeconomic impact of the EIB Group

European Commission

European Investment Bank

The EU bank

Assessing the macroeconomic impact of the EIB Group

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Prepared in collaboration between the European Investment Bank (EIB) and the Joint Research Centre (JRC) of the European Commission, under the guidance of Andrea Conte and Francesco Di Comite at JRC (and ex-JRC) and Debora Revoltella the EIB with inputs from Martin Christensen, Olga Diukanova, Patrizio Lecca, Giovanni Mandras and Andris Peize (all JRC) and Tim Bending, Sabine Bernabe, Markus Berndt, Antoine Dewatripont, Marco Galli, Alexandros Georgakopoulos, Giacomo Mangiante, David Pichler, Natacha Valla, Georg Weiers and Marcin Wolski (all EIB, or ex-EIB), and in collaboration with Marie-Therese Dockery, Vasileios Filandros, Helmut Kraemer-Eis, Benoit Marteau, Gauthier Monjanel, Viorica Revenco, Wouter Torfs and Virginie Wagnon (all EIB and EIF).

The mission of the EIB's Economics Department is to provide economic analyses and studies to support the Bank in its operations and in its positioning, strategy and policy. The Department, a team of 40 staff, is headed by Debora Revoltella, Director of Economics.

The Joint Research Centre (JRC) is the European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy.

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Executive summary

Key messages

- *The Economics Department of the EIB together with the Joint Research Centre of the European Commission (JRC) carried out an extensive quantitative analysis to evaluate the macroeconomic impact of the investments supported by the EIB Group (EIB and EIF together) within the EU-28.*

- *The framework, called RHOMOLO-EIB, capitalises on the well-established RHOMOLO model, initially developed by JRC to evaluate the performance of EU policies, and extends it to cover the business model of the EIB Group. The proposed methodology helps capture both the short- and long-term effects of implemented investment projects, exploiting cross-sector synergies and geographical interlinkages.*

- *According to RHOMOLO-EIB, overall investment approved by the EIB Group within the EU in 2015-2016 will add 2.3% to GDP and 2.25 million jobs by 2020. The results suggest also that by the same year the EIB Group's loans approved under the European Fund for Strategic Investments (EFSI) will add 0.7% to EU GDP and 690 000 jobs alone. These figures represent the additional GDP and employment compared to the baseline scenario describing 2013's steady-state economy.*

- *Following extensive sensitivity analysis, the results of RHOMOLO-EIB are found to be robust to reasonable variations in the working assumptions, input data and model specifications.*

Using a model to assess the macroeconomic impact of EIB Group-supported operation

Complementary to the bottom-up approach that mainly assesses the direct effects of EIB Group-supported operations, a macroeconomic modelling approach is pursued to better capture the indirect and induced effect of the EIB Group-supported investments. For example: building a road will create direct employment during the construction phase, but by lowering transport costs the potential impact on the economy can be much greater by making the region more accessible, or by lowering costs for goods and services. Such a project would foster exports and imports with possibly diverging effects. These and many other interlinkages can be better taken into account in a large-scale macroeconomic model that explicitly looks at such relationships and takes such trade-offs into account.

Therefore, to estimate the overall impact of EIB Group-supported operations the EIB uses a computable general equilibrium model called RHOMOLO-EIB. It is based on the RHOMOLO model, developed and used by the European Commission's DG JRC for policy impact assessment, and provides sector-specific, region-specific and time-specific simulation results. The difference lies in some specification and the use of the model to best reflect the EIB Group business model as a Bank, as opposed to a public-sector approach.

Any model has certain limitations, which need to be acknowledged and taken into account when interpreting the results. RHOMOLO-EIB is a Computable General Equilibrium model. Computable General Equilibrium models do not provide unconditional forecasts, but rather give answers to what-if type questions. The RHOMOLO-EIB model builds on good practices grounded in economic theory and available data, and it is published in a transparent manner. Certain assumptions enter the modelling specifications. All require interpretation and extensive sensitivity analysis to verify the robustness of the results.

Results and sensitivity analysis

The scope of the exercise encompasses all operations approved by the EIB Group within the EU-28 between 1 January 2015 and 31 December 2016. For EFSI this covers all operations approved from inception until 31 December 2016. Approvals supported total investments of EUR 544 billion, and the projects approved under EFSI mobilised EUR 161 billion of investments at that time.

According to RHOMOLO-EIB, overall investment supported by the EIB Group (including EFSI) within the EU approved in 2015 and 2016 will generate an increase of 2.3% of GDP and 2.25 million jobs by 2020 over the baseline. By the same year, supported investments under EFSI alone will have added 0.7% to EU GDP and 690 000 jobs.

The results reflect the relative increase in GDP and employment over a baseline scenario. Due to significant spillovers in the economy from one region or sector to another, results cannot easily be broken down and linked to sub-groups of investment activities, only in larger groupings. While each EIB project assesses the project's additionality – would this specific project have happened this way or not or differently? – the macroeconomic assessment looks at this from a different, complementary angle where the EIB role is channelling financing into productive investments.

An extensive sensitivity protocol is applied to check the robustness of the findings in relation to the underlying model options and parameters used in the model. The results are demonstrated to be robust to specific model and market assumptions. Importantly, the scope of the results is comparable to similar exercises carried out in similar contexts such as the use of structural funds in Europe, the impact of EFSI, or the American Reconstruction and Recovery Act.

Collaboration between the EIB and JRC will continue in the coming years, covering both the newly available EIB Group activities, e.g. approved in 2017 and beyond, but also updating the existing results as more accurate information is received throughout the operations' life.

Purpose and structure of the report

The purpose of this document is twofold. First, it aims to highlight the main methodology used in the impact assessment exercise. Second, it describes the outcome of the exercise, together with the robustness analysis. For presentational transparency, we divide these tasks into four sections. Section 1 describes the rationale behind the exercise and the choice of the model. Section 2 describes the model together with the caveats. Section 3 describes the way in which the EIB uses this model. Section 4 discusses the results, and section 5 lays out the approach and findings of the sensitivity analysis. The conclusions wrap up the findings and benchmark the scope of the results. The Annex lays out the details of the model specifications and the details of the sensitivity analys

1. BACKGROUND AND PURPOSE

As a public institution, the EIB Group[1] looks at the economic impact of its activities. As a Bank, the EIB Group focuses on financial results such as lending commitments, signatures, or disbursements in order to provide a sense of scope of its contributions to the economy. Going one step further, the EIB Group also assesses the results of its operations such as the physical outcomes and the employment created during construction and operation to provide a richer picture of what the EIB Group is achieving.[2] In addition, the EIB carries out a thorough ex-ante economic and financial analysis of each project. Yet, to assess the macroeconomic impact – such as GDP and employment – of EIB Group-supported operations in Europe a broader macro-modelling approach can be useful.

EIB operations produce indirect effects in the economy, positive and negative, which deserve to be quantified and explored in more detail. EIB Group-supported operations cannot be viewed in isolation because they are likely to generate spillovers and externalities to other sectors or regions and possibly influence the entire structure of the economy. For example, when investing in a broadband network some direct observable activities would refer to the amount of workers' time, machinery and materials, not least the fibre optic cables. Workers lay the cables underground. The km of cabling can be observed, the workers' time can be measured. They possibly connect homes and businesses to enable faster communication services. This too can be observed directly. What cannot be easily measured is what it takes to produce the machines and materials needed, what the workers may be spending their income on, and even harder, how the new services may help create new industries or disrupt existing ones, how productivity may be increasing, fostering new kinds of work, etc. For the most part, those aspects are unobserved and it would be impossible or prohibitively expensive to measure them on a case-by-case basis. A similar line of argument applies to the measurement of inputs needed to finance these investments. Funding needs to have sources and it has to be properly accounted for. It can come from extra savings, it can come from abroad, but it can also derive from existing savings that may have been invested differently. To be able to consider the range of such aspects – the positive and the negative –and to form a more comprehensive view of the economic impact, typically a modelling approach is used.

Indirect and induced effects are not typically observable, but they can be assessed through modelling (see Figure 1). Many methods and approaches exist to assess the economic impact of operations. They range from microeconomic assessments of a single operation to large-scale macroeconomic models of entire portfolios. A standard microeconomic impact assessment is typically based on a rigorous analysis of a wide range of project-related data to firmly establish a counterfactual vis-a-vis an observed scenario. Macroeconomic modelling approaches impact from a different angle, focusing more on the wider context such as multiple forward and backward interlinkages, sectoral and territorial proximity and heterogeneous behaviour of economic agents. Such macroeconomic modelling is widely used in academia, economic analysis and policy evaluation. Central Banks rely on them to forecast and assess policy changes, as does the IMF, the European Commission and economic forecasters.

[1] By EIB Group we refer to both the European Investment Bank (EIB) and the European Investment Fund (EIF).

[2] The exact figures and methodologies can be found in the EIB and EIF annual reports (Financial Report, Statistical Report, Activity Report) and results-related publications including the 'Annual Report on EIB operations inside the EU' and 'The EIB outside the EU' report.

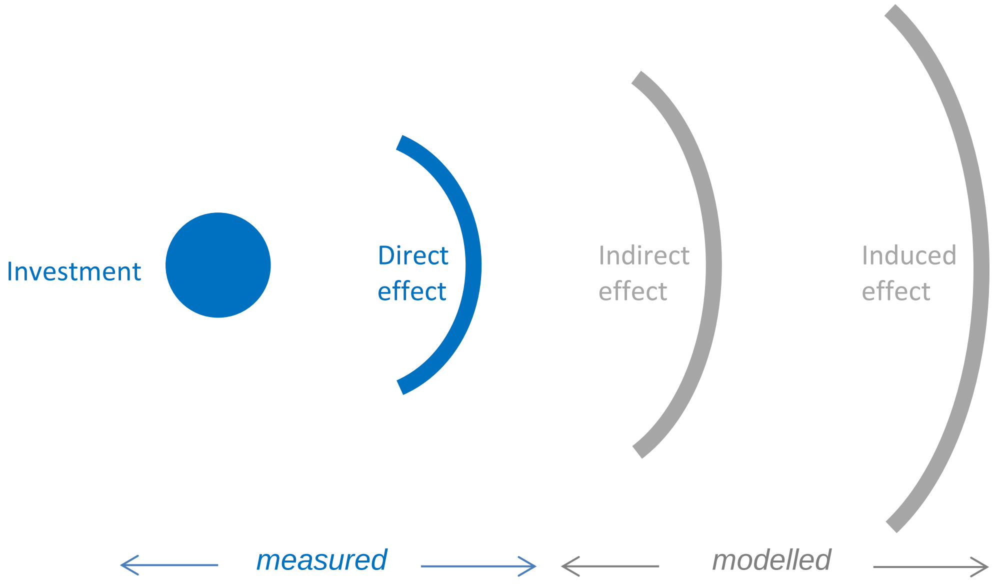

Figure 1: Why a macroeconomic impact assessment?

Many modelling approaches exist to assess macroeconomic impact. Econometric methods are usually applied for the ex-post evaluation of policies or programmes that have already been implemented. Computable general equilibrium models are the standard tool for conducting the ex-ante large-scale impact assessment of programmes or policies that do not yet exist, or are used to evaluate alternative versions of existing programmes, or to capture other ex-post aspects that are not easily measurable or easy to monitor. None of the existing modelling approaches is perfect and is able to capture all aspects of reality. Macroeconomic models should be seen rather as a stylised snapshot that captures important institutional characteristics of the economy being modelled. Limitation exists in the underlying economic theory – incorporating the institutional and structural details, economic mechanisms, data availability, and assumptions with regard to future economic development – and in the computing power required to perform complex simulations.

One approach to assess the macroeconomic impact of EIB group activities is a spatial computable general equilibrium (CGE) model developed by the European Commission's JRC. A range of complex applied models are already in use for various purposes. They are readily available and have already been scrutinised in a transparent and rigorous manner. Building one from scratch requires a vast amount of time and dedicated resources. Based on the most relevant features of the EIB Group's macroeconomic assessment, the availability and the reputation of the approach, the EIB selected the RHOMOLO model – a recursively dynamic spatial computable general equilibrium model – developed and currently used by the Joint Research Centre of the European Commission to assess a wide range of policy-funding instruments such as Cohesion Policy and other funding programmes directly related to innovation support and infrastructure development across all European regions and sectors. It is a well-established model, thoroughly based on academic research, publicly scrutinised and discussed in technical publications and scientific fora. The advantage of RHOMOLO has been identified in its ability to both simulate the effects of investment activities, but also – and this is what sets it apart from many other models – to model the structural effect of investments by taking into account the spatial and sectoral interlinkages of a specific investment activity. For instance, the construction of a road in one region, which may draw on the local construction industry, employ labour and consequently spill over through the economy, may also have a broader implication for surrounding regions or regions farther away. The model also takes into account the structural effects of the road, such as changes in competitiveness of the region due to the reduction in transport costs between and within regions. This makes RHOMOLO particularly well suited for analysing policies related to human capital, R&D, innovation and transport infrastructure.

The model is used for assessing the macroeconomic impact of the EIB Group-supported activities in general, and of EFSI in particular. After conducting an initial test run on the assessment of the macroeconomic impact of the EIB during the capital increase in 2012, the EIB has worked closely with the European Commission's JRC in Seville to further develop the modelling approach in order to run the macroeconomic assessment for the coming three years. The goal of the impact assessment is to provide a coherent and comparable framework throughout the three years. Therefore, all simulations are carried out under the same model specification, called RHOMOLO-EIB. Hereinafter in this report we always refer to the RHOMOLO-EIB version, unless stated otherwise.

The purpose of this document is twofold. First, it aims to highlight the main methodology used in the impact assessment exercise. Second, it describes the outcome of the exercise, together with the robustness analysis. For presentational transparency, we divide these tasks into four sections. Part 2 focuses on the model's main mechanisms and the characteristics of RHOMOLO. First, a brief overview is presented highlighting the complex structure of the model. Second, the main theoretical building blocks such as the labour and product market assumptions are explained together with the spatial and sectoral interlinkages embedded in the model. And lastly, some limitations and caveats are discussed. Part 3 discusses how the EIB uses the RHOMOLO-EIB model. This section describes the main channels of impact transmission and their relation to EIB Group-supported activities. Two channels are discussed: (i) the impact on demand supporting but also refinancing the investment activities in a region and sector; and (ii) the structural channels that result from such investments such as cheaper transport from transport infrastructure, productivity gains from research and development, effects from non-transport infrastructure, productivity gains from better quality capital and labour inputs. Part 4 presents the results from the 2017 exercise and discusses them in more detail and from various angles. Part 5 presents the sensitivity analysis conducted to verify the robustness of the modelling strategy, and it provides guidelines on how to interpret these results. The conclusion (Part 6) takes stock of the findings and contextualises the results. The Annex lays out in greater technical detail the sensitivity analysis together with the model options used and parametrisation employed.

2. THE RHOMOLO MODEL

2.1. Overview

RHOMOLO is a recursively dynamic spatial computable general equilibrium model. It has been developed and maintained by the regional economic modelling team at the European Commission's Directorate-General Joint Research Centre (DG JRC) in cooperation with the Directorate-General for Regional and Urban Policy (DG REGIO). It is used for policy impact assessment and provides sector-, region- and time-specific simulations to support EU policy evaluation of investments and reforms across a wide array of policies.

RHOMOLO is rooted in the tradition of Computable General Equilibrium (CGE) models. The model relies on a micro-founded neoclassical equilibrium framework where supply and demand are balanced through a system of relative prices and behavioural functions. Policy-driven scenario perturbations (technically referred to as "shocks") are introduced as deviations from a benchmark equilibrium state of the economy affecting the optimal supply and demand behaviours of all the agents in the economy. All equations are solved simultaneously, thus resulting in reallocation of goods and factors consistent with the new price system in a new counterfactual equilibrium. Policy appraisal is based on a comparison between the counterfactual and the benchmark equilibrium. RHOMOLO therefore provides an evaluation of the interaction effects between all agents through market transactions. Particular attention is devoted to the explicit modelling of spatial linkages, interactions and spillovers between regional economies. For this reason, models such as RHOMOLO are referred to as Spatial Computable General Equilibrium (SCGE) models.

A key feature of RHOMOLO is its high dimensionality to capture interlinkages between sectors and regions and to distinguish between the short and long-term effects of investments. RHOMOLO distinguishes between 10 economic sectors and captures sectoral interlinkages such as forward and backward linkages in value chains. Furthermore, there are spatial interlinkages between every pair of European regions and with the rest of the world (RoW) such as trade flows, factor mobility, competition, borrowing and lending of investment capital. It exploits the advantages of a full asymmetric bilateral trade cost matrix for all EU regions to capture a rich set of spatial market interactions and regional features. The focus on regions and sectors allows the model to take into account territorial specificities and better reflect the spatial interlinkages of an often substantially heterogeneous level of development or sectoral composition within European countries. It also makes it possible to work at a geographical scale where macro impacts of individual investments are non-negligible.

The model is calibrated at the base year of 2013 on the basis of publicly available data sources, including Eurostat and AMECO databases, and an inter-regional trade flow matrix provided by PBL following the methodology described in Thissen et al. (2015).[3]

[3] A description of the data used in RHOMOLOv2 at the national level is provided in Álvarez-Martínez and López-Cobo (2016) and the methodology used for regionalisation can be found on López-Cobo (2016) and Mercenier et al. (2016).

2.2. Theoretical background

The model is based on established economic theory and modelling techniques. In this section, we highlight the main theoretical building blocks of RHOMOLO. A full description of the model with all the facets, formulas and interlinkages is beyond the current scope (see Box 1). Here the main elements are briefly presented.

Box 1: **The RHOMOLO model – technical details, equations and reviews**

The RHOMOLO model draws on a long tradition of CGE modelling. The model has gone through several modifications to fit policy advice purposes, and is firmly grounded in an academic review process.

As a Computable General Equilibrium model it is based on a complex system of a large number of non-linear equations that are solved simultaneously. By its very nature the underlying model setup, with the equations and theoretical underpinnings, should be viewed as a whole.

RHOMOLO has made the underlying structure publically available for outside stakeholders and modellers. It has been extensively documented with *equation-by-equation* description and technicalities (Mercenier et al., 2016, Di Comite et al., 2017). RHOMOLO-EIB is based on the most recent version of the model (version 3) which has been documented by Lecca et al. (2018).

Every model builds on simplifying assumptions, whether due to the theory it is based on, or the techniques, data, and technologies available at the time. Given that it is virtually impossible to account for all aspects of reality, every model is a stylised snapshot, which represents the most important characteristics of reality. Some modelling techniques look puzzling to an untrained modeller. To ensure this is consistent with good practice, expert judgement of those familiar with such models is required. To this end, peer review and review board processes are important. RHOMOLO has a Review Board of academics and practitioners in place to assess the model and provide recommendations to further improve the modelling. The latest review was conducted in 2017 with the findings and recommendations published: Review of the RHOMOLO model (November 2017), available at
https://ec.europa.eu/jrc/sites/jrcsh/files/review_of_the_rhomolo_model_final.pdf

All transactions in the economy are included in the model as results of agents optimising decision-making. Goods and services are consumed by households, government and firms, and are produced in markets. Spatial interactions between regions and sectors are captured through trade matrices of goods and services, capital mobility is represented through inter-regional investment flow, labour mobility through the option of inter-or intra-regional reallocation (see Figure 2 for a stylised overview of a RHOMOLO-EIB region).

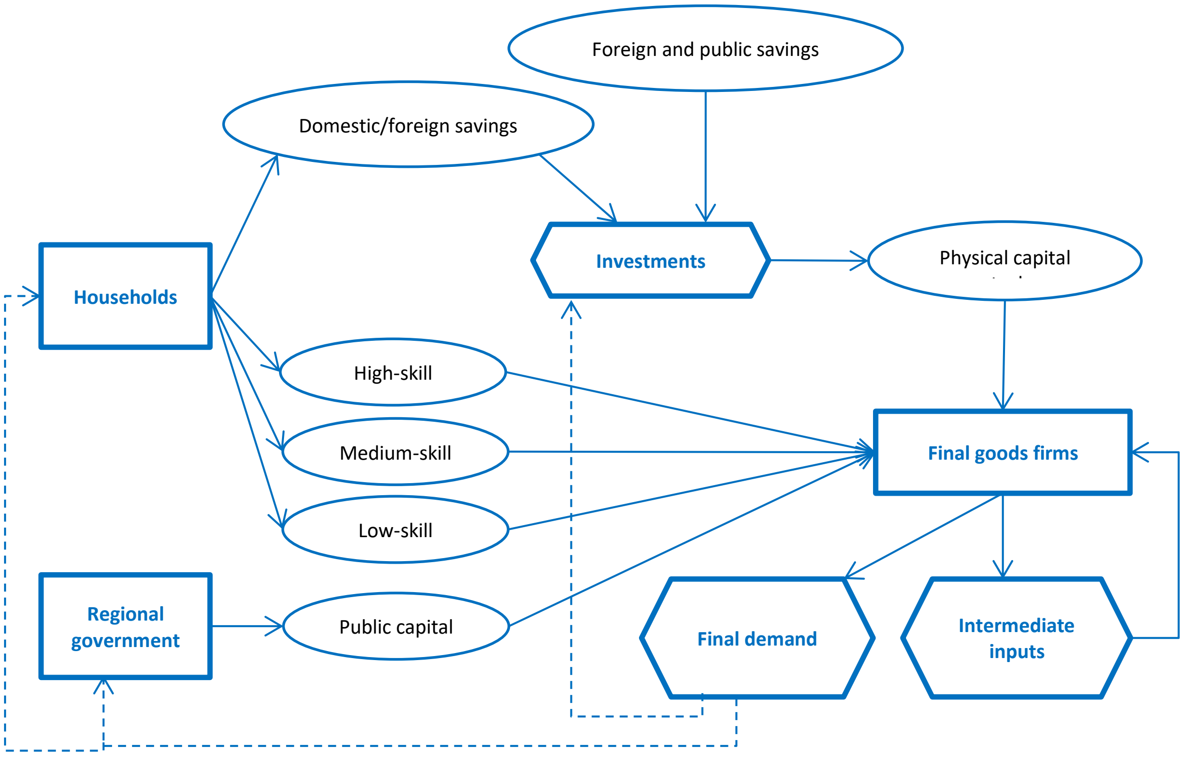

Figure 2: Overview of a RHOMOLO-EIB region

Spatial dimensions are a key element of the RHOMOLO model in terms of trade, labour and capital mobility (in terms of investment flows), and the location decisions of firms. Trade activities between regions depend to a great extent on transport costs, which are of iceberg type and imply that a given share of the goods 'melts' during shipping. Thus, transport infrastructure projects can reduce transport costs between and within regions, thereby increasing the competitiveness of regions.

Social Accounting Matrices (SAMs) represent the basic organisation of the main set of data feeding into RHOMOLO. A SAM is a matrix that reflects an account where each of the elements represents a flow of economic activities within the regional economy. This matrix displays economic relationships between all agents (households, firms, government and RoW) and represents a macroeconomic equilibrium where aggregate demand equals aggregate supply. The base year, and thus the assumed equilibrium period, is 2013. Figure 3 below shows a simplified version of a SAM.

	Commodities	Activities	Factors	Households	Government	Savings and investment	RoW	Total
Commodities		Intermediate demand		Consumption spending	Government spending	Investment demand	Intra- and extra-EU exports	Total use in purchasers' prices
Activities	Domestic supply							Activity income
Factors		Wages Employees' SSC Net Operating Surplus (-corp tax)						Total Factor income
Households			Wages Employees' SSC Net Operating Surplus (-corp tax)		Social transfers		Expenditure of tourists	Total Household income
Government	Taxes less subsidies on products	Net producer taxes Corp tax	Wages Employers' SSC Corporation tax Net producer taxes Taxes less subsidies on products	Employees' SCC Personal income tax			Net lending and borrowing	Government income
Savings and investment		Capital consumption		Household savings	Fiscal surplus	Net change in inventories	Capital transfers	Total savings
RoW	Intra- and extra-EU imports			Household expenditure abroad	Government transfers to abroad			Foreign exchange outflow
Trade and Transport Margins	Trade and Transport Margins							
Total	Total supply at purchasers' prices	Gross output	Factor expenditures	Total household spending	Government expenditures	Total investment spending	Foreign exchange inflow	

Figure 3: Social Accounting Matrix (Source: Potters et al., 2014)

2.3. Caveats and limitations

As with any model, RHOMOLO relies on a set of simplifying working assumptions that offer a stylised snapshot of economic activity. Such assumptions should be pointed out explicitly to make the interpretation of the results more meaningful.

- **Representation of economy**: As is common in CGE models, representation of the economy in RHOMOLO relies on simplified assumptions regarding behaviour of economic agents (profit maximisation of producers, utility maximisation of consumers, institution structure), the economic environment such as competition on product markets, factor mobility, behaviour of the rest of the world, and price signals. However, RHOMOLO allows for considerable flexibility in model specification, making it possible to select different types of competition in commodity markets, factor mobility, wage-setting and investment behaviour.
- **Equilibrium steady-state:** Given RHOMOLO's general equilibrium model features, the model has been calibrated to replicate a benchmark year. In the RHOMOLO-EIB case, the model is calibrated to replicate the year 2013. It is further assumed that the model is in steady-state in the benchmark year. This implies that in the long run and without structural shifts, variables will tend to converge to the assumed steady-state in 2013 over the simulation horizon. This may be problematic in cases where, for example, the unemployment rate does not represent the 'natural level'. In general, it is difficult to justify that one specific year represents the 'equilibrium' of an entire set of economies such as the EU-28. The year 2013 has been chosen because it is the latest available for which a full dataset was available. It would be more advantageous to use a longer-term average, but given the scarcity of data at the sectoral-regional level and the economic situation in Europe it is not clear which year would be the most appropriate.

- **Dynamic scenario:** There is an inherent discrepancy between the static nature of the steady-state representation of the economy, and the dynamic nature of the economic consequences of investment shocks, common to CGE models. Any dynamic disturbance to the model would be evaluated through a prism of a baseline development scenario based on 2013 data and therefore does not assume any counterfactual changes in the evolution of baseline model figures. This makes it difficult to assess the cyclicality of the results, however, simplifies the evaluation of the results, isolating the baseline situation from the complex interaction effects, thus avoiding the "black box" type of model responses, when it is difficult to attribute results to the concrete policy intervention. One can view the steady-state economy as a point in time, rather than throughout the cycle. One may try to superimpose the business cycle dynamics on the results; however, such an exercise would require additional working assumptions on the duration and the magnitude of the cycle, which we leave for further extensions of the model.
- **Non-intertemporal:** The high dimensionality of RHOMOLO enables sectoral and spatial relationships to be studied more coherently, but at the same time it requires greater computational power. The detailed regional and sectoral dimensions of RHOMOLO require hundreds of thousands of complex non-linear equations to be solved simultaneously. Therefore, in order to keep the model manageable from a computational point of view, the mechanisms of model dynamics are kept relatively simple without loss of generality. Agents are assumed to save a constant fraction of their income in each period and their decision-making is myopic with regard to the current and past states of the economy. The model is therefore solved recursively, computing year-by-year equilibrium with agents modelled as making instantaneously optimising choices. Each period is linked to the others through the accumulation or depletion of stocks (such as capital). The need for intertemporal optimisation seems more relevant for policy shocks where agents with full foresight can adjust to shocks before they happen ("prior announcements of policy changes"), but would constrain the approach used in other respects due to computational limitations[4].
- **Real economy:** The model has been developed in real terms, with barter trade of goods and services. All prices in CGE models are relative; consequently, there is no money and no financial frictions in the framework. Despite this, a special effort has been made to mimic the intermediary role of the EIB in the European economy.
- **Limited scope:** A number of variables have to be selected for reporting and analysis and in this case the choice fell on GDP and employment. Welfare aspects on the quality of life (benefits to the environment, to the quality of life, and possibly income) are harder to capture and are not part of the approach adopted here.

[4] Intertemporal CGE models are solved simultaneously for all periods, as agents optimise intertemporally. Large complex intertemporal models are computationally expensive to solve unless decomposition algorithms that split the model into separately solved submodules are applied.

3. MODELLING EIB GROUP-SUPPORTED OPERATIONS IN RHOMOLO-EIB

Inputs into RHOMOLO need to closely reflect the way the EIB group works. RHOMOLO was originally developed to assess the macroeconomic impact of EU structural funds. While both the European Commission and the EIB Group seek to achieve long-term economic impacts the approach differs to a certain extent. The use of grants and loans, in particular, makes a difference both in terms of financial flows (where the money comes from or how it is levied, direct taxes or household income or savings, and if and how this money is repaid) and the areas of engagement. These aspects are reflected in the use of the model rather than changing the model per se.

Projects realised affect the EU economy via two main channels, an investment effect and a structural effect. The short-term investment effect reflects higher demand for goods and services as the investments take place in a region, especially during the implementation and construction phase when the financing reaches the real economy. The longer-term structural effect of the completed investments reflects the effect on the structure and competitiveness of the economy, such as a better transport network, which can provide cheaper imports and exports, or greater availability of research facilities, which can lead to productivity-enhancing technologies. Both the investment and the structural channel will be discussed in turn.

Box 2: **How EIB operations affect the EU economy**

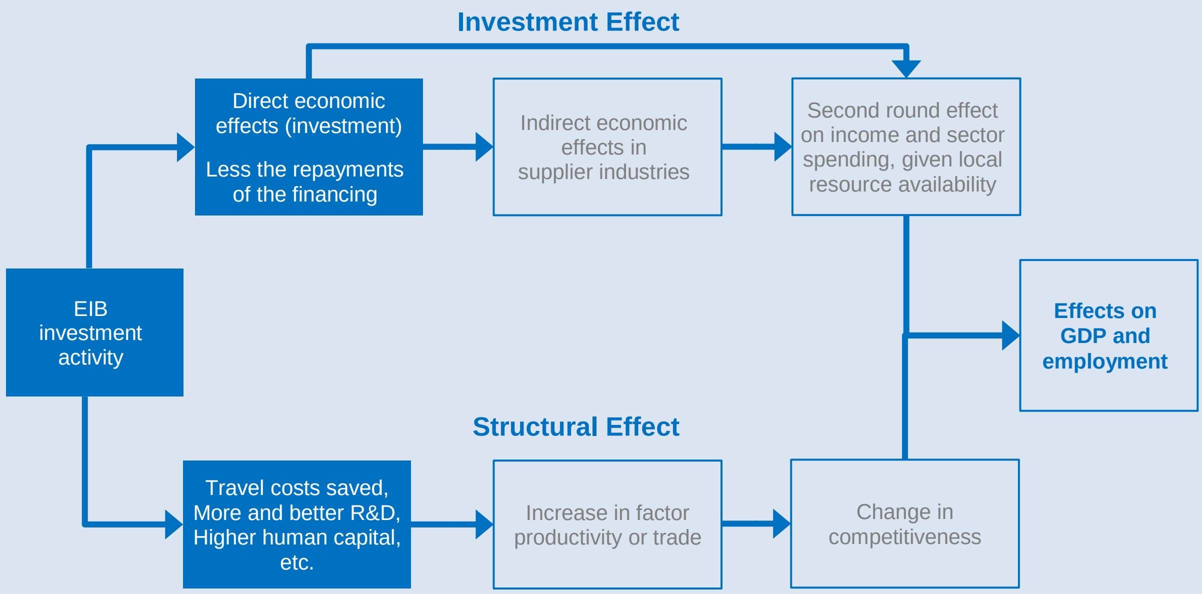

Figure 4: Impact channels in RHOMOLO-EIB

The investment effect is driven by the investments supported, but also by the financing needed for such operations. Investments reflect the EIB Group-supported operations in the EU. This means the EIB Group channels its funding to a specific sector and region. This has a direct effect on the local economy through the demand for fresh capital during project implementation or funds' disbursement. It increases investment in this area, which in turn has an effect on other sectors in the region, and also affects other regions, for example, through trade and factor mobility. Such investments need to be financed from existing sources. Unlike structural funds that are based on taxation revenues, the EIB Group draws funds from the capital market. The EIB Group issues bonds on the market to finance its support to the operations. These operations are co-financed by private investors and/or public institutions, similarly drawing in funds. Funding can come from either the EU or from abroad. As these are not grants but loans, funds need to be repaid over time. Initially, the financing impact on the recipient region is income-positive since a project region experiences a capital inflow, but the effect turns income-negative over time when the loan has to be repaid to its lenders. The reverse holds true for those regions providing the funding.

The long-term structural effect of a project can work through one of the five structural channels in RHOMOLO-EIB. In parallel to any impact of the investment financing and repayment, typically a structural effect on the model sets in once the investment is completed. This could be, for example, a road investment that, once completed, enables cheaper transport of goods between regions. RHOMOLO-EIB makes it possible to map EIB Group-supported operations to five structural channels: Transport infrastructure, Non-transport infrastructure, R&D, Human Capital, Industry and Services. All have a distinct effect on the local economy, e.g. through cheaper trade, new technology and production methods, improved labour productivity, more efficient public or private infrastructure, and enhanced capital quality.

3.1. Investment Effect

The investment effect consists of two components: capital deepening in a region, and the financing of such investments. The EIB Group, together with other co-financiers, supports private or public investors in financing a specific operation. This has an economic effect in the region where such investments take place. It deepens the capital base in the region over time and in specific sectors, which can then lead to a range of indirect effects. This is labelled the 'capital deepening' effect. Such investments need to be financed from somewhere in the economy or from abroad (an outflow of resources from the lending region) and paid back over time to those financing the project (an outflow of resources from the borrowing region, see Figure 5). This latter effect of borrowing and repayment is labelled the 'financing effect'. Both are discussed in turn.

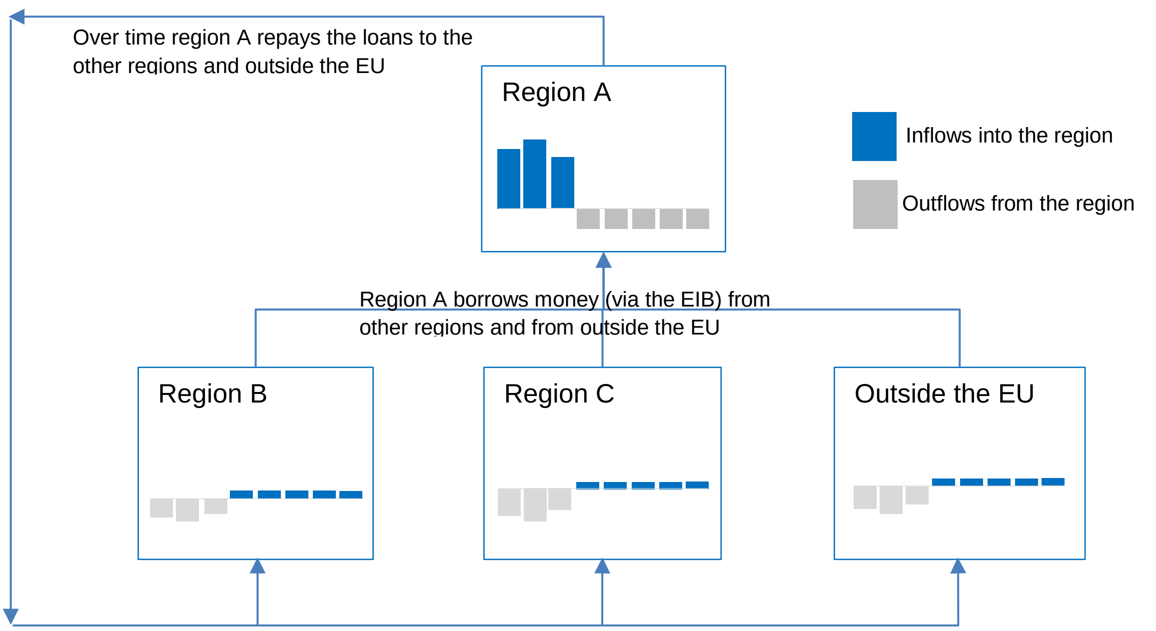

Figure 5: Borrowing and lending in RHOMOLO

3.1.1. Capital deepening

During the implementation period, EIB Group-supported projects raise the capital stock in a specific sector and region. The EIB Group supports the financing of specific investment operations. This means raising the capital stock through higher local demand for investments in the specific region and sector where the operation takes place. It constitutes the immediate effect. This may then lead to an effect on the local labour market, such as higher salaries and thus incentives to join the local labour force, which spills over into other sectors – the indirect effect. Overall, the benefits for the project region depend on many factors such as the sectoral structure, the local labour market, and how many inputs come from the local market rather than from other regions, all of which are determined by the RHOMOLO-EIB structure.

Investments lead to higher output. The investment directly translates to an increase in aggregate demand and in the physical capital stock in a given sector. In turn a higher capital stock, together with possibly attracting more labour, increases output in future periods. The effect on growth can come from the direct effect of an increased output in the sectors, but also from indirect effects on other sectors. As investments in one sector increase, this can affect supplier and client industries via the input-output linkages – within the constraints of available resources and effects on wages. In addition, with a change in production, trade and movement of production factors will be affected, which can further affect the growth pattern. The pattern and magnitude of the overall growth effect can vary but should lead to higher output in the invested regions for some time due to an immediate increase in one of the production factors.

Capital depreciates over time. Just like general capital stock, once in place new investments also depreciate over time, which also holds true for EIB Group-supported projects. With such depreciation the magnitude of the overall capital deepening fades over time. The magnitude of the depreciation rate can have a significant effect on results because of the implied initial capital stock in the counterfactual-baseline scenario (indirectly determining the relative amount of new capital associated with EIB Group-supported investments). This should be based on sound assumptions and is part of the sensitivity analysis.

The employment effect can be ambiguous. RHOMOLO-EIB does take employment effects into account. Investments can affect employment directly and indirectly. The direct effect stems from the increased demand in order to implement the EIB Group-supported project. However, in the long run capital investment could crowd out, and under circumstances also crowd in, employment mostly depending on the sector where the investment takes place. Employment can converge to a higher level compared to the base year level due to higher labour demand caused by an increase in private capital stock, labour productivity, and TFP, but could also be lower given its relative competitive position. In effect, the employment effect is per se ambiguous at the regional level.

3.1.2. Financing

As the financial sector, and with it the EIB Group, is not reflected explicitly in the model, the effects are exogenously introduced as transfers in RHOMOLO. The EIB Group borrows funds on the capital markets to finance its lending activities. Together with other co-investors the EIB Group-supported investment operations are realised. In effect, the EIB Group and its co-investors finance such investments with available funding from other sources in the economy. In the model these channels have to be explicitly introduced as input data to reflect both the location and amount of such financing. Investment projects are financed by available income in the economy and abroad, income that also needs to be repaid over time from the borrowers to lenders. While the investment project will have a direct effect on the capital stock in the borrowing region, the financing will also affect income in the lending regions, and, as the financing is repaid from the borrowing to the lending region, will affect both regions. Income in lending regions initially decreases to finance investments in other regions, and increases as repayments are made to the lending regions. Income in the borrowing regions is exogenously reduced over time as repayments are made to the lending regions (see Figure 5).

Lending draws on available income in the economy and from abroad. The source of such financing can be income in the EU or income from abroad. The EIB Group obtains its resources by issuing bonds on European and international capital markets to fund its financing activities. Similarly, co-financing from other sources may come from domestic sources or abroad. The share of financing from the EU and from abroad is derived from internal EIB bond-holding data, and the balance of payments of the EU and the rest of the world. The former approximates the share of EU external funds attracted to the project by the EIB Group in support of the operation, financed by bond issuances. To this end, the average share of the EIB bonds held outside the EU is relied on. The latter approximates the average foreign ownership of domestic EU assets as indicated by the financial account of the EU-wide balance of payments, published by Eurostat.

The source of financing matters for the overall impact. Financing from within the region implies that households residing in the region forgo current consumption to finance investments. Financing from within the EU is assumed to be borrowed from household incomes across the EU. The effect can be a reallocation of income from lending regions to borrowing regions if more investment takes place in some regions than others in proportion to regional income. Financing from outside the EU is assumed to be borrowed from household income in the rest of the world. In terms of the regional trade balance, external borrowing means importing resources, i.e. worsening of net exports. Hence, in the short run investments increase and net exports decrease. Over time capital accumulation improves competitiveness and net exports rise allowing the region to pay back loans to external lenders. De facto, imports, in the form of intermediate goods, are financed via increased exports of final goods by the region. Therefore, in terms of external borrowing, the additional physical capital stock accumulation – and with it the effect on the European economy in terms of GDP – is limited in the short run but potentially higher in the long run.

Over time, borrowed resources are paid back. With the implementation of the investment project, the borrowed financing is being repaid over time. The repayment period depends on the nature of the underlying investment and structure of the loan. Income is reduced in the borrowing region and transferred back to the lending regions or abroad according to where the money originated from.

3.2. Structural Effect

Once completed, operations can have a structural impact on the EU economy. In addition to the investment channel, EIB Group-supported operations contribute to a longer-term impact in the economy. Operations not only add capital, but, upon completion, are geared towards productive employment of this capital to foster a more efficient allocation of resources and more productive combination of inputs. For example, an inter-regional road not only has an investment effect while it is built, employing labour and capital in the process, but the true purpose is to enable better connectivity between regions.

RHOMOLO-EIB has five channels to translate such structural contributions into the model (Figure 6): (i) Transport Infrastructure, (ii) Non-Transport Infrastructure, (iii) Human Capital, (iv) Industry and Services, and (v) Research and Development.

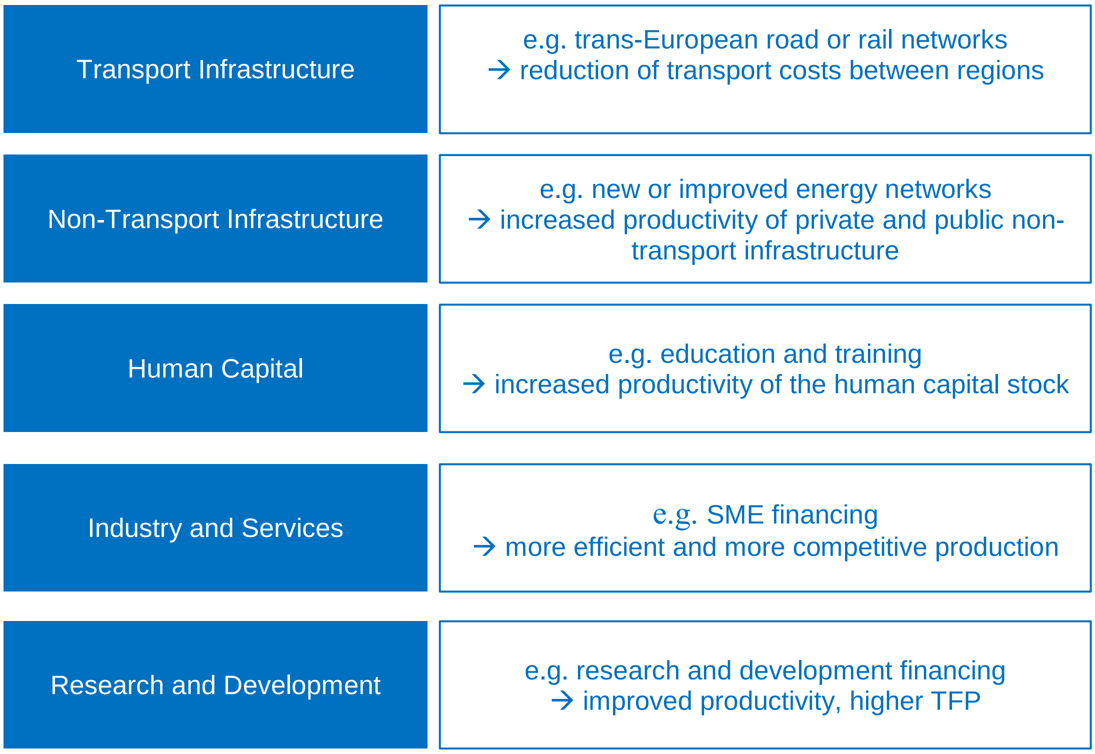

Figure 6: EIB structural impact transmission channels

3.2.1. Transport Infrastructure

Transport infrastructure projects aim to better connect people and markets across Europe and beyond. New transport routes are constructed (e.g. a new road, railway or port) and existing ones improved or expanded (e.g. ports, motorway extension, rehabilitation, etc.). This reduces transport costs, facilitates trade, and better connects the people of Europe.

Transport costs in RHOMOLO-EIB are applied to all shipments within a region, between regions and with the rest of the world. Transport costs in the model are of an iceberg type, which can be interpreted as if part of the good shipped melts during the shipping, and is a standard modelling assumption in international trade to account for the fact that more expensive goods are normally associated with higher insurance and handling costs, besides often opting for faster but more expensive modes of transport.[5] The "iceberg parameters" associated with each bilateral (i.e. region-

[5] The transport cost variable is represented by $\tau_{r,r',j} > 1$, which is the quantity of sector *j* goods that needs to be sent from region *r* in order to have one unit arriving in region *r'*. It is assumed to be identical for a given good but specific to sectors and trading partners.

pair) transport link in each sector and direction of shipment are estimated through TRANS-TOOLS, which is a European transport network model developed by JRC together with external scientific partners to estimate the time needed for a good to be shipped between any two points in Europe.[6] Thus, investments that lead to a reduction in transportation costs are introduced into the model by lowering the parameter for bilateral iceberg costs between regions by an amount proportional to the value of shipment lost due to the time lost to transport it. The scope of the change can be thought of as subsidy equivalent. An investment will only be made if, at the very conservative end, the cumulative costs of the project are lower or at most equal to what a subsidy would have been over the economic life of the asset.

Reduced transport costs will change the trading patterns and relative competitiveness of local industries. Lower transport costs make companies in the affected region more competitive by reducing both the costs of sourcing intermediate inputs and the costs of distributing goods to households and companies. This, in turn, allows them to charge a lower price and improve their competitiveness vis-à-vis companies in other regions, expanding their output and employment. However, it is also important to note that the better the connection of a region with the rest of Europe, the greater is the competition from other companies outside of this region, which can reach domestic markets more cheaply. Therefore, together with exports, imports are also expected to soar and increase welfare, while inducing efficiency-enhancing sectoral reallocation of factors in the affected economies. The impact of a better infrastructure is greater in regions with more potential for trade expansion, i.e. in regions that are already competitive and show a healthy export performance, but still lack transport links to reach new potential markets.

3.2.2. Non-Transport Infrastructure

Non-transport infrastructure projects aim to upgrade or expand existing infrastructure. Notably, this includes energy production, especially from renewable sources, improved energy efficiency, transmission networks, but also telecommunication infrastructure and broadband networks, water and wastewater infrastructure, etc.

The structural impact of non-transport infrastructure is introduced into RHOMOLO-EIB by adjusting the capital productivity parameters based on estimated elasticities from the literature. Two types of capital are distinguished: public, i.e. in the ownership of governments, and private, i.e. in the ownership of private economic agents. For public infrastructure investments we address the former, and for private non-transport infrastructure we target the latter, where the specific elasticities for capital productivity are in line with established parameters drawn from the respective literature.

Non-transport infrastructure offers another channel to mimic the impact of the EIB Group-supported operations. It comprises a range of infrastructure investments, which are not directly related to transport, including energy, utilities and communication. It lowers the unit costs of production and makes a regional industry more competitive. The impact will be higher in regions where inputs from the affected sectors (i.e., energy, ICT, water) account for a larger share of total production costs in the economy, so it can be expected that manufacturing-oriented regions will benefit more than the others.

[6] More information on TRANS-TOOLS can be found on http://energy.jrc.ec.europa.eu/transtools

3.2.3. Human Capital

EIB human capital projects aim at increasing the productivity of the human capital stock. These projects usually comprise the construction or improvement of education facilities such as schools and universities that will affect positively the quality and availability of teaching.

RHOMOLO-EIB models investments in human capital as an increase in the productivity of labour, differentiated by skill level. Given that the EIB does not typically engage in ongoing education programmes, but rather improves the quality of existing education facilities, it focuses on the quality of the existing education cohorts without distorting labour market participation. This means people currently in education receive a higher quality of education. Contrary to some other modelling approaches, it does not necessarily assume more people are trained and temporarily withdrawn from the labour market in addition to the existing education cohort that later joins at a different skill level as the EIB Group typically supports the surrounding infrastructure, not the programmes or attendance itself.

Since investment in support of human capital increases labour productivity, the relative factor composition of the economy is affected, and so are the returns on investment. Overall, it is expected to make a region more competitive and its benefits are spread over the long run because investments and the capital stock also adapt after labour becomes more productive to reap the benefits of higher returns. The impact is higher in regions where education expenditure is relatively low and production is more labour-intensive.

3.2.4. Industry and Services

Investments in new capital formation are typically associated with the deployment of more modern and productive technologies. New investments expand the capital stock or replace old capital, which is composed of less productive vintages of capital, with more productive capital, the typical example being the purchase of new computers to replace old ones. This includes direct operations in various industries and especially loans to SMEs and mid-caps.

Investments are thus assumed to improve the efficiency of the capital stock by replacing old machines with more modern ones at a faster pace than they would do in the absence of the policy. This is introduced into RHOMOLO-EIB by increasing private capital productivity based on existing elasticities of technology embodied in capital formation. The magnitude of this productivity increase depends on the scale of new capital formation relative to the existing private capital stock in the base year. Such technology elasticities are estimated separately for different sectors to better represent the cross-sectoral heterogeneity of the EU economy and EIB Group-supported operations.

As the productivity of capital increases, its relative input share in the production process increases, but production becomes more competitive and the sector expands, so that the impacts on labour demand are not determined a priori. However, if the output expansion is strong enough, the overall demand for labour can increase and attract more workers into the workplace. It should be pointed out that this channel alters capital productivity and, in fact, it can materialise over time. Even though in the short run the effects may seem to weaken labour demand in certain sectors or regions, over the medium to long term the effects can cascade through the economy, stimulating the production of interlinked businesses.

3.2.5. Research and Development

R&D projects aim to boost the number of innovations through greater R&D production, and consequently to increase the productivity and competitiveness of companies, which are expected to benefit from better products or more efficient production processes. Projects that are assumed to achieve this objective include the support of specific research programmes conducted by private corporates and public institutions.

In RHOMOLO-EIB, innovation is modelled as an increase in TFP, based on the relevant literature. The estimated elasticity that drives the increase in TFP depends on R&D intensity and R&D value added. Extending empirical firm-level observations to the regions at large, higher R&D intensity is associated with the higher elasticity of R&D spending to TFP increase. The intuition is that firms and regions that are already spending a lot on R&D before EIB support signal their pre-existing capacity to generate value from innovation activities.

Increases in TFP lower unit costs and make a company more competitive. This may attract more capital and labour, and expand trade and production capacity.

3.3. The use of EIB Group data

Sound modelling requires good data. To reflect EIB Group-supported activities in the macroeconomic model, detailed data on each operation is required. Each EIB Group-supported operation has a detailed set of data available on timing, implementation, location, sector, financing and objective. The data is broken down to the most granular available level that is relevant for the RHOMOLO-EIB model to most accurately reflect the investment activities in the real economy (see Figure 7).

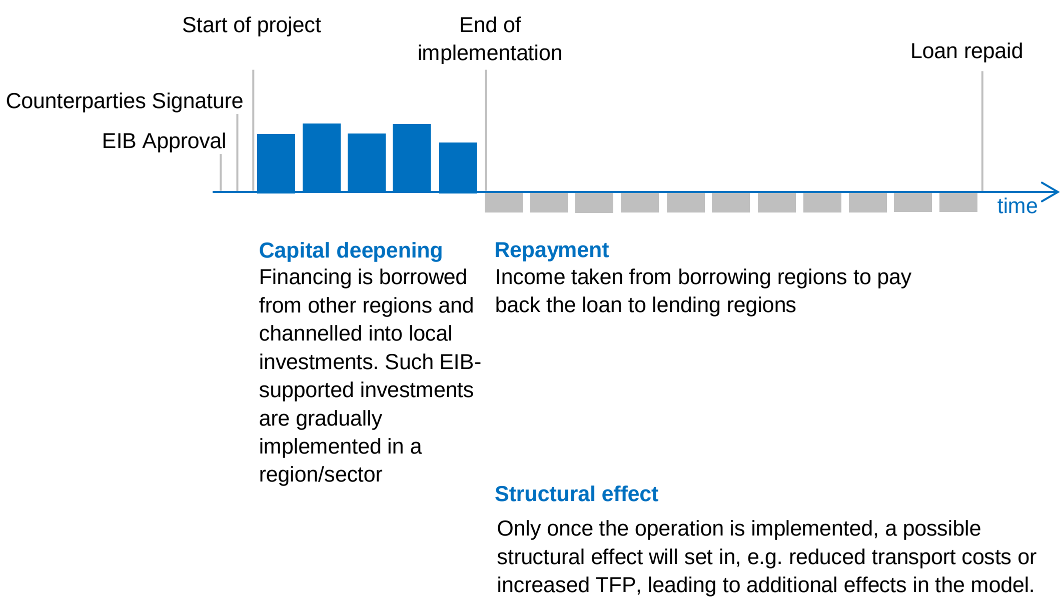

Figure 7: Data inputs for investment and structural effects over time in RHOMOLO-EIB

To model the investment effect, details of when and where the funds reach the real economy are required. For these start and end dates of the actual investment activity are needed together with the investment volumes over time. Each operation needs to specify in which sector and in which location such investment activity takes place to reflect this in RHOMOLO-EIB (see Table 1). For the financing effect, available EIB group data on the source of funding and additional assumptions on the sources and distribution of borrowing are made to account for the funds borrowed by the investing regions (see Table 2). Such borrowing is taken from incomes in the respective regions, from other regions, or from abroad, and channelled into the borrowing region. The reverse is true for lending regions. As the repayment process sets in, income is taken from the borrowing regions and transferred back to income in the lending regions. Repayment speed and volumes over time follow the available EIB Group data or stylised depreciation processes in the economy. The settlement period is taken from the detailed repayment schedules, and is netted out over all the operations and regions in a given year.

Table 1: Input table for investments by RHOMOLO sector and region – separate table for each year

Regions	A	BDE	C	F	GHI	J	K	L	MN	OPQ	RSTU
AT11											
AT12											
AT13											
AT21											
AT22											
AT31											
AT32											
AT33											
…											

Table 2: Input table for financing sources from various regions – separate table for each year

Regions	RoW	EU_PRIVATE	EU_PR_SAV	EU_PR_CON	EU_PUBLIC
AT11					
AT12					
AT13					
AT21					
AT22					
AT31					
AT32					
…					

The structural effect relies on additional data points. Each EIB Group-supported operation needs to clearly contribute to set policy objectives such as to improve European infrastructure, foster innovation, mitigate climate change, etc. These policy objectives in their most granular form can be mapped to the structural channels available in RHOMOLO-EIB to establish a clear link to the structural effects of the supported operation. For example, it is important to know if a project is supporting research and development in a specific sector or capital renewal. Together with the information on the timing, scope and location of the investments the model inputs can be described in necessary detail (see Table 3). Structural effects only take effect once the operation is completed – transport does not become cheaper until the bridge financed is actually completed.

Table 3: Input table for policy areas by region – separate table for each year

Regions	TRANS	INF-ENERGY	INF-ICT	INF-PUBLIC	HC	IND-(*by 11 sectors*)	RTD
AT11							
AT12							
AT13							
AT21							
AT22							
AT31							
AT32							
…							

Where data is not available ex-ante, proxies or estimates are used. At the time an operation is approved or signed, certain expectations are formed based on the nature and scope of the project and on when and what will be implemented and delivered. As actual (ex-post) data becomes available the data will be successively updated to reflect the most recent and most accurate information. For example, for certain types of operations such as SME finance or equity funds it is difficult to gauge the sector or geographic distribution of the investments ex-ante. Assumptions based on previous experience and details provided from the intermediary are used to model such distribution ex-ante. As the data is collected during implementation, this data will be updated and used for the exercise.

4. RESULTS

The first results are available. The objective of the RHOMOLO-EIB exercise is to assess the expected macroeconomic impact of the EIB Group-supported investments in general, and EFSI-supported operations in particular. The common denominator that combines the effect of the different products, sector operations, and policy objective is the effect on EU GDP and employment. RHOMOLO-EIB enables both to be assessed. The results are presented below. First the scope of the input is defined, then the results for overall EIB Group-supported operations and a specific subset funded under the European Fund for Strategic Investments (EFSI) are presented. Such results should be read with the appropriate care in terms of what they mean and the specific model context that produces them. Below they are broken down further to examine the results from a regional and sector perspective.

4.1.Scope of the EIB Group-supported investment inputs

Not all EIB Group activities are included. The EIB Group offers a range of products and activities. Not all can be covered in the model. The focus is on financially-supported operations. Advisory activities and knowledge work of the EIB Group are not included. And of those financially-supported operations, given the EU focus of RHOMOLO, only operations within the EU are considered.[7] Non-EU investments fall outside the scope of this exercise.

The exercise considers the overall investment volumes supported by the EIB Group as input. The reason behind this is twofold. First, the EIB aims to mobilise investment projects, which without the EIB's support would either not have materialised or, if they did, in a different form. Second, the projects are usually indivisible. It would be questionable to assess the impact of a fraction of a road, factory, or power plant instead of the full project, for example.

Only operations approved in 2015 and 2016 are considered. The exercise requires a clear timeframe of activities to cover. In the current context the analysis focuses on the EIB Group-supported investment activities in the EU approved in 2015 and 2016. It is important to reiterate that the approval date only determines the scope of activities, not the time of the actual investment. To determine when investments take place, the model considers the necessary project data (i.e. once approved the project starts building a bridge over the next five years; the shock to the model mimics this over that period, and the repayment according to the financing plan). Just as importantly, such cut-off also means that after 2016 there are, in terms of the modelling impact, no further approvals overlaying the results.

4.2.Overall results for the EIB Group

EIB Group-supported investments are expected to have a sizeable impact on Europe's economy. The total mobilised investments based on the approvals by the EIB Group in 2015 and 2016 amount to some EUR 544 billion over the following years. The financing is borrowed and attracted from EU households and from abroad, and channelled into investment projects in specific years, sectors, regions and in the EU. This, through the investment and structural effects will have an impact on EU

[7] Note that overseas countries and territories cannot be modelled in RHOMOLO as the data situation is insufficient so they had to be excluded for modelling reasons.

GDP and employment. The results from RHOMOLO-EIB suggest that EIB Group-supported investments are expected to add around 2.3% to EU GDP by 2020 and by then add 2.25 million jobs. In the long term, i.e. in 20 years (by 2036), EIB Group-supported investments are expected to still have added around 1.5% to GDP and some 1.27 million jobs (see Figures 8 and 9).

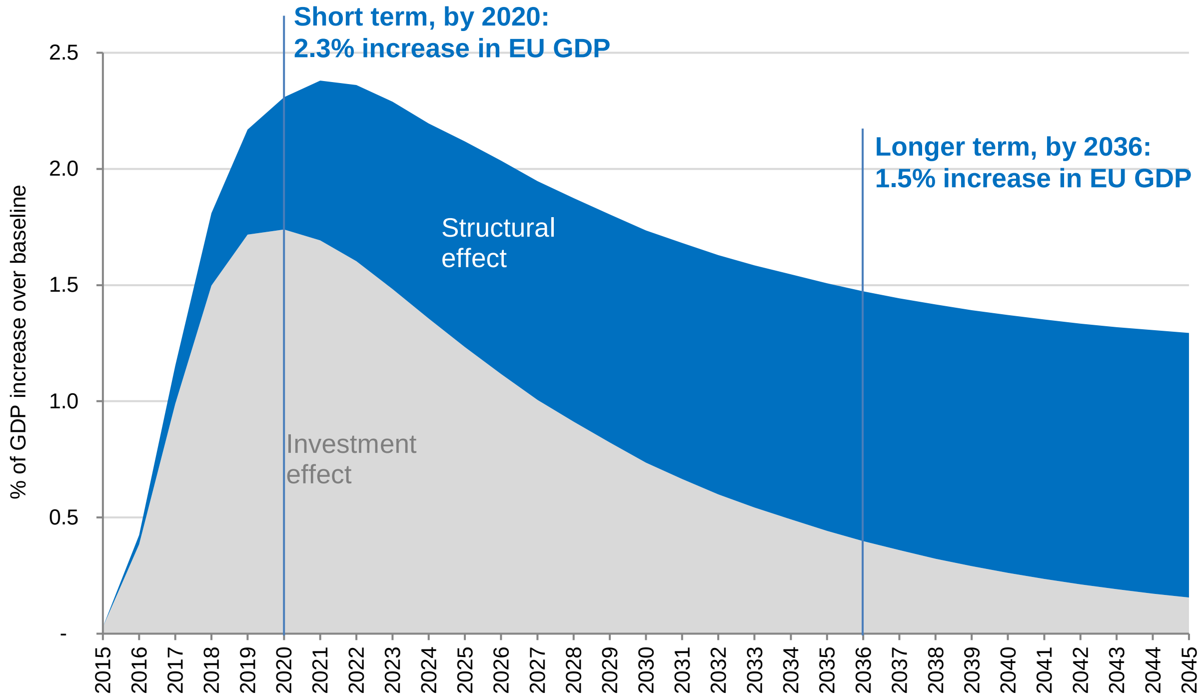

Figure 8: Expected GDP impact of EIB Group-supported operations, based on approvals 2015-2016

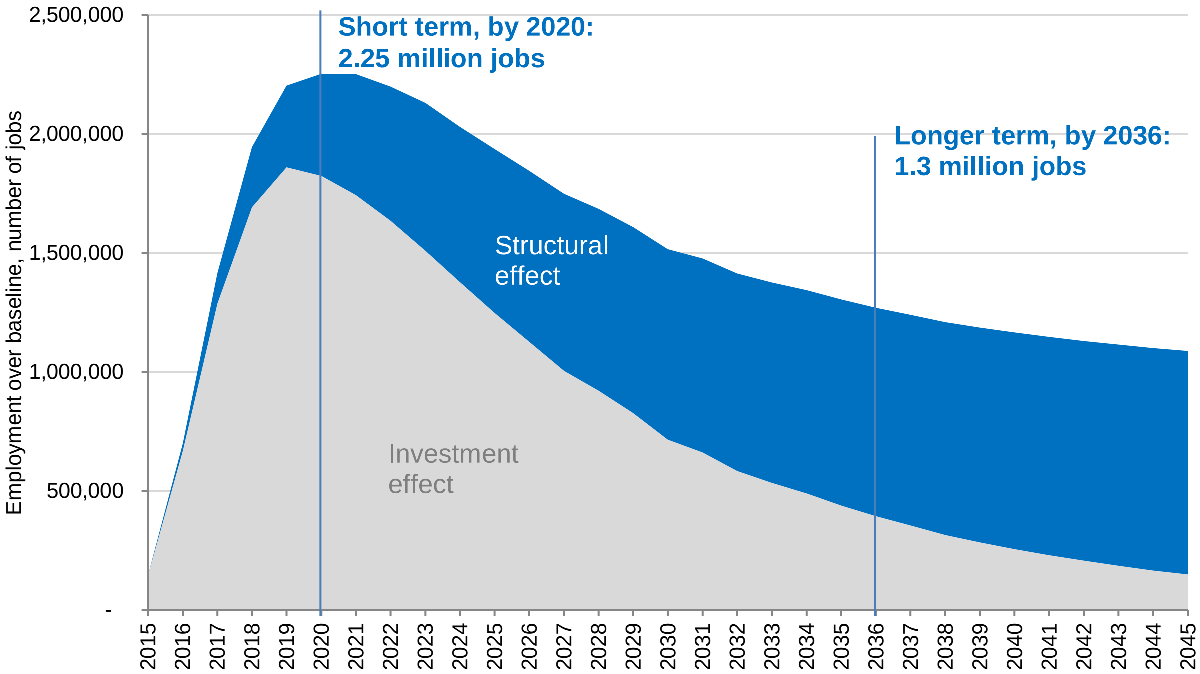

Figure 9: Expected employment impact of EIB Group-supported operations, based on approvals 2015-2016

Short-term results are mainly driven by the investment effect. The investment effect sets in quickly, and fades out over time. This reflects the implementation of the investments, such as building a road, conducting research and development, improvements to public infrastructure, firm investments etc. This has a direct effect in using capital and labour in the production process. It has forward and backward linkages along the value chain, and has an indirect, second-round effect on income and sector spending, while taking into account local resource availability (for more information, see Box 2). The effect would be steeper where resources are relatively more abundant, and somewhat slower to pick up in regions where resources, especially labour, are scarcer. As investment activities reach completion, the overall effect will start to phase out. New investment impetus will cease, the capital will depreciate over time, and loans will be repaid from borrowing regions to lending regions, which will also affect consumption spending. Overall, the investment effect phases out over time.

Longer-term effects are mainly driven by the structural effect. The structural effect is a key objective for the EIB as a long-term investor focusing on growth and competitiveness. The investment activity, such as laying a broadband cable, will be reflected in the investment effect. The structural effect, i.e. providing faster and better access to information and communication services, is possibly more important as the investment may have a profound structural impact on the region: it may disrupt certain services and lead to new services being offered. Similarly, completing a transport link will allow for cheaper imports that may compete with the local economy, but also offer cheaper exports which make the regional economy more competitive. These longer-term, structural effects only set in once a project is finished (a road can only be used once completed). Therefore, it would be expected to set in with some lag to the investment effect, and grow over time as more and more investment projects come to a close. Furthermore, the structural effect is much more persistent. Enhanced production technologies, better private and public infrastructure and greater labour productivity are expected to have a lasting impact on the economy. The results show such effect growing over some time and persisting compared to the baseline.

4.3. Overall results for the European Fund for Strategic Investments

The European Fund for Strategic Investments is an integral part of the EIB Group's activities. It reflects a sizeable part of EIB Group-supported investments. The operations approved from its inception to the end of 2016 are expected to support investments in the EU economy in the coming years totalling some EUR 161 billion. By 2020 European GDP is expected to have increased by 0.67% and some 690 000 jobs are expected to have been created. In the long term, by 2036 (i.e. after 20 years) European GDP is still expected to be 0.4% higher than it would have been, with about 340 000 thousand jobs more than would exist without such EFSI-supported investments (see figure 10). The difference in scope and shape between the EIB Group and the EFSI results is mainly due to the difference in the magnitude of the supported investments and the start date of EFSI. The EIB Group's overall supported investments based on the approvals in 2015 and 2016 amount to EUR 544 billion (including EFSI), whereas EFSI alone, which was only launched fully in mid-2015, had approved operations worth EUR 161 billion by end-2016. As EFSI commenced with a delay, the uptake in 2015 was slower, which affects the results. The regional and sectoral breakdown differs somewhat, which also affects the overall results. Importantly, as the effects of supported investments are non-linear, EFSI results cannot simply be seen as a subset of the EIB Group results.

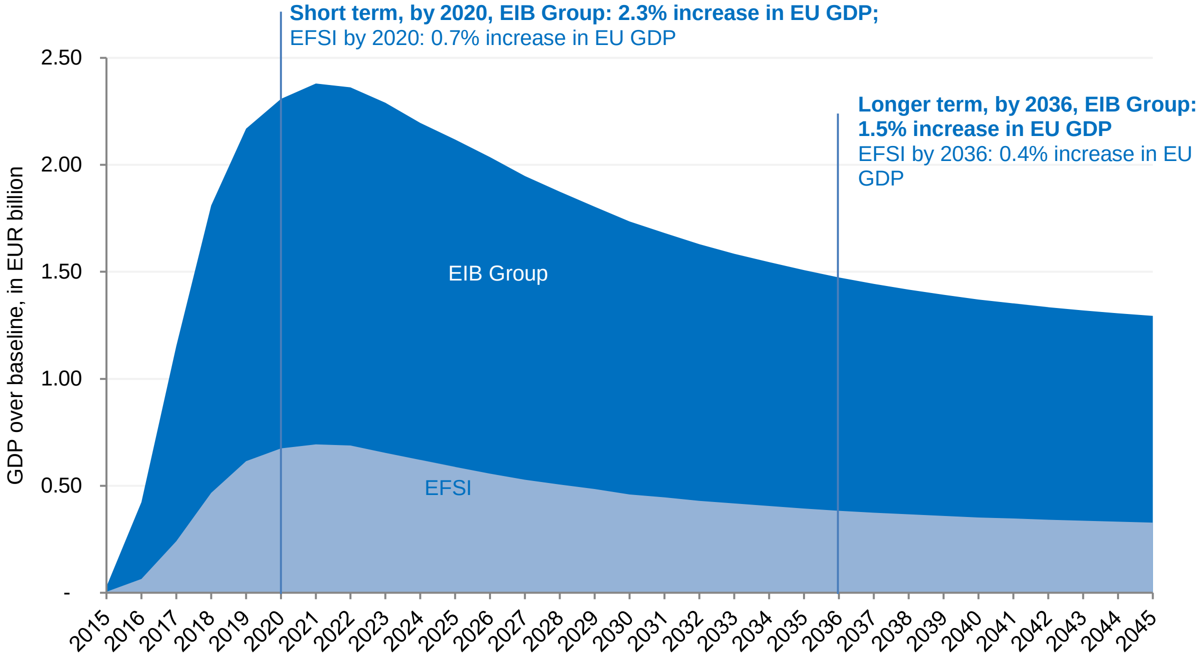

Figure 10: Expected GDP impact of EIB Group and EFSI-supported operations, based on approvals 2015-2016

4.4.Interpreting the results

Results should be interpreted with due care. Results reflect the relative increase in GDP and employment over a baseline scenario. For modelling reasons, the baseline scenario considers a world in a steady state. This is based on 2013 available detailed data in the EU. The model could be made dynamic, but this would merely shift the baseline over time and the effect should not differ significantly. The results should be read in such a way that the stated effect on GDP and employment is always over such a baseline, which assumes a counterfactual world without the EIB-supported investments, and also without the borrowing for such investments. The effect seen is 'additional' or 'over' such baseline. The results do not represent growth rates, but changes in the level of economic activity and employment over the baseline. Jobs created 'by' 2020 is different to jobs created 'in' 2020. The model expects to see 2.25 million more jobs in the EU economy *by* 2020, but only some 50 000 new jobs *in* 2020. Thus, in terms of annual contribution to GDP and employment the difference to the previous year would be the reference value.

Results reflect macro-additionality. Additionality is a critical aspect of EIB Group-supported operations. As a bank, the EIB engages in the market; as a public institution, the EIB should only engage in the market where a clear value added can be achieved. The macroeconomic assessment can only provide a partial answer to the question of additionality. The EIB Group will continue to critically assess additionality at a project-by-project level – would a specific project have happened or not, or would it have happened differently? The macroeconomic assessment looks at this from a different, complementary angle, where the EIB's role is channelling financing into productive investments, thus providing macro-additionality. The results show an overall increase in investments in the EU economy, and in priority sectors in particular.

The results cannot easily be broken down to national or regional level. The results reflect an aggregate level, i.e. for the EU-28. Whilst results are available at a country level, even at a regional level, the results cannot simply be disaggregated. Due to a high level of spillovers from regions to other regions, and a degree of non-linearity of results (building two roads is not double the effect of one, for example), country results cannot be compared to country investments. A region could have no investments in its territory and still benefit handsomely from investments in neighbouring regions or from an overall increase in competitiveness. Or vice versa, building a key network link as part of a trans-European transport corridor in a region could mean a significant investment activity in a specific region, yet the main benefits occur not in this region but in the trading centres across Europe that this corridor now connects better. Consequently, results show the aggregate effect, including the overlaps. Comparing the investment activities in a region or country with the disaggregated results for the same region or country would be potentially highly misleading. Some results are broken down into EU-wide groupings such as cohesion, periphery and other EU countries, or broken down by sector clusters, but should be interpreted only within the aggregate context.

4.5. Taking a closer look at the results – by region and sector

Results vary across regions. Results can be looked at through different prisms. One key dimension would be to look behind the aggregate data, and consider the relative performance within the EU – without losing the aggregate results perspective or relating results with inputs directly. In absolute terms, the model outcomes suggest the highest results in terms of additional value added and jobs created are achieved in the richest countries. But this may not be the most telling conclusion when looking at the underlying data. As illustrated by the baseline model data, well-off regions also have relatively higher capital intensity, and, in the European context, they are also some of the largest in terms of population and value added, such as France, the UK or Germany. More telling would be to look at the relative increase in terms of percentage increase of GDP and percentage increase in employment. This better reflects the relative macroeconomic impact. The results show that all European regions and countries benefit in terms of jobs and growth. What is more, those countries that were hit hardest by the financial crisis, and those that lag behind in terms of income, benefited relatively more than did the most well-off countries. Figures 11 and 12 plot respectively the percentage increase in GDP and employment in three different groups of countries: periphery countries (those countries that have been hit hardest by the lingering financial crisis), cohesion countries (the countries that are in a catching up process but still fall somewhat short of EU average income), and countries with higher GDP per capita (such as Germany, France, Sweden, Denmark, etc.).[8]

[8] A country is defined as a Cohesion country if it has access to the Cohesion Fund, except Greece, Cyprus and Portugal. The Fund is aimed at countries whose Gross National Income (GNI) per inhabitant is less than 90% of the EU average. Member States that can benefit from the Cohesion Fund are Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. Periphery countries are EU Member States that were affected by the crises comparably more than the other countries. They include Cyprus, Greece, Ireland, Italy, Portugal

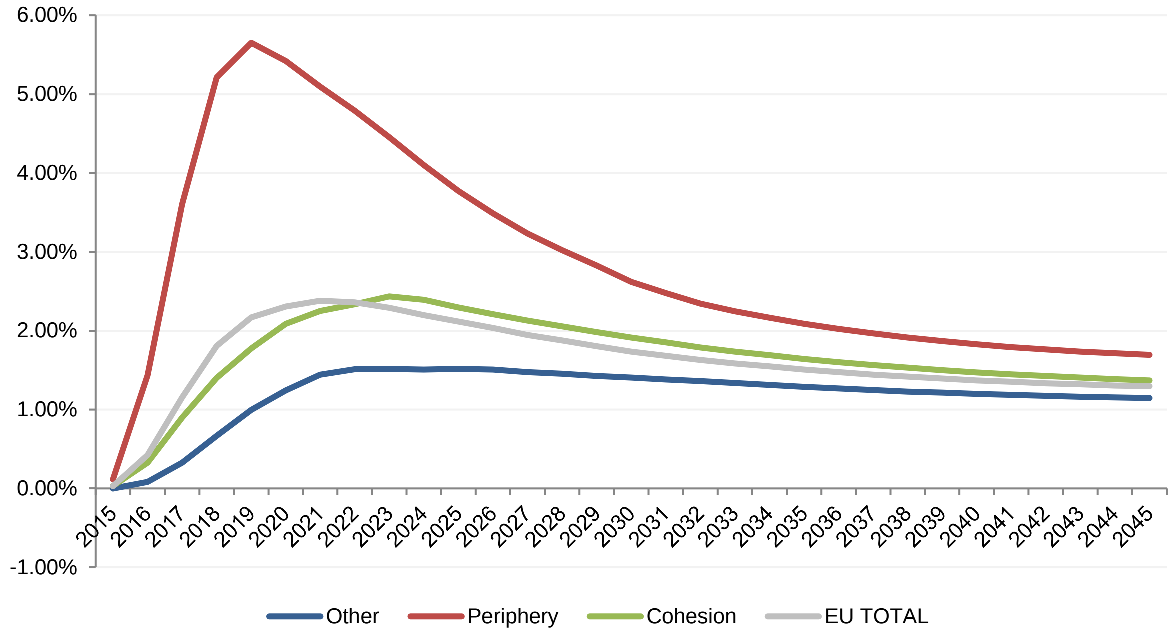

Figure 11: Expected GDP impact of EIB Group-supported investments by country groupings

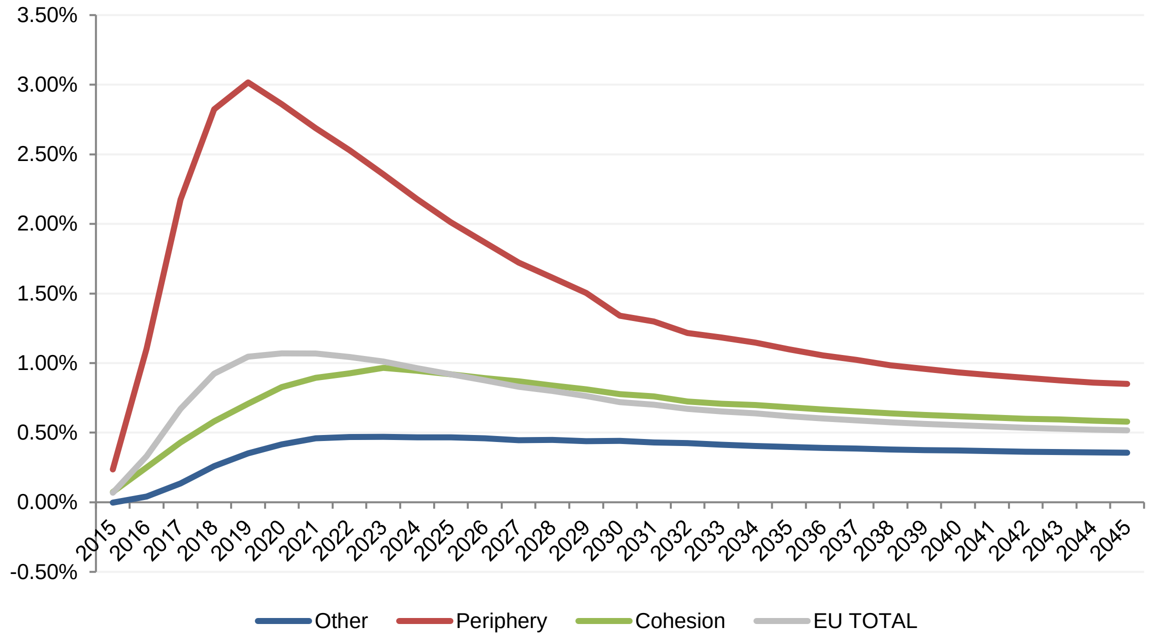

Figure 12: Expected employment impact of EIB Group-supported investments by country groupings

Cohesion and periphery countries benefit relatively more than other, better-off EU countries. The strongest effect can be seen in the **periphery countries** in terms of GDP and employment. This is unsurprising as these countries receive a substantial share of the EIB funds and in many of its regions unemployment was relatively high in 2013 and investment levels low. Supported investments will immediately turn into higher demand for workers, which will draw in workers and will be reflected in economic growth. The Greek region Kentriki Makedonia, for example, was facing a 30% unemployment rate in 2013 compared to, for example, only 2.5% unemployment in the German

and Spain. The group of Other EU members include the remaining 10 EU Member States: Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, Netherlands, Sweden, and United Kingdom.

region of Niederbayern. The capital stock was much lower compared to many better off regions and the investment levels in the 2013 baseline scenario were relatively low. Again, for example in Kentriki Makedonia the investment rate in 2013 was a mere 15% of regional GDP whereas in Niederbayern it was 23%. Direct investments, which are all the more significant compared to a lower baseline, but also spillovers from other regions, especially neighbouring or close trading partners, contribute to this effect in various ways.

The direct investment effect observed in RHOMOLO-EIB is substantial. Such crisis-hit regions and countries would therefore be expected to see a larger impact, as the results confirm. The structural effect only sets in over time, and compared to the investment effect it is more modest but also more persistent. It still contributes more than in other countries, also due to the difference in investment levels, but also again in relation to the existing infrastructure and productivity levels, and competitiveness in general.

For better-off **other countries** the picture is different, as expected. The direct effects of investments both on GDP and employment rate are more delayed and more limited in size compared to the periphery countries since the economic situation is better, unemployment levels lower, and investment levels typically higher. The effect is more modest and takes longer to pick up.

On the other hand, the structural effects achieved are able to significantly contribute to the long-run economic growth of these countries. This reflects their economic environment, with a more richly endowed infrastructure, human capital and technology, and the fact that they are characterised by a high GDP and employment rate.

Cohesion countries are between the two groups. They are not as hard hit by the crisis as the periphery countries, but the economic situation is also not as advanced and as favourable as in the better-off countries. The short-term effect is less marked than for the periphery. On the other hand, the long-term effect is extremely persistent and significant, meaning that even if the supported investment will have a limited direct effect on the local economy it will be able to enhance competitiveness in these regions to boost future economic growth.

Manufacturing is a key driver of the results. Looking at a sectoral decomposition of the impact adds interesting insights into the results (see Figures 13 and 14). In the initial periods it is chiefly the construction sector driving the results, especially in terms of employment. This seems reasonable as many investments require some time to be built – a road, a manufacturing plant, a research facility, a windfarm, etc. – thus drawing in labour.

Over time, also as more and more construction is completed, the various sectors benefit. Here it is interesting to note that manufacturing is a key sector. Not because the size of investments is the highest, but mainly also because of spillovers via indirect and induced effects from other investments (i.e. an increase in the overall income level will be directly reflected in a higher demand for machinery). Hence, by 2021 the resources devoted to the manufacturing sector will have added more than 970 000 jobs and the GDP produced in this sector will be 3.6% higher than in the baseline model. Even once the short-term effects fade, the structural effects generated by the improvement in productivity will still support economic growth in the long run. This should be read in the context of the underlying steady-state. It does not necessary imply an expansion of the manufacturing sector if indeed this sector sees long-term decline, but rather over the baseline of 2013.

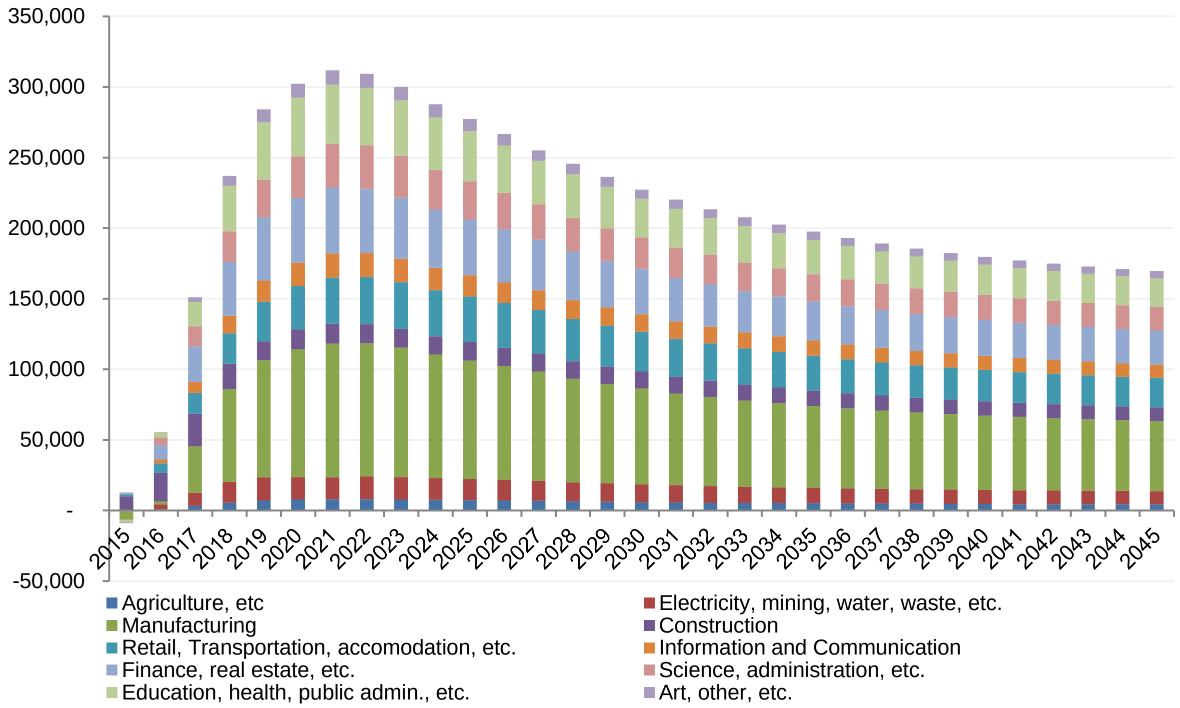

Figure 13: Expected GDP impact of EIB Group-supported operations, based on approvals 2015-2016, by sector

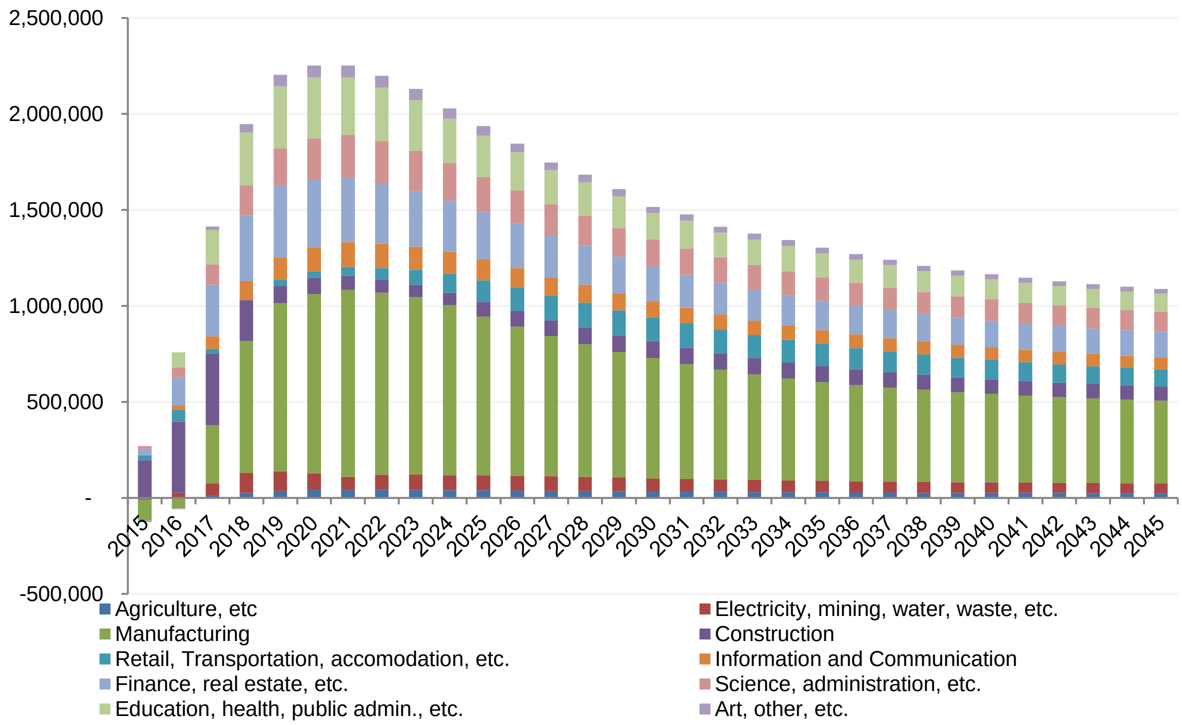

Figure 14: Expected employment impact of EIB Group-supported operations, based on approvals 2015-2016, by sector

Other sectors also see an increase, but to a lesser extent both in absolute and relative terms (see also Figure 15). Sectors vary in terms of export shares and in terms of the mix and sourcing of production inputs, and therefore benefit differently from improved competitiveness due to productivity gains and lower transportation costs.

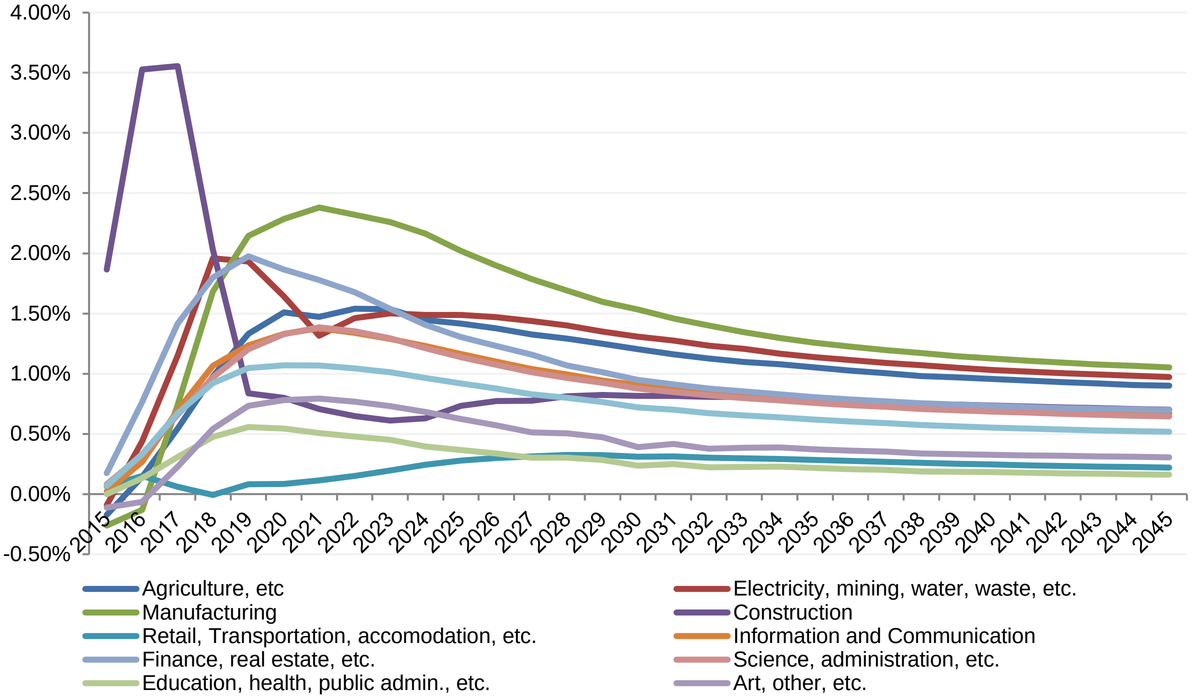

Figure 15: Expected % increase in employment, based on EIB Group approvals 2015-2016, by sector

Overall, to reiterate the argument of the risks of disaggregation, it is important to underline that the relationship between the amounts of investment devoted to a specific sector and the role that sector plays in GDP and employment is complex and tractable only through multiple effects in the model. The RHOMOLO-EIB model also takes into account the spillovers generated by the EU's intertwined economies so that the impact of the supported investments is not limited to the recipient sector or recipient region only.

5. SENSITIVITY ANALYSIS

The results are robust to reasonable variations in the working assumptions. To ensure the robustness of these results, an extensive sensitivity analysis has been conducted to look at different parametrisation and variation in the model specification to determine how sensitive the results are to the specifications made (in the Annex the sensitivity analysis is described in more detail). The sensitivity analysis exercise is based on the technical report (Diukanova 2018), which provides a detailed description of the technical details, algorithms and computer codes.

Results are only as good as the model setup. The RHOMOLO-EIB model contains a number of parameters which govern the institutional settings of the economy, the preferences and the behaviour of the economic agents, and market-specific rigidities. The values of these parameters are either estimated directly from the data or chosen in line with the existing literature. Moreover, the model can mimic various institutional and market structures, including wage dynamics, market imperfections and factor mobility. Even though the specific modelling options are chosen at a conservative level, they also potentially influence the model outcomes. Therefore, in addition to the results as discussed above, which are derived from the core specification of the RHOMOLO model, the results need to be complemented by a detailed and careful analysis on how sensitive the simulation results are to each of the parameters.

The sensitivity analysis covers two broad sets of tests. Firstly, the model contains a range of options to describe the underlying functioning of the economy. Their potential influence on the results is examined by comparing the most relevant combinations of modelling options. Secondly, the model uses a range of structural parameters, which interpret a given policy intervention as structural adjustment in the model, and parameters which describe agents' behaviour and market rigidities. Such parametrisation of the model needs to be assessed in terms of the sensitivity of the values employed and the effect of the interrelation of these values. To this end, the sensitivity of results to such parameters is assessed at the 10% interval boundaries, respectively.

Modelling options. The model setup serves to determine a range of discrete options on how the economy works, such as perfect or imperfect competition (including Cournot, Bertrand and monopolistic setups), some or no labour mobility between regions, perfect or imperfect capital mobility, autonomous or return-optimised investments, and Phillips-type, wage curve or flexible wage labour market. These settings will have a significant impact on the results. The sensitivity analysis verifies the degree of deviation from the baseline of the results for each of the above-mentioned options. As the analysis confirms, the baseline RHOMOLO-EIB relies on the most conservative of each of these modelling options (perfect competition, perfect capital mobility, return-optimised investments), except for the labour market. Only in the labour market, based on a wage curve, the impact results are reported as being 'more generous' than using the alternative options based on a Phillips curve or flexible wages. A Phillips Curve would imply that unemployment gradually returns to its previous level (at a presumed natural rate) whereas a wage curve would allow for more sustained employment of the previously unemployed. The rationale for choosing the wage curve over the alternatives is the notion of high unemployment during the model base year of 2013 in many regions. It seems reasonable to claim that the observed unemployment rates are well above the natural rate of unemployment, which would also leave room for a more lasting employment effect than a Phillips curve or flexible wages options would be able to account for.

Parametrisation: CGE models, and especially regional models like RHOMOLO-EIB where regional data is not always readily available, can be sensitive to changes in values of some parameters. Identification of the sensitivity of model results to the values of such parameters is done through a series of simulations, in each of which the value of the key exogenous parameters (elasticity parameters that define behavioural preferences of economic agents and parameters that characterise dynamics and investment behaviour) was changed by +/- 10%, holding all other parameters and settings constant. Computer simulations revealed that the degree of sensitivity to changes in parameter values falls within a limited range. For GDP figures this range is bounded by 10% and converges to 5% maximum deviations from the baseline in 10 years after the shock, and for employment impact it is bounded by 13% maximal deviation from the baseline and remains largely stable over time. To capture the possible co-effects between parameters, the multivariate sensitivity analysis then looks at the combined effect. Given the large number of possible combinations of parameters, a clear protocol is followed to assess the sensitivity in a credible manner (see Annex for details). The sensitivity analysis identified that the results are most sensitive to trade elasticity (often referred to as the Armington elasticity), the wage curve elasticity, the depreciation rate of capital and the firms' speed of investment adjustment. The multivariate analysis shows that the effects from combined 10% changes in the most crucial parameters and elasticities on GDP are bounded by 20% maximum deviations[9], steadily converging towards 8% at the end of the forecast horizon in 2050. On the other hand, the effects on employment are modestly more persistent, bounded by 20% maximum deviations and converging to around 15% with respect to the benchmark model in the long run. More detailed multivariate sensitivity results, including average effects for different time spans, can be found in the Annex.

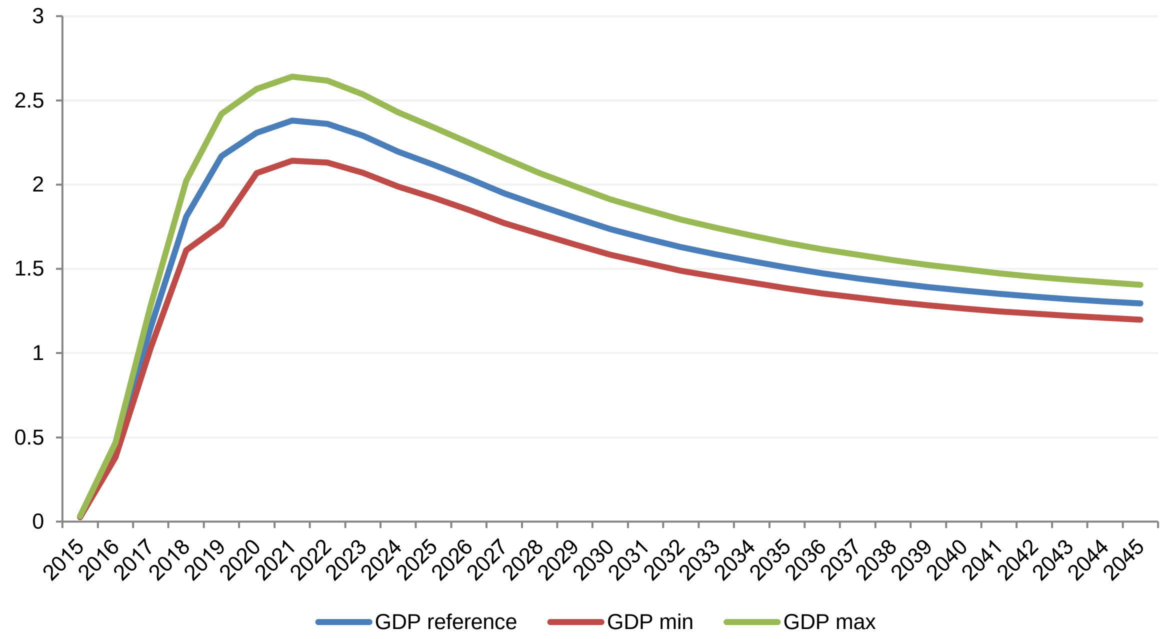

Figure 16: Maximum and minimum results for expected GDP impact (in % over baseline) from multivariate sensitivity analysis

[9] 20% maximum bound is observed only in 2019. The average effect is bounded by 10% deviations, as indicated in Table A3 in the Annex.

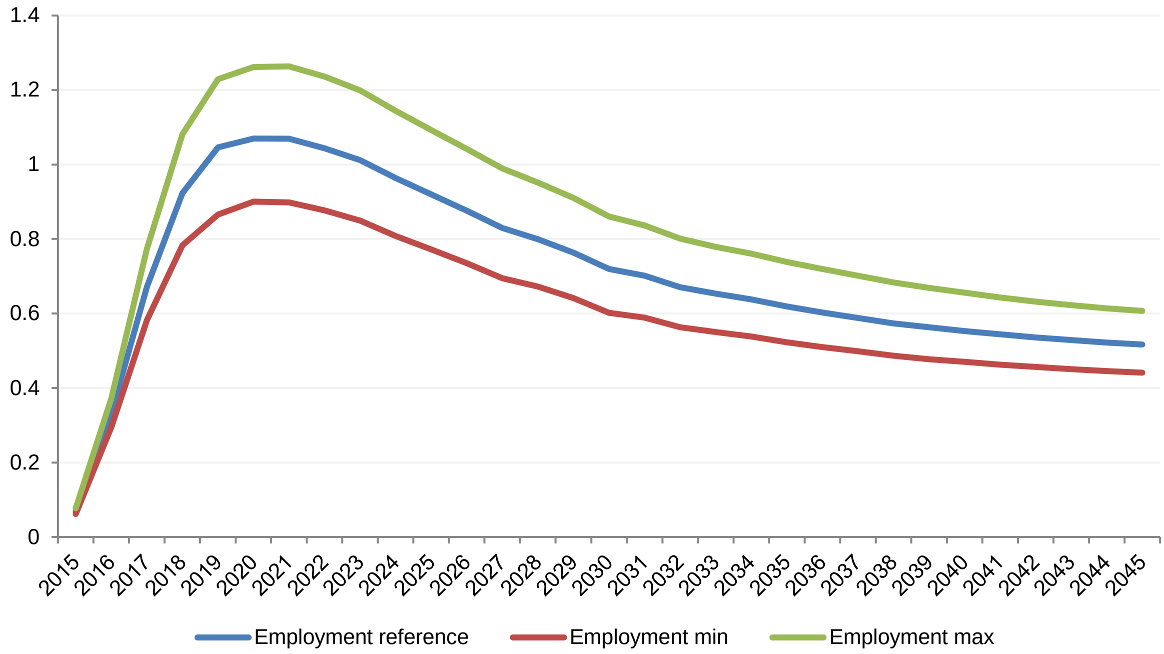

Figure 17: Maximum and minimum results for expected employment impact (in % over baseline) from multivariate sensitivity analysis

6. CONCLUSIONS

The RHOMOLO-EIB model is well suited to assess the macroeconomic impact of EIB Group activities. The purpose of the approach was to look beyond the direct effects of EIB operations and assess the macroeconomic impact of the EIB Group's supported investments in the EU. This complements the EIB's existing results focus that tracks the direct outputs and outcomes of its operation. Looking at the indirect and induced effects helps better understand the overall and lasting impact on the EU economy in terms of jobs and growth. To achieve this, RHOMOLO was chosen as the most suitable instrument. It reflects a well-established approach, already used in the policy arena to assess the macroeconomic impact on growth and employment. It has been around for some time, vetted and reviewed extensively in the relevant academic and policy forums. It provides a credible and adaptable approach that serves to assess the macroeconomic impact of EIB Group-supported activities. In a fruitful collaboration between the European Commission's Joint Research Centre and the EIB's Economics Department, the model was adjusted to properly reflect the EIB Group business model as a Bank employing financial instruments rather than grants.

The impact of EIB Group-supported activities is sizeable in terms of its contribution to both economic growth and employment in the EU. And the results are demonstrated to be robust. According to the RHOMOLO-EIB model, overall investment approved by the EIB Group within the EU in 2015-2016, supported EUR 544 billion of investment, will add 2.3% to GDP and 2.25 million jobs by 2020. The results also suggest that by the same year the EIB Group's loans approved under the EFSI until end-2016, supported by EUR 161 billion of investment, will add 0.7% to EU GDP and 690 000 jobs.

The scope of the results is comparable to similar findings. The detailed results the model provides have allowed a granular analysis of EIB Group-supported activities in terms of geographic scope and sector impact. The scope of the results, however, is difficult to benchmark as this is one of the first efforts to assess such macroeconomic impact in this way. A number of comparisons are possible to gauge a sense of scope of the results. The simplest is to compare the results of different interventions. Other benchmarks can be considered to get a broader sense of the results, either in terms of other indicatives using RHOMOLO, or other approaches looking at EIB activities, or other public investment programmes that have undergone a similar assessment, to provide a sense of scope of the results from RHOMOLO-EIB.

(i) At first glance, when looked at in isolation 2.4% of GDP and 2.2 million jobs at its peak look high. In relation to the overall economy this seems more reasonable. EIB Group investments (EUR 544 billion) in 2015 and 2016 correspond to roughly 4% of the EU GDP in the baseline year 2013, which in turn corresponds to 20% of gross fixed capital formation. This, of course, is invested over time and not easily compared to one year alone. Still, it represents a sizeable impetus in the economy. Comparing this to the results of an increase of 2.4% in GDP and 1.1% of employment in the EU with respect to the baseline model seems plausible.

(ii) RHOMOLO is a well-established model also used to assess other policy and investment initiatives. The European Commission has used it to assess the macroeconomic impact of the Cohesion Policy in Europe. From 2007 until 2013, cohesion-related mobilised investments, including co-financing from the public and private sector, amounted to some EUR 477 billion. By 2016 these investments, under similar model settings, were expected to have created 2.4

million jobs. Regional GDP in cohesion countries is expected to have increased by 4.2% by 2023. While the nature of the intervention differs, the regional focus is more targeted, and different sectors are focused on, the scope of the results is not so different.

(iii) With the initiation of EFSI, several stakeholders have independently tried to assess the macroeconomic impact of EFSI-supported investments. The approaches differ, but may provide a sense of scope. The European Commission uses Quest (the global macroeconomic model DG ECFIN uses for macroeconomic policy analysis and research) to estimate the impact of the EUR 315 billion. They concluded it has the potential to add EUR 330-410 billion to the EU's GDP. Oxford Analytica, an economics consulting firm, concluded that the EUR 315 billion of additional EFSI investment would result in a GDP increase of 1-1.8%. Extrapolating these results to EIB Group-supported activities as a whole (EUR 544 billion compared to EUR 315 billion for the overall expected EFSI) the results from RHOMOLO-EIB appear well within scope.

(iv) Other large-scale public investment schemes can also be used for some proxy benchmarking. Again, different approaches and different types of interventions are also used beyond investment, covering some tax incentives, and transfers, but it may still be reasonable to provide a sense of scope of the results. The American Recovery and Reinvestment Act (ARRA) was designed to make crucial public investments in order to save and create jobs, as well as to cushion the economic downturn in the wake of the global financial crisis. The American Congress approved the USD 787 billion ARRA in February 2009. The Executive Office of the President Council of Economic Advisers concluded that by 2012, ARRA was estimated to have created 6.8 million jobs. In this instance also, the RHOMOLO-EIB results seem well within the scope of other results.

Nonetheless, results should be read with care. While the model delivers very specific results in terms of the number of jobs and GDP over the baseline, the results provide more of a sense of scope of the impact than a concrete number. It should be recognised, that, as a model, it represents a simplified version of reality, and cannot anticipate all future events. Also, it is one of many possible modelling approaches. Other models may deliver different results, depending on their database, structure and underlying assumptions. While we believe this to be a robust and credible model, further dialogue on the results will be pursued to discuss other findings, compare notes and discuss assumptions and parameters to ensure as much as possible the credibility of the results.

This is the first of a series of results. The collaboration between the EIB and JRC started in 2016. These are the results of the first full set of model runs. This will be continued in the coming years covering both the newly available EIB Group activities, e.g. approved in 2017 and then beyond, but also updating the existing results as more accurate information is received throughout the operations' life (e.g. if a project is cancelled, or if a project looks like being different to the initial expectations). This will help refine the results further and deliver still better and more accurate results, taking into account the lessons learned from this initial exercise.

Further analysis will be conducted in the future. The results presented here come from the first run of the model. Many important lessons can be drawn from this exercise, and many interesting questions have emerged. In future runs of the model, additional aspects will be looked at and the data will be analysed and disaggregated further. For example, to better understand the spillover effects, the model could be run in partial sets to single out the scope of how activities in some regions affect the rest of the EU regions. Moreover, the economic scenario underpinning the baseline could be critically compared to the continuous improvements of the economic situation in Europe, and how this may affect the evolution of the results. Such and further questions will be investigated in more detail in the future use of the RHOMOLO-EIB model.

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TECHNICAL ANNEX

The appendix provides more technical details on the sensitivity analysis. Given the highly technical nature of this exercise, the main report examines only its main results and conclusions, with the details presented in this annex.

A.1. Different modelling options

RHOMOLO allows for a set of modelling options, which are described below. The options in bold denote the choices made for RHOMOLO-EIB.

Competition: In RHOMOLO-EIB it is assumed that all firms in the economy operate in perfectly competitive sectors. All firms are price takers in their input markets, have constant returns to scale technologies and are constrained by marginal costs pricing. RHOMOLO allows firms in a subset of sectors to operate under imperfect competition. These firms face fixed costs, and hence, increasing returns to scale in production. To survive, firms in imperfect competitive markets have to change positive mark-ups over marginal costs. These mark-ups are determined optimally conditionally on the competitive game, as well as the properties of the demand these firms face. RHOMOLO enables firms in the imperfectly competitive sectors to set prices according to Dixit-Stiglitz monopolistic competition, Cournot or Bertrand price behaviour, to generate a different mark-up of price over the marginal cost. **RHOMOLO-EIB operates under perfect competition assumption**.

Capital mobility: RHOMOLO allows for mobility of financial capital between regions. Under the assumption of capital mobility the allocation of investments between regions is driven by the differences between regional and EU average return to capital. Assumptions concerning the allocation of investments between regions can be altered to prevent mobility of capital. When capital mobility is absent, region-specific investments are driven by the distance between the regional rate of return to capital and the corresponding regional replacement cost of capital. **RHOMOLO-EIB operates under perfect capital mobility**, in line with the cross-border nature of the EIB portfolio.

Private Investment: The level of private capital in RHOMOLO is governed by an adjustment rule that determines the optimal path of private investment. According to this formulation, the investment-capital ratio is a function of the rate of return to capital and the user cost of capital, allowing the capital stock to smoothly reach its desired level. It is possible to add a constraint to RHOMOLO under which savings match the investment level. **RHOMOLO-EIB operates under the assumption that investments follow the investment-return behaviour described above.**

Wage setting: RHOMOLO incorporates friction in the labour market. The model makes it possible to switch between a wage curve and a Phillips curve. The setting further permits the use of a dynamic or a static form of wage setting. Wage setting, under the assumption of a wage curve, implies a negative relationship between the wage rate and unemployment. A Phillips curve implies that in the absence of migration or an exogenous increase in the labour force, in the long run the employment and unemployment rates will return to their steady-state levels. The model can also be run assuming neoclassical perfect competition in the labour market. Assuming no changes in the labour force the supply of labour forms a vertical line in each period of the model. Therefore, the wage rate for each type of skill can be determined endogenously. **RHOMOLO-EIB operates under the wage curve assumption.**

A.2. Multivariate sensitivity analysis with the RHOMOLO-EIB model

While CGE models are an established tool to analyse the aggregate welfare and distributional impacts of policies, with corresponding effects being transmitted through multiple markets, they are known to be susceptible to parameter uncertainty. In particular, uncertainty relates to structural parameters that characterise a) behavioural preferences (elasticities of transformation/substitution), b) technology (factor productivity parameters), c) policy decisions (allocation of funding) and d) dynamics and investment behaviour (e.g. growth/interest/depreciation rates).

Since there is often no available data to run reliable econometric estimates at a micro level for all the sectors and regions involved in large-scale general equilibrium models, a common practice is to relate the values of parameters in question to other models or econometric studies. While borrowing parameters are a sensible starting point in any modelling exercise, the elasticities obtained in external studies are generally at higher levels of aggregation, different sectoral composition and may cover different time horizons, reducing their applicability to a given policy context. The econometric methods used to derive such values are often incompatible with the structure of nesting of model expenditure functions[10]. For instance, the elasticities on lower nests of expenditure functions can depend on elasticities of higher nests, making their joint probability distribution ever harder to pin down. As a result, the covariation between parameters that are collected from different sources might not be well accounted for. Similarly, the temporal or spatial variability model is driven through a set of parameters, which need to be estimated externally. Such a problem is particularly severe for regional models because of the lack of large regional datasets (Partridge and Rickman, 1998).

Given that the values of elasticities have no impact on a base-year unperturbed situation in the economy, a common approach is to investigate the sensitivity of a CGE model output to a small subset of elasticities or parameters for one or several scenario shocks, assuming no changes in all the other inputs (Saltelli, Annoni and D'Hombres, 2010; Hermeling and Mennel, 2008; Hertel, et al., 2007; Webster, et al. 2008).

In the case of RHOMOLO-EIB, it is the EIB investment shock in question that builds a reference scenario. We then investigate the responsiveness of RHOMOLO-EIB to the different combinations of structural parameters that characterise behavioural preferences, dynamics and investment behaviour, thus performing the multivariate sensitivity analysis (MSA). Such selection of parameters is of particular importance in the context of the EIB investments in accordance with a number of corresponding policy objectives.

Because CGE frameworks are resource-intensive (in terms of time and CPU, see for instance Arndt (1996)), the sensitivity analysis resorts to a deterministic approach that does not require prior knowledge of the probability density functions of specific parameters. This is the only feasible option

[10] On each level of nesting of expenditure functions (e.g. CES, Cobb-Douglas, Leontief, CET, etc.) the elasticities of substitution/transformation characterise the behavioural choices of economic agents regarding consumption and/or supply.

considering RHOMOLO-EIB's dimensionality (Mercenier, et al., 2016)[11]. Resorting to the deterministic approach, we established two levels for each parameter (baseline value, +/-10%).

Even in this case, to investigate how the interactions between elasticities and parameters that characterise dynamics and investment behaviour impact model results, we would need to run RHOMOLO 524 228 times (2 to the power of 19). Clearly, this number of computations is unmanageable with models of the dimension of RHOMOLO-EIB simulated over a 36-year horizon. Therefore, to bypass the dimensionality curse we implement the MSA exercise in two steps.

In the **first step,** we run RHOMOLO-EIB varying one parameter per model run. We vary each of the 19 structural parameters two times (avoiding repetition of the baseline values) while keeping the values of the rest of the elasticities fixed at their baseline values. That requires 38 model runs (30 for elasticities and 8 for parameters that characterise dynamics and investment behaviour). This step enables us to identify the set of the most influential parameters.

In the **second step,** we consider all possible two-element combinations of the values of four parameters, determined as the most important, running the RHOMOLO-EIB 15 times (2 to the power of 4 minus one, to exclude the baseline combination). The results of the multivariate sensitivity analysis with RHOMOLO-EIB enable us to rank the combinations of parameters that characterise dynamics and investment behaviour according to their impact on model results.

Below we describe the details behind the multivariate sensitivity analysis exercise. The description of elasticities used in RHOMOLO-EIB is provided in Table A1.

Table A1. Selection of elasticities for multivariate sensitivity analysis

	Notation	Baseline value
Transformation of R&D/non-R&D high-skill labour supply	S_SL	1
Substitution between different household consumption goods	S_CH	1.2
Substitution between different public goods	S_CG	0.3
Substitution between primary factors and intermediate inputs	S_ZS	0.2
Substitution between intermediate goods	S_XS	0.25
Substitution between aggregate labour and capital	S_QS	1.1
Substitution between private and public capital	S_KS	2
Substitution between different labour skill groups	S_LS	2
Knowledge externality parameter	KnowK	0.0053
Substitution at the upper level of investment technology	S_EInv	3
Substitution at the lower level of investment technology	S_Inv	1.3
Substitution between goods from different regions	**S_A**	**4**
Wage curve elasticity	**WgeCurv**	**0.1**
Transformation of EU capital between regional markets	S_EK	3
Substitution between goods in R&D consumption	S_A_RnD	3

[11] Although there may be many other sources of uncertainty (the choice of nesting structure, temporal and spatial variability, etc.) they are outside the focus of this study, simply because it is impossible to estimate all parameters of complex models and the number of obtained model solutions may be beyond computable reach.

The selection of specific parameters that characterise dynamics and investment behaviour applied in the model is depicted in Table A2.

Table A2. Selection of parameters characterising dynamics and investment behaviour for multivariate sensitivity analysis

	Notation	Baseline value
Speed of investment adjustment	**phi_inv**	**1.5**
Internal rate of return	ir	0.04
Depreciation rate of private capital	**DepRK**	**0.15**
Depreciation rate of public capital	DepGK	0.05

Considering that structural parameters might have a strong impact on some policy indicators and a weak impact on others, we measure model responses with two macroeconomic indicators: real GDP and employment, all reported at regional, national and EU level. Boldface in Tables A1 and A2 determines the most important elasticities and parameters which are then used as an input for the multivariate analysis in the second step.

The MSA considers three different time frames, i.e. 2015-2026, 2027-2037 and 2038-2050. The GDP results are presented in Table A3 whilst the employment figures are depicted in Table A4.

Table A3. Multivariate sensitivity analysis of GDP results (average effects)

The most influential structural parameters				**Deviations from the baseline projections, %**		
S_A	**WgeCurv**	**phi_inv**	**DepRK**	**Av. 2015-2026**	**Av. 2027-2037**	**Av. 2038-2050**
+10%	-10%	-10%	+10%	10.07	10.01	8.72
-10%	-10%	-10%	+10%	9.37	6.39	4.74
+10%	+10%	-10%	+10%	5.78	5.64	3.38
+10%	-10%	+10%	+10%	5.57	1.18	3.00
-10%	+10%	-10%	+10%	5.18	1.62	-0.30
-10%	-10%	+10%	+10%	4.81	-2.47	-0.81
+10%	+10%	+10%	+10%	-10%	-3.76	-2.15
-10%	+10%	+10%	+10%	0.68	-6.99	-5.52
+10%	-10%	-10%	-10%	-0.62	8.84	8.15
-10%	-10%	-10%	-10%	-1.98	3.25	3.25
+10%	+10%	-10%	-10%	-4.44	4.04	2.82
+10%	-10%	+10%	-10%	-4.97	-1.05	0.77
-10%	-10%	+10%	-10%	-5.40	-4.28	-2.87
-10%	+10%	-10%	-10%	-5.73	-1.12	-1.60
+10%	+10%	+10%	-10%	-8.73	-5.60	-4.20
-10%	+10%	+10%	-10%	-9.10	-8.50	-7.45

Notes: Table presents average percentage deviations from the baseline GDP results for 2015-2026, 2027-2037 and 2038-2050 time frames. The description and calibration values for structural parameters are presented in Tables A1 and A2.

Ranking the results by their impact, from Table A3 we observe that the highest value of EU GDP is achieved when the elasticity of substitution between goods from different regions (S_A) and the depreciation rate of private capital (DepRK) are at their high and the speed of investment adjustment (phi_inv) and the wage curve elasticity (WgeCurv) are at their low levels, respectively. Symmetrically, the lowest value of the EU GDP is achieved at the low levels of S_A and DepRK, and at the high levels of phi_inv and WgeCurv.

Indeed, since the elasticity of substitution between goods from different regions determines the flexibility of substituting the goods when their prices change, higher S_A enables a region to easily replace a more expensive product with a cheaper one, and the opposite also holds true. The wage curve elasticity determines the flexibility of unemployment to wage changes. Therefore, lower WgeCurv results in higher GDP and employment.

Given that steady-state capital stock in the model is a function of steady-state investments and the assumed depreciation rate of capital, the higher DepRK results in in a lower calibrated steady-state capital stock and it increases the responsiveness of a model to EIB-supported investments, and vice versa.

In turn, the speed of investment adjustment governs the responsiveness of investments to changes in the ratio between the rental price of capital and the user cost of capital. The EIB-supported investments enter the model through a reduction in the risk premium, which lowers the user cost of capital. Hence, lower phi_inv produces higher decline in risk premium, rising GDP and employment, and the opposite also holds.

Varying either S_A or WgeCurv while keeping the rest of the parameters fixed at their less conservative levels preserves the GDP above the baseline GDP projections. Alternatively, varying either one of S_A, WgeCurv or phi_inv, while keeping the rest of the parameters at their more conservative levels, reduces the negative impact on GDP while keeping it below the projected baseline values. The rest of the combinations produce mixed results, which vary from one decade to another.

Table A4. Multivariate sensitivity analysis of employment results (average effects)

The most influential structural parameters				Deviations from the baseline projections, %		
S_A	**WgeCurv**	**phi_inv**	**DepRK**	**Av. 2015-2026**	**Av. 2027-2037**	**Av. 2038-2050**
+10%	-10%	-10%	+10%	15.87	19.08	17.65
+10%	-10%	-10%	-10%	6.02	18.30	16.87
+10%	-10%	+10%	+10%	10.37	7.43	10.11
-10%	-10%	-10%	+10%	11.93	10.18	8.78
+10%	-10%	+10%	-10%	0.04	4.82	6.82
-10%	-10%	-10%	-10%	1.00	6.79	6.71
-10%	-10%	+10%	+10%	6.42	-1.07	1.87
+10%	+10%	-10%	+10%	3.28	4.34	1.65
+10%	+10%	-10%	-10%	-5.34	3.19	0.93
-10%	-10%	+10%	-10%	-3.21	-3.10	-1.16
+10%	+10%	+10%	+10%	-1.80	-7.02	-5.02
-10%	+10%	-10%	+10%	-0.14	-4.20	-6.05
-10%	+10%	-10%	-10%	-9.79	-6.88	-7.79
+10%	+10%	+10%	-10%	-10.88	-8.97	-7.88
-10%	+10%	+10%	+10%	-5.24	-14.29	-12.02
-10%	+10%	+10%	-10%	-13.70	-15.83	-14.70

Notes: Table presents average percentage deviations from the baseline employment results for 2015-2026, 2027-2037 and 2038-2050 time frames. The description and calibration values for structural parameters are presented in Tables A1 and A2.

Ranking the results in Table A4, we observe that the largest effects on employment are achieved at the same combinations of S_A , WgeCurv, phi_inv and DepRK as for the GDP results. The highest positive effects on employment along the model horizon are achieved at low WgeCurv, phi_inv and high S_A irrespective of the values of and DepRK. Symmetrically, the lowest negative effects are attained at the high values of both WgeCurv and phi_inv and low S_A irrespective to the DepRK.

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Economics Department
economics@eib.org
www.eib.org/economics

Territorial Development Unit
JRC-B3-RHOMOLO@ec.europa.eu
https://ec.europa.eu/jrc/en/rhomolo

European Investment Bank
98-100, boulevard Konrad Adenauer
L-2950 Luxembourg
+352 4379-22000
+352 4379-62000
www.eib.org – info@eib.org

European Commission
Joint Research Centre (JRC)
Growth and Innovation Directorate
Edificio Expo; c/ Inca Garcilaso, 3
E-41092 Sevilla (SPAIN)
https://ec.europa.eu/jrc/en

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