



## **The Use of Econometric Modelling in Evaluating the Impact of Public Policies and Programmes**

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# Foreword

I am pleased to deliver to you the newest publication by Polish Agency for Enterprise Development, which deals with the notion of using advanced evaluation tools in improving the effectiveness of implementing and programming aid activities.

This time the new position from the PARP evaluation series focuses on the possibilities offered by the use of econometric modelling, both in macroeconomic impact evaluation concerning economic development programmes, in regulation impact assessment, as well as in various types of strategic analyses of selected policies, in particular those implemented under the Cohesion Policy of the European Union. As evidenced by the results of modelling-based PARP evaluation, positive macroeconomic effects of the Agency's innovation-oriented activities under the former EU perspective 2007–2013 still resonate strongly in the economy. The added GDP value gained at that time as a result of PARP activities under the Innovative Economy programme proved to be 6.4 times greater than the expenditure on their implementation. Additionally, PARP continues such evaluation studies, which use macro-modelling, in relation to operational programmes under the current perspective 2014–2020.

It should be noted that the examples discussed in the publication show that macroeconomic models both support the programming of large-scale aid schemes through *ex-ante* modelling of their impact, as well as serve the purpose of preparing alternative scenarios of interventions, affecting key indicators in the economy. The use of such research tools in institutions engaged in joint formulation of development policy is especially important in the period in which we now find ourselves, namely on the threshold of a new financial perspective, which will set out the scope of intervention of EU Cohesion Policy in Poland for the years 2021–2027. In this particular context, it is worth examining the crucial observations by the models used in leading centres in the country and abroad (such as the Polytechnic University of Milan, the Joint Research Centre of the European Commission in Seville). This could help us better understand new global challenges faced by Polish economy and set ambitious development goals, which take into account both the dynamic macroeconomic context and the flow of values between the interconnected economies of EU countries and regions. Relying on the solid foundation of macroeconomic

data may also allow for accurate planning of the appropriate allocations of funds and intervention mechanisms, enabling a discount of the effects of development-oriented investments in national economy as promptly as possible, which is particularly essential for stimulating weaker regions.

Herein, you will find both reflections on development policies' effectiveness, valuable for policy makers, as well as many methodological guidelines for policy researchers, including those referring to the Agency's experience in the field of evaluation. You are hereby invited to peruse this challenging, yet inspiring publication. Above all, I would like to thank the esteemed Authors and members of the Editorial Team (in particular my colleagues from the Analysis and Strategy Department), who contributed to the development of the concept of this publication, which I now have the pleasure of presenting to you.

**Małgorzata Oleszczuk**

President of the Polish Agency for Enterprise Development

# Introduction

Evaluation of the impact of public programmes, policies (strategies) and the effects of regulation ought to be based on a micro- and macroeconomic foundation.

The use of microeconomic data (e.g. consumer characteristics in a particular economic sector, characteristics of employees from a given sector or enterprises operating on a specific market) may contribute to the econometric model, which allows for determining the impact of selected characteristics of those individuals on microeconomic indicators. Microeconomic models in counter-factual analyses make it possible to take into account the functioning of the different groups of entities in the circumstances of a public intervention or a lack of it. This eventually creates the possibility of estimating the scale of impact of a given public programme (net effect) on a specific indicator reflecting the situation on the micro level.

Meanwhile, the macroeconomic approach aims not only to record the direct effects of a given public programme or policy, but also to take into account their broader impact on the economy of a country or region as a whole. Therefore, with the scale of financial support large enough to have a visible impact on the value of macroeconomic indicators, more or less detailed macroeconomic models may be used. Their use will allow for determining the extent to which such macroeconomic indicators as GDP, unemployment rate, work efficiency or investment dynamic have grown solely on account of a given public intervention. Thus, by using econometric modelling on a macro-scale, we are able to record and distinguish the multidimensional impact of public policies and programmes on various areas of economic reality at the macroeconomic level. Moreover, a number of models are fit to be used for policy design by applying them in foresight studies and *ex ante* evaluations that model the macroeconomic impact of analysed intervention scenarios (e.g. various budget options, target areas/groups, financing methods, etc.).

Microeconomic analyses offer better insight and greater detail into the mechanisms of policies' and public programmes' impact. They cannot, however, answer the question of whether the impact of a particular public programme or strategy reaches beyond the specified area of intervention. For instance, at the microeconomic level, transport

infrastructure construction from Cohesion Policy funds will generate effects in the form of an additional number of persons employed in relation to road construction, additional income from remunerations, improved availability of specific cities in terms of time, etc. However, micro-level analysis itself will not determine the degree to which the aforementioned infrastructure investments impact the income of companies and individuals in other economic sectors (e.g. through purchases made by construction workers), whether and how the new or modernised roads have affected the attractiveness for investment and the GDP of the entire country/region and its typical productivity of production factors. This is where macroeconomic modelling comes in, allowing the impact of a particular intervention to be recorded and quantified (provided that it is sufficiently large across the entire economy – generally between 1 and 4% of the annual GDP). This method allows for estimating not only the direct effects of a public programme (e.g. the number of jobs created in relation to road construction), but above all, the vast range of indirect and induced effects. Often these effects are neither tangible nor intuitive and concern, among other things, the impact of infrastructure programmes on production in the industry and service sector, and on the income of all inhabitants of a specific region/country. The role of macroeconomic modelling may also be explained with the example of the assessment of programmes stimulating innovation. On the micro level, we provide answers as to the impact of the aforementioned programmes on the competitiveness of companies in a given region and their capacity for producing and exporting innovative high value-added goods. It is only by using macroeconomic models that it becomes possible to record the broad impact of an exemplary programme on the economy as a whole.

This PARP publication focuses on the macroeconomic pillar. Its main purpose is to disseminate knowledge on the topic of using econometric modelling in evaluating the impact of public programmes, policies (strategies) and effects of regulation. Evaluation studies have thus far incorporated econometric models mainly for the purpose establishing the quantitative impact of the Cohesion Policy of the European Union (EU) on socioeconomic development. As evidenced herein, the possibilities of contributing to development policy by means of the aforementioned methods go far beyond simple counter-factual analysis of impact on GDP or unemployment rate. Macroeconomic models are presented as effective tools which may support public authorities in shaping and modifying policies and public programmes (for instance by guiding them towards an optimal public investment structure and tailoring interventions to the structure and specificity of a given country, region, or perhaps even a municipality). The publication also draws from the considerable

achievements of the Polish Agency for Enterprise Development in the field of evaluating the policy of fostering innovation, the labour market and territorial cohesion, including the use of various econometric models in evaluation.

The main focus of the publication is on the following notions, relevant to the quality of evaluation results and the corresponding recommendations for decision makers:

- **Various methods of macroeconomic modelling**

The articles presented in this publication are a source of accessible information on the main methods of macroeconomic modelling used in assessing the impact of policies and public programmes. They demonstrate the various possibilities offered by each tool to public authorities in shaping and modifying development policies and programmes. For that purpose, the most important models used in the EU for assessing the effectiveness of public interventions were also included. This means the HERMIN models, initially defined by John Bradley, PhD, as well as the MASST4 macroeconomic model, developed by a team led by Prof. Roberta Capello from the Polytechnic University of Milan, which is the main tool used under the ESPON programme (European Observation Network for Territorial Development and Cohesion). On the other hand, the presentation includes the RHOMOLO model, one of the general equilibrium models and a key tool of DG REGIO of the European Commission, used for evaluating public policies. The main idea behind each chapter of the book is above all to present models in the context of using them in evaluation studies. To a limited extent, they are also complemented by examples of empirical analyses' results.

- **Various spatial and administrative areas subject to analysis**

The book presents modelling elements at national, macroregional, regional and local level. Therefore, it was possible to consider opportunities related to using macroeconomic models for the purposes of government administration and the different levels of local government administration. Examples include the first HERMIN model for a metropolitan city (the capital city of Warsaw) in Poland confirming that it is possible to successfully model the economies of Polish NUTS-3 subregions. It would be an essential element of evaluation studies, facilitating the assessment of effectiveness in terms of territorialisation of regional development strategies (also taking into account e.g. integrated investment strategies of the different metropolises) and regional development programmes (also taking into account modelling the effects

of implementing regional strategies and programmes under the new territorial division for statistical purposes, i.e. one which distinguishes a 17th region – the capital).

- **Various thematic areas, with particular emphasis on supporting innovation**

We present, among other things, the use of models classified as DSGE, including an example of using the VESPA models (containing for instance a dedicated module developed for PARP, taking into account the specificity of R&D&I activities, including the occurrence of spill-over effects of such interventions in the field of knowledge and know-how, and a module enabling performance and structure analyses in the area of the labour market) to evaluate programmes supporting entrepreneurship and innovation, implemented under EU Cohesion Policy in Poland.

- **Various approaches to modelling and assessing the effectiveness of public programmes for regional development**

Two approaches are presented: 1) a region-centric approach, which aims to strike an appropriate balance between applying theoretical knowledge, sophisticated econometric techniques and familiarity with the characteristics and specificity of the modelled regions, used to analyse a small number of regions, and 2) a one-size-fits-all approach, based on the broad application of theoretical knowledge and econometric analysis techniques, used for modelling a large number of regions, and thus offering no possibility of delving into the development potentials and barriers of individual territorial units, which cannot always be assessed based on public statistics.

- **The role of interregional economic links in assessing the effectiveness of policies and public programmes**

On the basis of the system of integrated regional HERMIN models and the RHOMOLO model, it was demonstrated that the effects of a specific programme implemented in a particular region may “flow” into other voivodeships, for instance through the import of investment and consumer goods. On the other hand, this particular region may be a beneficiary of the effects of public programmes implemented in other parts of Poland, or even Europe. This flow of public policies’ effects on the interregional scale ought to be of great relevance in planning the appropriate allocation of support at regional level. This notion was only partially addressed, if at all, in past evaluation studies in Poland.

The order of chapters in the book creates a cohesive narrative concerning the role of macroeconomic modelling in the evaluation of programmes and public policies. The first text introduces the concept of macroeconomic modelling and its usefulness for the public sector. The following three chapters are devoted to the most recognisable macroeconomic models used for evaluation studies and foresight analysis at regional level in the EU (HERMIN, MASST4 and RHOMOLO). The contents of two further chapters are embedded in the context of evaluating policies oriented at developing innovative capacity. However, the first of the two is of a cross-cutting nature, while the second is dedicated to the VESPA model and the evaluation results of PARP's innovation-oriented activities that incorporate this tool. Further on, the focus shifts to the impact of public policies on the labour market, taking into account the issue of territorial cohesion. The last chapter provides insight into macroeconomic modelling in the broader context of research, considering which enables this method of analysis to become even more useful for evaluation purposes.

Through this publication, we wish to emphasise the value of macroeconomic modelling as a method for not only reporting effects, but above all – generating guidelines regarding the appropriate form of public intervention. However, we are not indiscriminate in doing so. We consider the said method as part of a broader reflection on economic research and its utilitarian value for the public sphere, indicating good practices in terms of specific uses of macromodelling.

**The Editorial Team**



# I. Econometric Modelling in the Evaluation of Policies and Public Programmes – Actual Usefulness for Central and Local Government Authorities

Janusz Zaleski

## Introduction

Planning an undertaking of any kind involves pursuing a predetermined objective. A key element of planning lies in its optimisation dimension, manifested through the application of various optimisation criteria, both qualitative and quantitative. The latter include all criteria of economic optimisation, generally based on optimisation in terms of costs-effectiveness (costs-production, costs-results and costs-impact).

In the public sphere we encounter two types of undertakings: projects and programmes/policies, separated by a rather blurred line in terms of concepts and definitions. In general, a project is understood as a deliberate action, with its own budget, goal, resources and deadline<sup>1</sup>. A programme is generally understood as a public action on a much larger scale, which in the simplest option may consist of a number of conceptually-related projects forming one whole (e.g. the investment National Roads and Motorways Construction Programmes, National Urban Waste Water Treatment Programme, etc.). A concept even broader than a programme is the concept of public policy.

Generally, programmes may be associated with actions and action priorities, leading to the achievement of the predetermined objective with regard to a larger area and

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<sup>1</sup> J.R. Meredith, S.J. Mantel, *Project Management. A Managerial Approach*, Fifth Edition, John Wiley & Sons, 2003.

population. Components do not have to be specific projects. They may be project selection criteria or concepts which are to be analysed in detail and solved during the project's implementation. A good example of this are Operational Programmes implemented under the Cohesion Policy of the European Union (EU).

In the public sphere, we are generally dealing with competition between various interested parties for the right to implement a great variety of undertakings. As a result, the need arose to develop a methodology and evaluation methods for projects and public programmes. These allow for i.e. the marginalisation of discussion on political grounds concerning the issue of which projects and programmes should be prioritised when it comes to implementation, through references to objectivized evaluative criteria and data (empirical evidence).

The second dimension of the discussion on the choice and effects of implementing public undertakings revolves around the fact that they are financed from public funds (regional, national, EU, etc.) which, as such, are obtained through direct or indirect taxation. This is often connected to the territorial relocation of those funds from the areas they were obtained to areas of a temporary or permanent public intervention. Carrying out such activities in a democratic system requires the authorities to be capable of justifying a given policy using the social and political functions of evaluation<sup>2</sup>. This increases the chances of being positively verified in democratic elections and remaining in power.

The third dimension of the discussion on effectively conducted actions and public policies is related to the issue of time. Each public undertaking requires evaluation not only prior to the beginning of its implementation, but also after its completion. In the case of long-term programmes and actions, evaluation in the course of their implementation is also advised. It allows to take into account modifications to a specific programme, based on new facts and up-to-date information.

Taking into account the three dimensions mentioned above takes place on the basis of certain evaluation process standards and is being introduced to the activities of public administration. In Poland, this occurred after the period of social and economic

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<sup>2</sup> Cf. *Ewaluacja. Poradnik dla pracowników administracji publicznej*, Ministry of Regional Development, Warsaw 2012, p. 15 ([https://www.ewaluacja.gov.pl/media/11102/Poradnik\\_ewaluacji.pdf](https://www.ewaluacja.gov.pl/media/11102/Poradnik_ewaluacji.pdf), accessed on 6.07.2019)

transformation commenced in 1989 and formally also in relation to Poland's inclusion in the implementation of EU structural policy, as part of pre-accession measures, and in particular in the scope of operational programmes following accession to the EU. This resulted in particular from the requirements of the European Cohesion Policy<sup>3</sup>, of which Poland is the biggest beneficiary since 2007.

At the national level, this meant the introduction of appropriate standards and procedures concerning such things as feasibility studies, costs and benefits analyses or environmental impact assessments (i.e. ex-ante analyses) for the prepared investments. They should allow for project implementation that is rational and compliant with European standards (taking into account, as well as laying the foundation for, future on-going and ex-post evaluations of the entire group of similar projects) and subordinated to a higher level objective (e.g. at the level of a specific aid scheme or action).

The broadly defined evaluation of prepared and implemented public programmes remained much more complex. In the area of *sensu stricto* evaluation, public administration in Poland works on the basis of principles propagated and required with regard to participation in Union funds. These rules are set out in the form of guidelines, updated for each subsequent budget perspective<sup>4</sup>. It should be emphasised, however, that the process of evaluating public programmes should be looked at from a broader perspective, as a spectrum of procedures and tools which foster the use of Union funds in accordance with European standards (i.e. elements supporting programming, the implementation system, monitoring and appropriate assessment/evaluation of the use of funds). Such tools of a *sensu largo* evaluative nature, allow for the preparation of rational, logical and adequate

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<sup>3</sup> In particular, the so-called "general" regulations for EU Cohesion Policy funds (e.g. Regulation (EU) No 1303/2013 of the European Parliament and of the Council of 17 December 2013 laying down i.a. common provisions on the European Regional Development Fund, European Social Fund and the Cohesion Fund), or the analogous Council Regulation (EC) No 1083/2006 of 11 July 2006 for the 2007–2013 perspective.

<sup>4</sup> e.g. European Commission (EC) guidelines entitled "The Programming Period 2014–2020: Guidance document on monitoring and evaluation – European Cohesion Fund, European Regional Development Fund. Concepts and Recommendations", European Commission (DG REGIO), Brussels 2014 ([https://ec.europa.eu/regional\\_policy/sources/docoffic/2014/working/wd\\_2014\\_en.pdf](https://ec.europa.eu/regional_policy/sources/docoffic/2014/working/wd_2014_en.pdf), accessed on 6.07.2019) or the national guidelines of the Minister competent for Regional Development, i.e. Guidelines of 22 September 2015 (as amended) on Cohesion Policy 2014–2020 evaluation, Ministry of Infrastructure and Development, Warsaw 2015 (<http://www.funduszeuropejskie.gov.pl/strony/o-funduszach/dokumenty/wytyczne-w-zakresie-ewaluacji-polityki-spojnosci-na-lata-2014-2020>, accessed on 6.07.2019).

public programmes (including ones which take into account specific social and economic conditions). The key elements of such evaluation are:

- social and economic diagnosis,
- system of indicators for programme implementation monitoring, along with target values,
- *ex-ante* assessment, including assessment of the macroeconomic impact of programme implementation,
- strategic prognosis of environmental impact,
- public consultation on the document, prior to its adoption for implementation.

The public administration in Poland started activities related to assessment on a broad scale<sup>5</sup> in 2002. They were connected to the National Development Plan 2004–2006 (NDP 2004–2006) and the related Operational Programmes being prepared for consultations with the EC. Experiences from previous years, including observations of activities at central (Ministry competent for Regional Development, Ministry of Finance), regional and local (Marshal Offices and selected gmina local governments) level, make it possible to assess how broadly-defined evaluation mechanisms of the use of public programmes function in Poland and with what results.

The main aim of the Chapter is to present reflections on the usefulness of applying macroeconomic modelling in the broadly-defined evaluation of programmes and public policies for shaping the development of Poland and its regions. The Chapter presents the main research tools of that kind used in Poland and the EU, as well as their evolution over the last dozen years. Lastly, findings will be presented concerning the exploitation of possibilities offered by econometric modelling by central and local authorities so far. Additionally, valuable directions for its use in future evaluation studies will be indicated.

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<sup>5</sup> On a much broader scale than was the case with pre-accession measures in that area, coordinated by the Office of the Committee for European Integration and as part of grassroots evaluation initiatives, such as the Polish Agency for Enterprise Development or the Implementing Authority for the Cross-Border Cooperation Programme Phare.

# Macroeconometric Modelling as a Tool in Evaluation Studies – Conditions for its Proper Use

Macroeconometric modelling is a tried and tested tool used for conducting research into the social and economic development of economically cohesive areas. Countries and their national economies undoubtedly are such areas. On account of the above, macroeconometric modelling is applied primarily to national economies which meet the following basic requirements:

- they are described by available statistical data detailing the historical and current values of primary variables, relating to social and economic phenomena, necessary for modelling,
- groups of experts involved in macroeconometric modelling operate within them, which have sufficient experience in building and using macroeconometric models in conjunction with knowledge of the mechanisms of the national economy.

The second condition is not obligatory, as it is possible for external experts to construct and use a macroeconometric model. Nevertheless, it should be expected that in such a case problems may occur at the level of calibration and simulation, caused by lack of direct contact with social and economic processes of the area, for which the model is being constructed.

In closed economies, characterised by a relatively low importance of foreign trade and a high level of regulation, there was no need for, nor much sense in, constructing models for areas larger than the country. However, as economies began opening for foreign trade and such exchanges became more liberalised, demand emerged<sup>6</sup> for models of transnational systems (i.a. EU, NAFTA). An area known for its wide variety of transnational econometric models is the EU. On one hand, the EC supported the development of the QUEST model,

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<sup>6</sup> It should be noted, that this was a long and gradual development process, which triggered the economic policy's demand for such models, and economic sciences, in response to the identified demand, provided the appropriate econometric models in due time. It is difficult to pinpoint the exact dates, when the breakthrough occurred.

used for constructing models of EU economy<sup>7</sup>, on the other hand, the European Central Bank (ECB) contributed to the development of macroeconomic modelling as regards the euro area – the Smets-Wouters model<sup>8</sup>. Academic institutions also play a leading role in that regard. The NiGEM model<sup>9</sup> is a good example of this. Transnational models most often have internally defined subcomponents for the different national economies. This is both due to utilitarian reasons (separate mechanisms of national governments exercising impact on the economy, e.g. public expenditure policy), as well as due to cognitive reasons (results presented in a multilevel system enable comparative analysis).

A relatively new direction in macroeconomic modelling are the attempts to use it at regional and national level simultaneously. This is justified only when all of the following conditions are met:

- an autonomous regional entity exists, which has a social and economic policy distinctly independent from central authorities,
- objective statistical data is available, the length and scope of which allows for the construction and use of macroeconomic models,
- there is a practical and cognitive need for the results of such modelling,
- the modelling team has the relevant knowledge of real processes which occur in the regional economy, on the basis of which the model is being constructed.

At present, Poland meets the above conditions. As a result of the administrative reform of 1999, sizeable voivodeships were created, with autonomous regional authorities in the form of a Marshal, a Voivodeship Board and a Sejmik of the Voivodeship. These authorities have sufficient competencies to be in charge of their own regional policy. The possibilities for developing and implementing a social and economic policy at regional level are certainly more limited than at national level. Nevertheless, the current degree of voivodeships' independence (in particular, taking into account voivodeship authorities managing significant funds allocated

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<sup>7</sup> M. Ratto et al., "QUEST III: An Estimated Open-Economy DSGE Model of the Euro Area with Fiscal and Monetary Policy", *Economic Modelling* 2009, vol. 26, No 1, pp. 222–233 (also published as: European Economy Economic Paper 335); J. Varga, J. in 't Veld, "A Model-based Analysis of the Impact of Cohesion Policy Expenditure 2000–06: Simulations with the QUEST III endogenous R&D model", *Economic Modelling* 2011, vol. 28, No 1–2, pp. 647–63 (also published as: ECFIN European Economy Economic Paper 387).

<sup>8</sup> F. Smets, R. Wouters, "An Estimated Stochastic Dynamic General Equilibrium Model of the Euro Area", *Journal of European Economic Association* 2003, vol. 1, No 5, pp. 1123–1175.

<sup>9</sup> NIESR (National Institute of Economic and Social Research), *Recent developments to the NiGEM Model. The World Model Manual*, NIESR 1997.

to Regional Operational Programmes) justifies the use of tools such as macroeconomic modelling for evaluating the impact of policies. This must, however, involve considering social and economic links between the modelled region and the entire country's economy, as a very important part of the macroeconomic model under construction.

The steady development of public statistics in Poland, presenting data at regional level, should be considered as a positive impulse for modelling the economies of Polish voivodeships. There are also research groups with substantive potential, guaranteeing the reliability of such analyses' implementation. Together with the continuous demand of public authorities for simulation results, this provides a strong basis for the development of macroeconomic modelling at regional level.

## Development of Macroeconomic Modelling for Assessing the Impact of Public Interventions on Social and Economic Development in the years 2002–2019

It should be noted that prior to Poland joining the EU, macroeconomic modelling was used for the assessment of the impact of large scale public interventions (programmes/policies) on the country's or regions' social and economic development only to a limited extent. In the pre-accession process it became necessary to make the appropriate preparations to conduct *ex-ante*, ongoing and *ex-post* assessments of the basic document being a prerequisite for access to EU funds – NDP 2004–2006, followed by Operational Programmes. The relevant EC guidelines were the factor which outlined the directions for the construction of macroeconomic models used for such analyses or for adjusting existing models. It should be emphasised that the Commission modified its approach to valuation of proposed programmes and public policies based on macroeconomic tools. This was expressed through changes to the requirements concerning macroeconomic modelling. It is worth mentioning that the guidelines for the 2000–2006 Financial Perspective, in which Poland participated since May 2004, were the most detailed ones and largely determined the development of macroeconomic impact assessment

of European funds in Poland<sup>10</sup>. Firstly, they listed specific indicators which were subject to the assessment of social and economic development: national/regional GDP, level of employment measured through the unemployment rate, productivity, unit labour costs. They were referred to as the baseline indicators for Goal 1 of the Cohesion Policy of that period. The aforementioned guidelines also pointed to the need of comparing two scenarios (counter-factual analysis): “without support from the Cohesion Policy” and “with support from the Cohesion Policy”, in both cases with the omission of funding from the private sector<sup>11</sup>. Additionally, requirements concerning the structure of macroeconomic models were set out:

- a macroeconomic model should contain a demand and a supply part. The former should reflect the impact of EU funds in the areas of infrastructure, human capital and entrepreneurship,
- the basic variables explained are: GDP, investments, employment, remuneration, inflation, budget deficit, import and export,
- taking into account opportunity costs of the so-called effects of alternative spending of EU funds and national co-financing (so-called opportunity cost analysis),
- depicting how the scale of the effects changes when the level of financing from the Cohesion Policy is modified (“sensitivity analysis”).

Further guidelines in that respect were published for the programming period of 2007–2013 and announced in August 2006.<sup>12</sup> They were very similar to the guidelines from 1999. A requirement was added, to distinguish the effects related to investments in research and implementation of its results. Moreover, sensitivity analysis was to take into account not only possible changes in EU funds spending, but also changes in social and economic policy.

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<sup>10</sup> EC DG REGIO, “The Ex-Ante Evaluation of the Structural Funds interventions, The New Programming period 2000–2006: methodological working papers”, *Working paper* No 2, 2000.

<sup>11</sup> The omission of funding from the private sector was a reasonable assumption, since in the case of projects financed in that sector, it is challenging to adopt reliable assumptions about the scale of such co-funding. It can be 50% at a minimum, but it may just as well be 90% of the project’s value. It is therefore difficult to determine the extent to which the omission of the private sector affected the scale of obtained results in the area of macroeconomic impact, without running the appropriate simulations.

<sup>12</sup> EC DG REGIO, “Indicative Guidelines on Evaluation Methods: Ex Ante Evaluation”, *Working Document* No 1, 2006.

For the purpose of carrying out macroeconomic analyses, the Commission used its own QUEST model<sup>13</sup>, preferred by the Directorate-General for Economic and Financial Affairs (DG ECFIN), and a HERMIN model used by the Directorate-General for Regional and Urban Policy (DG REGIO). Modelling took place at the level of national economies. Both models were developed over many years, with support from the EC, by independent research centres.

The Polish government administration, in charge of preparing, planning and carrying out the process of evaluating the macroeconomic impact of EU funds, mobilised academic circles to create models which meet EC requirements. As a result, in the years 2002–2004, the HERMIN methodology was adopted for Poland at the level of a national model and then at the level of models of Polish voivodeships' economies – with help from its author, John Bradley.

HERMIN methodology<sup>14</sup> blazed the trail in terms of evaluating the macroeconomic impact of public interventions in Poland. The first HERMIN model was constructed towards the end of the 80s for the purpose of analysing the Irish economy. In subsequent years, it served as a basis for models of all Member States (including countries which joined the EU in the years 2004 and 2007)<sup>15</sup>. Regional models were also constructed for the Italian region of Mezzogiorno, eastern States in Germany, as well as Polish, Slovak and Czech regions. In Poland, HERMIN methodology was implemented by a team from the Wrocław Regional Development Agency, in cooperation with John Bradley.

HERMIN is a *sensu stricto* macroeconometric model, meaning it is not based on the general equilibrium theory. It is, however, based on analysis of time series which at the same time uses economic theories<sup>16</sup>. It is a 5-sector model which incorporates: industry, market and non-market services, construction and agriculture. At present, HERMIN models in Poland include: the national model, 16 independent regional models, a system of integrated

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<sup>13</sup> More information on the QUEST model can be found in Chapter 5.

<sup>14</sup> J. Bradley et al., "Modelling in the EU Periphery. The Hermin Project", *Economic Modelling* 1995, vol. 12, No 3, s. 219–220; J. Bradley, G. Untiedt, *The COHESION System of HERMIN Country and Regional Models: Description and Operating Manual. Version 3*, GEFRA, EMDS, Muenster 2008.

<sup>15</sup> J. Bradley et al., *The Cohesion System of HERMIN Models: CSHM, DG REGIO, EMDS, GEFRA, WARR*, Sixth European Conference on Evaluation of Cohesion Policy: New Methods for Cohesion Policy Evaluation. Promoting Accountability and Learning, Warsaw, November 30 – December 1, 2009.

<sup>16</sup> The HERMIN model combines neo-Keynesian and neoclassical characteristics. The next Chapter of the book deals with this subject in more detail.

HERMIN models of voivodeships' economies, as well as a model of the economy in the capital city of Warsaw<sup>17</sup>.

For the purpose of macroeconomic impact assessment, the administration in charge of implementing EU Cohesion Policy in Poland demonstrated the need for alternative models to HERMIN, which would meet EC requirements. This led to the development of two new research tools enabling Cohesion Policy impact analysis. These were general equilibrium models MaMoR3 and EUImpactMod, used by the Ministry of Regional Development for macroeconomic impact assessment of EU Cohesion Policy implemented in Poland since 2007.

MaMoR3 is a national model, extended to include regional segments in 2008. It belongs to the group of general equilibrium models "Computable General Equilibrium", or CGE models in short. It is a tool which, aside from the national economy, also allows for research into certain economic aspects at the level of voivodeships. MaMoR3 considers regional economies to be fully autonomous as regards the process of product generation, consumption and investments. It also assumes that the economic situation in a particular voivodeship depends on processes taking place in other regions of the country. In the MaMoR3 model, relations with foreign countries are based on the mechanisms of a small,

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<sup>17</sup> Complete and detailed information on Polish implementation of the model on the national and regional level can be found in: J. Bradley, J. Zaleski, "Ocena wpływu Narodowego Planu Rozwoju Polski na lata 2004–2006 na gospodarkę przy zastosowaniu modelu HERMIN", *Gospodarka Narodowa* 2003, No 7/8, pp. 18–45; J. Bradley, J. Zaleski, *Modelling EU accession and Structural Fund impacts using the new Polish HERMIN model*, paper presented at the 2002 Macromodels International Conference & Modelling Economies in Transition, AMFET, Cedzyna, 4–7 December 2002; J. Zaleski, *Regionalisation of the HERMIN macroeconomic modeling framework in Poland*, Sixth European Conference on Evaluation of Cohesion Policy: New Methods for Cohesion Policy Evaluation. Promoting Accountability and Learning, Warsaw, November 30 – December 1, 2009; J. Bradley et al., *Regionalny model HERMIN gospodarki województwa dolnośląskiego – Podręcznik*, Wrocław 2005 (analogous reports for other voivodeships); Z. Mogiła, J. Zaleski, "Modelling territorial cohesion as an inter-related process", in: *Territorial Cohesion: A missing link between economic growth and welfare. Lessons from the Baltic Tiger*, Gdańsk 2017, pp. 169–204 and additionally in the next Chapter of the book. The results of HERMIN modelling for Polish regions were presented i.a. in: European Commission, *Investing in Europe's future, Fifth Report on Economic, Social and Territorial Cohesion*, Brussels 2010, pp. 248–254.

open economy. This means that, for instance, entities consider prices on international markets to be data.<sup>1819</sup>

EUImpactMod II/III/IV – are subsequent versions of the DSGE-type model i.e. a dynamic, stochastic general equilibrium model. According to its assumptions, households and companies, operating in conditions of uncertainty, make decisions which maximise the expected usability and expected profit respectively, given budget and production constraints. EUImpactMod is a model of a small, open economy. In the case of this model, processes taking place in the global economy have an exogenous character. In the process of constructing this research tool, special attention was paid to the expansion of the fiscal sector, which allowed to record the effects of a specific public intervention on the public finances sector<sup>20</sup>.

In the period after 2012, on account of the needs for expert analyses of the impact of public funds in terms of innovation, expenditure on research and development, climate change and energetics, further models were developed and used in macroeconomic assessments in Poland. The following models should be mentioned in this context:

- VESPA – a large-scale structural macroeconomic model, based on dynamic stochastic general equilibrium methodology (DSGE). The model's construction is based on microeconomic foundations, to the fullest extent possible. The model's basic structure consists of several related modules: households, manufacturing companies, banks, the

<sup>18</sup> A description of the national MaMoR3 model is available in the literature (i.a. T. Kaczor et al., *Wpływ realizacji polityki spójności na kształtowanie się głównych wskaźników dokumentów strategicznych NPR 2004–2006 i NSRO 2007–2013*, Gdańsk, Warsaw 2009), however, the detailed methodology of data calculation for particular voivodeships with the use of this tool has not been published.

<sup>19</sup> The assumption of a small, open economy is typical for macroeconomic models describing the economy of countries, whose scale is too small to have an impact on prices on global markets. This is why the assumption is adopted of an exogenous (independent from processes taking place in the given small, open economy) impact of external markets on the modelled economy.

<sup>20</sup> Detailed descriptions of regional mechanisms incorporated in the EUImpactMod model were not published, although the national model itself was described extensively (M. Bukowski, D. Pelle, *Wpływ realizacji polityki spójności na kształtowanie się głównych wskaźników dokumentów strategicznych – Narodowego Planu Rozwoju 2004–2006 i Narodowej Strategii Spójności 2007–2013 oraz innych wybranych wskaźników makroekonomicznych na poziomie krajowym i regionalnym – raport roczny: Część II – zestawienie wyników*, Warsaw 2009; M. Bukowski, D. Pelle, *Wpływ realizacji polityki spójności na kształtowanie się głównych wskaźników dokumentów strategicznych – Narodowego Planu Rozwoju 2004–2006 i Narodowej Strategii Spójności 2007–2013 oraz innych wybranych wskaźników makroekonomicznych na poziomie krajowym i regionalnym – raport metodologiczny*, Warsaw 2009).

R&D sector and the government. In the national version, modelling takes place on the basis of 19 subsectors of the economy. Meanwhile, in the regional version (7 subregions) three sections were distinguished: agriculture, industry and services.<sup>21</sup> A detailed description of the model can be found in Chapter 6.

- EduMod – an application based on the hybrid DGSE model (its main part is a module implementing the DSGE-type model, complemented by so-called external models, which in the majority of cases are flow models based on Markov chains). It models phenomena related to educational decisions and policies and human capital in the context of the economy as a whole. It can be used at both national and regional level.<sup>22</sup>
- PomMOD – a multi-sector, dynamic, stochastic general equilibrium model (DSGE) used for the purpose of analysing the economy of Pomorskie Voivodeship. It is based on the EUImpactMod model. Modification of the model included, among other things, a change to the sectoral structure (on account of limited access to data at voivodeship level) and the introduction of mechanisms responsible for simulating the extended intervention catalogue (e.g. addition of the R&D sector)<sup>23</sup>.

They are used in impact evaluation at national and regional level.

In the years 2008–2010, before the next programming period 2014–2020, DG REGIO commissioned a research project, which led to the development of the RHOMOLO model – a dynamic, spatial general equilibrium model, enabling the analysis of public policies' impact at the level of all NUTS-2 EU regions<sup>24</sup>. Upon the project's completion by an independent research company (Netherlands Organisation for Applied Scientific Research – TNO), the Joint Research Centre (JRC) of the EC in Seville took over the project to further develop and use it.

<sup>21</sup> WiseEuropa Foundation & OPI PIB, *Analiza wybranych działań PO IG na poziomie sektorowym i makroekonomicznym za pomocą modelu przepływów międzygałęziowych. Raport Końcowy*, Warsaw 2017.

<sup>22</sup> IBS, *EduMod: Model symulacyjno-prognostyczny polskiej gospodarki uwzględniający zjawiska związane z kapitałem ludzkim. Raport podsumowujący projekt*, Warsaw 2015.

<sup>23</sup> IBS, *Ocena efektów realizacji Regionalnego Programu Operacyjnego dla Województwa Pomorskiego na lata 2007–2013*, Warsaw 2017.

<sup>24</sup> The model's detailed description can be found in Chapter 3 of the present book, as well as in reports (O. Ivanova et al., *Study on the "System of Regional Models for Impact Assessment of EU Cohesion Policy", third interim report*, TNO, Brussels 2010; A. Ferrara et al., "Modelling the Policy Instruments of the EU Cohesion Policy", *Working Paper No 2/2010*, European Commission, Regional Policy 2010; P. Lecca et al., "Znaczenie analizy międzyregionalnych efektów polityk UE – zastosowanie modelu RHOMOLO dla Polski", pp. 50–67 in the present publication).

RHOMOLO is a model intended solely for counter-factual analysis of macroeconomic impact. Its purpose is not, however, to predict the social and economic development of EU regions.

Nevertheless, this model became the leading tool in macroeconometric analyses and evaluations conducted by DG REGIO. This may explain why, in the next EC guidelines (from March 2014), concerning evaluation for the 2014–2020 financial perspective, there were no longer any detailed requirements for macroeconomic modelling<sup>25</sup>. This seems to be connected with the fact that the RHOMOLO model did not meet the former requirements on account of its entirely different nature and structure. Any significant change in expectations, eliminating all former models developed not only in Poland, but also in other countries covered by the Cohesion Policy, would be impossible to justify in a substantive manner. The waiver of detailed guidelines also had its positive aspects, as it created a space for Member States to choose the model type and at the same time, it enriched methodological diversity. However, as a result it is more difficult to compare the impact results for the respective countries and regions covered by the Cohesion Policy, as they are obtained through very different modelling tools.

Guidelines for the 2014–2020 period are essentially limited to the need to conduct counter-factual analyses. They do not specify any particular expectations when it comes to the tools used for macroeconomic impact assessment. This means that in macroeconomic analyses of Cohesion Policy, DG REGIO currently limits itself to using only its proprietary RHOMOLO model and the JRC's calculations. Meanwhile, Member States and regions covered by the Cohesion Policy can in principle conduct analogous analyses, for instance by using formerly applied macroeconomic models – the majority of which are still being developed by regional and national research centres. It ought to be emphasised that many such models may at the same time be used for forecasts and scenario analyses, provided that the modelling team is well-prepared. However, the RHOMOLO model – at its current level of development – cannot be used to conduct such studies.

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<sup>25</sup> Cf. [https://ec.europa.eu/regional\\_policy/en/information/legislation/guidance/](https://ec.europa.eu/regional_policy/en/information/legislation/guidance/) (accessed on 6.07.2019). The EC guidelines only mention that macroeconomic models may be used as one of the approaches to the evaluation of big, complex and comprehensive programmes (Cf. *The Programming Period 2014–2020: Guidance document on monitoring and evaluation – European Cohesion Fund, European Regional Development Fund. Concepts and Recommendations*, European Commission (DG REGIO), Brussels 2014, p. 9).

There is no indication that in the next 2021–2027 financial perspective the situation outlined above will change. One may even expect the strengthening of the RHOMOLO model's position, as DG REGIO's main tool for counter-factual analyses of macroeconomic impact.

An important and only equivalent of RHOMOLO designed for modelling all EU regions is the MASST (Macroeconomic, Sectoral, Social, Territorial) model, created at the Polytechnic University of Milan by a team led by Professors R. Capello and R. Camagni.<sup>26</sup> MASST is a macroeconometric model based on endogenous growth theories, in which the competitiveness of the economic system depends on such structural elements as human capital, knowledge, workforce and the economy's capacity for accumulating them over time through endogenous and mutually-reinforcing mechanisms.<sup>27, 28</sup>

## Summary

On account of Poland joining the EU, a culture of evaluating policies and public programmes is gradually taking shape, in which an important role is played by macroeconomic modelling.

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<sup>26</sup> R. Capello, A. Caragliu, "Ilościowa analiza *foresight* na poziomie regionalnym – makroekonomiczny model MASST", pp. 68–83 in the present publication; R. Capello, "A Forecasting Territorial Model of Regional Growth: the MASST Model", *Annals of Regional Science* 2007, vol. 41, No 4, pp. 753–787.

<sup>27</sup> R. Capello, "A Forecasting Territorial Model of Regional Growth: the MASST Model", *Annals of Regional Science* 2007, vol. 41, No 4, pp. 753–787. A more in-depth description of this model's properties can be found in Chapter 4 of the present book.

<sup>28</sup> Elements of the endogenous growth theory are used by different macroeconomic models, to a different extent. The outcomes of this line of considerations about economic growth processes are largely incorporated into general equilibrium models. The assessment of their impact on macroeconomic simulations, however, would require in-depth analysis of the equation structure of each model, which goes beyond the scope of this paper. The issue of the endogenous growth theory should not be confused with the assumption about the exogenous character of economic processes taking place in the surrounding area of a particular country or region. It may be said that in the case of models reflecting economic processes in Poland and its regions, the assumption about the exogenous character of the economic environment is adopted, while the conclusions related to the endogenous growth theory are implemented to a varying extent. The use of the aforementioned theories does not, in itself, implicate the notion of the model's high cognitive value. Only the assessment of the model's structure through the lens of the verification of its results against historical data and sensitivity analysis (e.g. through simulations combined with various macroeconomic assumptions) would allow for more meaningful assessment of the different models.

It ought to be noted, however, that in recent years the EC, which initiated this process under the EU Cohesion Policy is implementing activities in the area of modelling, which in practice lead to the monopolisation of macroeconomic impact assessments at EU level and narrow them down to only one methodology, which can be considered as inconsistent with general evaluation standards. For instance, in the document “*The Programming Period 2014–2020, Guidance Document on Monitoring and Evaluation – European Regional Development Fund and Cohesion Fund, Guidance for the Terms of Reference for Impact Evaluations*”<sup>29</sup> it is indicated that:

- “The Commission services consider it as best practice to assign the evaluation to external experts or to a different organisation from that responsible for implementing the programme and any of the intermediate bodies reporting to it. With regard to the issue of functional independence, this arrangement does not raise any doubts.
- A good practice is to assign the implementation of the programme and the evaluation to different departments within the same organisation (usually in a ministry)”.

At present, macroeconomic impact evaluations are and will be carried out on behalf of DG REGIO by the JRC in Seville, as the sole operator of the RHOMOLO model. Therefore, DG REGIO does not implement the solution indicated as the best practice in the Guidelines, although the path taken by this institution is of course permissible. This leads to macroeconomic impact analyses being monopolised at EU level and limited to a single methodology. As G.E.P. Box once said, “All models are wrong, but some are useful”<sup>30</sup>. Given that no model faithfully reflects the social and economic realities and each can constitute a somewhat useful simplification of real mechanisms, in studies concerning the impact of EU Cohesion Policy different models, based on various theoretical foundations, should be used in equal measure. If these models generate similar results, their credibility will be greater. Meanwhile, if we obtain divergent results, this gives reason for detailed, additional analyses and for approaching the results of each modelling with caution. Methodological diversity allows for a broader spectrum of information on a particular intervention to be obtained. This eventually leads to the increase of the actual usefulness of the results generated by the model, information-wise.

<sup>29</sup> EC DG REGIO, *The Programming Period 2014–2020, Guidance Document on Monitoring and Evaluation – European Regional Development Fund and Cohesion Fund, Guidance for the Terms of Reference for Impact Evaluations*, 2013.

<sup>30</sup> G.E.P. Box, R. Draper, *Empirical model-building and response surfaces*, John Wiley & Sons, Oxford, England 1987.

In Poland, there was a period when counter-factual analyses of the macroeconomic impact of Cohesion Policy<sup>31</sup> were commissioned by the relevant ministry competent for regional development, in two or even three different centres using varying models (MaMoR, EUImpactMod and HERMIN). As a result, a space for discussion was created, both on the topic of modelling, as well as on the different tools. Above all, this enabled a debate on the topic of the results obtained and the reasons for the differences between them with persons in charge of implementing the development policy in a country or region. The competitive elimination process for selecting one contractor is currently applied, however, in subsequent few year periods this leads to the simulation being carried out by different contractors using various modelling tools. The outcome is lack of methodological continuity and of comparability between results obtained in subsequent periods. A benefit is the reduction of evaluation studies' costs. It would seem justified to resume the practice of conducting such analyses in research centres, using different macromodels. These could be for instance DSGE, neoknesian, hybrid, econometric models based on different theoretical foundations.

If several research centres were to provide assessments of the macroeconomic impact of public policies, the discussion on the differences between the obtained results would be effectively animated. This problem may undermine the usefulness of<sup>32</sup> macroeconomic studies from the decision makers' standpoint.

In the context of modelling the effects of policies and development programmes in Poland in itself, it should be noted that over the last dozen years, a rather broad spectrum of macroeconomic models was created. Additionally, experts emerged who are capable of carrying out evaluation studies using these tools. A possible problem may be associated with the fact that thus far the usefulness of macroeconomic models for central and local government authorities consisted for the most part in estimating the impact

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<sup>31</sup> Analyses falling within the exact same thematic scope and serving the same purpose.

<sup>32</sup> In particular when it comes to large-scale discrepancies, as was the case with the comparison between the assessment of benefits for countries which are net contributors resulting from the implementation of Cohesion Policy in Poland, in research conducted by Bradley, Untiedt and Zaleski (J. Bradley et al., "The Economic Return of Cohesion Expenditure for Member States", *Study Number PE 419.106*, European Parliament, Directorate-General for Internal Policies, Policy Department B, Structural and Cohesion Policies, May 2009 <http://www.europarl.europa.eu/studies>, accessed on: 15.05.2019) for the European Parliament and the IBS (IBS, *Jak Państwa UE-15 korzystają z realizacji polityki spójności w krajach grupy wschodniej?*, Warsaw 2017 <https://www.ewaluacja.gov.pl/media/41768/UE15KorzysciRk.pdf>, accessed on: 15.05.2019) for the Polish Ministry of Regional Development.

of specific interventions on the GDP or the number of people in employment. Therefore, the information function of modelling was most frequently used, and the demand for counter-factual analyses stemmed mostly from the formal obligation to use modelling in assessing the macroeconomic impact of operational programmes.

It ought to be underlined that macroeconomic modelling may be a valuable tool for decision makers in programming and then implementing development policies at national and regional level. This occurs, for instance, when its use consists in analysing different options of political interventions. Once they are expressed as different scenarios and translated into the model's assumptions, the simulation's results may be helpful when choosing an intervention. Preference should be given to the options, which show better effects in the results of macroeconomic modelling as regards the indicators adopted as criteria for achieving the aims of such an intervention.<sup>33</sup> Another important source of macromodelling usefulness for decision makers is the analysis of interregional effects of public policies. The results of such a study may have a real impact on the algorithm of EU funds allocation. Attention should also be drawn to issues related with internal diversification of regional economies, territorial cohesion at the level of voivodeships, as well as the development of metropolitan economies, in particular the circumstances of each economy in terms of the labour market and innovativeness.

The source of increased usefulness of macroeconomic modelling may also be its autonomous use by government and local government administration. For instance, the RHOMOLO model is made available for calculations in the form of a computer application for registered users who gain access and can run their own simulations. Registered users cannot change the model's parameters; they can, however, enter different amounts of financial transfers for particular regions, in specific expenditure categories. The HERMIN-REG application, based on the HERMIN model structure, operates on a similar basis. In both cases policy makers gain access to a simple and transparent tool, which enables them to run simulations quickly and to use their results for such purposes as internal discussions and analyses, as well as in official reports.

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<sup>33</sup> The usefulness of foresight scenario analyses is presented in Chapter 2 (HERMIN model) and Chapter 4 (MASST model).

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36. Varga J., in 't Veld J., "A Model-based Analysis of the Impact of Cohesion Policy Expenditure 2000–06: Simulations with the QUEST III endogenous R&D model", *Economic Modelling* 2011, vol. 28, No 1–2, pp. 647–63. (also published as: ECFIN European Economy Economic Paper 387.)
37. WARR, *Ocena wpływu realizacji polityki spójności w ramach NSRO 2007 2013 na rozwój społeczno-gospodarczy Polski za pomocą ilościowego modelu ekonomicznego*, Wrocław 2016.

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# II. Development of HERMIN Models in Poland in the Context of Evaluation Studies

Zbigniew Mogiła

## Introduction

The HERMIN models were developed for the purpose of evaluating the effectiveness of EU Cohesion Policy. Their creator J. Bradley aimed for a favourable compromise between a strictly theoretical approach to economy (characteristic of such models as the Dynamic Stochastic General Equilibrium, DSGE) and referring solely to historical economic processes (as is the case e.g. with vector auto-regression models, VAR). Calibrating the HERMIN models based- among others- on the projected structural changes occurring in the economy renders them more resilient against the so-called Lucas critique<sup>34</sup>. Yet at the same time they do not operate in the corset of formal limitations, which are difficult to accept, as their premise lies, among other things, in full economic rationality and the economy's propensity to gravitate towards general equilibrium.

This chapter aims to present the potential of HERMIN models as tools for evaluating public policies and programmes. These evolved alongside the models. The focus was set on:

- counter-factual analysis, allowing to evaluate the impact of public investments (implemented through strategies, operational programmes, etc.) on socio-economic processes;
- scenario analysis (quantitative foresight);
- analysis which takes into account interregional relations;
- analysis of metropolitan economies.

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<sup>34</sup> A critical opinion expressed by Robert Lucas with regards to the usefulness of econometric models in economic policy analysis. It is grounded in the belief that model parameters estimated on the basis of historical data are not policy-invariant. R. Lucas, *Econometric Policy Evaluation: A Critique*, Carnegie-Rochester Conference Series on Public Policy, 1976, pp. 19–46.

To illustrate the above research areas, elements of evaluation studies concerning territorial areas of different scale were applied<sup>35</sup>.

## Basic Characteristics of HERMIN Models as Evaluation Tools

The HERMIN models distinguish five sectors of the economy: manufacturing (main sector subject to trade on the international market), market services, non-market services, building and construction, and agriculture. The models' structure rests on three blocks: supply, absorption and income. Together they form an integrated system of identity and behavioural equations, reflecting the logic of the national accounts (Figure 1).

Conventional Keynesian mechanisms are at the core of the models. However, these tools also possess neoclassical features<sup>36</sup>. Output in manufacturing is not only driven by demand. It is also influenced by cost competitiveness<sup>37</sup>. Moreover, the demand for production factors in manufacturing and market services is estimated through a neoclassical optimisation process, using a CES production function constraint (constant elasticity of substitution) and the relative prices of labour and capital. Introducing the relationship described by the Phillips

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<sup>35</sup> A. Jarosz, Z. Mogiła, S. Skóra, A. Tiukało, J. Zaleski, *Ocena wpływu realizacji polityki spójności w ramach NSRO 2007–2013 (z wyszczególnieniem wpływu wybranych programów operacyjnych) na rozwój społeczno-gospodarczy Polski za pomocą ilościowego modelu ekonomicznego*, Report commissioned by the Ministry of Investment and Economic Development, Wrocław Regional Development Agency, Wrocław 2016; J. Kudełko, Z. Mogiła, A. Poproch, P. Tomaszewski, M. Zaleska, J. Zaleski, *Prognoza trendów rozwojowych województwa warmińsko-mazurskiego*, Report commissioned by the Office of the Marshal of Warmińsko-Mazurskie Voivodeship. Wrocław Regional Development Agency, Wrocław 2012; B. Król, Z. Mogiła, W. Paluch, S. Skóra, A. Tiukało, J. Zaleski, *Bilans efektów międzyregionalnych polityki spójności 2014–2020 dla Dolnego Śląska*, Report commissioned by Dolnośląskie Voivodeship – Institute for Territorial Development. Wrocław Regional Development Agency, Wrocław 2017; A. Jarosz, Z. Mogiła, S. Skóra, A. Tiukało, M. Wysocka, M. Zaleska, J. Zaleski, *Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju m.st. Warszawy*, Report commissioned by the Office of the Capital City of Warsaw, Wrocław Regional Development Agency, Wrocław 2016.

<sup>36</sup> In other words, the structure of HERMIN models combines a demand-side approach, according to which production is determined by private and public consumption (a Keynesian element), with the supply-side approach, according to which the volume of produced goods and services depends on the factors of production and their efficient utilisation in the production process.

<sup>37</sup> J. Bradley, J. FitzGerald, "Industrial output and factor input determination in an econometric model of a small open economy", *European Economic Review* 1988, vol. 32, pp. 1227–1241.

curve<sup>38</sup> to the wage bargaining mechanism constitutes a yet another channel for taking into account relative prices.

In counter-factual evaluation studies, the HERMIN models generate two types of effects: on the demand side and on the supply side. The former are related to the Keynesian multiplier mechanism. Public investments contribute to an increase in the income of the programme's beneficiaries. This is in turn spent on the purchase of goods and services from other economic sectors, thus increasing output and generating new income, which in a subsequent round will be spent on consumption and investments. Such multiplication leads to GDP growth. Supply effects manifest in the long term (also after the funds implementation is completed) and are related to i.a. development and modernisation of basic infrastructure, greater competitiveness and innovativeness of the enterprise sector, as well as an increase in the resources and quality of human capital. Their estimation takes into account the parameters responsible for the scale of supply effects (known as "spill-over elasticities"). These parameters were set for output and labour productivity in three economic categories: basic infrastructure, human capital and R&D. Additional parameters were distinguished for the manufacturing and market services sector (Table 1).

**Table 1.** Types of "spill-over elasticities" parameters

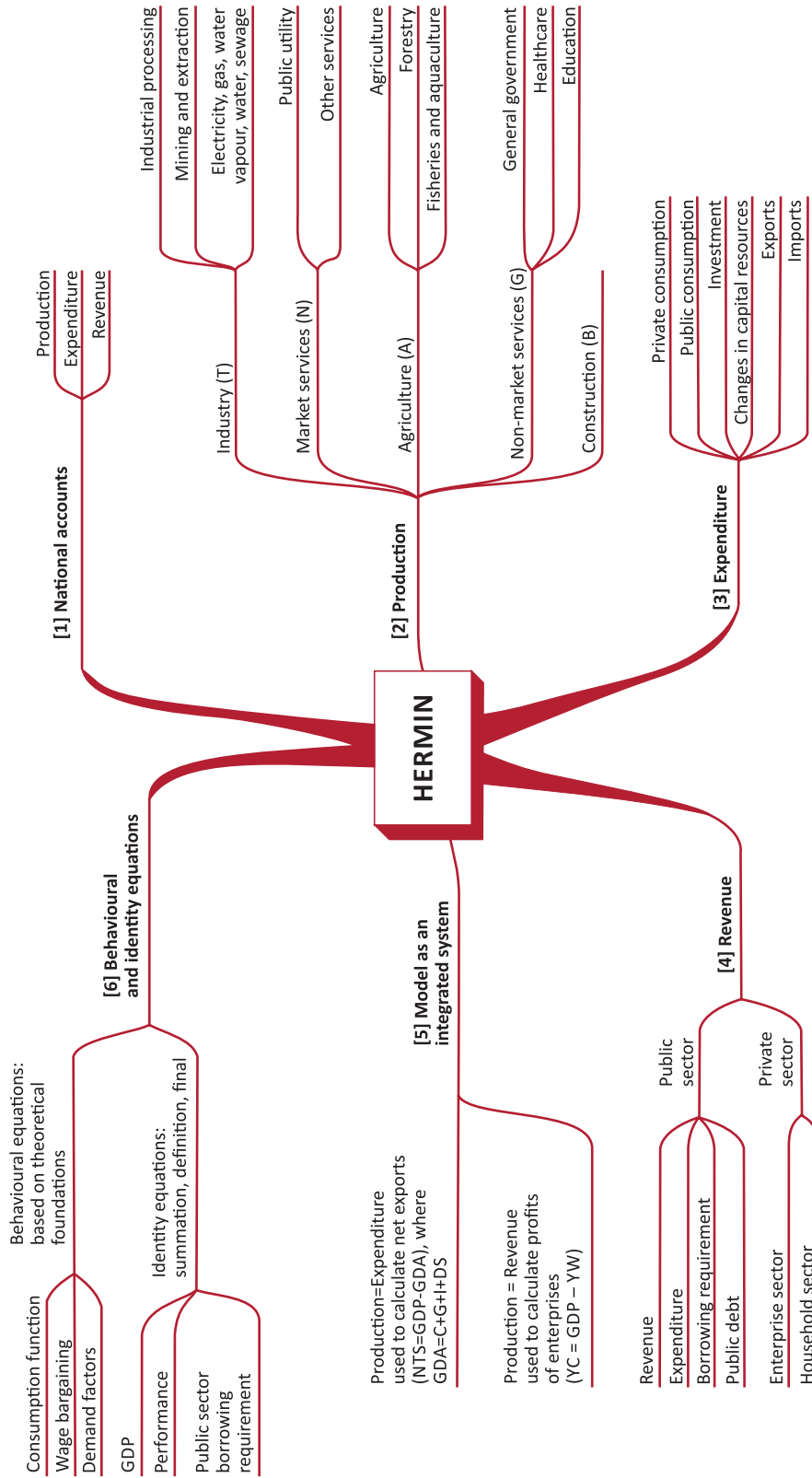
Parameters affecting the labour productivity in the services sector through expenditure on:	human capital development	0.03 <sup>39</sup>
	basic infrastructure	0.03
	research and development	0.0
Parameters affecting the output in the services sector through expenditure on:	human capital development	0.03
	basic infrastructure	0.03
	research and development	0.03
Parameters affecting the labour productivity in the manufacturing sector through expenditure on:	human capital development	0.1
	basic infrastructure	0.1
	research and development	0.03
Parameters affecting the output in the manufacturing sector through expenditure on:	human capital development	0.1
	basic infrastructure	0.2
	research and development	0.03

Source: J. Bradley, G. Untiedt, *The COHESION system of HERMIN country and regional models. Description and operating manual, Version 3*, GEFRA, EMDS, Muenster 2008.

<sup>38</sup> The Phillips curve depicts the inverse relationship between changes in the unemployment rates and changes in wages.

<sup>39</sup> The parameter value is interpreted as follows: a 1% increase in human capital resources contributes to GVA (Gross Value Added) growth in the market services sector by 0.03%.

**Figure 1.** Schematic outline of the HERMIN model



Source: Z. Mogiła, J. Zaleski, "Modele HERMIN jako narzędzie służące kształtowaniu i ocenie polityki rozwoju krajów i regionów", in: D. Woźniak, O. Kendiukhov (ed.), *Scientific Research Priorities – 2017: theoretical and practical value*, Wyższa Szkoła Biznesu – National-Louis University, Nowy Sącz 2017.

The aforementioned parameters play a vital role in estimating the supply effects of public interventions. Their estimation results from a very complex research process<sup>40</sup>. Thus far evaluation analyses have used “spill-over elasticities” parameters based on a broad enquiry conducted as part of John Bradley’s research<sup>41</sup>.

## Development of HERMIN Models in Poland

In 2002, a team from the Wrocław Regional Development Agency (WARR), led by Prof. J. Zaleski, in cooperation with J. Bradley, created a HERMIN model for Poland<sup>42</sup>. In 2005, the first HERMIN models for the economies of 16 voivodeships (NUTS-2) were created. This allowed for research into the impact of EU Cohesion Policy on the social and economic

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<sup>40</sup> O. Ivanova et al., *Study on the “Identifying and Aggregating Elasticities for Spill-over Effects due to Linkages and Externalities in the Main Sectors of Investment Co-financed by the EU Cohesion Policy”*, DG Regional Policy, Brussels 2011.

<sup>41</sup> J. Bradley, G. Untiedt, op. cit., pp. 83–98.

<sup>42</sup> J. Bradley, “Evaluating the Impact of European Union Cohesion Policy in Less-developed Countries and Regions”, *Regional Studies* 2006, vol. 40, pp. 189–199; J. Bradley, G. Untiedt, “Do Economic Models Tell Us Anything Useful about Cohesion Policy Impacts?”, in: U. Stierle-von Schutz et al. (ed.), *Regional Economic Policy in Europe: New Challenges for Theory, Empirics and Normative Interventions*. Edward Elgar, Cheltenham 2008, pp. 159–180; J. Bradley, J. Zaleski, “Modelling EU Accession and Structural Fund Impacts Using the New Polish HERMIN Model”, in: W. Welfe (ed.), *Modelling Economies in Transition. Proceedings of the 7th Conference of the International Association*, AMFET, Łódź 2003; J. Bradley, J. Zaleski, “Ocena wpływu Narodowego Planu Rozwoju Polski na lata 2004–2006 na gospodarkę przy zastosowaniu modelu HERMIN”, *Gospodarka Narodowa* 2003, No 7–8. Szkoła Główna Handlowa, Warszawa; J. Bradley et al., *Ocena wpływu Narodowych Strategicznych Ram Odniesienia i wybranych Programów Operacyjnych na lata 2007–2013 na gospodarki polskich województw przy pomocy modeli regionalnych HERMIN*, Wrocławska Agencja Rozwoju Regionalnego, Wrocław 2006; Z. Mogiła et al., *Effects of EU Cohesion Policy on social and economic disparities between Poland and Slovakia – comparative analysis based on the macroeconomic HERMIN models*, Proceedings of the Conference “Regional disparities in Central and Eastern Europe. Theoretical models and empirical analyses”, The Institute of Economic Research of the Slovak Academy of Sciences, Bratislava, Smolenice November 17–19, 2010; J. Zaleski et al., *Ocena wpływu realizacji polityki spójności na kształtowanie się wybranych wskaźników makroekonomicznych na poziomie krajowym i regionalnym za pomocą modeli makroekonomicznych HERMIN*, Report commissioned by the Ministry of Infrastructure and Regional Development, Wrocław Regional Development Agency, Wrocław 2014; J. Zaleski et al., *Ocena wpływu Programu Rozwoju Obszarów Wiejskich 2007–2013 na gospodarkę Polski*, Ministry of Agriculture and Rural Development, Warsaw 2015.

development of Polish regions<sup>43</sup>. Figure 2 shows the evolution of HERMIN models in Poland.

From the initial four-sector version (manufacturing, market and non-market services, agriculture), the models evolved into a five-sector version, which distinguished building and construction and had a separate mechanism taking into account investments in R&D. In 2015, the first model integrating 16 regional HERMIN models through a system of economic connections was developed by the author of this chapter (3rd generation)<sup>44</sup>. Previously, models of voivodeship economies functioned as independent research tools. They did not form a system of interconnected regions. In the analyses concerning the impact of Cohesion Policy on economic growth, interregional relations were approximated using a HERMIN model for Poland as a whole.

Next, a successful attempt was made at developing a macroeconomic model reflecting the economic relations within an urban metropolis<sup>45</sup>. This led to the development of a HERMIN model for the economy of the capital city of Warsaw. It paved the way for a wide-ranging

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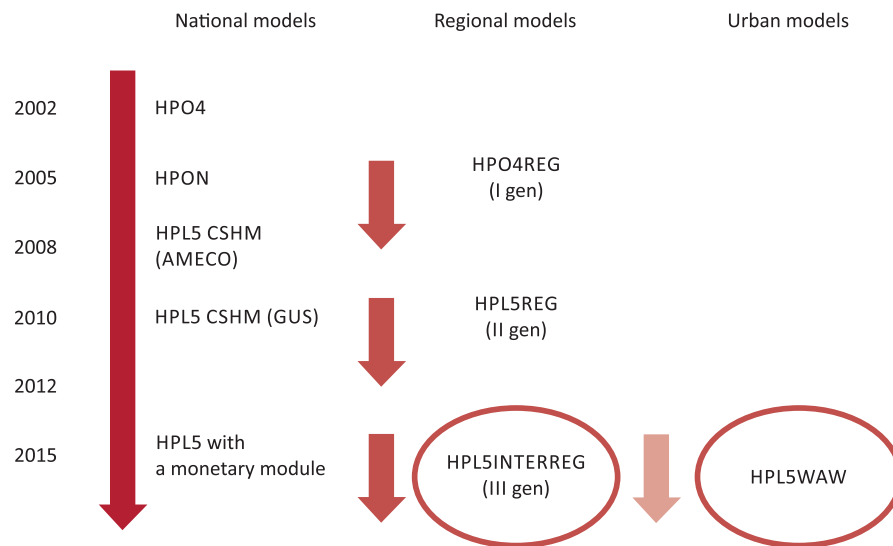
<sup>43</sup> J. Kudełko et al., "Leaders and outliers in the race of regions – EU Cohesion Policy in Poland in the light of macroeconomic modelling", in: T. Markowski, M. Turała (ed.), "Territorial Cohesion Policy in Poland – Issues In Impact Assessment", *Studia Regionalia KPZK PAN* 2012, vol. 33, pp. 30–43; J. Kudełko et al., "Rola polityki spójności po 2013 r. w procesie konwergencji społeczno-gospodarczej polskich regionów", in: A. Harańczyk (ed.), "Perspektywy rozwoju regionalnego Polski w okresie programowania po 2013 r. Część II", *Studia KPZK PAN* 2012, vol. CXL, 170 p., pp. 39–56; Z. Mogiła, M. Zaleska, "Polityka spójności w ramach RPO województwa dolnośląskiego a orientacja na długookresowy rozwój regionu – próba oceny na gruncie analizy kontrfaktualnej", in: E. Małuszyńska (ed.), *Dynamika, cele i polityka zintegrowanego rozwoju regionów. Perspektywa europejska*, Bogucki Wydawnictwo Naukowe, Poznań 2013; Z. Mogiła et al., "Jobless-growth or Employment-oriented Development – Dilemma of the New EU Financial Perspective", in: T. Kudłacz, D. Woźniak (ed.), "Programming Regional Development in Poland. Theory and Practice", *Studia Regionalia KPZK PAN* 2013, vol. 35, pp. 86–110; J. Zaleski et al., *Ocena wpływu realizacji polityki spójności na kształtowanie się wybranych wskaźników makroekonomicznych na poziomie krajowym i regionalnym za pomocą modeli makroekonomicznych HERMIN*, Report commissioned by the Ministry of Infrastructure and Regional Development, Wrocław Regional Development Agency, Wrocław 2014; J. Zaleski et al., *Oszacowanie wpływu realizacji Narodowego Planu Rozwoju 2004–2006 (NPR) i Narodowych Strategicznych Ram Odniesienia/ Narodowej Strategii Spójności 2007–2013 (NSRO/NSS) na wybrane wskaźniki makroekonomicznych na poziomie regionalnym do roku 2020 przy użyciu modeli regionalnych HERMIN*, Report commissioned by the Ministry of Regional Development, Warsaw 2011.

<sup>44</sup> J. Zaucha et al., *Terytorialny wymiar wzrostu i rozwoju*, Difin, Warszawa 2015.

<sup>45</sup> A. Jarosz et al. *Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju m.st. Warszawy*, Report commissioned by the Office of the Capital City of Warsaw, Wrocław Regional Development Agency, Wrocław 2016.

analysis of the impact of public programmes, development strategies and operational programmes on intraregional heterogeneity.

**Figure 2.** Evolution Process of the HERMIN Models in Poland



Key: HPO4 – the four-sector HERMIN model for Poland; HPON – the HERMIN model for Poland taking into account the disaggregation of economic activity into 10 economic sections; HPL5 CSHM (AMECO) – the five-sector HERMIN model for Poland, as part of the EU Cohesion System of HERMIN Models based on AMECO data; HPL5 CSHM (GUS) – the five-sector HERMIN model for Poland, as part of the EU Cohesion System of HERMIN Models based on data from Statistics Poland; HPO4REG (1st generation) – the 16 four-sector HERMIN models for the economies of Polish voivodeships; HPL5REG (2nd generation) – the 16 five-sector HERMIN models for the economies of Polish voivodeships; HPL5INTERREG – the system of 16 integrated regional HERMIN models; HPL5WAW – the HERMIN model for the economy of Warsaw.

Source: Z. Mogiła, J. Zaleski, "Modele HERMIN jako narzędzie służące kształtowaniu i ocenie polityki rozwoju krajów i regionów", in: D. Woźniak, O. Kendiukhov (ed.), *Scientific Research Priorities – 2017: theoretical and practical value*, Wyższa Szkoła Biznesu–National-Louis University, Nowy Sącz 2017, p. 35.

## Counter-factual analysis

The main objective of counter-factual analysis conducted on a macroeconomic level is to identify the pure quantitative effect of investment expenditure (such as the net effect of a particular investment). The use of a macro-econometric model allows for determining the extent to which the values of certain indicators describing the social and economic

development of a country/region change solely as a result of implemented public investments. A number of other determinants are disregarded (e.g. changes on international markets, macroeconomic policy of central authorities, etc.); they create the so-called apparent effect of a financial intervention and are not related to investment expenditure. Two scenarios are developed as part of the analysis: the first with the assumption of a financial intervention and the second, a hypothetical one, omitting this intervention. Differences in the value of macroeconomic indicators in the two scenarios determine the extent of public investments' impact.

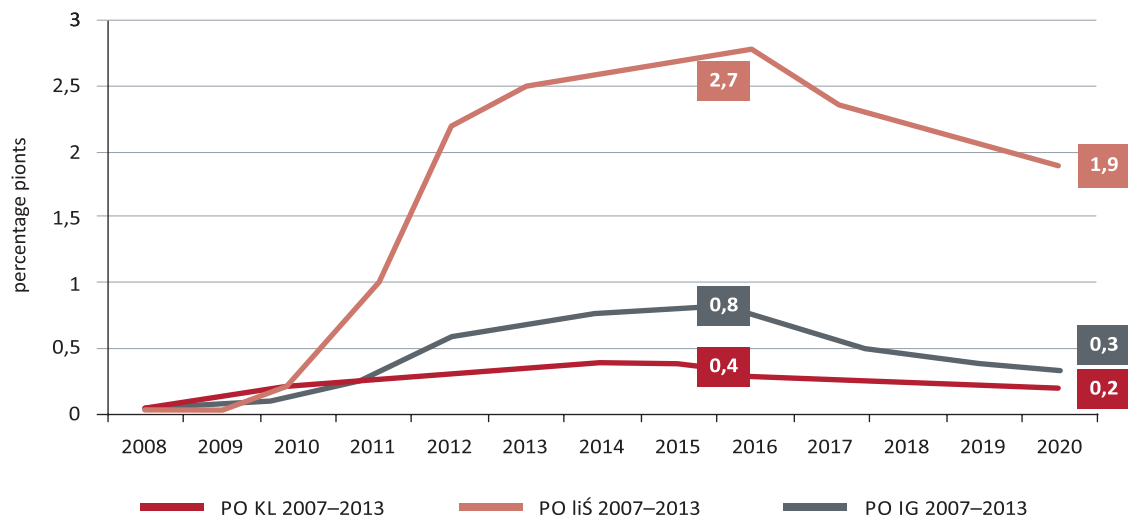
An example of a counter-factual analysis, conducted with the use of the HERMIN models, is the evaluation of the impact on the economy of the Eastern Poland macro-region of three main programmes carried out under the National Strategic Reference Framework 2007–2013: Infrastructure and Environment Operational Programme, Operational Programme Innovative Economy and Human Capital Operational Programme<sup>46</sup>. At the same time, this illustrates the application of HERMIN models for analysing the impact of Cohesion Policy on economic convergence, understood as eliminating the distance between the poorest regions and the EU average (Figure 3).

By implementing the three programmes mentioned above, the macro-region of Eastern Poland eliminated the distance between its development and the average level in the European Union (Figure 3). The strongest impact was observed in the programmes' implementation period. This was the result of demand-side effects related to the Keynesian multiplier mechanism. For instance, in 2015, the implementation of the Operational Programme Innovative Economy led to growth of the GDP level per capita in PPS by 0.8 percentage points, compared to the hypothetical situation, where the programme had not been implemented. It should be noted that even when the Cohesion Policy investments are terminated, their positive effect on economic cohesion will continue. This can be attributed to supply-side effects related, i.a., to the long-term improvement in innovation and competitiveness of enterprises, as a result of support under the Operational Programme Innovative Economy, or to the increased investment attractiveness of Eastern Poland, due to improved transport infrastructure.

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<sup>46</sup> A. Jarosz et al., *Ocena wpływu realizacji polityki spójności w ramach NSRO 2007–2013 (z wyszczególnieniem wpływu wybranych programów operacyjnych) na rozwój społeczno-gospodarczy Polski za pomocą ilościowego modelu ekonomicznego*, Report commissioned by the Ministry of Investment and Economic Development, Wrocław Regional Development Agency, Wrocław 2016.

**Figure 3.** Impact of the Infrastructure and Environment Operational Programme (PO IiS 2007–2013), Operational Programme Innovative Economy (PO IG 2007–2013) and Human Capital Operational Programme 2007–2013 (PO KL 2007–2013) on GDP per capita in PPS (EU-28=100) for Eastern Poland (percentage points)



Source: A. Jarosz, Z. Mogiła, S. Skóra, A. Tiukało, J. Zaleski, *Ocena wpływu realizacji polityki spójności w ramach NSRO 2007–2013 (z wyszczególnieniem wpływu wybranych programów operacyjnych) na rozwój społeczno-gospodarczy Polski za pomocą ilościowego modelu ekonomicznego*, Report commissioned by the Ministry of Investment and Economic Development, Wrocław Regional Development Agency, Wrocław 2016, pp. 63–64.

The greatest impact of the Infrastructure and Environment Operational Programme is a result of not only the scope of expenditure, which accounted for ca. 60% of the entire allocation under Cohesion Policy. It is also due to the fact that under this programme the major infrastructure deficits identified in Poland were consequently supplemented. For this reason, subsequent investments generated the greatest supply-side effects. Infrastructure is a necessary requirement for the long-term development of the macro-region, as it guarantees its availability both in the internal and external dimension. Without infrastructure, investments supporting entrepreneurship and innovation cannot be fully effective. Along with the saturation of the economy with basic infrastructure, relatively stronger effects of investments in R&D and human resources development should be expected. It should also be underlined that despite the greater allocation of funds for the Human Capital Operational Programme, the observed impact of that programme is lower than in the case of the Operational

Programme Innovative Economy. This ought to be attributed to the fact that the effects of supporting R&D become visible quicker than the corresponding effects of investments in human capital. The development of human capital is a long-term process, stimulated, among other things, by the development of the enterprise sector and the demand for innovative technological solutions it represents.

Traditional counter-factual analysis often plays a purely informative role for decision makers. It is not an instrument that might be used in the process of shaping public programmes and development strategies. As the HERMIN models evolved, new opportunities for their practical application emerged.

## Scenario Analysis (Quantitative Foresight)

The application of the HERMIN models, both national and regional, in that regard relates to comprehensive and multidimensional evaluation. The subject of evaluation is the efficiency of various financial intervention variants in different scenarios of the development of a country/region and its surroundings. Firstly, different narratives are developed as part of three groups of assumptions concerning:

- the environment of a country/region (e.g. as regards demographic tendencies, political and economic developments, changes in the policy of major financial and monetary institutions, etc.),
- development processes within a country/region (e.g. as regards structural changes, making use of endogenous potentials, territorial heterogeneity and the role of urban centres, changes in the technological advancement of the economy, etc.),
- development policy (e.g. as regards the economic structure of funds – basic infrastructure, human capital, support for enterprises, R&D; the magnitude of long-term supply-side effects; saturation with investments in the areas of infrastructure, human capital, support for enterprises and R&D).

Development narratives may be based on, for instance, heuristic methods (e.g. brainstorming, Delphi method), direct in-depth interviews and focus groups. Each group of qualitative assumptions is then described by a number of quantitative

parameters, used in macroeconomic simulations<sup>47</sup>. Combining the above groups of assumptions creates various scenarios. They enable the evaluation of development policy's effectiveness in different socio-economic circumstances, as well as allow for determination of the effectiveness of assorted variants of the public investment structure (investment-mix).

In the exemplary scenario study using the HERMIN model of the economy of Warmińsko-Mazurskie Voivodeship (NUTS-2 region), 9 development scenarios were analysed (Table 2)<sup>48</sup>.

The strongest effects of RPO WM implementation in the period between 2014 and 2030 were to be expected in the pessimistic scenarios (Figure 4). Meanwhile, where the optimistic vision came true, the relatively weakest impact of the Programme was to be observed. This results mainly from the differences in the level of capital and human resources in the aforementioned scenarios and the differences between the amount of investment multipliers. In the case of the pessimistic scenarios, as a result of the assumed regression in global economy and the worsening situation within the region, resources reach a significantly lower level than in the case of the optimistic scenarios. With the limited capital base, each additional investment generates greater effects, as compared to the situation where the amount of resources and saturation with investments are high. In the case of the group of pessimistic scenarios, we are also dealing with an increased investment multiplier on account of limited imports of goods and services.

It should also be noted that the pro-innovation intervention structure under RPO WM is characterised by the strongest impact on the GDP of Warmińsko-Mazurskie Voivodeship. This is because investments in R&D stimulate the region's non-cost competitiveness and contribute to an increase in the added value created in the region.

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<sup>47</sup> The above refers to such points as demographic indicators, rate of technological progress in manufacturing, market services and building and construction, expenditure on R&D, structure of the sector GVA and the labour market, industrial production and the dynamics of its prices among main economic partners, exchange rates, internationalisation scale of the economy in question, etc. The nature of the aforementioned indicators in the HERMIN models is exogenous (they are not computed by the model and must be investigated by researchers prior to attempting macroeconomic simulations).

<sup>48</sup> J. Kudełko et al., *Założenia dotyczące różnych scenariuszy rozwojowych województwa warmińsko-mazurskiego*, Report commissioned by the Office of the Marshal of Warmińsko-Mazurskie Voivodeship, Wrocław Regional Development Agency, Wrocław 2012 and J. Kudełko et al., *Prognoza trendów rozwojowych...* *op. cit.*.

**Table 2.** Sets of assumptions selected for the construction of 9 development scenarios for Warmińsko-Mazurskie Voivodeship

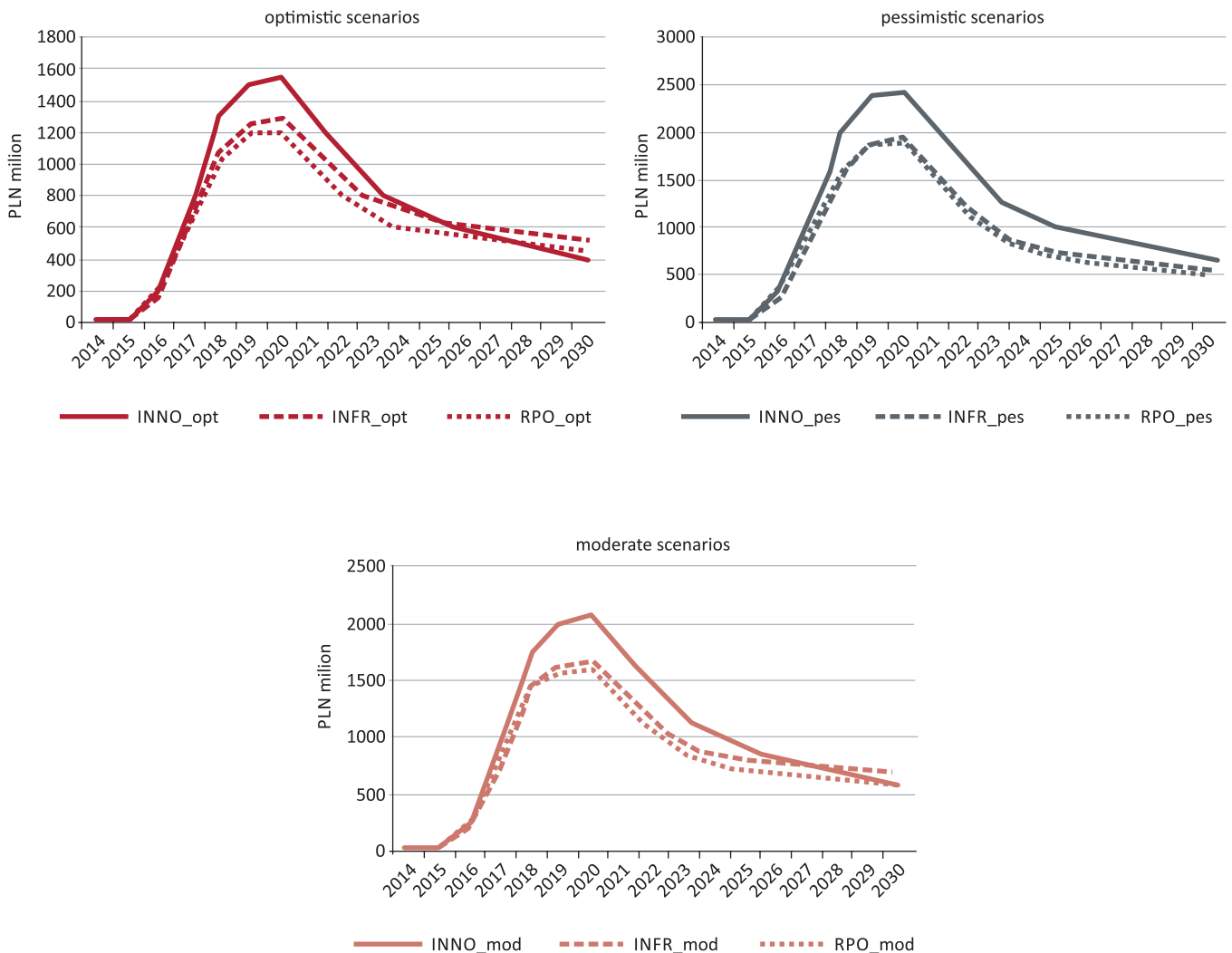
Projections of the national and global economic situation	Projections of the economic situation in Warmińsko-Mazurskie Voivodeship	Projections of the economic structure of funds under the Regional Operational Programme for Mazowieckie Voivodeship (RPO WM) 2014–2020 <sup>49</sup>	Designation
DEVELOPMENT	DEVELOPMENT	pro-innovation	INNO_opt
DEVELOPMENT	DEVELOPMENT	pro-infrastructure	INFR_opt
DEVELOPMENT	DEVELOPMENT	established in the RPO WM	RPO_opt
STATUS QUO	STATUS QUO	pro-innovation	INNO_mod
STATUS QUO	STATUS QUO	pro-infrastructure	INFR_mod
STATUS QUO	STATUS QUO	established in the RPO WM	RPO_mod
CRISIS	CRISIS	pro-innovation	INNO_pes
CRISIS	CRISIS	pro-infrastructure	INFR_pes
CRISIS	CRISIS	established in the RPO WM	RPO_pes

Key: red – optimistic scenarios, orange – moderate scenarios, grey – pessimistic scenarios

Source: Z. Mogiła et al., *Alternative scenarios for regional growth in the context of the Cohesion Policy – an example of the region of Warmińsko-Mazurskie*, Paper submitted to the ERSA Congress 2014 Saint Petersburg: Cities & Regions: Smart, Sustainable, Inclusive?, Wrocław Regional Development Agency, Wrocław 2012.

<sup>49</sup> In the reference scenario depicting the actual structure of RPO WM 2014–2020 funds, allocation divided into economic categories was as follows: basic infrastructure – 41.4%; support for the enterprise sector – 38.6%, including expenditure on R&D – 27.4%; human capital – 20%. In the pro-innovation scenario, allocation for support for the enterprise sector was increased to 60%. Moreover, it was assumed that the entirety of support for business will be dedicated to pro-innovation activities. The pro-infrastructure scenario assumed an increase in allocations for infrastructure up to 60% of the entirety of allocations under RPO WM 2014–2020. It should be underlined that only investments in basic infrastructure, financed from the RPO WM, are analysed in the study. In regional operational programmes, the main focus is on infrastructure oriented towards improving intraregional accessibility. Therefore, the long-term supply effects are lower here, compared to investments financed from sectoral programmes. These contribute more to the development of a voivodeship's external accessibility.

**Figure 4.** Results of RPO WM 2014–2020 effects on the GDP level in constant prices in Warmińsko-Mazurskie Voivodeship in 9 region development scenarios (in PLN million)



Source: Z. Mogiła, J. Kudęłko, A. Poproch, J. Zaleski, *Alternative scenarios for regional growth in the context of the Cohesion Policy – an example of the region of Warmińsko-Mazurskie*, Paper submitted to the ERS Congress 2014 Saint Petersburg: Cities & Regions: Smart, Sustainable, Inclusive?, Wrocław Regional Development Agency, Wrocław 2012, pp. 17–18.

The development and modernisation of basic infrastructure allows for an even more effective allocation of available resources. It does not, however, generate results allowing for the quality parameters of regional development to be changed, or does so to a limited extent. These depend mainly on innovation and technological progress. The reduction of economic effects, observed towards the end of the research period in the pro-innovation variants, may

be attributed to their quicker economic depreciation compared to the results of investments in infrastructure and human capital. A product or technology can, after all, be innovative only for a certain time and in that time generate stronger economic effects. After that – if there are no further investments – they stop being innovative. The nature of investments in infrastructure (i.a. motorways, airports) allows them to contribute to relatively high economic effects in the long-term perspective.

Foresight analysis with the use of the HERMIN models found its practical use i.a. in ex-ante evaluation of regional operational programmes in the EU financial framework 2014–2020 (i.a. for Dolnośląskie, Wielkopolskie and Podlaskie Voivodeship)<sup>50</sup>. It allowed to indicate the optimal economic structure of the allocated support, as regards its impact on regional development. Moreover, this type of research was used for the purpose of the original version of Dolnośląskie Voivodeship Development Strategy, where the effects of its implementation in the context of various regional development scenarios were presented<sup>51</sup>.

## Analysis Taking into Account Interregional Relations

The system of models integrating 16 regional economies is an important stage in the development of the HERMIN method. Taking into account the economic interplay between voivodeships opens a new dimension of evaluating public policies on the macroeconomic level. It is now possible to capture the interregional “flow” of effects generated by strategies and operational programmes. This is a very significant aspect of public investment analysis, as it enables realisation of their actual impact on the economy. Some of the funds invested

<sup>50</sup> N. Baczyńska et al., *Ewaluacja ex-ante Regionalnego Programu Operacyjnego Województwa Podlaskiego na lata 2014–2020*, Report commissioned by the Office of the Marshal of Podlaskie Voivodeship, Ecorys Polska, Geoprofit Wojciech Dziemianowicz, WARR, Warsaw, Wrocław 2014; Wrocław Regional Development Agency, *Ocena ex-ante projektu regionalnego programu operacyjnego dla Wielkopolski na lata 2014–2020*, Report commissioned by the Office of the Marshal of Wielkopolskie Voivodeship, Office of the Marshal of Wielkopolskie Voivodeship, Poznań 2014; Ecorys Polska, Wrocław Regional Development Agency, *Ewaluacja ex-ante projektu Regionalnego Programu Operacyjnego Województwa Dolnośląskiego 2014–2020*, Report commissioned by the Office of the Marshal of Dolnośląskie Voivodeship, Wrocław Regional Development Agency, Wrocław 2014.

<sup>51</sup> J. Zaleski (ed.), *Strategia Rozwoju Województwa Dolnośląskiego 2020. Projekt ekspercki*, Wrocław Regional Development Agency, Wrocław 2012.

in a particular region may be relocated to a different voivodeship by purchasing investment goods (e.g. equipment components, technologies). This reduces the demand-side effects of public intervention. Additionally, part of the income generated by way of investments implemented in the long-term, may be spent in other regions. The scale of supply-side effects of the adopted development policy will thus be reduced. Naturally, the scenario of increased export in a particular region on account of the effects of public investments implemented in other voivodeships is also possible. Such “spreading” of economic benefits may have a significant impact on the development rate of each voivodeship, either by speeding up or slowing down convergence processes. This can in turn have major implications for the shape of regional development policy adopted in Poland. Even the most optimised public intervention – understood as oriented towards the specificities and economic structure of the region in question (place-based) – may not bring the expected results, if it does not pay enough attention to its environment<sup>52</sup>.

An example of the application of the integrated HERMIN models system is the analysis entitled *“Bilans efektów międzyregionalnych polityki spójności 2014–2020 dla Dolnego Śląska”* [“Balance of the interregional effects of cohesion policy 2014–2020 for Dolnośląskie”]<sup>53</sup>. Its main objective was to record and quantify the effects of Cohesion Policy which “spread” from Dolnośląskie to other NUTS-2 regions, as well as those which “flow into” this voivodeship’s economy from the rest of the country. The analysis covers the period between 2014 (beginning of the current EU financial perspective) and 2030 (seven years after the end of EU funds implementation in the aforementioned perspective, which allows for the long-term economic effects to be recorded).

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<sup>52</sup> For the purpose of endogenization of interregional economic connections, the external demand of a particular voivodeship was linked with the endogenous variables, reflecting the GVA in the manufacturing sector in other regions (first channel of interregional connections). In turn, the GVA remains under the influence of demand and supply effects of the public intervention in question. The impact of interregional relations on price-forming processes in a particular voivodeship was also endogenized (second channel of interregional connections). This allowed i.a. for assessing the impact of interregional relationships on a particular voivodeship’s price competitiveness. A gravity model was used to determine the strength of trade relations between the economies of 16 voivodeships. A detailed description of the integrated HERMIN model system can be found in: J. Bradley, J. Zaucha, T. Brodzicki, D. Ciołek, T. Komornicki, Z. Mogiła, J. Szlachta, J. Zaleski, *Territorial Cohesion: A missing link between economic growth and welfare. Lessons from the Baltic Tiger*, Uniwersytet Gdański Katedra Makroekonomii, Gdańsk 2016.

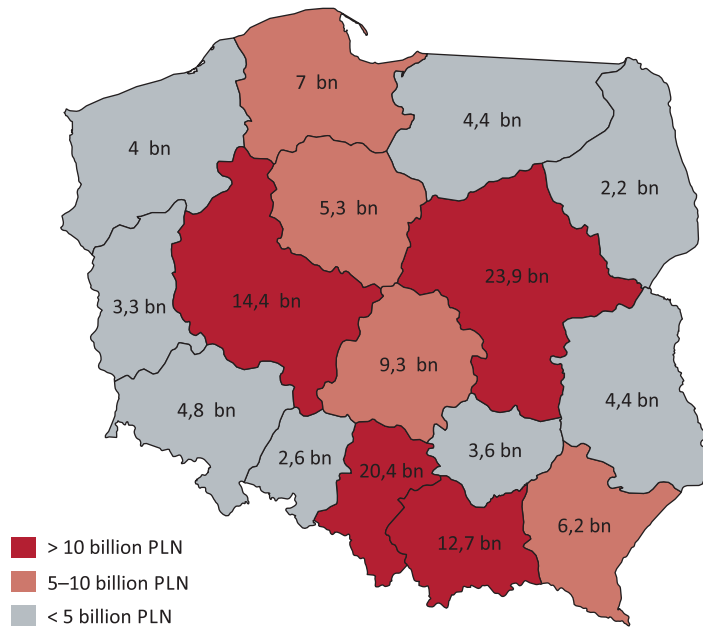
<sup>53</sup> B. Król et al., *Bilans efektów międzyregionalnych polityki spójności 2014–2020 dla Dolnego Śląska*, Report commissioned by Dolnośląskie Voivodeship – Institute for Territorial Development, Wrocław Regional Development Agency, Wrocław 2017.

The scale of effects discounted by the economy of Dolnośląskie as a result of Cohesion Policy implementation in other regions is significant (Figure 5). In the years 2014–2030, the cumulative value of the impact of EU funds implemented in the rest of the country on the GDP in Dolnośląskie Voivodeship amounted to over PLN 82 billion. This constitutes 54% of the GDP of this region in 2015. The value of the effects of the Cohesion Policy implemented in Dolnośląskie Voivodeship, which spread to other regions, is PLN 43 billion (around 29% of the GDP of Dolnośląskie in 2015) (Figure 6). The balance of analysed benefits for Dolnośląskie Voivodeship is therefore unambiguously positive and significant from the macroeconomic standpoint.

The strength of trade relations between voivodeships is not the key factor determining the scale of the transfer of macroeconomic Cohesion Policy effects. The leading role is played by: economic structure, competitiveness of the enterprise sector, level of technological advancement and the import intensity of the economy. The conducted analysis showed that the greatest economic impact can be observed in relations between Dolnośląskie and the following voivodeships: Mazowieckie, Śląskie, Opolskie, Wielkopolskie, Małopolskie, Podkarpackie, Łódzkie and Świętokrzyskie. This conclusion demonstrates the need to take into account interregional economic connections when creating macroregional structures, which are then used for the purpose of shaping and implementing the development policy. In-depth analysis may demonstrate the need to redefine the macroregions of Eastern and Western Poland for the purpose of making even greater use of economic complementarities and achieving stronger synergies. For instance, for the Western Poland macroregion, one of the axes linking the voivodeships is the river Oder. Once the interregional economic impacts are considered, this may prove to be an insufficient argument for institutionalised development of a broad cooperation front in the form of an artificial macroregion.

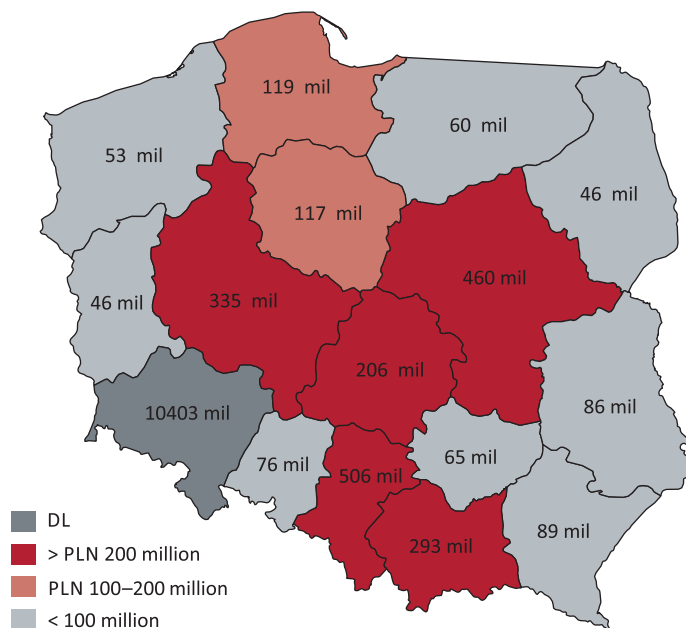
Aside from demonstrating interregional relations, which may strengthen or limit the effectiveness of public intervention in a particular voivodeship, one more area for the potential application of the HERMIN models system ought to be indicated. It concerns the territorial allocation of funds under Cohesion Policy (i.a. regional operational programmes). A study conducted for all voivodeships, corresponding to the one for Dolnośląskie, may show a negative balance of interregional effects in some of them. This would in turn provide an argument in favour of incorporating the aforementioned effects in the algorithm for allocating EU funds in the financial perspective 2021–2027.

**Figure 5.** Impact of the Cohesion Policy implemented in 2014–2020 in fifteen voivodeships on the GDP level of Dolnośląskie Voivodeship in current prices (average for 2014–2030) in PLN billion



Source: B. Król et al., *Bilans efektów międzyregionalnych polityki spójności 2014–2020 dla Dolnego Śląska*, Report commissioned by Dolnośląskie Voivodeship – Institute for Territorial Development, Wrocław Regional Development Agency, Wrocław 2017, p. 50.

**Figure 6.** Impact of the Cohesion Policy implemented in 2014–2020 in Dolnośląskie Voivodeship on the GDP level of other Polish regions in current prices (average for 2014–2030) in PLN million



Source: B. Król et al., *Bilans efektów międzyregionalnych polityki spójności 2014–2020 dla Dolnego Śląska*, Report commissioned by Dolnośląskie Voivodeship – Institute for Territorial Development, Wrocław Regional Development Agency, Wrocław 2017, p. 56.

## Metropolitan Economies Analysis

The types of evaluation studies presented thus far engaged the HERMIN models constructed and calibrated on the entire country level or the regional level (NUTS-2). Such levels of territorial disaggregation are commonplace in macroeconomic modelling. This is mainly due to two factors: availability of factual evidence and the empowerment of key decision-making centres in charge of shaping and implementing regional development policies. The analysis of economic process taking place in metropolitan urban centres, which are – in a way – development hubs, thus becomes all the poorer. Moreover, conclusions reached against the backdrop of spatially aggregated evaluation studies refer to regions/countries as homogeneous territorial units. This limits our knowledge of the impact of public policies on the areas of particular voivodeships, which are varied in terms of their territory, as well as on their internal cohesion. The positive impact of a specific operational programme or strategy on a particular region may result solely from the effects generated and discounted by major agglomeration centres. The share of the remaining areas (such as rural areas, medium-sized and small cities) in increased production and income may be limited.

Given the above, a successful attempt was made at creating a HERMIN model for the economy of a metropolitan city. The creation and calibration of such an analytical tool for the capital city of Warsaw was a pioneering step. A structure of equations and mechanisms typical for regional (NUTS-2) HERMIN models was used in its construction. In other words, the HERMIN model of the economy of Warsaw reflects the same dependencies, interactions, feedbacks, as well as rests on the same theoretical foundations, as the analogous models for Polish voivodeships. The missing data required to create the model's data base, calibrate the parameters of its equations and generate a scenario of the capital's development was disaggregated on the basis of data for Mazowieckie Voivodeship. This was due to the lack of a complete set of factual evidence at the NUTS-3 level (i.e. the level of statistical disaggregation corresponding to Warsaw at the moment of the model creation in 2015). In the process of disaggregating data from the NUTS-2 level (Mazowieckie Voivodeship) to the NUTS-3 level (Warsaw), all the available information was used, which allows for the special place occupied by Warsaw in the economy of Mazowieckie Voivodeship to be reflected<sup>54</sup>.

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<sup>54</sup> A detailed algorithm for disaggregation was presented in the report: A. Jarosz A., Z. Mogiła, S. Skóra, A. Tiukało, M. Wysocka, M. Zaleska, J. Zaleski, *Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju m.st. Warszawy*, Report commissioned by the Office of the Capital City of Warsaw, Wrocław Regional Development Agency, Wrocław 2016, p. 163.

An example of using the aforementioned model is the study commissioned by the capital city of Warsaw, entitled “*Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju Warszawy w okresie 2004–2014*” [“Impact assessment of the amount and type of investment expenditure on the development level of Warsaw in the period 2004–2014”]<sup>55</sup>. The study took into account investments funded from the city budget (including its budgetary entities and organisational units), by city companies and other public bodies. The HERMIN model was used in the evaluation for such purposes as presenting the economic importance of alternative scenarios of public investments in the years 2015–2030. The reference scenario was based on the assumption of the actual investment structure from the years 2004–2014 being maintained, with expenditure on basic infrastructure development playing the dominant role (93%). In the case of alternative scenario I, it was assumed that investments directly supporting the enterprise sector will account for 75% of the entirety of expenditure appropriated for the capital’s development, including 50% of resources allocated to stimulate and support R&D. Alternative scenario II reflected the sustainable development of basic infrastructure and innovative economy. Meanwhile, scenario III focused on support for human capital, as the key factor stimulating long-term development. The share of expenditure on basic infrastructure in the entirety of investment expenditure was analogous to scenario II. Meanwhile, resources allocated for entrepreneurship development (including R&D) were significantly lower. The aim of this scenario was to present the extent to which increased expenditure on human capital would impact economic processes in Warsaw, compared to the scale of impact of the actual economic structure of investments. Simulations were run for two extreme assumptions (Variant I and II). In the case of Variant I, the assumption was that in the period between 2015 and 2030, the expenditure on infrastructure would translate fully into a long-term development of the capital’s economy. By making the city more attractive and limiting transaction costs, the volume of produced goods and the productivity of the production factors (labour and capital) will grow. Meanwhile, Variant II was based on the assumption that all expenditure on basic infrastructure in the years 2015–2030 would generate only short-term demand-side effects. This is related to the economy’s saturation with infrastructural resources<sup>56</sup>.

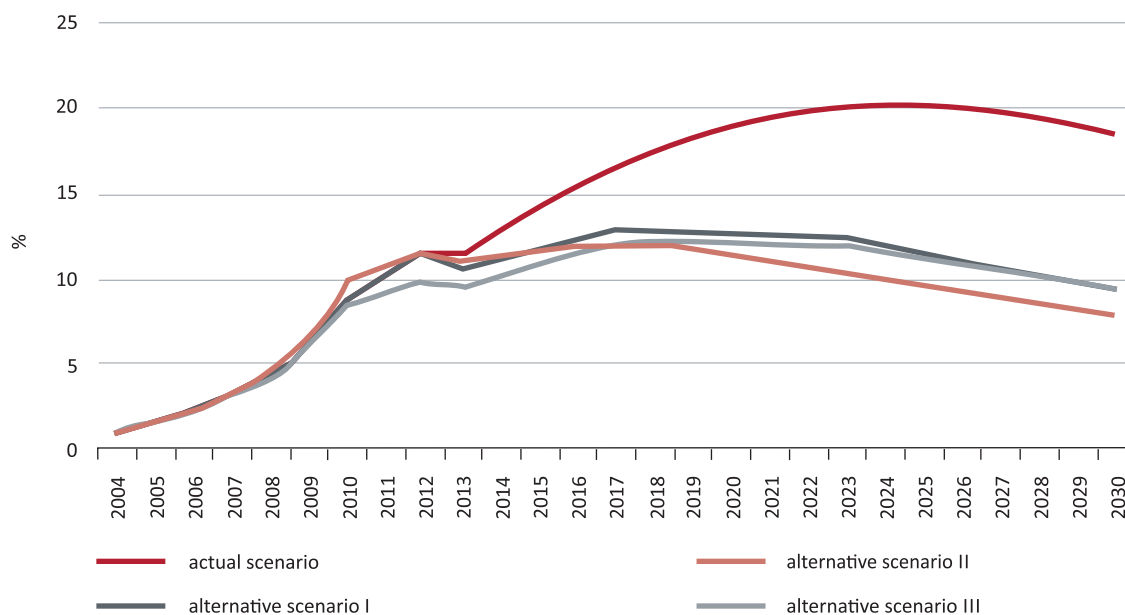
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<sup>55</sup> Ibid.

<sup>56</sup> This can be illustrated by the example of building an airport in that city, which, although exaggerated, is clearly understandable. Provided that this investment is justified from the economic standpoint, it should be further assumed that its completion would significantly improve the city’s attractiveness in the eyes of investors through increased accessibility. This would, in turn, enhance investment expenditure, along with production and income. If another airport was built in the city – for instance for the purpose of improving the quality of services offered to citizens – its impact on economic processes would be significantly lower than in the first case or there would be no such impact, on account of the costs of maintaining tangible assets.

Adopting two extreme assumptions should allow for a certain indicative range of the possible impact of future investments on the city's economic development to be determined.

**Figure 7.** Impact of actual (2004–2014) and anticipated (2015–2030) investment expenditure on GDP of Warsaw in current prices in the years 2004–2030 (in %) – Variant I “demand and supply-side effects”

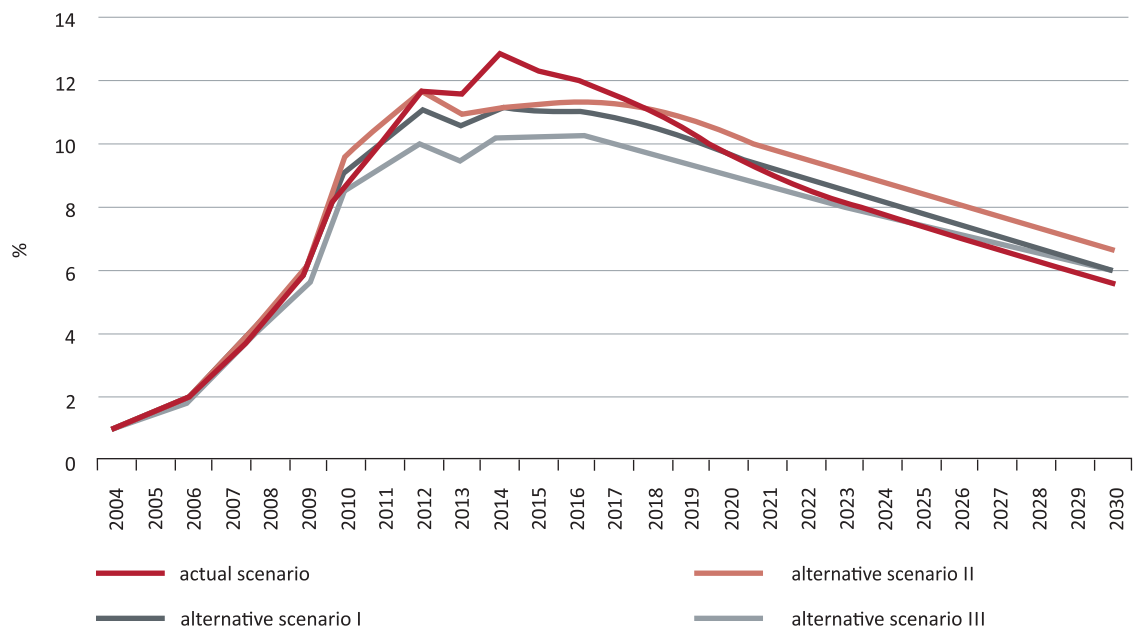


Source: A. Jarosz A., Z. Mogiła, S. Skóra, A. Tiukało, M. Wysocka, M. Zaleska, J. Zaleski, *Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju m.st. Warszawy*, Report commissioned by the Office of the Capital City of Warsaw, Wrocław Regional Development Agency, Wrocław 2016, p. 122.

In the case of Variant I – based on the assumption of infrastructure expenses being allocated fully to Warsaw's long-term development – the actual structure of investment expenditure clearly dominates over the results of alternative scenarios. However, plausibility of the assumption that subsequent infrastructure investment expenditure will generate significant economic results, regardless of the economy's saturation with tangible capital, can be questioned. Analysis of Variant II unequivocally indicates that along with the progressing “saturation” of the city with infrastructure, its potential to generate long-term macroeconomic effects is dwindling. At the same time, expenditure on the development of innovation and human capital is becoming increasingly more important and, therefore, deserves more attention. It is evident that the moment is drawing closer where additional expenditure on new infrastructure will be connected only with the costs

of maintaining the results of those investments and with the lack of satisfactory economic effects. The need to strike the right balance – in line with the will of the citizens – between expenditure targeted solely at improving the quality of life (e.g. pools, playing fields) and investments which may explicitly translate into Warsaw’s long-term economic development (e.g. supporting business incubators and high risk R&D projects) is becoming much more evident.

**Figure 8.** Impact of actual (2004–2014) and anticipated (2015–2030) investment expenditure on GDP of Warsaw in current prices in the years 2004–2030 (in %) – Variant II “demand-side effects”



Source: A. Jarosz, Z. Mogiła, S. Skóra, A. Tiukało, M. Wysocka, M. Zaleska, J. Zaleski, *Ocena wpływu wysokości i rodzaju wydatków inwestycyjnych na stopień rozwoju m.st. Warszawy*, Report commissioned by the Office of the Capital City of Warsaw, Wrocław Regional Development Agency, Wrocław 2016, p. 123.

The development of the HERMIN models dedicated to levels of territorial disintegration lower than NUTS-2 opens new, crucial areas of evaluation analysis:

- firstly, the possibility for evaluating the effectiveness of policies, strategies, public programmes dedicated to metropolitan urban areas, which largely shape the development trends in particular countries and regions. As evidenced by the example of the HERMIN model of the economy in the capital city of Warsaw, such analytical tools

allow for evaluating the effects of macroeconomic investments implemented by city authorities and the related organisational units. Furthermore, they may significantly foster decision making processes as regards shaping the optimal investment-mix, i.a. through strategies of integrated investments for particular metropolises. The HERMIN models may contribute to the development of macroeconomic analysis on the metropolitan level, which is strongly emphasised in Cohesion Policy through Integrated Territorial Investment (ITI);

- secondly, the possibility for evaluating the effectiveness of territorialisation of public policies and the impact of strategies and public programmes on territorial cohesion. The available factual evidence enables the creation and use of the HERMIN models for particular NUTS-3 subregions of certain voivodeships. This makes for an opportunity for research into whether the authorities' policy effectively addresses the development potentials and barriers of the respective subregions (place-based approach), whether the sectoral and regional operational programmes stimulate convergence processes in intraregional systems, and whether metropolitan centres absorb the great majority of Cohesion Policy effects;
- thirdly, the possibility for evaluating the effects of strategies and regional programmes under the new territorial division for statistical purposes, i.e. one which distinguishes a 17th region in Poland – the capital. In this case, it is vital that Statistics Poland publishes full and reliable time series for the local government unit in question.

## Conclusions

This chapter is, in a way, a resume of the evolution of HERMIN models in Poland and their use in evaluating policies, strategies and public programmes. The aforementioned research tools may be used both in counter-factual evaluations of the impact, as well as in foresight studies. In the first case, the results of the simulation indicate which part of the change to macroeconomic indicators (i.a. GDP, unemployment rate, employment rate, investment rate, etc.) is attributed solely to the implementation of a specific development strategy or public programme. They disregard other determinants of social and economic processes, such as fluctuations on international markets, monetary and fiscal policy, or changes in the geopolitical situation. Foresight studies are oriented towards creating scenarios of regional development. They combine heuristic and questionnaire methods with macroeconomic modelling. Different development narratives translate into quantitative assumptions. These

are then incorporated into the HERMIN models and used for research into alternative scenarios of regional development policy. Moreover, the chapter presents functionalities of the two newest tools from among the HERMIN models – a system of integrated models of 16 regional economies and the model for the capital city of Warsaw. They open new areas for evaluation studies in Poland. Their results may support public authorities in shaping and implementing strategies and development programmes. The presented analytical capacity of the HERMIN models was illustrated by examples of evaluation studies conducted for central authorities and local government units at various levels.

Further development of the HERMIN models will be a two-way street. First of all, steps will be taken to consider other channels of economic links in the integrated system of regional models. This refers mainly to recording the interregional transfer of production factors: labour and capital. Doing so would allow for a more precise reflection of the impact of public policies on regional economies. Second of all, efforts will be made to create the HERMIN models for each subregion of Dolnośląskie Voivodeship. This will allow for analysis of the impact of the voivodeship government's policy on the region's territorial cohesion. Furthermore, it will be possible to establish the extent to which the effects of public interventions (i.a. Cohesion Policy) are discounted by the metropolitan area, subregional growth centres and peripheral territories.

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# III. The importance of studying inter-regional spillover effects of European policies: application of the RHOMOLO applicationmodel for Poland

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## Introduction

The European Commission plays a key role in developing the overall strategy of the European Union (EU) as well as in designing and implementing its policies. This is carried out mainly by proposing legislation to the European Parliament and the Council of the European Union, by helping the Member States (MS) implementing EU legislation and managing the EU budget. In doing so, the European Commission is also responsible for systematic reporting on the progress in the implementation of EU policies and their evaluation. This is done by publishing periodical reports in accordance with the annual strategic plan and programming cycle. Particular attention is being paid to the effectiveness, efficiency, relevance and coherence of policies, as well as their contribution to EU added value.

There are different types of policy impact assessments/evaluations. Ex-ante evaluations are conducted before a decision is issued and prior to implementation, and serve the purpose of supporting policymakers in the selection of different policy designs. Interim and on-going evaluations highlight the areas of progress/delay, which could be tackled during current policy implementation with a view to improving the efficiency/effectiveness of the selected policy strategy. Finally, ex-post evaluations take place upon the completion of an intervention, when data on its implementation become available. At the European level, impact assessments (IAs) are carried out with respect to all initiatives which are expected to have significant economic, social or environmental impact. Their findings are

always summarised in IA reports, whose quality is checked by the Regulatory Scrutiny Board, an independent body within European institutions. The Board examines and issues opinions and recommendations on all of the Commission's draft impact assessments, major evaluations and fitness checks of existing legislation. After passing this quality check, IA reports are published with the proposals or acts proposed by the Commission and sent to the Parliament and the Council for consideration when deciding whether or not to adopt the proposed law.<sup>57</sup>

Most policy assessments are carried out using different instruments, including economic model simulations, counterfactual analyses and econometric studies (for an analysis of the instruments used between 2009 and 2014 see Petrov et al., 2017). Some recent examples of evaluations of specific EU policies include the following: the IA of the European and Regional Development Fund and the Cohesion Fund (ERDF and CF, respectively; see European Commission, 2018a); the IA of the European Social Fund (ESF; see European Commission, 2018b); the IA of Horizon Europe (European Commission, 2018c); the ex-post evaluation of the European Fund for Strategic Investments (EFSI; see European Commission, 2018d). These four examples have one thing in common: the spatial dynamic computable general equilibrium (CGE) model called RHOMOLO (Lecca et al., 2018) which has been used either as the sole analytical tool or in combination with other instruments. Modern macroeconomic models such as RHOMOLO provide coherent and internally consistent frameworks to analyse the channels through which macroeconomic policies affect national and regional economies.

The RHOMOLO model has been developed by the Joint Research Centre (JRC), the European Commission's science and knowledge service, and the Directorate-General for Regional and Urban Policy (DG REGIO). The structure of the model – calibrated based on data for 267 EU NUTS2 regions – makes it a suitable tool for evaluating policies implemented at the regional level, as well as for evaluating the territorial impact of policies implemented at national and European level. Among the said policies, and despite all of them have interesting implications at the regional level in the EU, the one with a more pronounced territorial aspect is the European Structural and Investment Funds (ESIF). ESIF include five different funds, which are all covered by Regulation (EU) No 1303/2013 of the European

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<sup>57</sup> IAs are required by the Better regulation guidelines (European Commission, 2015). These guidelines state that evidence should be quantified as much as possible and based on transparent assumptions, uncertainties and methods.

Parliament and of the Council, the so-called “Common Provisions Regulation”. Structural Funds have two components: the European Regional Development Fund (ERDF), providing financial support since 1975 for the development and structural adjustment of regional economies, economic change, enhanced competitiveness, as well as territorial cooperation throughout the EU; and the European Social Fund (ESF), which was set up in 1958 and seeks to contribute to the adaptability of workers and enterprises, access to employment and participation in the labour market, social inclusion of disadvantaged people, combating all forms of discrimination, and creating partnerships to manage reforms in employment. The other three funds constituting ESIF are the Cohesion Fund, which supports exclusively less-developed Member States; the European Agricultural Fund for Rural Development; and the European Maritime and Fisheries Fund. In particular, under the 2014–2020 Multi-annual Financial Framework (MFF), slightly more than €461 billion have been allocated from the Community budget to these funds (the total budget including national funding totalling €645 billion).

While it is important to evaluate the economic and social effects of such policies in the regions which receive the funds and are affected by the measures provided for in EU programmes (as in, for example, Di Comite et al., 2018a), we argue that it is essential to understand the system-wide implications of EU policies even when the analysis focuses on specific territories. The intuition behind such statement lies in the fact that almost any intervention, however small and implemented in a specific territory, will probably affect one or more regions outside the targeted one. The reason is that all European regions are interconnected through trade links as well as factor mobility, that is workers (labour) and investments (capital) moving from one region to another without barriers.<sup>58</sup> This Chapter contains an analysis carried out using the RHOMOLO model to demonstrate the importance of accounting for inter-regional spillover effects when studying European policies.

The remainder of the Chapter is organised as follows: Section 2 illustrates in a non-technical way the RHOMOLO model and argues for its relevance in support of policy making. Section

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<sup>58</sup> Since the Schengen Agreement signed in 1985, the freedom of movement and residence for persons in the EU has been one of the cornerstones of Union citizenship, established by the Treaty of Maastricht in 1992. The gradual phasing-out of internal borders under Schengen agreements was followed by the adoption of Directive 2004/38/EC on the right of EU citizens and their family members to move and reside freely within the EU. As for capital, the European Commission is continuously working on removing of the existing international barriers to the movement of capital (Christensen *et al.*, 2018b).

3 presents some results pertaining to the ex-ante IAs of the 2014–2020 European Regional and Development Fund and Cohesion Fund, and Section 4 does the same but focuses on Polish regions. Section 5 provides a conclusion.

## Introduction to the RHOMOLO model

The RHOMOLO model was developed by the European Commission's Joint Research Centre (JRC) in collaboration with the Directorate-General for Regional and Urban Policy (DG REGIO) to support EU policymakers by providing sector-, region-, and time-specific simulations on investment policies and structural reforms in the EU and in its Member States. Broadly speaking, general equilibrium models are used to generate insights into the effects of policies and others shocks in the areas of trade, fiscal policy, demography, immigration, labour markets and the environment. More specifically, computable general equilibrium (CGE) models permit to quantify these effects with respect to industries, occupations, regions and socioeconomic groups (Dixon and Jorgenson, 2013). The standard way to specify a CGE model is to use data of a certain region or groups of regions for a certain year (labelled base year) organised in the form of Social Accounting Matrices (SAMs) and perform a calibration exercise resulting in the evaluation of certain model parameters. SAM is a way of organising information regarding an economy to account for all the transactions in the product and resource markets and also include the characteristics of labour force, government policies (taxes and transfers) and other allocations of income. Essentially, a SAM includes more information than a simple IO table (containing information on the production and use of goods and services and the income generated in that production), as it includes information on the secondary distribution of income, detailing the roles of labour and households (Miller and Blair, 2009).

The main distinctive feature of the model lies in its regional dimension, RHOMOLO being calibrated based on data for 267 EU NUTS 2 regions, as well as for a residual region accounting for the rest of the World. The model is unique in its geographical description of EU regions which are interrelated economically via a system of multi-regional IO tables and geographically via the use of big data and satellite information for the purpose of establishing territorial proximity and accessibility (Persyn et al., 2019). As such, the nature of the model makes it a suitable tool to analyse the territorial impact of funding programmes and policies – especially those with a marked geographical focus such as the EU cohesion

policy – although over time the scope of the model has been broadened in order to meet the additional requests coming from EU institutions and other external stakeholders.

At the time of writing, several alternative versions of the RHOMOLO model are available depending on the type of analysis to be carried out. Moreover, the model framework allows some degree of flexibility on certain patterns such as the modelling, for example, of some assumptions on the labour market structure (i.e. wage-setting mechanisms, migration dynamics) and on the mobility of production factors. In turn, this makes RHOMOLO a truly flexible tool useful for the evaluation of a number of different types of policies and funding programmes.

Currently, beyond the standard RHOMOLO model version, it is worth mentioning the existence of (a) the RHOMOLO-EIB version used for the evaluation of the so-called Juncker plan (EIB, 2018); (b) the RHOMOLO-IO (IO stands for input-output) version used, e.g., for the evaluation of the European Globalisation Adjustment Fund (European Commission, 2018b) and the impact of Energy Union under the third pillar of the Investment Plan for Europe (Christensen et al., 2018a).

The full mathematical description of the RHOMOLO model is beyond the scope of the present Chapter and can be found in Lecca et al. (2018). Suffice it to say that the model has a set of ten economic sectors (based on the NACE 2 industry classification<sup>59</sup>) and firms are assumed to maximise profits and produce goods and services according to a certain production function. The remaining agents in the model include utility-maximising households and a government which collects taxes and spends money on public goods and transfers<sup>60</sup>. Capital and labour are factors of production, and trade is fully characterised by taking advantage of a transport module explained by Persyn et al. (2019). The model is flexible in terms of a number of its behavioural parameters, including its labour market assumptions as illustrated in Lecca et al. (2019).

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<sup>59</sup> As such, this is consistent with the Polish Classification of Activities (PKD 2007).

<sup>60</sup> The high dimensionality of RHOMOLO in terms of regions and sectors implies that the number of (non-linear) equations to be solved simultaneously is very large (in the order of hundreds of thousands). To keep the model manageable from a computation point of view, its dynamics are kept relatively simple. The model is solved in a recursively dynamic mode, where a sequence of static equilibria is linked to each other through the law of motion of state variables. This implies that economic agents are not forward-looking and their decisions are solely based on current and past information.

The RHOMOLO dataset is a multi-regional IO table for the EU-28 at the NUTS 2 level which results from a complex procedure making use of a number of data sources and procedures, as explained in detail by Thissen et al. (2019). Essentially, the Supply and Use tables for the 28 MS of the EU published by Eurostat are the starting point for the construction of the dataset. The tables are then trade-linked using information on the trade of both goods and services, and then regionalised using information available at the NUTS 2 level. Finally, the inter-regional IO tables for the NUTS 2 regions of EU-28 are created, taking into account a number of issues such as re-exports and the existence of logistic hubs. The model is calibrated based on data for 2013, although the dataset is updated periodically in order to reflect the most recently available economic situation of the EU.<sup>61</sup>

As briefly mentioned above, the results obtained from the use of the RHOMOLO model have been featured in a number of recent European Commission's IAs and are highly visible thanks to official policy documents (for instance, see European Commission, 2018e, in relation with the EFSI) and communications (such as European Commission, 2018f for the Investment Plan for Europe). For transparency and accounting reasons, the analyses supporting such documents are fully illustrated in corresponding research reports. One example is offered by Christensen et al. (2018a) whose main results are also summarised in a non-technical policy brief published in the same year (Christensen et al., 2018b).

Since the aim of this Chapter is to illustrate real model applications for funding programmes, the next section is devoted to the illustration of the European cohesion policy and the resources mobilised under it during the current programming period (2014–2020). Then, section 4 zooms on Poland to offer some policy insights for its regions based on the results of the RHOMOLO modelling analysis.

## The European cohesion policy

The European cohesion policy is the EU's main investment policy and it targets all regions and cities in the EU to support job creation, business competitiveness, economic growth and sustainable development. The aim of cohesion policy is to achieve economic and social cohesion, namely to reduce the disparities between EU regions by promoting more balanced

<sup>61</sup> Data updates in the model depend on the availability of Supply and Use tables at national level (Thissen et al., 2019). There will be a new release with 2014 data in the course of this calendar year.

and sustainable territorial development. Under the 2014–2020 Multi-Annual Financial Framework (MFF), more than €460 billion of Community funding<sup>62</sup> has been allocated. Around 70% of the resources go to the economic, social and territorial cohesion objective, with more than half of that targeting less developed regions where GDP is less than 75% of the EU average. The implementation of the policy is constantly monitored by European institutions (see, for instance, European Commission, 2018g).

The analysis of the impact of European cohesion policy in Poland follows the approach and methodology used in Di Comite et al. (2018b), where the system-wide effects of structural and cohesion policy funds have been estimated. The model takes into account the fact that the cohesion policy is financed by contributions of each Member State proportionally to its contribution to the overall EU budget. Each Member State's contribution is assumed to be proportional to its GDP and is financed through lump-sum taxes. In turn, increasing taxes adversely affects economic performance and this partly offsets the positive impact of the programmes. In the 2014–2020 programming period, expenditure under cohesion policy has been officially split into 123 categories, but, for the purposes of the present simulation, we have regrouped them into six main groups of policies: transport infrastructure investments (TRANSP); other infrastructure investments (INFR); investments in human capital (HC); investments in research and innovation (RTD); aid to the private sector (AIS); and technical assistance (TA). These six categories of investment are implemented in RHOMOLO through eleven different variables (policy shocks) as described in Table 1.

Financial resources under cohesion policy amount to roughly €77 billion in Poland and around €273 billion in the Rest of the EU (REU) in 2011 prices.<sup>63</sup> The relative allocation of funding across expenditure items is not identical in all regions, but is tailored to the specific needs of each territory. For Poland, in the 2014–2020 programming period, 36% of total investments are allocated to transport infrastructure investments, 26% to other infrastructure investments, 16% to human capital, 15% to research and development, while 5% and 3% are allocated to aid to private sectors and technical assistance, respectively. Each policy category is assumed to generate temporary and structural effects on the regional economies. The temporary effects directly reflect the transfer of resources resulting from the implementation of the cohesion policy package, while the structural effects are introduced with the idea to capture long-lasting changes associated to each policy intervention.

<sup>62</sup> <https://cohesiondata.ec.europa.eu/overview>

<sup>63</sup> Simulations for ex-ante impact assessment are performed with original financial allocation at 2011 prices.

**Table 1.** Introduction of cohesion policy shocks in RHOMOLO

Type of Shock	TYPE	MODEL VAR	No	Temporary effect /EU budget money flow	Permanent policy effect
Infrastructure - Transport	TRNSP	TCOST	1	Increase in government consumption	Decrease in transportation costs
Infrastructure - Other	INFR	IG	2	Increase in public investment	-
		G	3	Increase in government consumption	
Human Capital	HC	TRAIN	4	Decrease in labour supply (all workers) + Increase in government consumption	Increase in labour productivity (all types of labour)
		TRAINH	5	Decrease in labour supply (highly skilled workers) + Increase in government consumption	Increase in high-skill labour productivity (highly skilled workers)
R&D	RTD	FCA	6	Increase in government consumption	Increase in TFP
		RPREMA	7	Investment subsidy to reduce risk premium	
Aid to Private Sector	AIS	FCY	8	Production subsidy	-
		RPREMK	9	Investment subsidy to reduce risk premium	
		G	10	Increase in government consumption	
Technical Assistance	TA	G	11	Increase in government consumption of "other services" in recipient regions (financed by the others)	-

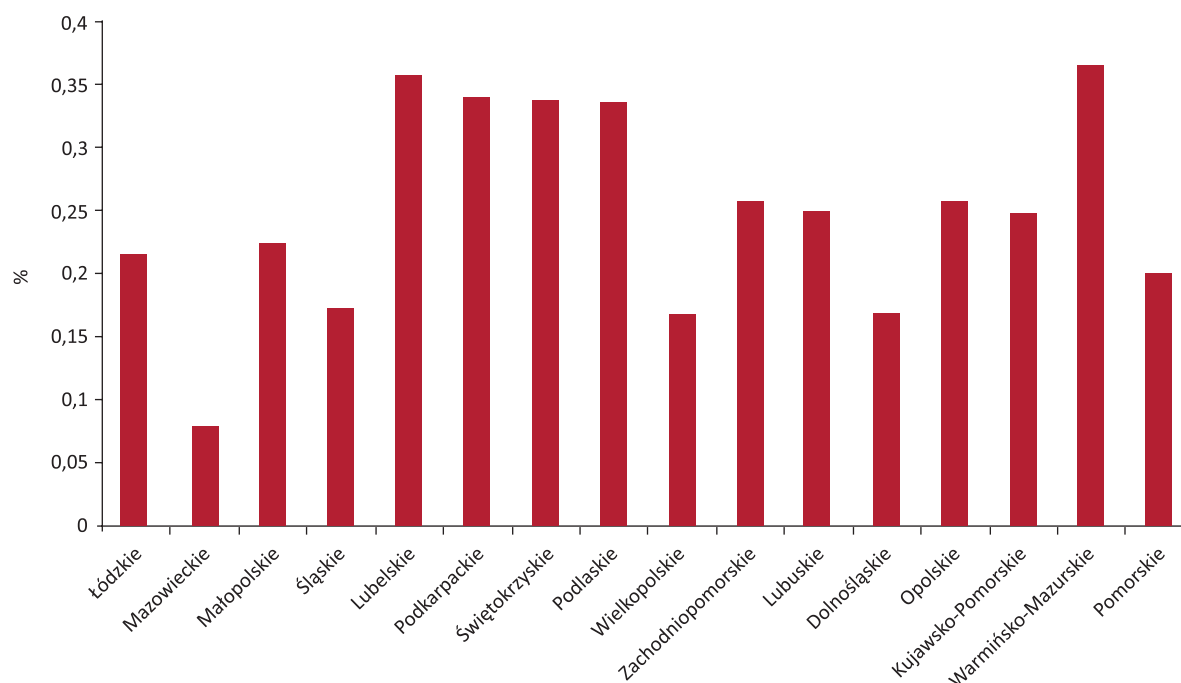
TCOST – inter-regional transportation costs; IG – government investment; G – government consumption; FCA – entry costs to intermediates; FCY – fixed costs final demand firms; TRAIN(L,M,H) – worker training; RPREMK – shock to tangible capital cost; RPREMA – shock to intangible capital cost.

Four types of temporary shocks are covered: government purchases of goods and services from the market, as in the shocks number 1, 3, 4, 5, 6, 10 and 11 in Table 1; public investments, as in shock number 2; production subsidies, as in shock number 8; investment subsidies aimed at reducing the risk premium, as in shocks number 7 and 9.

There are five main types of structural shocks: reductions in transport costs (shock number 1); increase in TFP (shock number 6); increase in labour productivity combined with a temporary reduction in labour market participation (shocks number 4 and 5).

To get an idea of the magnitude of the investments and the relative allocation of funding across regions, Figure 1 plots the investments as a share of GDP for each of the Polish regions. We observe that the spatial allocation of funding is uneven across regions benefitting relatively more the poorer regions. Indeed, there is a group of regions, i.e. Lubelskie (PL31), Podkarpackie (PL32), Świętokrzyskie (PL33), Podlaskie (PL34) and Warmińsko-Mazurskie (PL62), that receive relatively more than other regions. Mazowieckie (PL12) – the largest, most populous and most prosperous region in Poland – receives a lower amount of funding relative to its own GDP.

**Figure 1.** ESI Funds as a share of GDP in Polish NUTS 2 regions<sup>64</sup>



Source: European Commission, DG REGIO (<https://cohesiondata.ec.europa.eu/browse>)

<sup>64</sup> <https://ec.europa.eu/eurostat/web/nuts/nuts-maps-.pdf>

## Modelling analysis of Polish regions

In this section, we present the results of the simulations implemented in RHOMOLO, as described in the section above. We mainly focus on the macroeconomic impact of the cohesion policy in Poland at national and regional level. The simulation results suggest an increase in Polish GDP for the entire programming period and beyond, with long-lasting effects generated by the structural policies simulated (Figure 2). In the year 2062 (forty years after the end of the policy, considered here as the very long-run time horizon of the analysis), GDP increases by 0.63% compared to base year values and reaches its peak in 2023, that is at the end of the financing period. In Figure 2, we also plot the level of the investment shock (bars) as a share of GDP. We observe that in the short-run and for the period between 2014 and 2020, the investment expenditure in Poland is higher than the benefits in terms of GDP generated in the country. This means that in this time-frame, multiplier effects are positive, but lower than one.<sup>65</sup> Nevertheless, after this period, positive permanent effects remain as the interventions durably improve the structure of the Polish economy, thus allowing the policy to have an impact even many years after the termination of the programmes. In the long-run, the structural change effects associated with the interventions might be very substantial and able to generate cumulative multipliers greater than 1, as in this case.

The response to the investment funds is asymmetric across the regions in Poland. This is confirmed in Figure 3, where we show the long-term impact on GDP and employment disaggregated at NUTS 2 level. Typically, we observe that the impact is higher in regions receiving relatively more in terms of funds, as confirmed by Figure 1. We also notice that changes in GDP are greater than changes in employment. This suggests that capital stock is increasing more than employment. Essentially, the European policy is targeted to stimulate investments generating bigger substitution effects<sup>66</sup> in favour of capital. Overall, employment does rise in the long-run, implying that the general equilibrium

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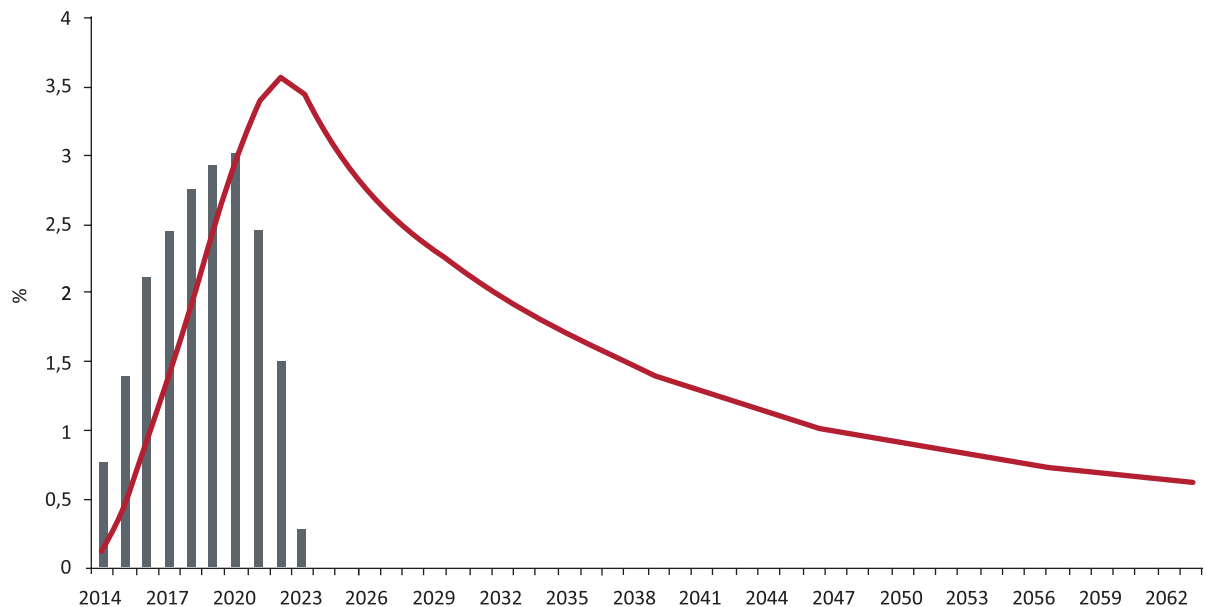
<sup>65</sup> Multiplier is defined as the ratio between the changes in national income to the change in government expenditures. Therefore, a multiplier greater than 1 implies changes in GDP larger than the changes in the initial stimulus.

<sup>66</sup> The substitution effect is the change in the demand of factors of production (here capital and labour) due to changes in the relative prices of factors of production. In this case, policy intervention makes the price of capital lower than the price of labour.

demand curve for labour is wage-elastic, that is employment is fully responsive to changes in wages.

According to Di Comite et al. (2018b), the EU average long-run increase in GDP settles to 0.62% from base-year values. Hence, with the exception of the Mazowieckie and Wielkopolskie Voivodeships, the remaining regions in Poland are growing at a bigger long-term rate than that registered for the EU as a whole. This partially means that Polish regions are catching up and that structural and cohesion funds are largely helping the process of regional convergence.

**Figure 2.** Cohesion policy investments as a share of GDP (bars) and GDP impact (black line) as % deviations from the baseline GDP in Poland

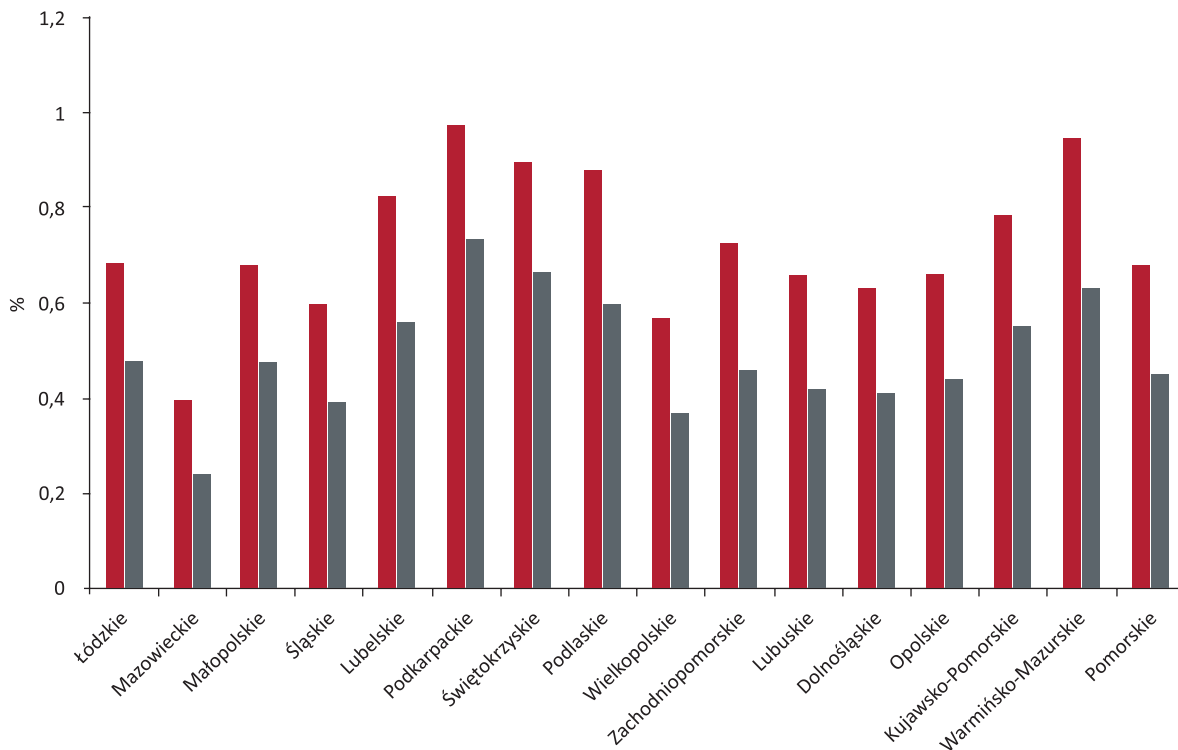


Source: Authors' simulations.

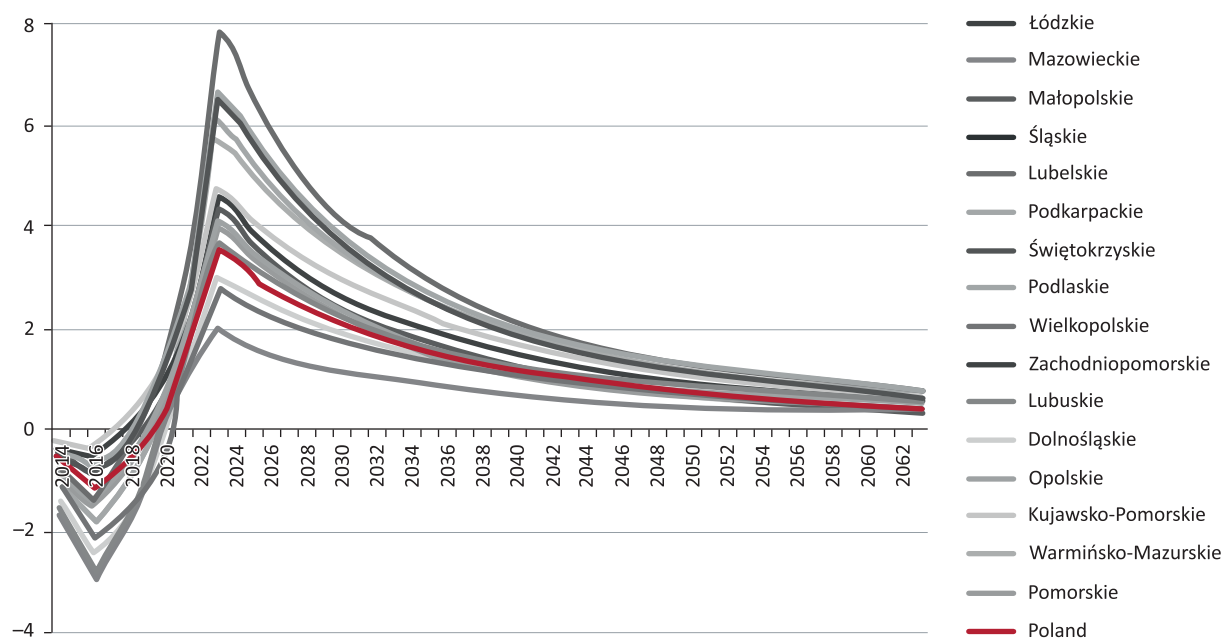
The macroeconomic adjustments generated by the European cohesion policy induce a system-wide increase in the efficiency of Polish economies in the long run. The stimulus to investments is then translated into a reduction in the price of capital that in turn puts downward pressure on the price of all commodities. This has the effect of increasing real income in the target economy, thereby raising consumption of domestic goods. Moreover, the fall in prices provides a source of positive effects in terms of international trade, which

eventually stimulate foreign demand for goods and services, increasing output in the economy even further. This mechanism is confirmed by Figure 4 where we show the deviation from base-year values of exports of all the NUTS 2 regions of Poland. In all regions, exports fall in the short run, because the demand-side effects of the policy interventions dominate the overall impact putting upward pressure on prices and, in turn, generate a reduction in competitiveness. On the contrary, in the long run, the economies involved are able to fully adjust, materialising the supply-side effects intrinsically incorporated into the policy shocks, and therefore stimulating an increase in exports through a reduction in domestic prices.

**Figure 3.** GDP and employment impact (% deviations from the baseline) in Polish NUTS 2 regions, very long run.



Source: Authors' simulations.

**Figure 4.** Evolution of exports of goods and services in Polish NUTS 2 regions

Source: Authors' simulations.

## Inter-regional spillover effects

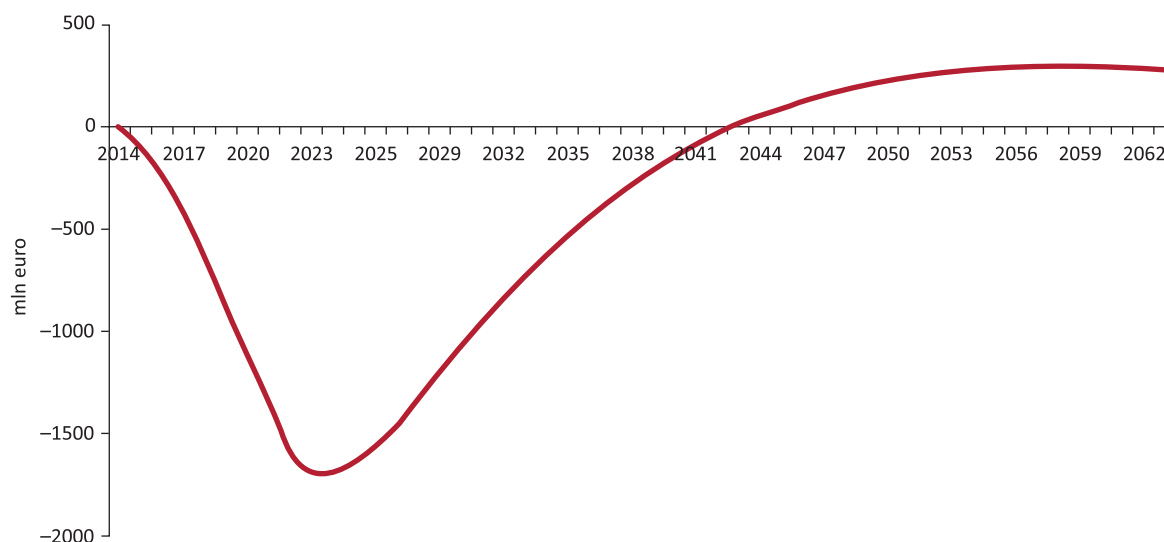
In the preceding section, we have discussed the economic impact that would occur in Poland as a result of a coordinated effort where the policy is implemented simultaneously in all regions and countries in Europe. We are now interested in exploring the nature of inter-regional interactions and spillover effects that would occur as a result of implementing the European cohesion policy in a single country and to what extent the rest of the regions are likely to be affected. In particular, we would like to quantify the scale and the determinants of inter-regional spillover effects and detect channels of adjustment and drivers of benefits (or losses) due to the policy, for the territories not receiving the investments. What would happen if all countries except one would contribute to the policy without receiving any funding from it? Would the policy-induced benefits occurring in the recipient country spill over to the rest of the EU as a result of the indirect trade effects and other inter-regional inter-dependencies? These are essentially the main questions we will attempt to answer.

Our simulation strategy remains the same as the one described in section 3. This means that the simulations performed include the six policy shocks described in Table 1 and that

the monetary injections as well as the structural effects implemented are unchanged. However, for the purpose of this section, the investments are directed exclusively to all regions of Poland, while all the other regions of the EU are simply financing such investments through a lump-sum tax on household income in order to ensure a balanced EU budget.

It is appealing in the first instance to quantify the differences between the GDP impacts obtained under coordinated efforts that we discussed in the previous section with the results obtained when Poland is the only country receiving policy funds. Figure 5 plots the discounted cumulative differences in Polish GDP between the two simulations.<sup>67</sup> We can see that from the short to medium run Poland would be better off if the European policy was only targeted at its regions. However, the opposite occurs in the long run. Once the structural change effects fully materialise in all Member States, Polish economy will gain more if all countries in Europe benefit at the same time from the cohesion policy. As the economy of the other Member States expands due to the cohesion policy, the aggregate effects on the Polish economy will be larger. There is therefore a clear system-wide benefit of the Cohesion policy in the long run.

**Figure 5.** Discounted cumulative differences in Polish GDP between two alternative simulations



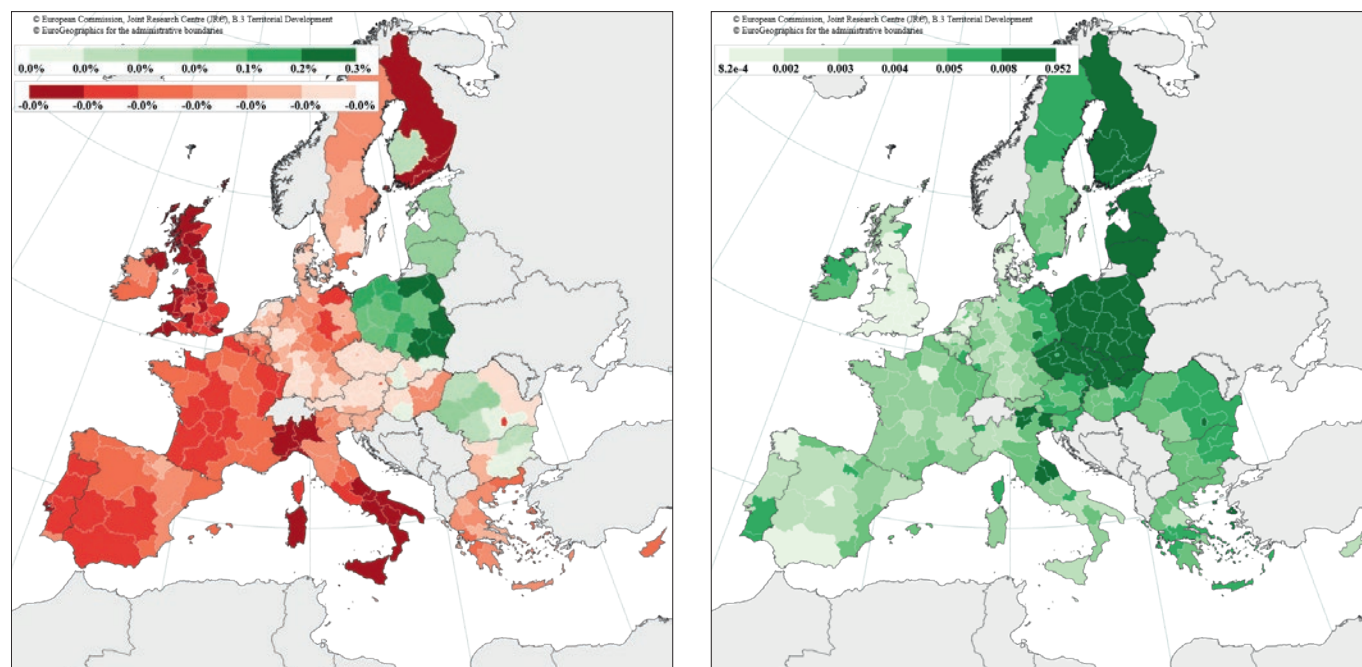
Source: Authors' simulations.

<sup>67</sup> The discount factor is set to 5%.

Figure 6 shows the short- and long-run impact of cohesion policy for all EU regions, in a hypothetical situation, where Poland is the only beneficiary of EU funds. The left-hand pane maps the percentage change in GDP from baseline scenario obtained in the first period of the simulation whilst the right-hand pane shows GDP deviations for the year 2063.

The results of our modelling exercise suggest that in the first period after the implementation of the shock, the impact on the recipient regions is positive as expected. However, for some (not all) of the non-receiving regions the effects are significantly negative, in particular for the Italian region of Mezzogiorno, the south of Spain and the wider UK. The average negative effect for the economies of the rest of the EU is however around 0.003% and reaches the highest negative impact in Abruzzo at 0.015%.

**Figure 6.** The impact of investment under the EU cohesion policy in Poland in the period 2014–2020 on the GDP of EU regions in the short run (left pane) and in the long run (right pane) as % deviation from the baseline



Source: Authors' simulations.

It is interesting to see that a higher share of the positive benefit spills over in the first place to the regions neighbouring the areas financed under the policy, either partially or totally offsetting the negative impact associated with the reduction in income in the regions providing funds. This is due to the fact that it is easier to trade with regions which are closer geographically, which means there is a closer integration among neighbouring economies. For example, negative impact in CZ05, CZ07 and DE40 is almost negligible, while, in Latvia, the impact on GDP is positive. Nevertheless, the majority of non-simulated-contributor regions experience a negative impact on economic activities in the short run. Thus, the issue here is that the incentive to undertake costly policies that generate a positive stimulus to a local economy such as Poland could be discouraged if much of the short-run impact was actually negative for a prolonged period in the non-stimulated regions.

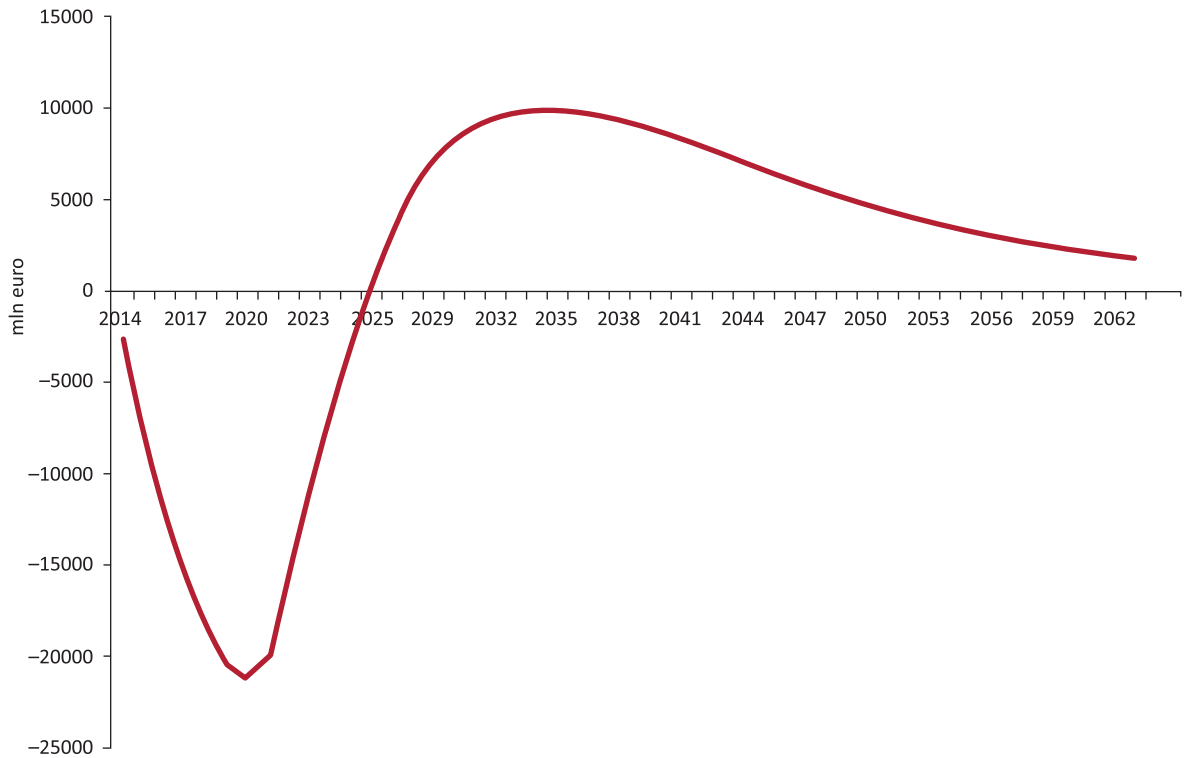
However, as the supported regional economies grow, further additional output is generated. Therefore, a bigger share of the local benefits spill over to those regions not necessarily located in the neighbourhood of the ones where the interventions took place. As the right-hand pane of Figure 6 suggests, all regions in the EU enjoy positive economic benefits in the long run. This implies a form of delayed compensation for the non-beneficiaries that have partly contributed to external policy benefits for other local economies.

In order to verify whether the efforts undertaken by the REU to finance the overall cohesion policy in Poland is financially viable, we compute the Net Present Value (NPV) of investments for the EU as a whole. The NPV in this context gives us the magnitude of the (discounted) multiplier effect in each period for the entire EU. Note that even if the NPV is negative, the overall impact on the economy is not necessarily negative. It could simply mean that the multiplier effect is less than 1.<sup>68</sup> The NPV in this case provides an indication of the time in which the EU economy is able to fully absorb the exogenous demand shock implemented in Poland. The results plotted in Figure 7 suggest that the NPV is negative for a prolonged period, but then eventually becomes positive in 2026. Hence, our results suggest that the funding countries should wait for a protracted period of time before seeing some returns. The gains for the funding countries could be bigger if investments in the target regions were directed towards interventions that are intrinsically supply-side policy with long-lasting effects (such as improvements in transport infrastructure or policies aiming to increase labour productivity).

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<sup>68</sup> Meaning that the proportionate changes in GDP are lower than the initial stimulus.

**Figure 7.** Net present value of investments under the EU cohesion policy in Poland (EUR million)



Source: Authors' simulations.

The type of policies considered can generate a different set of results. The long-lasting effects of the EU cohesion policy are crucial in that sense. This particular policy, at least part of it, is designed intrinsically to develop a better supply-side regional policy and our simulations suggest that, in this case, it is capable of generating overall positive spillover effects in the long run. This is reassuring, as alternative policies (either supply-side or demand-side) could have led to different results and entail negative effects due, for instance, to increased competitiveness in one region adversely affecting its neighbours.

## Conclusions

The European cohesion policy is the EU's main investment policy which targets all regions and cities across the EU to support job creation, business competitiveness, economic growth, and sustainable development. The aim of the cohesion policy is to achieve economic

and social cohesion, that is to reduce the disparities between EU regions by promoting more balanced and sustainable territorial development. In the 2014–2020 programming period, one third of the EU budget has been allocated to the projects under this policy. The European Commission is responsible for the evaluation and reporting of its policies on a regular basis, and the cohesion policy is no exception. These evaluations and the IAs of the European policies are carried out with a number of instruments, including economic models. This Chapter makes use of one of them, RHOMOLO, and focuses on Polish regions.

RHOMOLO is a spatial CGE model of the European Commission focusing on EU regions. It has been developed and maintained by the Regional Economic Modelling team at JRC Seville in cooperation with DG REGIO. The model is particularly well-suited for analysing policies related to investments in human capital, transport infrastructure and innovation. RHOMOLO is being used extensively for evaluating interventions financed by European Structural and Investment Funds, such as the ERDF and the ESF, and is used together with the European Investment Bank (EIB) to evaluate the macroeconomic impact of the EIB group.

The above analysis deals with the inter-regional interactions that would occur as a result of implementing the EU cohesion policy in a single country, namely Poland. The intention is to determine whether the policy-induced benefit enjoyed by one country receiving the cohesion policy funds would spill over to the rest of the EU as a result of indirect trade effects and other inter-regional inter-dependencies and interactions. In these regions, the positive spillover effects coming from the supported regions in terms of increase demand of imports partially offset the negative impact associated with the reduced income required to finance the policy.

Cohesion policy interventions substantially increased GDP in Poland, especially in the regions which are the main beneficiaries of the policy. The highest impact is found in Podkarpackie (PL32) and Warmińsko-Mazurskie (PL62) Voivodeships, where at the end of the implementation period GDP increases by ca. 1%.

The analysis shows that the policy has a long-run impact, lasting years after the end of the programmes. This reflects the fact that cohesion policy supports investments in key engines of growth and durably improves the structure of the Polish economy. Finally, the results suggest that interventions in Poland also benefit other EU regions as they produce positive spillover effects, thereby partly offsetting the partial financing of the costs of the Polish programmes.

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# IV. Forecasting regional growth: the MASST model

Roberta Capello and Andrea Caragliu

## Abstract

Nowadays, forecasting regional growth is not possible without taking into account the recent economic dynamics at national and supranational level. In fact, the particular focus of the European Union on sovereign debts and deficits imposed by the economic slowdown, the macroeconomic trends that emerged as a result of the crisis and, last but not least, new politically sensible decisions concerning the future of the European Union play a role in explaining the remarkable industrial and geographic heterogeneity in the response to the crisis and the persistence of some of the contraction-induced effects in some countries and regions. All this introduces complexity in the way regional economic growth can be modelled for forecasting purposes. The MASST model is a regional econometric growth model built to simulate regional growth scenarios in the medium and long run (typically, over a 15–20-year time horizon), taking into consideration also macroeconomic aspects; in its estimation step, in fact, it explains regional growth as the result of national macroeconomic trends and regional growth assets at the same time. This paper aims to present the model and its interpretative power by merging national macroeconomic trends and the long-term regional structure. Particular emphasis will be given to the outcomes of two recent simulations for Polish regions.

## Introduction

The recent economic contraction has drawn the attention to the impact of macroeconomic trends on regional growth. In particular, EU countries entered the crisis in 2007/2008 with large differences in terms of outstanding debt, levels of deficits, tax rates, trends in productivity growth and, consequently, different chances for recovery and growth. A huge debate focused on the role of austerity measures in prolonging the contraction

especially in the countries on the southern tip of the continent (Spain, Italy, Greece and Portugal).

Moreover, the impact of the recent substantial financial crisis on public debt in some EU countries has been severe. While prior to the crisis most EU countries witnessed a decrease in debt/GDP ratios, following the criteria of the Maastricht Treaty, the recent slump has reversed this process, following the resurgence of Keynesian public expenditure. After a decade of financial stability induced by the creation of the euro, international markets started associating positive chances of default with some EU countries, mostly located in the south. Some of these countries (e.g. Spain and Portugal) agreed to austerity measures to counterbalance this debt crisis. Other states partially defaulted on their debt (Greece); many others (e.g. Italy) now suffer from positive risk premiums with respect to more solvable countries (chiefly Germany<sup>70</sup>), which translates into unproductive extra public expenditure just to service their debt.

These macroeconomic elements play a major role for the development of both countries and regions. They may also exert substantial influence on the convergence process at both EU and country level<sup>71</sup>. Such effects have been modelled over time both through standard econometric analyses<sup>72,73</sup>, as well as within more complex macroeconomic model simulation exercises. Within the latter branch, a relevant role has been played by the MASST (Macroeconometric, Social, Sectoral, Territorial) model<sup>74</sup>. Now at its fourth generation, the MASST model has over the last twelve years evolved to forecast regional growth taking into

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<sup>70</sup> The Technical Appendix shows interest rates on 10-year maturity bonds for euro-denominated debt for Germany, Spain, Greece and Italy between 1993 and 2019. As of 18 June 2019, German Bunds sell for a 2.47 per cent discount with respect to Italian BTPs with the same maturity (-0.29% vs 2.18%, respectively). Source of raw data: Bloomberg.

<sup>71</sup> R. Capello i in., „Spatial heterogeneity in the costs of the economic crisis in Europe: are cities sources of regional resilience?”, *Journal of Economic Geography* 2015, vol. 15, no. 5, s. 951–972.

<sup>72</sup> *i.e.*, interpreted through econometric analysis without the use of partial or general equilibrium econometric simulation models, such as MASST.

<sup>73</sup> S.P. Groot i in., „The crisis sensitivity of European countries and regions: stylized facts and spatial heterogeneity”, *Cambridge Journal of Regions, Economy and Society* 2011, vol. 4, no. 3, s. 437–456.

<sup>74</sup> R. Capello (red.), „A Forecasting Territorial Model of Regional Growth: the MASST Model”, *The Annals of Regional Science* 2007, vol. 41, no. 4, s. 753–787; R. Capello, U. Fratesi, „Modelling regional growth: an advanced MASST model”, *Spatial Economic Analysis* 2012, vol. 7, no. 3, s. 293–318; R. Capello i in., „Modeling regional growth between competitiveness and austerity measures: The MASST3 model”, *International Regional Science Review* 2017, vol. 40, no. 1, s. 38–74.

consideration structural relations among regional growth asset factors and regional economic growth, complementing in this way other methodologies, like Vector Auto-Regression<sup>75</sup>, macroeconomic models (Hermin model<sup>76</sup>), and the Input-Output model<sup>77</sup>.

Thanks to its structure, the MASST model takes both the macroeconomic trends and policies, as well as the regional asset endowment into account in the explanation of regional growth. The MASST model is in fact a regional econometric forecasting growth model comprising two main subcomponents, viz. the national and a regional sub-model, where the units of observation are the NUTS 2 regions of EU-28. While national GDP growth is built on aggregate demand-side features, regional differential growth depends mostly on supply-side elements. Both national growth rate and regional differential growth rate feed regional growth.

This paper aims to: (i) highlight the structure of the MASST model, underlining its specificities; (ii) provide two scenarios for the period 2018–2035<sup>78</sup> with results at both national and regional level, with special reference to Poland and Polish regions.

We proceed as follows: in Section 2 we discuss the conceptual structure of the MASST model. In Sections 3 and 4 we present, respectively, the assumptions of the reference and of the integration scenarios. Finally, Section 5 contains a conclusion.

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<sup>75</sup> A. Brandsma i in., „RHOMOLO: A dynamic spatial general equilibrium model for assessing the impact of cohesion policy”, *Papers in Regional Science* 2015, vol. 94, no. S1, s. S197–S222; A. Varga, T. Sebestyén, „Does EU Framework Program participation affect regional innovation? The differentiating role of economic development”, *International Regional Science Review* 2017, vol. 40, no. 4, s. 405–439.

<sup>76</sup> See: model Hermin; J. Bradley, J. Zaleski, „Ocena wpływu Narodowego Planu Rozwoju Polski na lata 2004–2006 na gospodarkę przy zastosowaniu modelu HERMIN”, *Gospodarka Narodowa* 2003, no. 7–8, s. 17–46.

<sup>77</sup> A. Masouman, C. Harvie, „Forecasting, impact analysis and uncertainty propagation in regional integrated models: A case study of Australia”, *Environment and Planning B: Urban Analytics and City Science* 2018, online first. DOI: 10.1177/2399808318767128.2018).

<sup>78</sup> These two scenarios were elaborated by the authors as part of the ESPON-ETRF (2018) project.

## Modelling regional growth: the structure of the MASST model

The general theory behind the MASST model is deeply rooted in endogenous development theories in which the competitiveness of an economic system depends on the presence of structural elements (like human capital, knowledge, labour force) and on the ability of the economic system to cumulate them over time through endogenous and self-reinforcing processes. Among these sources of competitiveness, a role is given to intangible ones, in particular social capital in the form of trust and sense of belonging, which gives the economic system, *ceteris paribus*, a competitive edge. Beyond that, the sources of regional competitiveness are enlarged, encompassing the role of innovation and of an equilibrated urban system on regional growth on the basis of new, recently developed conceptual approaches<sup>79</sup>.

The MASST model also draws on recent theoretical reflections, starting with neoclassical growth models<sup>80</sup> that implicitly assume that technological progress is characterised by a worldwide global interdependence among economies which depends on their geographical connection with other economies<sup>81</sup>. The inter-regional link is at the basis of a cumulative and self-reinforcing local growth process à la Myrdal-Kaldor-Krugman<sup>82</sup>. In line with endogenous growth theories, the MASST model highlights an endogenous law

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<sup>79</sup> R. Camagni et al., „One or infinite optimal city sizes? In search of an equilibrium size for cities”, *The Annals of Regional Science* 2013, vol. 51, no. 2, s. 309–341; R. Capello, C. Lenzi (red.), *Territorial patterns of innovation: An inquiry on the knowledge economy in European regions*, Routledge, London (UK) 2013

<sup>80</sup> N.G. Mankiw et al., „A contribution to the empirics of economic growth”, *The Quarterly Journal of Economics* 1992, vol. 107, no. 2, s. 407–437.

<sup>81</sup> E. Lòpez-Bazo i in., „Regional externalities and growth: evidence from European regions”, *Journal of Regional Science* 2004, vol. 44, no. 1, s. 43–73; C. Ertur, W. Koch, „Growth, technological interdependence and spatial externalities: theory and evidence”, *Journal of Applied Econometrics* 2007, vol. 22, no. 6, s. 1033–1062. Recently, Ertur and Koch (2011) have also proposed an extension of the multi-country endogenous (Schumpeterian) growth model that includes technological interdependence between economies in order to take account of the neighbourhood effects on growth and convergence processes. (C. Ertur, W. Koch, „A contribution to the theory and empirics of Schumpeterian growth with worldwide interactions”, *Journal of Economic Growth* 2011, vol. 16, no. 3, s. 215).

<sup>82</sup> G. Myrdal, *Rich lands and poor: the road to world prosperity*, Harper & Row, New York 1957; N. Kaldor, „The case for regional policies”, *Scottish Journal of Political Economy* 1970, vol. 17, no. 3, s. 337–348; P. Krugman, „Increasing returns and economic geography”, *Journal of Political Economy* 1991, vol. 99, no. 3, s. 483–499.

of accumulation for the population expressed in a long-term neoclassical view as a resource for production development which should not be wasted on emigration.

Last but not least, the MASST model refers to growth theories claiming that regions are part of a wider economic system, and that much of their growth still depends on national factors, such as: (i) institutional features such as the efficiency of the legislative, judicial and governmental functions of the state; (ii) organisational factors such as the quality of services of general interest like education, transport, communication, health and security services; (iii) economic factors such as general fiscal pressure, effectiveness of public expenditure, pervasiveness of environmental regulations, efficiency of contract enforcement procedures, sovereign debts and deficits. These last elements were missing in the previous versions of the model; in the new version, public expenditure growth rates at national level become endogenous, making the model define its growth rate according to the public debt/GDP ratio and to the distance of public debt to exogenously given policy targets.

The MASST model has some distinct features that differentiate it from other forecasting models<sup>83</sup>. It contains an interesting mixture of demand- and supply-side elements that explain regional growth at national and regional level: whilst, in fact, national growth is mostly explained by aggregate demand elements, the model is also intended to capture price competitiveness effects at national level. At regional level, while differential regional growth is mostly explained by territorial capital elements, in line with most advanced regional growth theories, demand elements are captured by the mix of sectors present in the region.

Another important feature of MASST resides in that it allows to simultaneously model competition and cooperation among regions. Competition is related to the generative part of the model, which guarantees higher regional growth rates to more competitive regions; cooperation is assured by interregional linkages inserted in the form of regional growth spillovers in the regional differential shift equation and through classical proximity and accessibility effects, which is kept from the first version of the model<sup>84</sup>.

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<sup>83</sup> R. Capello, U. Fratesi, op. cit.

<sup>84</sup> See: R. Capello in., *Modelling regional scenarios for the enlarged Europe: European competitiveness and global strategies*, Springer Science & Business Media 2008.

A final feature of MASST resides in its true territorial nature, where not only regional growth spillover effects are modelled, but also the settlement structure of regions is taken into consideration both in the estimation and in the simulation phase.

Some specificities of the previous MASST model are worth inspecting, before presenting the model, that still hold for the new version. The purpose of the MASST model is to create territorial scenarios under different assumptions about the main driving forces of change that will act in the future. The quantitative results of the model are not precise values of specific economic variables in the future, but – on the basis of a system of past socio-economic relations – they depict the tendencies and relative behavioural paths of regional GDP (and regional employment) in each individual region under certain conditions, i.e. probable states of the system that may become real under certain conditions that are exogenously assumed. Therefore, the model does not work as a short-term forecasting tool, but a long-term quantitative foresight model.

In a scenario-building exercise of this kind, the presence of the MASST model guarantees that the results do not directly derive from the assumed exogenous, context conditions (scenarios), since they are based on the structural relationships that hold together the economic system in an objective way (estimates).

## Reference scenario

The MASST model has recently been applied to develop two scenarios: one reference scenario, which serves as a benchmark scenario, and an integrated scenario. Concerning the reference scenario, structural changes occurring during the crisis have to be taken into account. In fact, EU countries have come out of the economic crisis differently from what they looked like in 2007–2008. The productivity slowdown to which much of the slow pre-2007 growth is attributed<sup>85</sup> has not abated during and after the crisis, at least in most western economies<sup>86</sup>. Yet, after-crisis structural relations, especially at the regional level,

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<sup>85</sup> G. Cetto et al., „The pre-Great Recession slowdown in productivity”, *European Economic Review* 2016, no. 88, s. 3–20

<sup>86</sup> J.G. Fernald, „Productivity and Potential Output before, during, and after the Great Recession”, *NBER macroeconomics annual* 2015, vol. 29, no. 1, s. 1–51.

have been found to be significantly different than those before, and also after the end of, the crisis<sup>87</sup>.

An extrapolative scenario is impossible to be derived on the basis of estimations of the pre-crisis or of the crisis period. For this reason, the MASST model has been developed so as to take into account structural changes. In the most recent version, macroeconomic relations are tested so as to isolate possible inflection points, on the basis of the identified estimates periods (2000–2008; 2008–2012; 2012–2016) that takes into account the most important events associated with the crisis. By the same token, the regional sub-model of MASST introduces similar periodization and tests whether and for which equations the three periods behave differently and in a statistically significant way.

Looking at the data on GDP growth since 2012, we can identify three relatively homogeneous clusters of EU countries. One is made up of four countries (Greece, Italy, Finland and Cyprus) which exited the crisis with stagnant GDP levels. A second cluster, comprising the majority of other EU-15 countries (“Old-15”), resumed growing as fast as during the crisis, which still slowed down their economies in the 2008–2012 period. A third cluster (comprising mostly Central and Eastern European countries, henceforth, CEECs with the exception of Ireland and Luxembourg) managed not to slow their economies during the years 2008–2012 and regained momentum, with some countries growing even faster than before the crisis.

The reason for the differences in GDP rates of these three groups emerge quite evidently in econometric estimates. In the post-crisis period, the reactivity of investment growth to GDP growth triplicates, showing much higher cumulative effects than before the crisis. This is particularly true for the fast- and medium-growth countries. At the same time, investments became more volatile, showing that they are less linked to their long-term trend. This is especially true for low-growth countries (Figure 1).

Other structural changes emerge. In its estimation phase, the MASST model shows that in the post-crisis period, after the pre-crisis de-industrialisation process of the European economy, an initial launch of high-tech industry in Europe takes place, under the influence of the new technological paradigm “Industry 4.0”. Moreover, an increase in high-value added services is replacing the pre-crisis development of the service sector.

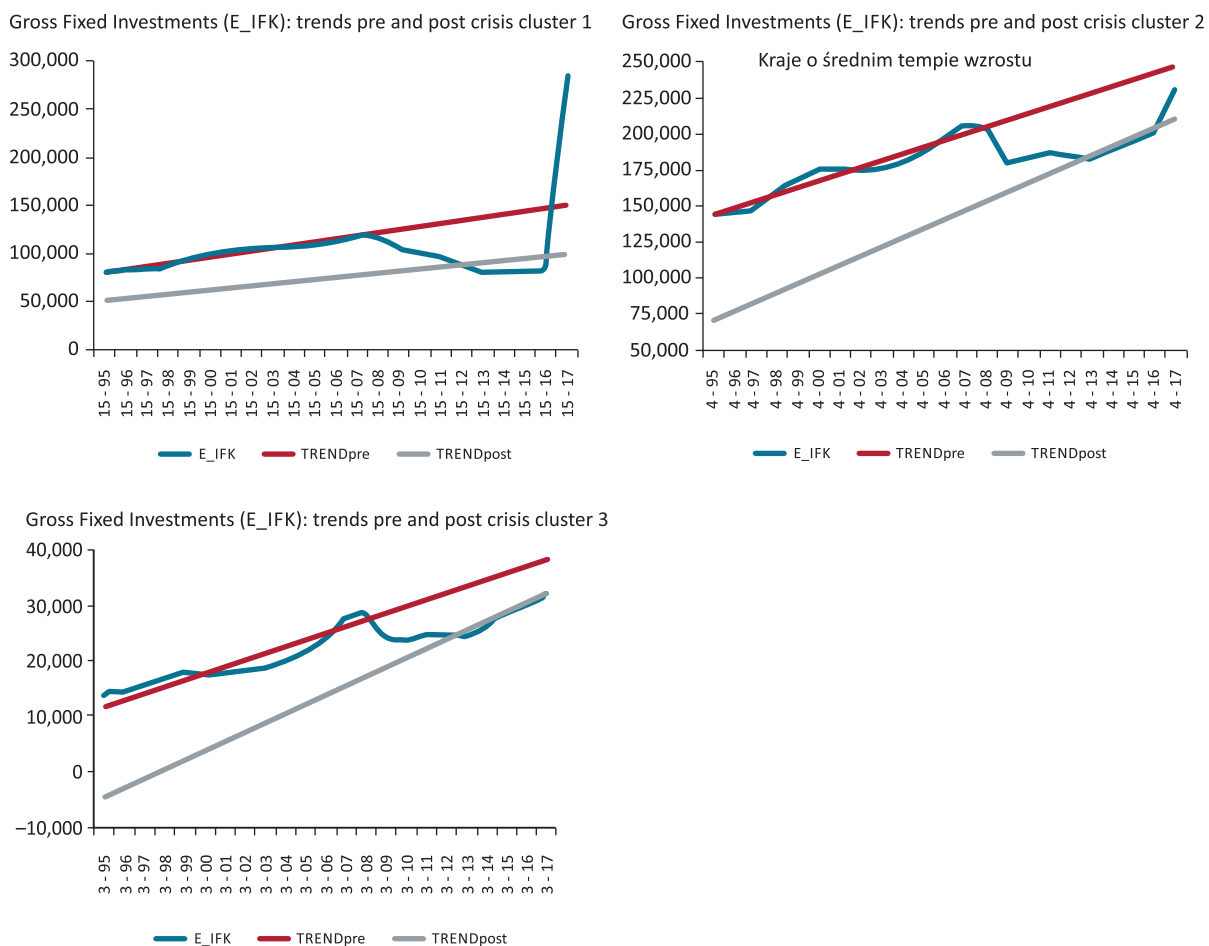
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<sup>87</sup> R. Capello i in., „Compensation modes of border effects in cross-border regions”, *Journal of Regional Science* 2018, no. 58, s. 759– 785. <https://doi.org/10.1111/jors.12386>

These structural changes represent the assumptions for a “reference scenario”, complemented by additional elements that come from political and institutional decisions already made or under discussion:

- permanent controls on national deficits and debts, as decided by the European Union;
- some controlled exceptions of public expenditures for low-growing and indebted countries (due to political risks, like the recent Italian elections showed);
- an increase in the risk of protectionism;
- end of the expansionary monetary policy (quantitative easing), as decided by the European Central Bank;
- Brexit taking place in 2019.

**Figure 1.** Pre- and post-crisis investment trends in the three blocks of countries



Therefore, the reference scenario differs from the baseline scenario, as it extrapolates the structural changes in the future. Run on the basis of such assumptions, the MASST model produces average regional GDP growth rates for the period 2018–2035, as presented in Table 1.

**Table 1.** 2018–2035 average yearly GDP growth rate by country and for the EU in the reference scenario

Country	Average GDP growth rate
Austria	1.54
Belgium	1.34
Bulgaria	1.97
Croatia	1.35
Cyprus	1.74
Czech Republic	1.46
Denmark	1.79
Estonia	2.04
Finland	1.19
France	1.60
Germany	1.72
Greece	1.38
Hungary	1.79
Ireland	1.74
Italy	1.60
Latvia	1.81
Lithuania	1.67
Luxembourg	1.60
Malta	1.92
Netherlands	1.45
Poland	1.74
Portugal	1.58
Romania	1.70
Slovakia	2.02

Country	Average GDP growth rate
Slovenia	1.44
Spain	1.37
Sweden	1.50
United Kingdom	1.49
EU-28	1.60
Old-15	1.59
CEECs	1.72

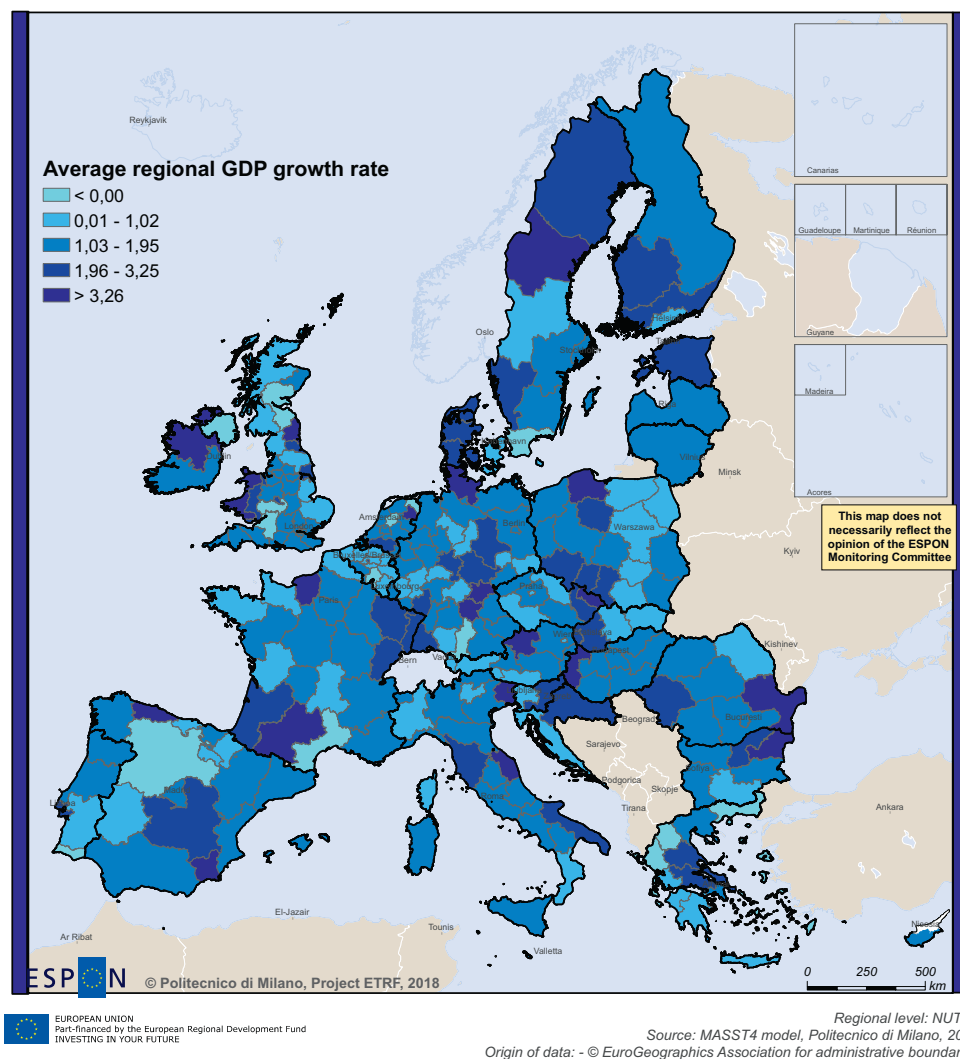
From a macroeconomic perspective, the reference scenario is characterised by a stable relaunch after the crisis, with an average yearly growth rate of 1.6% for EU-28. This result would have been slightly higher (1.61%) had the United Kingdom, for which the projection of economic growth is worse due to the potential negative consequences of Brexit (1.49%), not been taken into account in the simulation. Central and Eastern European countries are developing faster than EU-15 countries (1.72% vs 1.59%), but the difference is much smaller than before the crisis. UE-15 countries are characterised by a slow increase in overall productivity, which in line with the forecasts presented in OECD<sup>88</sup>. Moreover, the difference between Old-15 and New-13 is more consistent in terms of productivity than in terms of employment growth. CEECs are likely to experience a second transition, although a less problematic one with respect to the first one, towards a more equilibrated, endogenous pattern of development. Old-15 countries, instead, are entering a stage of re-launch thanks to an advanced and pervasive use of new technologies and the benefits of what is commonly known as “Industry 4.0”. In this scenario, Poland is expected to keep on outperforming EU-28 in both scenarios,<sup>89</sup> although the rest of CEECs will grow slightly faster, but at a smaller pace than other Eastern countries.

<sup>88</sup> OECD, *The future of productivity*, Paris 2017.

<sup>89</sup> MASST simulations represent quantitative foresights, rather than standard forecasts. They present likely future growth rates that should not be interpreted as point estimates, but rather as differential growth rates with respect to other regions in the same period. In qualitative terms, though, Poland’s performance is still expected to be stronger than the average EU, although its pace is projected to slow down relatively to what happened over the past two decades. As in many other CEECs, Poland is facing a process of major transformation, from an externally-driven fast growth country to a high-income country. This prompts many challenges that may affect its future economic performance.

Figure 2 presents the results at regional level, i.e. annual average GDP growth rates between 2018 and 2035 in EU NUTS 2 regions. The map does not highlight any longer the macro-regional patterns that were present in the recent past (namely the celebrated East-West divide and the North-South differentials that emerged in the early stages of the crisis). Regional growth rates are now converging around the averages and diverging behaviours involve some single regions (like Castilla Leon, Algarve, Languedoc-Roussillon, Croatia, North-Western regions in Greece and the Aegean islands and southern Sweden).

**Figure 2.** Average annual regional GDP growth rate, reference scenario, 2018–2035



Source: Authors' elaboration

Some dualism is still left in terms of regional GDP growth rates within individual countries, and even more so in terms of per capita GDP levels. The major and more evident cases refer to:

- the eastern part of Poland with respect to the more dynamic western (and particularly south-western) part of the country and to the capital region of Warsaw;
- the eastern and southern part of Greece, with respect to the core, central area;
- the Mediterranean axis in France, less dynamic than the rest,
- some (not all) regions in the Italian Mezzogiorno, like Abruzzo, Calabria and Sicily;
- the eastern part of Denmark, including Copenhagen, less dynamic than the rest of the country;
- some scattered regions in UK.

In general, major cities and their regions, although in good shape, are not necessarily the most dynamic in their respective countries, as could be expected. Major diffusion processes of new technologies and best organisational solutions will be apparently at work in the direction of solid, mid-income regions and medium-size cities.

## An integration scenario

A second scenario has been built to verify the effects of a more integrated European economy, with the aim to simulate the costs of the present Eurosceptic attitude. With respect to the reference scenario, five additional assumptions have been included, namely:

- increase in the global value chain among EU countries (*“production integration effect”*);
- further elimination of non-tariffs barriers among European countries (*“market integration effect”*);
- increase in trust within and among countries (*“social effect”*);
- higher quality governance (*“institutional effect”*);
- stronger cooperation networks among cities (*“cooperation effect”*).

Other assumptions, including Brexit in 2019, remain valid.

The results of running the integration scenario simulation are presented in Table 2 which shows annual average GDP growth for the simulation period (2018–2035) in the integration scenario as a difference with respect to the reference scenario. The results show that, while

on average all macro areas gain from a more integrated scenario, these gains are larger for CEECs than for Old-15 countries. Without UK, the European Union registers a slightly positive sign, witnessing that Brexit does not constitute a loss for the EU.

**Table 2.** GDP annual average growth rate in the integration w.r.t. reference scenario by country and for the EU

Country	GDP annual average growth rate in the integration w.r.t. reference scenario
Austria	0.21
Belgium	0.37
Bulgaria	0.19
Croatia	0.14
Cyprus	0.20
Czech Republic	0.28
Denmark	0.18
Estonia	0.20
Finland	0.16
France	0.13
Germany	0.17
Greece	0.13
Hungary	0.25
Ireland	0.26
Italy	0.12
Latvia	0.20
Lithuania	0.24
Luxembourg	0.48
Malta	0.39
Netherlands	0.28
Poland	0.17
Portugal	0.12
Romania	0.19
Slovakia	0.27
Slovenia	0.24

Country	GDP annual average growth rate in the integration w.r.t. reference scenario
Spain	0.14
Sweden	0.18
United Kingdom	0.11
EU28	0.24
Old15	0.23
CEECs	0.29
Poland	0.17

Source: Author's elaboration

In general, all countries benefit from an integration process, as broadly argued by international economics theories emphasising the advantages of scale and scope economies obtained through a larger market. UK gains much less than the average, registering a damage from leaving the Single Market. Within Old-15, Luxembourg, Belgium and the Netherlands, located in the core of Europe, gain the most, as expected. However, some exceptions are worth discussing; especially Ireland, a geographically peripheral country, and to some extent Austria, gain more than the average from the economic integration process. Ireland is also an open country, based on multinationals and their embeddedness in international input-output relationships and Global Value Chains. All CEECs benefit from the integration scenario, with the exceptions of Croatia and Poland, which gain relatively less compared to other CEECs.<sup>90</sup>

Figure 3 presents the results of the differences in GDP growth rates between the integration and reference scenario at regional level. A rather diverse picture emerges, with some regions even losing with respect to the reference, probably because of their lower ability to grasp the advantages of sudden integration. Instead of benefiting from a larger market, their non-competitive peripheral local markets suffer from being closer to the core, becoming easier areas to conquer by strong, competitive and centrally located firms.

<sup>90</sup> While the interactions among model equations makes it impossible to precisely identify and trace back the source of this relatively less strong impact of the integration scenario for Poland and Croatia, it could be argued that the structure of these economies hampers the full exploitation of a more integrated Europe. More specifically, most levers used in the definition of the integration scenario act through the regional sub-model, and Polish regions appear to be structurally less endowed with the growth-enhancing factors assumed to improve as a consequence of more integration (trust, cooperation networks, and quality of regional institutions) with respect to average EU28 values.

In general, most regions gain. However, the reasons are different, and specific advantages emerge in some areas. In particular:

- southern regions in Italy, the Mediterranean regions of Spain and in the Bulgarian areas take advantage from the “production integration effect” and the “proximity to a larger market effect”, which combine their impact;
- the southern part of Spain, Ireland and Scandinavian countries gain thanks to a “proximity to a larger market effect”;
- the core of Europe, all the Benelux regions and the northern regions of Germany strongly gain, by being in the centre of a larger market.

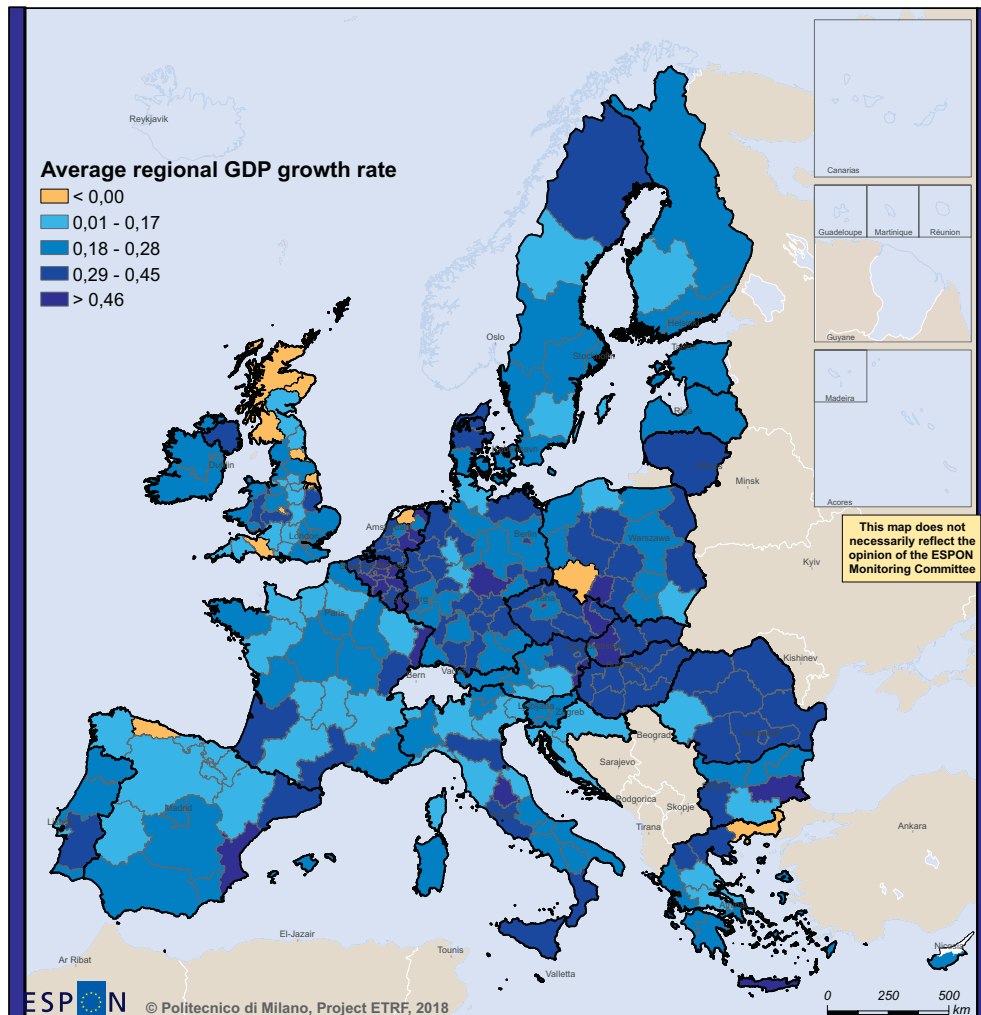
It is interesting to see that there are regions that gain less in the integration scenario compared to the reference scenario (Figure 3). Even if this result may sound counter-intuitive, since integration is expected to be a positive push for economic systems, there are a few cases where this does not hold: integration means fiercer competition which calls for a certain degree of competitiveness in an economic system. Some regions in Scotland, in eastern countries and in the Iberian peninsula, still have better growth trajectories under reference scenario assumptions with respect to integration assumptions, demonstrating a limited capacity of their economic system to deal with higher competition. This situation is in line with what happened after the enlargement processes of the EU, when lagging regions strongly suffered from higher integration, something that pushed the Italian politicians to ask (and to obtain) to double cohesion policy funds for a country preparing for single market integration<sup>91</sup>. For what concerns Poland, Mazowieckie will continue its overall good performance, growth will diffuse to other peri-urban areas (for instance, Łódzkie and Kujawsko-Pomorskie). The Pomorskie Voivodeship, which is expected to perform very well in the reference scenario, will instead gain the least in a more integrated scenario. In this scenario, regions bordering Belarus and Ukraine in Poland will benefit greatly.<sup>92</sup>

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<sup>91</sup> R. Camagni, „Scienze regionali e Mezzogiorno: concetti, principi e riflessioni normative”, w: R. Camagni, A. Hoffmann, F. Latella (red.), *Mezzogiorno e scienze regionali: l'analisi e la programmazione*, Franco Angeli, Milano 1992, vol. 17, s. 23–45.

<sup>92</sup> The negative value for the Dolnośląskie Voivodeship is due to its openness, and, as a consequence, to its being more vulnerable to integration and increased competition. Still, it is worth reminding that this negative value must be interpreted as a difference with respect to the reference scenario. All Polish regions' growth rates remain positive even in the integration scenario.

**Figure 3.** Average annual regional GDP growth rates, integration scenario compared to reference scenario, 2018–2035



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Regional level: NUTS2  
Source: MASST4 model, Politecnico di Milano, 2018  
Origin of data: - © EuroGeographics Association for administrative boundaries

Source: Authors' elaboration

## Conclusions

In this paper, we presented the MASST model, with particular reference to the way macroeconomic stability mechanisms and long-run structural trends are modelled. We also synthetically presented the results of two simulations of the model, namely a reference

scenario, taking long-run trends and structural changes into account, and an integration scenario, which instead assumes a step forward in the process of within-EU integration.

The results of these two simulations suggest that (i) more integration leads to a more expansionary economy, with nevertheless remarkable spatial heterogeneity in these effects; (ii) more integration further increases the costs of Brexit for the UK; (iii) more integration may also cause losses in some regions less endowed with crucial assets; and (iv) more integration also tends to increase cohesiveness.

For Polish regions, in both scenarios, the Mazowieckie Voivodeship will grow at a slightly slower pace compared to the past two decades, but only in relative terms. In the reference scenario, the region of Pomorskie will benefit the most. In the integration scenario, instead, regions to the East and West of Poland will be gaining the most.

Poland faces several challenges in dealing with the major changes induced by a more integrated scenario. The country has been successfully enjoying a long period of major economic and social transformations, which made it the most competitive economy among CEECs. Still, the quality of regional production factors will soon have to be raised to the standards of Old-15 countries. This means fostering connectivity both in terms of physical transportation networks, but especially in terms of long-distance cooperation networks; enhancing trust within Polish regions; and improving the quality of regional institutions.

These policies require time and remarkable effort, since they imply a major restructuring of the development model which is currently adopted; however, they will be needed for making Poland's economic performance sustainable in the medium and long run, and for truly distributing its economic growth effects to the widest number of Polish citizens.

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# V. The Use of Macroeconometric Modelling in Innovation Policy Evaluation

Tomasz Kossowski

## Introduction

Innovation policy evaluation relies on methods developed on the basis of social sciences over many decades. While economists and persons in charge of formulating various policies agree that research and development (R&D) and broadly defined innovation activity have a role to play in social and economic development<sup>93</sup>, there is no general view on how to measure that impact on a macroeconomic scale<sup>94</sup>. Therefore, the use of macroeconometric modelling methods in evaluating pro-innovation public interventions is doubtlessly associated with greater difficulties than the use of other methods.

Modelling the impact of interventions in the area of innovation is generally not an aim in itself, but is an element of broader research, for instance into the effects of Cohesion Policy (EU countries in particular)<sup>95</sup>. Support of the R&D sector constitutes one of the intervention areas under these studies. An analysis of possible approaches is made more difficult by the fact that the results of performed evaluations do not have to be published. The group of potential recipients may also be limited by the publication of the report in a national language. It also has to be borne in mind that determining the probable impact

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<sup>93</sup> Z. Griliches, "Research Expenditures and Growth Accounting", in: B.R. Williams (ed.), *Science and Technology in Economic Growth*, Palgrave Macmillan, London 1973, p. 59–95; Z. Griliches, *R&D and Productivity: The Econometric Evidence*, University of Chicago Press 1998.

<sup>94</sup> F. Di Comite, d'A. Kancs, "Macro-Economic Models for R&D and Innovation Policies", *JRC Technical Reports*, European Commission 2015.

<sup>95</sup> M. Ferry, "The Achievements of Cohesion Policy: Evidence and Methodological Challenges from an EU10 Perspective", *Working Papers GRINCOH* 2013.

of investment expenditure in the research and development sector on economic growth is the most difficult task out of all the analysed categories of economic investments<sup>96</sup>.

This chapter focuses on presenting different approaches towards macroeconomic modelling of the impact of innovation policy. First, different methodologies used in the EU are presented. Next, the methods of using macro models to quantify the impact of interventions targeting the growth of innovativeness in Poland are gathered and compared. The results of the performed queries should provide policy-makers with information about the possibility of using macromodeling for the purpose of innovation policy evaluation.

## Macroeconometric modelling in studies of the impact of the innovation policy in the EU

There are several macroeconomic models existing in Europe used for the purpose of evaluating the innovation policy. General equilibrium models (*Computable General Equilibrium – CGE*) are one of the classes of models used as part of the evaluation process. They formed the basis for the development of other analytic tools, such as spatial general equilibrium models (*Spatial Computable General Equilibrium – SCGE*) and dynamic stochastic general equilibrium models (*Dynamic Stochastic General Equilibrium – DSGE*). From the perspective of their usefulness for the purpose of modelling specific effects, it should be noted that CGE and SCGE models are better for measuring long-term impact of interventions. On the other hand, for the purposes of short-term analysis, it is more convenient to use DSGE class models, which perform well on the basis of data gathered more frequently than once a year<sup>97</sup>.

Out of the above models used for the purpose of evaluating innovation policy, the following should be mentioned: QUEST – DSGE model, GEM-E3 – CGE model, RHOMOLO – SCGE model and NEMESIS – econometric model not belonging to any of the previously mentioned classes.

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<sup>96</sup> J. Bradley, G. Untiedt, *Analysis of EU Cohesion policy 2000–2006 using the CSHM: aggregate impacts and inter-country comparisons*, Report to the European Commission (DG Regional Policy), Dublin, 2009.

<sup>97</sup> K. Piech, “Ewaluacja oddziaływania funduszy unijnych – teoria i praktyka modelowania makroekonomicznego”, in: K. Olejniczak, M. Kozak, B. Ledzion (ed.), *Teoria i praktyka ewaluacji interwencji publicznych. Podręcznik akademicki*, Wydawnictwa Akademickie i Profesjonalne, Akademia Leona Koźmińskiego, Warsaw, 2008, p. 179–211.

The European Commission (EC) has developed these tools and their use is recommended for the purpose of carrying out evaluation studies. They differ in terms of their geographical scope, the level of detail and the mode of taking the research, development and innovation sector into account. The basic features of these models are presented in Table 1.

**Table 1.** Features of macroeconometric models used for the purpose of analysing the impact of innovation policy in the EU

Feature	QUEST	RHOMOLO	GEM-E3	NEMESIS
Type of model / class	DSGE	SCGE	CGE	Other
Geographical scope	EU countries	EU countries / NUTS2 regions	One country / group of countries	EU countries
Number of sectors / competitiveness <sup>98</sup>	1 Monopolistic competition	6 Monopolistic competition	38 Perfect competition	30 Monopolistic competition
Time optimisation <sup>99</sup>	Yes / fully dynamic	No / recursively dynamic	No / recursively dynamic	No / recursively dynamic
Parameterisation	Stochastic estimation and calibration	Structural estimation and calibration	Structural estimation and calibration	Structural estimation and calibration
R&D in the private sector – knowledge production	Yes	Yes	Yes	Yes
Econometrically estimated flexibilities in the R&D private sector	No	No	No	Yes
Quality of research activities	No	No	No	Yes
Knowledge spill-over <sup>100</sup>	Yes	Yes	Yes	Yes

Source: F. Di Comite, d'A. Kancs, "Macro-Economic Models for R&D and Innovation Policies", *JRC Technical Reports*, European Commission 2015, as amended, with own extensions.

<sup>98</sup> This differentiation is related to the theoretical foundations on which the models are based. It is assumed that entities/companies produce either heterogeneous (monopolistic competition) or identical (perfect competition) goods.

<sup>99</sup> Fully dynamic models assume that the agents' expectations depend on the future states of the economy. For this reason the model is estimated for all periods at the same time. The situation is different in the case of recurrently dynamic models, which may be estimated sequentially: for one period or for several subsequent periods. This stems from the assumption that the agents' behaviour is driven only by the current and past states of the economy.

<sup>100</sup> It is a process of "spilling over" knowledge, i.e. disseminating the beneficial effects of pro-innovative interventions among other entities as a result of external effects.

The first of the models – QUEST – is mainly based on a neo-Keynesian approach with microeconomic foundations stemming from optimisation of usefulness and profit and taking into account the goods, labour and financial markets<sup>101</sup>. Currently, several different types of the QUEST model are used, depending on the purpose for which they are applied. They prove their usefulness in situations requiring a higher level of data disaggregation, both at the regional and sectorial level. One of the variants of the QUEST model covers the R&D sector and differentiates between various workforce resources. Implementation and simulation of innovation policy under this model is carried out by means of a broad spectrum of channels and parameters. These include: 1) subsidisation of innovative activity by means of tax reliefs, 2) reducing the amount of tax on profits from patents, 3) subsidisation of remuneration of highly qualified workers employed in the R&D sector, 4) increasing innovative activity by reducing the associated risk.

Good practices stemming from using the QUEST model for the purpose of analysing the impact of innovation policy are presented in the following studies. The first one is “Ex post evaluation of Cohesion Policy programmes 2007–2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund, WP1 – synthesis report”<sup>102</sup>. The study was carried out for EU countries with the use of the QUEST III model<sup>103</sup>. Intervention in the research and development sector covers all expenditure related to research and technological development, including expenditure incurred for the purpose of establishing partner networks, and is reflected in the model by seven categories: 1) R+D activity in research centres, 2) R&D infrastructure and centres established for the purpose of developing specific technologies, 3) technology transfer and strengthening the cooperation network, 4) supporting R&D, especially in small and medium-sized enterprises, 5) investments in companies directly involved in research and innovation, 6) other means of stimulating research, innovation and entrepreneurship in small and medium-sized enterprises, 7) cooperation in the field of developing new products, technologies and processes. Under the QUEST III model, the results of evaluation of the macroeconomic impact of the intervention concerned: 1) GDP, 2) investments, 3) the number of patents,

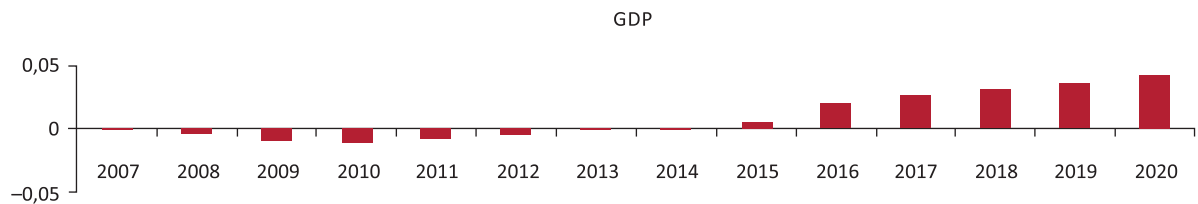
<sup>101</sup> [https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macroeconomic-models\\_en](https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macroeconomic-models_en) (accessed on: 15.05.2019).

<sup>102</sup> *Ex post evaluation of Cohesion Policy programmes 2007–2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund, WP1 – synthesis report.*

<sup>103</sup> *Ex post evaluation of Cohesion Policy programmes 2007–2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund, WP14a – The impact of cohesion policy 2007–2013: model simulations with QUEST III.*

4) factor productivity and covered the intervention period 2007–2013, including the forecast until 2020. In the case of GDP, a negative impact was noted in the period from 2007 to 2013 (to ca. -0.02%), followed by an increase by 0.04% in the perspective until 2020 (Fig. 1). Provision of support to the R&D sector will also lead to a decrease in the level of investments in this sector<sup>104</sup> from ca. 0.03% to 0.06% in each year of the analysed period. The model forecasts a decisively positive impact in terms of the increase in the number of patents and total factor productivity (TFP): up to more than 1% in the case of patents and up to ca. 9% in the case of TFP. The study emphasised, however, that positive impacts of interventions in the research and development sector predominate. Using the QUEST model for the purpose of the above-mentioned study may be regarded as a good practice. The analysis is quite detailed, and the presented results are not limited exclusively to the modelling of the impact of interventions on GDP.

**Figure 1.** Impact of the support in the field of R&D on EU countries' GDP



Source: *Ex post evaluation of Cohesion Policy programmes 2007–2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund, WP14a – The impact of cohesion policy 2007–2013: model simulations with QUEST III. Annex 2.*

Another study entitled “*A Model-based Analysis of the Impact of Cohesion Policy Expenditure 2000–2006: Simulations with the QUEST III endogenous R&D model*”<sup>105</sup> points to the possibility of using the QUEST model to analyse the shock associated with the reduction of fixed costs and risk premiums incurred by companies using the research and development sector’s products. This reduction was either permanent or temporary. The impact of intervention in the R&D sector on changes in macroeconomic indicators was limited to modelling the share of this sector in the national GDP. In the case of Poland, the modelling

<sup>104</sup> *Ibid.*, Annex 2.

<sup>105</sup> J. Varga, J. in ’t Veld, “A Model-based Analysis of the Impact of Cohesion Policy Expenditure 2000–06: Simulations with the QUEST III endogenous R&D model”, *European Economy Economic Papers*, no. 387, European Commission 2009.

revealed that as a result of interventions conducted under EU Cohesion Policy, the share of R+D sector in the GDP will systematically increase up to ca. 0.15% in 2025.

As the RHOMOLO model<sup>106</sup> was presented in the earlier part of the book, there is no need to analyse it in greater detail. This section will therefore focus on presenting how the innovation policy is implemented into the structure of the model. The impact of the above-mentioned policy is modelled via the following channels: 1) subsidies to the national R&D sector provided by means of government or EU interventions, 2) subsidisation of the remuneration of highly qualified workers in the R&D sector, 3) improving innovativeness by reducing the fixed costs borne by companies, which would translate into higher demand for R&D services, 4) reducing the costs related to education, 5) increasing the supply of workers to the R&D sector.

Conclusions concerning pro-innovative interventions stemming from the evaluation carried out based on the RHOMOLO model are phrased in very general terms<sup>107</sup>. The results confirm the existence of inter-regional spill-over effects generated by investments in R&D and accumulation of knowledge in the regions. One can even venture the statement that the RHOMOLO model's potential in the field of analysing the effectiveness of the innovation policy is currently not being utilised to its full extent. Selective use of channels through which the role of various innovation policy instruments can be analysed (such as subsidisation of the remuneration of R&D sector workers or reducing the costs of education) should be the new direction for the process of discounting the analytical capacity of this tool. This would provide policy-makers with important information about the optimal structure of instruments for supporting innovation.

Two other models, GEM-E3 and NEMESIS, are slightly different from the above-mentioned models, since they do not model basic macroeconomic indicators. However, they may be used for the purpose of evaluating innovation policy in specific sectors of activity. The GEM-E3 model was developed by the Centre of Economic Studies of the Catholic University of Leuven. It focuses primarily on links between the economy, the environment and the energy sector. This instrument may be used for the purpose of evaluating the effects

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<sup>106</sup> A. Brandsma *et al.*, "RHOMOLO: a dynamic spatial general equilibrium model for assessing the impact of Cohesion policy", *Working paper of the European Commission (DG Regional Policy)*, no. 1/2013, Brussels.

<sup>107</sup> *Ex post evaluation of Cohesion Policy programmes 2007–2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund, WP14b – The impact of cohesion policy 2007–2013: model simulations with RHOMOLO.*

of different scenarios provided under environmental policies. In this context, the analysis of innovative capacity is restricted to investments carried out in the clean energy sector. Modelling of innovations is carried out by means of three channels<sup>108</sup>: a) the use of research and development services in other sectors, b) learning-by-searching based on expenditure on R&D and c) learning-by-doing based on total production. Scenario simulations related to innovation policy are carried out by 1) changing the cost benefits obtained as a result of increasing research and production of high-tech sectors, 2) changing the rates of direct, indirect and environmental taxes, VAT, generating subsidies, social insurance contributions, duties for imported goods and the use of foreign subsidies.

On the other hand, the NEMESIS model consists of the core and four modules: energy and environmental, regional, agricultural and spatial. It is very robust, since it includes ca. 200 000 equations with ca. 250 000 variables. Modelling of innovation under NEMESIS is equated to investments of private companies in R&D, ICT and OI (open innovations) sectors providing innovative services. They improve the economic effectiveness of enterprises by means of two channels of influence: a) increase in total factor productivity and b) increase in demand. Innovation policy simulations are carried out by means of: 1) changing the rate of return on expenditure on research and development – all elements of the policy which have an impact on its value or on the return on other assets may induce companies to make decisions related to innovation, 2) changing tax rates, which may have an impact on costs of production and the amount of expenditure on research in private companies, with research in the public sector being financed from taxes, 3) changing the flexibility of supply of highly qualified workers in the R&D sector, 4) changing the flexibility of the increase in remuneration as compared to the level of unemployment, which may also shape the supply of workers in the R&D sector. The current version of the model distinguishes between process and product innovations. Clearly, the NEMESIS model provides numerous instruments for the analysis of public authorities' impact on innovation in the private sector, which plays decisive role in building a knowledge-based economy.

Aside from the above-mentioned macroeconomic models, the evaluation studies carried out in the EU also apply the HERMIN models<sup>109</sup>. Since these tools are covered in another chapter

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<sup>108</sup> F. Di Comite, d'A. Kancs, *op. cit.*

<sup>109</sup> The list of projects using the HERMIN model is available on the [www.hermin.pl](http://www.hermin.pl) website and in: M. Radvansky *et al.*, *Impact of Cohesion Policy on Regional Development of Slovakia. Ex-post Assessment of National Strategy Reference Framework 2007–2013*, Institute of Economic Research, Bratislava, 2016.

of the book, they will not be discussed in detail here. On account of the possibility to use them for the purpose of evaluating innovation policy, the analysis focuses only on presenting – in summarised form<sup>110</sup> – the means of incorporating EU funds from aid for the R&D sector in these models. In HERMIN models, direct aid for the enterprises sector is divided into two categories: 1) funds for R&D, 2) other funds. It is assumed that support for R&D has a long-term impact on the other economic sectors and that it is financed simultaneously from EU funds and from national public funds. Increase of R&D resources thanks to the Cohesion Policy (e.g. modern machine parks, innovative technologies, infrastructure supporting innovation, such as science parks, etc.) contributes to supply effects. These effects consist in increased production in the industrial sector and the market services sector. They may also have negative, short-term implications for the labour market. This stems from the fact that an increase in overall performance of production factors in the industrial and services sectors decreases the demand for workforce. Therefore, HERMIN models allow for a more general assessment of the impact of innovation policy (such as the assessment of its impact on the size of the R&D sector). In this regard, the analysis of the impact of pro-innovative public investments is usually carried out in the context of analysing the optimal economic structure of the investment.

The models presented above differ from one another also in terms of the theoretical assumptions concerning the structure of the economy and its functioning<sup>111</sup>. These differences are related to two key issues. The first of these differences concerns short-term impact of the financial intervention on the demand side of the economy. All models include stimulation of demand by structural funds, which leads to increased consumption. They also reflect the negative consequences for the private sector stemming from the increase in wages and prices, and therefore lower competitiveness on international markets. Whereby, in the case of QUEST and RHOMOLO, the scale of above-mentioned negative effects is greater, since they include decisions taken at microeconomic level. It is also worth mentioning another issue, which differentiates the analysed models i.e. the long-term supply effects of financial intervention. In the case of all models it is assumed that investments in human capital, research and development and public infrastructure increase production capacity and effectiveness. It has to be noted, however, that QUEST and RHOMOLO exert the

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<sup>110</sup> J. Bradley in., *Analysis of Impact of Cohesion Policy. A note explaining the HERMIN-based simulations*, Project-No. 2006 CE.16.0.AT.035, Münster, Dublin, 2007.

<sup>111</sup> S. Davies, "Does Cohesion policy work? Meta-Review of Research on the Effectiveness of Cohesion policy", *European Policy Research Paper* 2017, no. 99.

strongest effects, which stems from the nature of incorporated mechanisms responsible for endogenous accumulation of capital resources.

## Macroeconometric modelling in studies of the impact of the innovation policy in Poland

Macroeconometric models are also used for the purpose of evaluating innovation policy in Poland. However, the scope of their use is very limited and is generally based on only three research tools: VESPA (Verifiable European Structural Policy Assessment), EUImpactMod and HERMIN. The basic characteristics of these models are presented in Table 2.

**Table 2.** Features of macroeconometric models used for analysing the impact of innovation policy in Poland

Feature	VESPA	EUImpactMod	HERMIN
Type of model / class	DSGE	DSGE	Other (macroeconometric)
Geographical scope	Country/macoregions	Country/regions	Country/regions
Number of sectors / competitiveness	19 <sup>112</sup> or 3 <sup>113</sup> Monopolistic competition	10 Monopolistic competition	5 –
Time optimisation	Yes / fully dynamic	Yes / fully dynamic	No / recursively dynamic
Parameterisation	Stochastic estimation and calibration	Stochastic estimation and calibration	Estimation and calibration
R&D in the private sector – knowledge production	Yes	Yes	Yes
Econometrically estimated flexibilities in the R&D private sector	No	No	No
Quality of research activities	No	No	No
Knowledge spill-over	Yes <sup>114</sup>	Yes	No

Source: own study.

<sup>112</sup> In national version.

<sup>113</sup> In regional version.

<sup>114</sup> An additional module which includes the effect of knowledge spill-over is available.

As mentioned earlier, the HERMIN models<sup>115</sup> address the issue of innovation policy on a relatively general level, focusing mainly on analysis of the investment structure under the EU Cohesion Policy<sup>116</sup>. For this reason, the following two models ought to be regarded as primary tools for assessing the impacts of pro-innovation investments in Poland: EUImpactMod IV and VESPA<sup>117</sup>. An additional innovation module based on Romer's endogenous growth model is a distinguishing feature of EUImpactMod (IV)<sup>118,119</sup>. This module is based on the assumption that companies may invest in innovative activity in two different ways: 1) by allocating the difference between the price of goods and their production costs for this purpose, 2) by providing external support for innovative activity. EUImpactMod was used *inter alia* in 2017 for the purpose of drafting an evaluation report for the Ministry of Investment and Economic Development.<sup>120</sup> It was used to analyse the impact of EU Cohesion Policy implemented in Poland on three groups of indicators measuring: 1) the scale of innovative activity, 2) the sales of innovative products, 3) the scale of R&D activity. The results of the conducted simulation indicated that capital expenditure on innovation have the strongest impact on the indicators belonging to the first and the second group. These indicators significantly exceeded the value projected for the "without the Cohesion

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<sup>115</sup> J. Zaleski, "Modelowanie makroekonomiczne gospodarek regionalnych – użyteczne narzędzie czy nieprzydatna zabawa intelektualna?", *Zarządzanie publiczne* 2010, vol. 4, no. 14, pp. 5–28.

<sup>116</sup> The HERMIN model was also used for the purpose of conducting an *ex ante* evaluation of the macroeconomic impact of the Smart Growth Operational Programme 2014–2020. The analysis focused on the increase of expenditure on R&D in particular as a result of: supporting enterprises operating in the area of innovation as well as research and development, improving the quality and inter-disciplinary nature of scientific studies and development-related work, increasing the level of commercialisation and internationalisation of scientific studies and development-related work. The study carried out based on the HERMIN model concerned the 2004–2023 period and contained an estimation of the impacts of public funds (EU and national) under the 2014–2020 financial perspective on selected macroeconomic indicators. An additional element in this analysis is the fact that the results of HERMIN modelling were combined with the model of innovation diffusion developed for the purposes of this study. Source: *Ewaluacja ex-ante Programu Operacyjnego Inteligentny Rozwój 2014–2020. Raport końcowy*, PSDB and Regio Group, commissioned by the Ministry of Regional Development, Warsaw, 2014.

<sup>117</sup> VESPA has a B&R&I modelling module. This model has been described in greater detail in another chapter of the book, therefore it is not presented here.

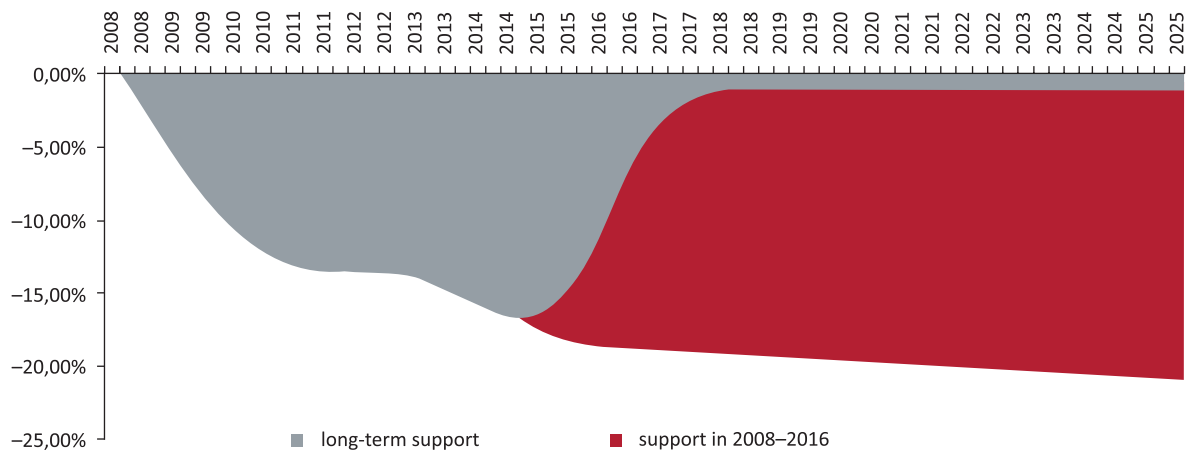
<sup>118</sup> P. Romer, "Capital Accumulation in the Theory of Long Run Growth", in: R. Barro (ed.), *Modern Macroeconomics*, Harvard University Press, Cambridge 1989.

<sup>119</sup> P. Romer, "Human capital growth: Theory and evidence", *Carnegie-Rochester Conference Series on Public Policy* 1990, Elsevier, vol. 32, no. 1, pp. 251–286.

<sup>120</sup> M. Antosiewicz *et al.*, *Ewaluacja ex-post wpływu funduszy unijnych w ramach perspektywy finansowej 2007–2013 na podstawowe wskaźniki innowacyjności i działalności B+R*, Institute for Structural Research, Warsaw, 2017.

Policy” scenario. It was also proved that employment in the R&D sector increased in line with the amount of expenditure on innovation stimulated by EU funds. Owing to the Cohesion Policy, by 2020, the expenditure on innovation in Poland will increase by 30%<sup>121</sup>, assuming that long-term support is maintained (cf. Figure 2) after 2017<sup>122</sup>.

**Figure 2.** Alternative scenario concerning the level of expenditure on innovative activity in enterprises – scenario assuming continued lack of support in subsequent years<sup>123</sup>



Source: M. Antosiewicz *et al.*, *Ewaluacja ex-post wpływu funduszy unijnych w ramach perspektywy finansowej 2007–2013 na podstawowe wskaźniki innowacyjności i działalności B+R*, Institute for Structural Research, Warsaw, 2017, p. 138.

The EUImpactMod model was also used in the following assessment “*Ocena efektów realizacji Regionalnego Programu Operacyjnego dla Województwa Pomorskiego na lata*

<sup>121</sup> *Ibidem*, p. 138.

<sup>122</sup> Similar results were obtained during evaluation of the impact of the Cohesion Policy on the increase in competitiveness and innovation of Polish enterprises and the Polish economy, which was also conducted by the Institute for Structural Research. The aim of the study at that time was to assess the impact of EU Cohesion Policy implemented in Poland under the 2004–2006 National Development Programme on these aspects. The EUImpactMod III macroeconomic model was used for this purpose – it confirmed the positive impact of innovation expenditure on the GDP of the Polish economy. However, this study does not distinguish between various modes of supporting innovation and their impact on macroeconomic indicators (cf. P. Bartkiewicz, H. Dębowski, *Ocena wpływu polityki spójności na wzrost konkurencyjności i innowacyjności polskich przedsiębiorstw i gospodarki*, Institute for Structural Research – Reytech, Warsaw, 2010).

<sup>123</sup> The graph was drafted so as to present the percentage by which innovation expenditure will decrease in the absence of Cohesion Policy support. This is the reason why the numbers do not match the text.

2007–2013”<sup>124</sup>. This model was adapted to the regional scale by changing the sectoral structure, which stems from lower availability of data at this aggregation level. In addition, mechanisms responsible for sets of interventions were introduced into the model (including the addition of the R&D sector), though the results of modelling the impact of these interventions were treated rather generally in this report.

In the variant of the EUImpactMod model modified for the purposes of the above-mentioned study – PomMOD<sup>125</sup> – a smaller number of economic sectors than the one presented in Table 2 was implemented (7). The impact of EU funding was estimated in two steps: 1) by constructing a baseline scenario making use of the data from the Local Data Bank kept by Statistics Poland and the guidelines of the Ministry of Finance (in the absence of regional data, national data were re-scaled to the values for the given region in 2015), 2) by simulating the impact of the funding by constructing a scenario of deviations from the baseline scenario; this produces a scenario without the impact of EU funding.

The results of this modelling for the Pomorskie Voivodeship were as follows: total GDP growth in the region increased in 2007–2015 by 29.1%, while according to the PomMod model, in the absence of EU funding this increase would have been by ca. 1.5% smaller. The intervention in the R&D sector amounted to ca. 20% of the change in the level of GDP, as compared to the EU average in 2010. It was shown that this impact would gradually grow weaker and that in 2020 the intervention will correspond to only 10% of the change in GDP.

The second of the above-mentioned models, VESPA2<sup>126</sup>, was developed by WiseEuropa Foundation. It was used to evaluate the macroeconomic impacts of selected activities of Operational Programme Innovative Economy implemented by PARP in 2007–2016<sup>127</sup>.

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<sup>124</sup> M. Antosiewicz, *et al.*, *Ocena efektów realizacji Regionalnego Programu Operacyjnego dla Województwa Pomorskiego na lata 2007–2013. Raport końcowy*, commissioned by the Office of the Marshal of Pomorskie Voivodeship, IMAPP sp. z o.o., Institute for Structural Studies, Warsaw, 2016.

<sup>125</sup> This report also presents and compares the results obtained under the PomMod and HERMIN models.

<sup>126</sup> Its latest version – VESPA3 – will be described in greater detail in the next chapter of the book.

<sup>127</sup> M. Bukowski *et al.*, *Analiza wybranych działań PO IG na poziomie sektorowym i makroekonomicznym za pomocą modelu przepływów międzygałęziowych. Raport końcowy*, WiseEuropa Foundation and OPI PIB for PARP, Warsaw, 2016.

In addition, VESPA2 was used to assess the impact of the 2007–2013 Cohesion Policy on competitiveness of enterprises and development of entrepreneurship in Poland<sup>128</sup>.

VESPA2 and EUImpactMod IV models, which belong to the same class (DSGE), have similar characteristics. Differences between them relate *inter alia* to the number of analysed economic sectors and the spatial scale. Both models function on the national level. In addition, VESPA2 operates on macroregions, and EUImpactMod IV has regional sub-models (e.g. the above-mentioned PomMOD). Under the VESPA2 model used in the study commissioned by PARP, economic categories such as: direct support for the production sector, direct support for the innovation sector (R&D&I) and support for export are taken into account. In the case of the EUImpactMod IV model, the following two approaches are considered: 1) bottom-up approach, which makes use of five economic categories: direct support in the form of co-financing for innovation companies sector, non-refundable support for innovation projects, refundable support for the enterprises sector in the form of reliefs and co-financing, investments in employees' human capital, investments in public research and development infrastructure, and 2) top-down approach, which makes it possible to determine the total impact of innovation policy on the economy through three transmission channels: direct impact, spill-over effect and general equilibrium effect. Contrary to the VESPA2 model, macro-modelling concerns the impact of pro-innovative interventions on macroeconomic indicators linked to the R&D sector, such as: enterprises' expenditure on R&D as compared to the GDP, the level of employment in R&D, the share of innovative enterprises in the overall number of enterprises, the share of high-tech exports in overall exports, etc. Therefore, the VESPA2 model can be used to evaluate the effects of innovation policy in the economy analysed through the prism of the key macroeconomic indicators. On the other hand, the EUImpactMod IV model makes it possible to assess the macroeconomic impacts in the innovation sector.

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<sup>128</sup> B. Ciężka *et al.*, *Wpływ polityki spójności 2007–2013 na konkurencyjność przedsiębiorstw i rozwój przedsiębiorczości w Polsce. Raport końcowy*, WiseEuropa Foundation for the Ministry of Infrastructure and Development, Warsaw, 2016.

## Summary

This chapter focuses on the practical application of macroeconomic modelling for the purpose of evaluating policies supporting innovation. First of all, the most important types of models used in the EU for the purposes of the above-mentioned evaluation (QUEST, RHOMOLO, GEM-E3, NEMESIS, HERMIN) were presented. Subsequently, the same method was applied to the innovation policy evaluation instruments used in Poland (VESPA, EUImpactMod, HERMIN). In both cases, the goal was to present how innovation and the research and development sector are taken into account in the structure of the models. Examples of good practices related to the use of these research tools were also presented.

The inquiry carried out showed that macroeconomic modelling is not as popular a method of innovation policy analysis as other evaluation techniques. The *Science and Innovation Policy Evaluation Repository*<sup>129</sup> database kept by the University of Manchester contains practically no such documents. Nevertheless, macro-econometric modelling is becoming increasingly more important *i.a.* due to the fact that it is frequently used for the purpose of assessing the impact of EU Cohesion Policy.

All presented models include implemented modules or mechanisms pertaining to innovation as well as the research and development sector. They can therefore be used in attempts to evaluate the innovation policy and to measure its impact on the basic macroeconomic indicators. Since the models differ in terms of their approach towards innovation, by using several of them – as is the case in the context of evaluating the Cohesion Policy at EU level – one can capture various aspects related to the impact of pro-innovation investments on the overall economic situation or the condition of the innovation sector. The above-mentioned analytic tools reflect the relations between the research and development sector and the rest of the economy with a varying degree of precision (different number of considered indicators/variables, different number of equations, different methods of establishing the values of parameters).

Macroeconomic modelling may also supplement microeconomic evaluation. For example, we can analyse the impact of pro-innovation policies on the operations of private companies in the research and development sector (increase in research investments, production

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<sup>129</sup> <http://si-per.eu> (date of access: 15.05.2019).

of innovative goods) at micro level, and subsequently analyse the impact of such policies at macro level on the entire economy. In addition – depending on the selected model – this impact may be analysed at national or regional level or for a given group of countries. An additional advantage of macroeconomic modelling is the possibility to develop different variants/scenarios of innovation policy impact by changing the values of particular variables/indicators (e.g. reflecting R&D expenditure) and to assess the impact of these scenarios on the economic situation. However, it is worth noting that so far this method is not being utilised to a sufficient extent for the purpose of conducting smart specialisation analyses and for measuring their impact on economic systems (including National Innovation Systems).

The model approaches presented in this book also have certain limitations. The first of them is the fact that macro-models – which are able to reflect economic mechanisms only in general terms – tend to oversimplify reality. Therefore, the information provided by such models is somewhat imprecise. The second limitation is related to the scope of the analysis and the quality of data used. For this reason, analysis should always be based on reliable sources of information, though it should be borne in mind that such sources may prove to be incomplete (e.g. too short time series available in public statistics). Another limitation is related to the values of the model parameters, especially its behavioural parameters. Such values may be established based on studies conducted for Western European countries. For this reason, they may be inappropriate due to structural differences between Poland and those countries. This in turn may have negative implications for the prognostic function of such models.

Another important element, which should be considered, is the correctness of the constructed macroeconomic model. In general, an econometric model may be assessed based on two groups of criteria: substantive and formal. Substantive criteria relate primarily to the sources of the model, *i.e.* whether it is a model based on the latest economic theory and whether it reflects the current state-of-the-art in this field. Such models are considered to be better than those whose equations are based solely on observable phenomena. The values of the model's parameters should have the potential of being meaningfully interpreted and should be in line with the assumptions of economic theories. Formal criteria concern primarily the means of determining the values of the model's parameters. These values may be established as part of the estimation procedure or through calibration of the model. The models whose parameters are estimated are considered to be better, while calibration is used when the number of observations is smaller than the number of estimated

parameters or when random effects occurring in the economy are omitted. Model estimation requires very large samples, which is why calibration is so popular, especially in general equilibrium models such as QUEST or VESPA.

When assessing the correctness of the model, one should also pay attention to the compliance of generated results with reality, *i.e.* on the level model fit. This is especially true with regard to *ex post* modelling. In the case of large discrepancy between the theoretical values of the *ex post* model and the real values, even a model which is correct from the formal and substantive point of view is of little use, which is particularly important when forecasting the impact of innovation policy in the future. The correctness of a model constructed on an *ex ante* basis is much more difficult to assess, since in principle no methods of determining the reliability of future values of variables projected by the model exist. What is more, it is particularly difficult to do when projected values (e.g. GDP growth) seem to be achievable in the assumed time horizon. One possible solution to this problem consists in drafting several forecasts based on different macroeconomic models (or based on a single model, but with changes to certain parameters or variables), and subsequently averaging the results, discarding the most extreme ones.

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# VI. Innovation and competitiveness policy in the light of the VESPA 3 model

Maciej Bukowski, Jacek Pokorski

## Introduction

Technical progress, innovation, investments and increase in competitiveness of companies are at the centre of interest of modern development policies. The theoretical and empirical achievements of economy over the last seventy years lie at the basis of this phenomenon. Economy of economic growth, *i.e.* a branch of economy focusing on the analysis of mechanisms responsible for gradual improvement of the average living standard in industrialised economies, is of key importance in this regard. Economic models analysing economic growth have been developed since the ground-breaking publication by Solow<sup>130</sup>, which explained how technological changes translate into long-term increase in wealth. According to this model, technical progress makes it possible to overcome the problem of diminishing marginal revenue from capital, allowing for unlimited increase in production and capital per employee by improving marginal factor productivity, and especially capital. This allows for gradual accumulation of capital in the economy and improvement of the capital labour ratio.

However, from the point of view of Solow's model, the source of innovation is a mystery, as it remains an exogenous factor, *i.e.* not explained by the model itself. Romer<sup>131</sup> was one of the first economists to propose a theoretical solution to the problem of endogenisation of the process of emergence of new ideas in the economy. He indicated that accumulation of factors of production – especially capital – may in itself constitute a source of innovation. This requires, however, abandoning the neoclassical assumption concerning diminishing

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<sup>130</sup> R.M. Solow, "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 1956, vol. 70, pp. 65–94.

<sup>131</sup> P.M. Romer, "Endogenous Technological Change", *Journal of Political Economy*, 1992, vol. 98, pp. 71–102.

marginal economies of scale from its accumulation. This approach – in its original form – was criticised by Jones<sup>132</sup>, who proved that, from a purely empirical point of view, the effects of scale, i.e. for example a faster growth rate of larger economies, implied by Romer's model, are improbable. At the same time, Jones confirmed that expenditure on research and development are of key importance for economic growth in the long term, while capital expenditure contribute to it in emerging economies (which are closing the technological gap to leading countries). Romer's idea concerning endogenisation of economic growth, i.e. indicating economic mechanisms through which individual activities of entities which manage resources (households and companies) translate into increase in productivity, and therefore an increase in GDP *per capita*, was incorporated into a new generation of macroeconomic models. Over the last thirty years, very extensive theoretical literature proposing alternative endogenisation methods has been published.<sup>133</sup> The literature looked for sources of growth *inter alia* in (1) accumulation of human capital, (2) expenditure on R&D, (3) institutional reforms balancing the interests of innovators who create new ideas and imitators who promote them, etc. Thanks to these efforts we now understand much better the factors which induce households to devote part of their time and income to raising their competences, and companies to invest in research and development, productive capital accumulation, expanding the scale of activity, export expansion or, more broadly – internationalisation, as well as building competitive advantages such as brand or unique design, i.e. areas which may be covered by PARP support provided i.a. via European funds.

Studies related to economic growth served as a source of inspiration for the construction of models focused on analysing public policy, including models used by international institutions in practice (*i.a.* OECD, the World Bank and the European Commission), primarily general equilibrium models (CGE) and large scale dynamic stochastic general equilibrium models (DGSE), which expand upon them. CGE models include *i.a.* the GREEN model developed by OECD<sup>134</sup>, the EPPA model<sup>135</sup>, the EDGE model developed by Jensen

<sup>132</sup> C.I. Jones, "R & D-based models of economic growth", *Journal of political Economy*, 1995, pp. 759–784.

<sup>133</sup> Cf. *i.a.*: G.M. Grossman, E. Helpman, "Quality ladders in the theory of growth", *The Review of Economic Studies*, 1991, vol. 58, No. 1, pp. 43–61.; P. Aghion, P. Howitt, "A Model of Growth Through Creative Destruction", *Econometrica*, 1992, vol. 60, No. 2, pp. 323–351 and C.I. Jones, "Sources of US economic growth in a world of ideas", *The American Economic Review*, 2002, vol. 92, No. 1, pp. 220–239.

<sup>134</sup> OECD, *GREEN – Reference and User Manual*, Paris, 1994.

<sup>135</sup> Z. Yang *et al.*, *The MIT Emissions Prediction and Policy Analysis (EPPA) Model*, MIT Joint Program on the Science and Policy of Global Change Report 6, 1998.

and Thelle<sup>136</sup>, the WIAGEM model developed by Kemfert<sup>137</sup>, the PACE model developed by Boehringer<sup>138</sup>, the DART model<sup>139</sup> or the PRIMES model used by the European Commission to evaluate climate policy. On the other hand, numerous DSGE models are used by Central Banks for the purposes of monetary policy (including the Smets-Wouters model<sup>140</sup> which lies at the basis of most of them), as well as the QUEST model used by the European Commission *i.a.* for the purposes of evaluating EU Cohesion Policy<sup>141</sup>.

The main advantage of the general equilibrium models – from the point of view of applied research – lies in their connection with the real economy, including representation of their internal structure and tracking interactions between different markets or sectors. In the case of CGE models and large scale DSGE models, mutual interactions between entities from different sectors are described by means of input-output matrices or social accounting matrices (SAM). The latter are an expansion of input-output matrices in which input-output flows cover not only the production, but also the consumption segment of the economy (i.e. households, government). At the same time, these models are based on microfoundations, therefore the behaviour of the entities managing resources is determined in them on the basis of a set of equations (first order conditions) stemming from optimising procedures (maximisation of usefulness, maximisation of cash flows, etc.), while the structural parameters of models are estimated or calibrated on the basis of data. In this manner, the general equilibrium method strives to limit the number of arbitrary parameters that do not stem directly from measurable economic variables whose values have to be determined in a more complex and indirect way. The supply side of CGE and DSGE models, in particular the function of production, is presented as a nested structure which makes it possible to analyse substitution of factors of production (labour, capital, indirect goods, energy, etc.)

<sup>136</sup> J. Jensen, M.H. Thelle, “What are the Gains from a Multi-Gas Strategy?” *FEEM Working Paper* 2001, no. 84. Available at SSRN: <https://ssrn.com/abstract=291942> or <http://dx.doi.org/10.2139/ssrn.291942>

<sup>137</sup> C. Kemfert, “Economy-Energy-Climate Interaction – The model WIAGEM”, *Discussion paper* 2001, University of Oldenburg.

<sup>138</sup> C. Böhringer, A. Löschel, “Assessing the costs of compliance: the Kyoto Protocol”, *European Environment* 2002, vol. 12, No 1, pp. 1–16.

<sup>139</sup> Developed by G. Klepper *et al.* (G. Klepper *et al.*, “DART97: A Description of the Multi-regional, Multi-sectoral Trade Model for the Analysis of Climate Policies”, *Working Paper*, no. 1149, Kiel Institute for the World Economy 2003).

<sup>140</sup> F. Smets, R. Wouters, „An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area”, *Journal of the European Economic Association* 2003, MIT Press, vol. 1, No 5, pp. 1123–1175.

<sup>141</sup> [https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macro-economic-models\\_en](https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macro-economic-models_en) (accessed on: 6.07.2019)

in a different manner in various branches of the economy. In new generation DSGE models, entities which manage resources also operate in a dynamic environment (in contrast to older, static CGE models), taking into account not only the current period, but also the future.

The main difference between CGE and DSGE models concerns precisely the method of considering the future. In CGE models, the future is perfectly well known (perfect foresight) which means that companies and households are able to perfectly predict future economic events. This approach is justified since, on a macroeconomic scale, the economy usually behaves in a stable manner in the long term (i.e. in the perspective of decades), which can be determined *ex ante*.<sup>142</sup> However, this limits the possibilities of conducting public policy analysis only to long term studies, which usually makes it more difficult (or impossible) to precisely determine within the model direct, indirect and induced effects of interventions, in the case of which short and medium term perspectives are important (i.e. periods covering several years from the implementation of the intervention). For this reason, for the purposes of public policies analysis, CGE models are currently being replaced or supplemented with large scale DSGE models, i.e. DSGE-type models additionally equipped with an input-output matrix and multi-sector structure, similar to the one used in CGE models.

DSGE models are fully dynamic, which means that entities that manage resources take into account future consequences of their decisions and uncertain (random) macroeconomic disruptions when taking decisions in a given moment. Investments and savings are interrelated, as well as endogenously dependent upon predictable future behaviour of the economy, including public policy, and thus e.g. subsidies for R&D activity, taxes and tax reliefs, public investments, capital or advisory support provided to enterprises, etc. They also directly take into account the stochastic nature of the economy (e.g. the randomness of the process of emergence of new ideas in the economy) and imperfect forecasts related to the future shape of economic policy. They may also take into account the information asymmetry between the different types of entities which manage resources or economic frictions such as e.g. labour market or financial market failures. The stochastic nature of DSGE models is of key importance for their dynamic properties in the medium term, and every economic problem which may be examined by means of a CGE model may be analysed in greater detail by using the DSGE methodology, but not the other way around.

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<sup>142</sup> For example, the average annual economic growth rate in developed economies is constant, while catching-up economies – including Poland – are characterised by a constant rate of convergence i.e. dynamics of closing the gap between them and more developed countries.

DSGE type models also take advantage of the achievements of the economic growth theory by implementing in their structure mechanisms related to creation and destruction of companies and jobs, development of new ideas, expenditure on R&D and imitation of ideas developed by others or building monopolistic advantages of companies and differences in competitive position of different company categories. These types of DSGE models are naturally predestined for analysing both short-term and medium-term phenomena, but also long-term phenomena which require the implementation of modules responsible for economic growth. This is precisely how VESPA3 (Verifiable European Structural Policy Assessment)<sup>143</sup> operates – a DSGE-type general equilibrium model which takes into account various types of endogenous technical progress: (1) developing new business ideas by companies in the manner proposed by Jones<sup>144</sup> (2) creating and destroying companies and ensuring that they obtain competitive advantages on the market (including brand building) and (3) taking advantage of the generalised proposal by Acemoglu<sup>145</sup> concerning modelling of targeted technological change at sectoral level. In the VESPA3 model, all of the above-mentioned types of technical changes are integrated with the public policy module, taking into account i.a. subsidies for R&D, purchase of machinery, equipment and licenses or improving the companies competences (know-how). In this way, the VESPA3 model makes it possible to analyse public interventions that use European funds allocated to support innovation and competitiveness of companies. A specific feature of the VESPA3 model is also the fact that it is a large scale model (large scale DSGE), i.e. a multi-sector model which incorporates in its structure an input-output matrix. It is therefore a model taking advantage of the achievements in the field of CGE and IOM (input-output models) modelling<sup>146</sup> with additional analytical capacity, including the possibility to analyse direct, indirect and induced impacts in the short and medium term. Due to substantial computational requirements imposed by the stochastic nature of DSGE models creating such

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<sup>143</sup> It needs to be stressed that elements of VESPA model technical specification presented in this chapter, developed by WISEEuropa, were used to a various extent also in other studies, in particular in methodological reports and reports on macroeconomic analyses based on this model, e.g. those commissioned by PARP in 2017. (Cf. M. Bukowski, M. Feldy *et al.*, *Analiza wybranych działań POIG 2007–2013 na poziomie sektorowym i makroekonomicznym, za pomocą modelu przepływów międzygałęziowych. Raport metodologiczny i Raport końcowy*, WiseEuropa Consortium and OPI PIB, commissioned by PARP, Warsaw, 2017.).

<sup>144</sup> C.I. Jones, “R & D-based models...” *op. cit.*; C.I. Jones, “Sources of US economic...” *op. cit.*

<sup>145</sup> D. Acemoglu, “Directed technical change”, *The Review of Economic Studies*, 2002, vol. 69, No. 4, pp. 781–809.

<sup>146</sup> Cf. W. Leontief *et al.*, *Studies in the Structure of the American Economy*, Oxford University Press, New York, 1953.

instruments became possible only recently. Bukowski and Kowal<sup>147</sup> and Conte<sup>148</sup> were the first to integrate multi-sectoral structures taking into account input-output tables to DSGE models and to propose a compromise between a realistic representation of entities which manage resources (DSGE) and the high degree of complexity of the economy (CGE). The VESPA3 model belongs to this group of models. Nevertheless, its earlier iterations, i.e. VESPA and VESPA2 models, were also successfully used to evaluate the impact of European funds on the Polish economy<sup>149</sup>.

## Class of the model

VESPA3 model is a multi-sectoral, multi-regional macroeconomic model constructed on the basis of dynamic stochastic general equilibrium (DSGE) methodology. This means that it describes the economy as a result of the interactions between several entities which manage resources, taking into account the expectations concerning the future situation (*dynamic model*), economic decisions taken in conditions of uncertainty (stochastic model), the way in which households and companies react to economic impulses (shocks), including expectations of other entities, with the markets balancing each other by means of pricing mechanisms (general equilibrium model). Similarly to other general equilibrium models (DSGE and CGE), the VESPA3 model makes it possible to understand how different markets depend on one another. It takes into account interrelations between economic sectors,

<sup>147</sup> M. Bukowski, P. Kowal, *Large scale, multi-sector DSGE model as a climate policy assessment tool – Macroeconomic Mitigation Options (MEMO) Model for Poland*, Institute for Structural Research, Warsaw, 2010.

<sup>148</sup> A. Conte, A. Labat, J. Varga, Z. Zarnic, “What is the growth potential of green innovation? An assessment of EU climate policy options”, *European Economy – Economic Papers 2008–2015 413*, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission, 2010.

<sup>149</sup> For example, in 2017 – at the request of the Ministry of Development – VESPA2 model was used as part of the study entitled *Wpływ polityki spójności 2007–2013 na konkurencyjność przedsiębiorstw i rozwój przedsiębiorczości w Polsce* (cf. B. Ciężka *et al.*, *Wpływ polityki spójności 2007–2013 na konkurencyjność przedsiębiorstw i rozwój przedsiębiorczości w Polsce*, report commissioned by the Ministry of Development, WiseEuropa Foundation, Warsaw, 2017, <https://www.ewaluacja.gov.pl/strony/badania-i-analzy/wyniki-badan-ewaluacyjnych/badania-ewaluacyjne/wplyw-polityki-spojnosci-2007-2013-na-konkurencyjnosc-przedsiębiorstw-i-rozwoj-przedsiębiorczosci-w-polsce/>, accessed on: 6.07.2019) and as part of the study commissioned by PARP entitled *Analiza wybranych działań Programu Operacyjnego Innowacyjna Gospodarka 2007–2013 na poziomie sektorowym i makroekonomicznym, za pomocą modelu przepływów międzygałęziowych* (cf. M. Bukowski, M. Feldy *et al.*, *Analiza wybranych... op. cit.* <https://www.parp.gov.pl/component/publications/publication/analiza-wybranych-dzialan-po-ig-na-pozomie-sektorowym-i-makroekonomicznym-za-pomoca-modelu-przeplywow-miedzygaleziowych>, accessed on 6.07.2019).

dependencies between revenues of entities and their expenditure, relations between factors of production and thus also the feedback effects of each policy. Under CGE and DSGE models, both the volume of production and consumption and relative prices are calculated in an endogenous manner. The numerical solution of the model establishes prices of equilibrium simultaneously on the markets of all products and factors of production, and thus explains the mechanisms of resource allocation in the economy. In other words, in general equilibrium models relative prices are established at a level balancing the different markets (products, money, labour, etc.), reflecting one of the paradigms of the mainstream economy (i.e. the marginal theory), according to which differences between demand and supply (on a given market) may be only short-term, which means that the economy remains constantly in a state of (dynamic) equilibrium – a situation in which the potential lack or surplus of a given good results in either an increase or a decrease of production or leads to appropriate adjustment of prices resulting in a decrease or an increase in demand.

Contrary to CGE models, establishing a solution under DSGE models (i.e. a point of long-term equilibrium in the economy) consists in finding a linear approximation of the optimisation problems composing the model. This approximation (carried out by means of the perturbation method) is performed around the baseline path, approximating the system of first order conditions describing the behaviour of entities which manage resources in relation to the reference scenario<sup>150</sup>. The mechanism, represented by the structural form of the model, contains encoded decision-making rules for economic entities in the form of a dynamic system describing the reaction of variables that compose the economy being modelled in response to shocks included in the model. In other words, it decodes decision-making rules included in the model and saves them in an operational form which allows simulations to be performed.

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<sup>150</sup> In both type of models (CGE, DSGE), the steady state is calculated in a similar manner, i.e. by means of numeric algorithms (solvers) used to find the optimum of the complex non-linear function forming a part of the model by solving the corresponding system of linear equations (first order conditions). In CGE models, two (or more) solutions of this type for the pathway of changing the selected model parameters as a result of shocks are compared, thus analysing the long-term impact of a given intervention on the economy. In DSGE models, a dynamic system is established instead which describes the optimal behaviour of the economy in response to potential random disruptions. This system is usually a linear approximation (performed around the baseline path) of the original, highly non-linear functions describing the economy. This method is used since such problems cannot be solved in an exact manner, and the obtained result reflects a solution close to the accurate one (but not 100% identical to it). Aside from economy, this method is used also in physics or engineering sciences for the purpose of solving problems described by complex non-linear equations.

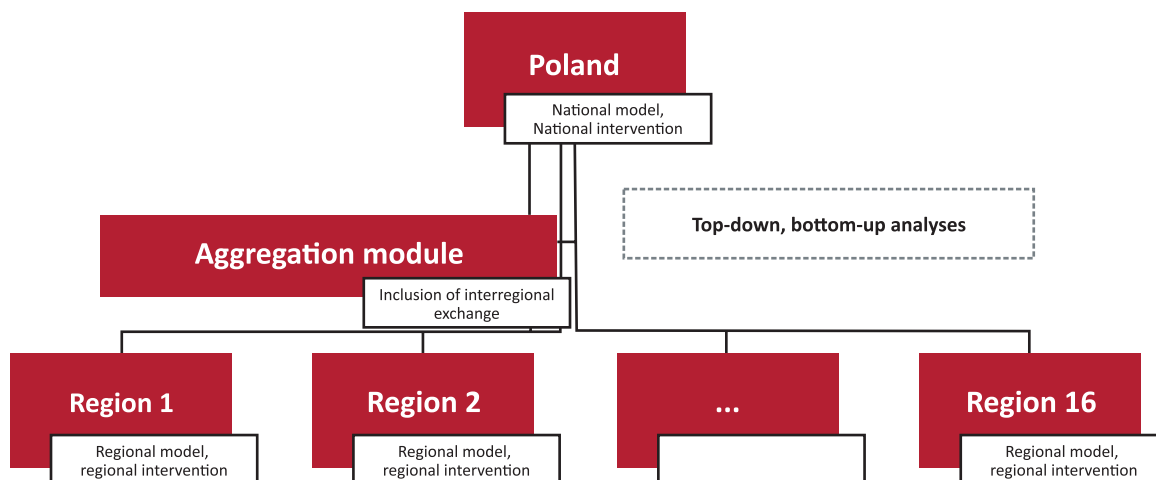
## Sectoral and regional structure of the model

The basic specification of the VESPA3 model includes:

- division into sectors: (1) agriculture, fisheries and forestry, (2) processing industry, (3) mining, quarrying, fuel production and energy, (4) building and construction, (5) private services, (6) public services.
- division of enterprises into categories: micro (up to 9 people), small (9–49 people), medium-sized (50–249 people) and large (250+ people).
- division into macroregions: (a) Mazowiecki (MAZ), (b) central (LDZ and SWK), (c) southern (MLP, SLA), (d) northern (KJP, POM, WMZ), (e) eastern (LUB, PKP, PDL), (e) south-western (DLN, OPL), (F) north-eastern (WMZ, PDL), (g) north-western (LBS, WLK, ZPM).

In the regional layer, the model takes into account economic differences between the different voivodeships (i.a. the level of economic development, the sectoral structure, the situation on the labour market) and variations in the scale and structure of spent EU funds (funding for human capital, investment support, innovation, etc.). VESPA3 captures the impact of EU expenditure on the economy by directly recording regional expenditure and then aggregating results to the national level. Trade with other voivodeships and other countries was taken into account, thus modelling a spillover effect of the intervention between voivodeships and indirect effects of expenditures in a particular region.

**Figure 1.** National and regional models in VESPA

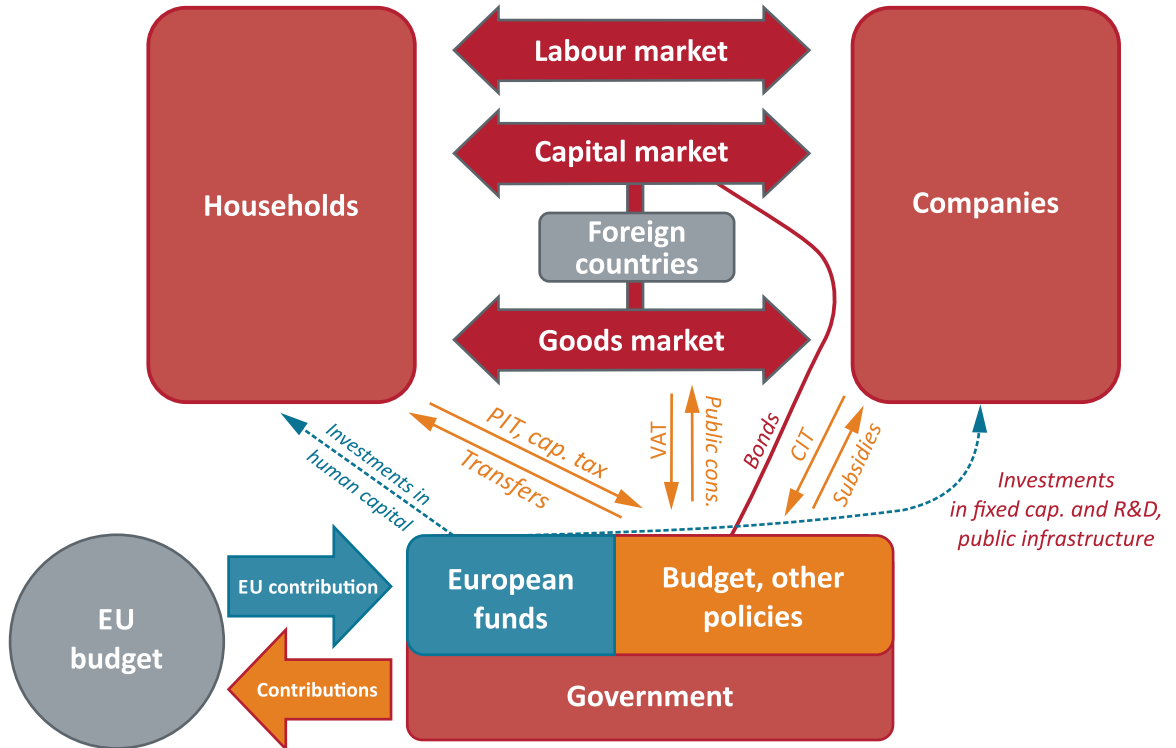


# Main sections in the model

## Markets

In general equilibrium models, such as VESPA3, supply and demand in the economy counterbalance each other. The former defines the productive capacity of the economy and factors determining it (i.e. accumulation of physical and human capital, infrastructure, accumulation of innovation-driven technology, labour resource utilisation, direct foreign investments, etc.) and the latter identifies the needs of the private sector (consumption and private investments), the public sector (consumption and public investments) and the foreign sector (net exports). The two sides combined allow for the analysis of the public intervention impact on the economies of voivodeships and the country as a whole, including interventions carried out in the context of the EU cohesion policy in Poland.

**Figure 2.** VESPA3 model structure



Source: WiseEuropa's own study.

VESPA3 also takes into consideration the structure of transfers received from the EU and paid into the budget, which effectively introduces opportunity cost (best available use of identical national/European funds) into the model. Optimisation takes place based on decisions made by companies and households, using data for public sector intervention (tax and expenditure), EU-funded intervention and operations abroad data, and leads to setting relative prices and the final supply-demand balance.

The individual model modules are linked by markets. The goods market sets the prices of consumer goods, materials, capital and public goods. Production companies sell their goods to both final and intermediate customers while buying capital goods, materials and energy from the other companies (domestic and foreign) and from businesses generating capital and R&D ideas. In turn, the labour market determines remunerations and levels of employment, unemployment and inactivity.

## Households

Households in the VESPA3 model are marked by a bifactorial utility function (consumption and leisure) increasing over time indefinitely by utilizing savings to postpone consumption. In general, the formula is as follows:

$$U_t = u_t + \beta E_t[u_{t+1}]$$

where the momentary utility function is a constant relative risk aversion (CRRA) function linked to the consumption of conglomerate market and non-market consumer goods  $\tilde{C}_t = C_t + \vartheta NE_t$ , where non-market goods (domestic production) are produced by non-employed (unemployed or inactive) household members ( $NE$ ). Households divide their members into three categories based on their labour market status (employed, unemployed, inactive) and maximize the discounted expected utility by determining labour supply, consumption demand, bank deposit volumes ( $D_t$ ), demand for money ( $M_t$ ) and the value of government bonds held ( $B_t$ ). A non-Walrasian labour market (i.e. admitting the existence of unemployment) allows households and companies to negotiate remuneration and working hours (sector-specific, depending on the company size) and affects job-seeking among the unemployed. Consumption and income from labour and capital remain taxed, the government provides households with social transfers ( $T_t$ ) based on the number of inactive and unemployed individuals.

## Production companies

Companies operate in the modelled sectors and determine the demand for intermediate goods ( $MAT_t$ ), investment volumes ( $I_t$ ) and demand for labour ( $N_t$ ). The company's optimisation problem lies in maximising the expected value of future cash flows.

$$\Pi_t = \pi_t + E_t[\Lambda_t \pi_{t+1}]$$

Current cash flows ( $\pi_t$ ) are based on the difference between marketed production ( $P_t Y_t$ ) and production expenses including, but not limited to, raw material costs (intermediate consumption,  $MAT_t$ ), capital expenditure ( $P^I I_t$ ), labour costs ( $W_t N_t$ ), R&D expenditure ( $BR_t$ ) and finance costs ( $R_t B^F$ ). The production process consists of 5 stages. In the first stage, the basic good is produced. In the second stage, it is diversified in monopolistic competition (of companies offering unique ideas developed in the R&D process). Then, in stage three, national goods are aggregated (at sector level) with foreign goods (component imports). They are then exported (stage four) and next, in stage five, sectoral goods become final products (consumer, capital and public goods). The subsequent stages of the production process are reflected in the model using a multi-level nested CES (Constant Elasticity of Substitution) function. For instance, in the first stage, the production of non-diversified (sectoral) basic goods ( $Y_t$ ) uses KLEMS-type<sup>151</sup> technology, taking into account capital ( $K_t$ ), labour ( $N_t$ ), energy ( $ENG_t$ ), raw materials and component ( $MAT_t$ ) expenses and externalities of public infrastructure ( $K^P$ ).

$$Y_t = \left( \left( K_t^P \right)^\omega Y_t^{KLEMS} \right)$$

where:

$$Y_t^{KLEMS} = CES(K_t, MAT_t, ENG_t, N_t)$$

is a nested CES-type utility function incorporating private capital, intermediate consumption, energy use and labour input. The supply of final goods responds to the consumption demand of households (private consumption) and of the government (public consumption), as well as to the investment demand of companies producing basic goods.

<sup>151</sup> KLEMS productivity account – cf. GUS, *Rachunek produktywności KLEMS – Polska 2005–2016*, Warsaw 2018, (<https://stat.gov.pl/statystyki-eksperymentalne/klems-rachunek-produktywnosci/rachunek-produktywnosci-klems-polska-2005-2016,1,1.html>, access: 6.07.2019). The acronym comes from words 'capital' (K), 'labour' (L), 'energy' (E), 'materials' (M) and 'services' (S).

Operating costs of manufacturing companies are partially financed with debt (operating and investment loans) and subject to frictions dependent on company category (size categories according to the number of employees). These categories are characterised by different access to the capital market and innovation capacity.

When producing basic goods and diversifying them on the market, companies benefit from government support (subsidies) which reduces investment and R&D costs, as well as from externalities provided by public infrastructure. Furthermore, an incomplete capital market affects profit distribution between households (dividends) and future investments and also impacts the number of newly established manufacturing companies and new ideas (R&D sector). Labour demand is reflected in open vacancies and wage rates accepted by the relevant household members.

## Government

In the VESPA3 economy model, the government's tasks relate to fiscal and monetary functions: state revenues from taxes (imposed on public consumption of  $G_t$  and pollution, i.e. PIT, CIT, VAT (among others), social contributions and CO2 fees) and EU funds, as well as funds from new bonds issues. Expenditure, in turn, refers to public consumption of  $G_t$ , public investment ( $I_t^p$ ) in infrastructure ( $K_t^p$ ), transfers ( $T_t$ ) linked to the number of unemployed and inactive household members, discretionary transfers, including corporate subsidy policy ( $S_t^p$ ), and bond redemption. This category also covers expenses incurred in the implementation of EU programmes, including those financing innovation and private sector investments. The government sector is limited by the requirement for revenues to be equal to current expenditure and debt servicing costs. Public debt is modelled based on the literature concerning limitations in the formation of public debt. The increasing cost of its servicing leads implies introducing limitations to the model<sup>152</sup>.

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<sup>152</sup> P. D'Erasmus, E.G. Mendoza, J. Zhang, "What is a Sustainable Public Debt?", *NBER Working Papers* 21574, National Bureau of Economic Research Inc 2015.

## Goods market

The goods in the model are mainly exchanged by companies operating at the different production stages (purchasing materials from other economic sectors, purchasing capital goods from companies producing such goods, importing and exporting goods under foreign trade). The VESPA3 model shows the difference between tradables and non-tradables, the partial interoperability of domestic and foreign goods, price differentiation and foreign trade transaction costs. Apart from capital goods sold to companies, final production goes to households (private consumption) and to the government (consumption and public investment). Government goods (public consumption and infrastructure), meanwhile, are available to the private sector (positive externalities) free of charge. The goods market is implemented in separate VESPA3 model modules (production, consumption, government) using a price mechanism balancing the different (sectoral) submarkets. This means that the model incorporates several relative prices reflecting the prices of final ( $P_t^f$ ), sectoral ( $P_t^s$ ) or tradable ( $P_t^c$ ) goods.

## Labour market

In the model, the labour market is based on the search and matching theory according to Mortensen's and Pissarides' methodology<sup>153</sup> where employers open vacancies ( $VAC_t$ ) and the unemployed seek employment via market offers ( $O_t$ ). The imperfect intermediation process results in fewer vacancies filled than the number of employees searched for by employers and fewer than the number of unemployed job seekers suggests. Labour market wage rates ( $W_t$ ) are negotiated according to Nash's scheme that relies heavily on individual conditions (of both companies and households). The negotiations take into account the impact of new rates and working hours on household consumption and leisure time and thus, on the workers' usefulness, and are held at sector and company level (by size).

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<sup>153</sup> D.T. Mortensen, C.A. Pissarides, "Job creation and job destruction in the theory of unemployment", *The review of economic studies* 1994, vol. 61, No. 3, pp. 397–415.

## Financial market

The financial sector is composed of the central bank (cash issuer) and commercial banks that grant loans for operational activity and investments. The borrowing companies are subject to liquidity constraints according to their size and sector. In the case of the banking sector, money creation is possible. Monetary policy involves open market operations and high-powered money creation in the process of exogenous monetary policy. The monetary policy in the model is set using the econometrically estimated Taylor's principle<sup>154</sup>.

## Model parametrisation

VESPA3 model parameters fall into three categories. The first group contains parameters defining variables in the steady state. The second class consists of parameters controlling the response of variables to shocks. The third group contains parameters describing the nature of such shocks as seen by economic operators.

**The first class of model parameters** covers approximately 80% of the parameters.

It includes parameters defining the model's steady state reflecting long-term interactions between macroeconomic variables in the field of national accounts (global production, GDP, sector structure of added value, consumption, investments, exports, imports), labour market (employment, unemployment, professional activity, remuneration), public finance sector accounts (revenues from VAT, PIT, CIT, social security contributions, public consumption expenditure, public investments, transfers, debt service) etc. They include the rate of inter-period household utility substitution (*beta*), capital depreciation rate (*delta*), shares in CES-type utility function (*omega*), shares of particular expenditure categories, such as transfers, consumption, public investment and taxes (PIT, CIT, social security contributions, VAT) in the structure of state expenditure and revenue (*theta*), labour market efficiency defining the unemployment level in equilibrium (*gamma*) and the share of public debt in GDP. The parameter values are direct functions of relevant macroeconomic variables, such as input-output flows (I/O matrices), national accounts, labour market data and public sector accounts. The data is obtained directly from EUROSTAT and GUS databases. For the banking sector, the model uses NBP data, while the EU block

<sup>154</sup> A. Sznajderska, "On asymmetric effects in a monetary policy rule. The case of Poland", *NBP Working Papers* 125, National Bank of Poland, Economic Research Department 2012.

uses MIR data. The observed data conclusively determine the model's steady state, so they directly determine this category of the model's parameters (parameters take values implied by observations and by the structure of the model, making the model's steady state reflect the structural (stable in the long term) aspect of the Polish economy i.e. long-term interactions between macroeconomic variables (such as natural unemployment rate, share of public consumption in GDP, etc.).

**The second group of model parameters** covers approximately 15%–17% of the total number of parameters and focuses mainly on flexibilities (indexed with *eta* or *sigma* symbols in the model) in functions representing the various model segments, such as production technologies, labour market parameters, household utility function, etc. These flexibilities account for individual variables' relative response to macroeconomic shocks and, consequently, their deviation from the reference variable (GDP, for instance). They are generally determined based on European data or calibrated according to reference literature. In the former case, the estimation is calculated in a way similar to the Smets' and Wouters' model<sup>155</sup>, that is, using Bayesian estimation methods and the highest credibility. They are commonly used in DSGE modelling<sup>156</sup> as they are flexible, universal and unbiased, i.e. resistant to the preferences of the modelling team. In principle, the parameters should not depend significantly on a given economy as they reflect more universal properties of the operators: the nature of social preferences, global production technology specifics or the nature of invention processes. As such, they do not need to, or should not even, be determined on the basis of national data, but rather be underpinned by cross-sectional international data (EU data for the VESPA3 model) or specialised reference literature on specific thematic areas i.e. theoretical and empirical research conducted by authors who dealt with DSGE model parametrization.

For some parameters, estimation is unnecessary, given the large consensus on the parameter variability range in reference literature. It may also be impossible due to lack of relevant data.

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<sup>155</sup> F. Smets, R. Wouters, "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area", *Journal of the European Economic Association* 2003, MIT Press, vol. 1, No 5, pp. 1123–1175.

<sup>156</sup> Cf. An and Schorfheide (S. An, F. Schorfheide, "Bayesian Analysis of DSGE Models", *Econometric Reviews* 2007, vol. 26, No 2–4, pp. 113–172); Herbst and Schorfheide (E.P. Herbst, F. Schorfheide, *Bayesian Estimation of DSGE Models*, Princeton University Press 2015.)

This applies to approximately 5% of model parameters. In such cases, a given parameter is determined based on reference literature<sup>157</sup>.

**The third class of model parameters** is the smallest (3%–5% of total number of parameters) and depends on specific research questions that the model is to answer. This concerns parameters describing the patterns of macroeconomic imbalances in the economy (covariance matrices between shocks and their variances). Generally, they may take any value depending on the type of questions set to the model. If we assume, for example, that operators considered the intervention as short-lived, the autocorrelations of the relevant shocks will be close to zero. If it is found to be permanent, the assigned values will be close to 1. Intermediate values are also possible, depending on simulation requirements. The situation is similar for other shocks. The values are set in line with the needs of the specific research topic.

## Reference scenario

The VESPA3 model presents findings against a baseline (reference) scenario encompassing historical and forecast behaviour of macroeconomic variables simulated in the model, including:

- GDP, added value, production, productivity;
- GDP components (investments, consumption, exports, imports);
- labour market (employment, unemployment, inactivity, productivity, wages);
- public finances (taxes and expenditure including EU funds);
- business performance (profits, innovation, productivity, R&D and capital expenditure);
- environmental variables, such as energy consumption or CO<sub>2</sub> emissions.

Predictive analyses take into account three scenarios: positive (maintaining relatively high GDP dynamics), intermediate (slowdown in GDP growth), negative (very low growth

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<sup>157</sup> This includes the substitution flexibility between labour and capital assumed at level 1 (Cobb-Douglas function). Similarly, the risk aversion parameter in the consumption function is determined at level 2, based on reference literature (*sigma* = 2, cf. F. Kydland, E. Prescott, “Time to build and aggregate fluctuations”, *Econometrica* 1982, vol. 50, pp. 1345–1371). It is a value applied on a standard basis in DSGE models. The consumer’s time preferences, on the other hand, are determined directly by the model’s annual frequency (*beta* = 0.93, cf. F. Smets, R. Wouters, “An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area”, op. cit.).

or stagnation). The different variables in the baseline scenario are represented in cross-sections corresponding to the disaggregation of the model (regional, sectoral, by company size category, etc.). In Poland, the intermediate scenario used in the VESPA model derives from a forecast reflecting long-term convergence trends within the EU. The simulation results are presented as a deviation from the baseline scenario (in %) or converted into appropriate units (such as EUR/PLN billions, thousands of people, etc.).

## Functionality of the model

The following features determine the functionality of VESPA3 model:

- Imaging an open economy, its impact on company internationalisation and reflecting EU funds.

The VESPA3 model describes an open economy (with international links). International trade is modelled in a procedure similar to that used for domestic economy modelling, whereas the trade structure relies on empirical data. The actual trade process between economies concerns goods and services as well as capital flows. Firstly, this enables analysis of EU funds' impact against a similar intervention funded from domestic funds. Secondly, it enables analysis of the effectiveness of measures aimed at promoting export and company internationalisation. In the first aspect, inflow of capital from abroad affects the expenditure and tax module of the model, which covers different categories of public expenditure (infrastructure, human resources, R&D, subsidies for the production sector, social transfers, public consumption, etc.) and taxes (PIT, CIT, VAT, excise, etc.) and depicts the actual functioning of the economy. This module shows in detail how EU funds are spent, incorporating the distinction, embedded in public policy, between investments in basic infrastructure, human resources development and direct support for the production sector.

- Direct, indirect, induced and fiscal effect estimations.

The multi-module design of the VESPA3 model enables to factor the full complexity of the real economy, including the constraints imposed by input-output, cross-sectoral, interregional and inter-company ties between companies of various sizes. These constraints affect the impact of aid granted to a given sector, among others. This impact is not limited

to the sector or category of companies receiving aid, but has an indirect and induced spill-over on other sectors, households and the public finance sector. The multi-aspect nature of the model thus enables to separate the **direct effects** of intervention from the **indirect and induced effects**, while the government segment allows for separation of the **fiscal effect**. These effects will be identifiable for macroeconomic variables described by the model, such as GDP, employment, unemployment, R&D expenditure, etc.

- Determination of substitution, crowding out and no-load loss effects.

The core assumption of DSGE models, including VESPA3, is that they are based on microeconomic foundations. This means that equations in the model describing the behaviour of participants in the economic cycle (households, companies, the financial sector, the government, etc.) stem from many interrelated optimisation problems which maximise different target functions, whilst maintaining limitations resulting from the functioning of particular operators in uncertain conditions. This makes VESPA3, similarly to other DSGE models, resistant to Lucas critique which has been directed at econometric models that are generally insensitive to changes in such multiples. This feature allows for the analysis of **substitution** (supported operators gain at the expense of other operators deprived of such aid), **crowding out** (intensity of an activity decreases due to the need to finance another activity), and **no-load loss effects** (granting subsidies to projects that would have been undertaken even without such aid). Such negative phenomena reduce the effectiveness of an intervention, which means that the magnitude of a model economy reaction to changes in the scale and structure of public expenditure (in particular, intervention from EU funds) reflected in the expense multiples is actually lower than simple I/O or econometric models would suggest.

## Evolution of VESPA model functionalities

The VESPA3 model is a follow-up to VESPA and VESPA2 models formerly used by WISEEuropa<sup>158</sup> in evaluation studies on Operational Programmes 2007–2013 commissioned by PARP and the Ministry of Infrastructure and Development (2016–2017).

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<sup>158</sup> Warsaw Institute for Economic and European Studies Foundation.

It was designed for the next evaluation by the Agency, scheduled for 2019–2022<sup>159</sup>, which use macroeconomic modelling to analyse the effects of PARP aid granted under the Smart Growth and Eastern Poland 2014–2020 Operational Programmes.

The VESPA model was designed to study the impact of the EU funds on the Polish economy (at macro level). The studied impact was limited to aid divided into three main categories: basic infrastructure, direct aid to enterprises and human capital. The model allowed for the analysis of substitution, crowding out and no-load loss effects, as well as indirect and induced effects combined. The VESPA2 model expanded the VESPA model by a multiregional module (in a way similar to the one described above) and implementation of pro-innovation policy (R&D&I module), a fiscal module enabling to analyse impact on public revenues and expenditure, and minor changes enabling to separate indirect and induced effects. The VESPA 3 model, in turn, further explores the path taken by the VESPA2 model, adding the various categories of enterprises and innovation support in particular, and updating it with the latest data.

## Innovation and competitiveness policy effects in Poland in the light of VESPA model data

As an illustration of the possibilities of the VESPA model, it is worth recalling by the evaluation results of PARP activities addressed to companies under the Operational Programme

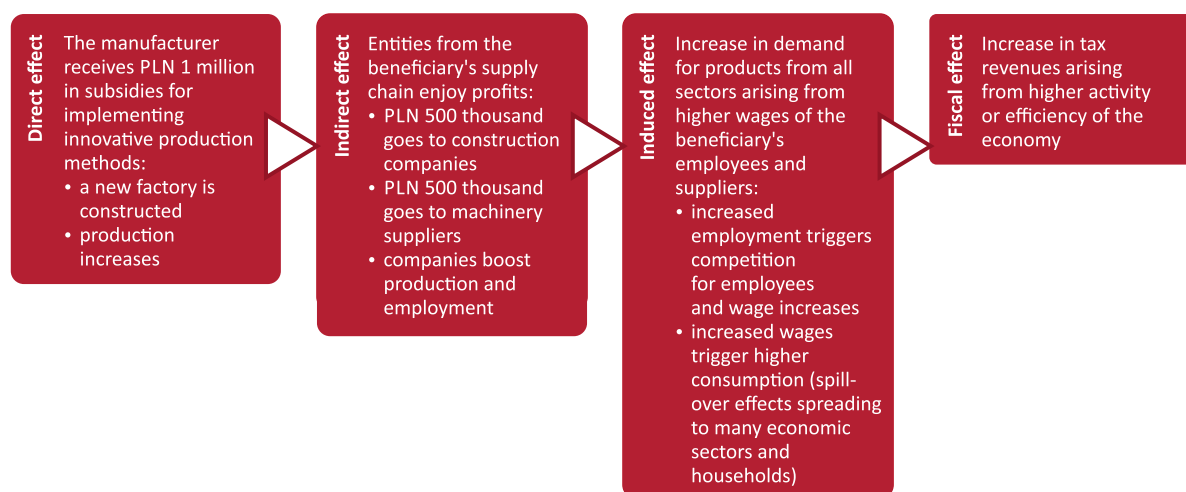
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<sup>159</sup> Cf. PARP, Wykonanie ewaluacji pn. “Analiza efektów wybranych działań POIR i POPW na poziomie sektorowym i makroekonomicznym za pomocą modelu makroekonomicznego”, SIWZ, Warsaw 2019. (<https://zamowienia.parp.gov.pl/pn/parp/demand/notice/public/3788/details>, access: 6.07.2019).

The present multi-stage project of PARP is focused on research and development in terms of the approach applied to modelling macroeconomic effects. In particular, it aims at embedding the model in the precise categories of aid set out in the GBER (Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty) and at broadening the research horizon to include the group of so-called ineffective applicants. The offer of public aid and entrepreneurs’ effort to prepare project documents in general certainly impact the development activities undertaken by this group of entities, despite the absence of cofunding.

Innovative Economy 2007–2013 (OP-IE)<sup>160</sup>. The evaluation study of PARP was to determine, *inter alia*, the magnitude of possible direct, indirect, induced and fiscal effects that could arise from financial aid granted to companies. As the economy is a system of ‘communicating vessels’, it was expected that the financial aid received by beneficiaries of the OP-IE would, to some extent, alter the broader socio-economic environment, including related sectors and households. The effects of subsidies granted to enterprises can also simultaneously be observed in the revenues of the public finance sector<sup>161</sup>. The analysed causal model of PARP’s intervention effects on the economy is depicted in the diagram below.

**Figure 3.** Causal model of intervention effects on the economy



Source: Own study based on M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit., p. 8.

<sup>160</sup> M. Bukowski, M. Feldy et al., *Analiza wybranych działań Programu Operacyjnego Innowacyjna Gospodarka 2007–2013 na poziomie sektorowym i makroekonomicznym, za pomocą modelu przepływów międzygałęziowych. Raport końcowy*, Konsorcjum WiseEuropa – Warsaw Institute for Economic and European Studies Foundation and Information Processing Centre – Polish Research Institute, commissioned by PARP, Warsaw 2017 (<https://www.parp.gov.pl/component/publications/publication/analiza-wybranych-dzialan-po-ig-na-pozomie-sektorowym-i-makroekonomicznym-za-pomoca-modelu-przeplywow-miedzygaleziowych>, accessed: 6.07.2019).

<sup>161</sup> Cf. PARP, *Analiza wybranych działań PO IG na poziomie sektorowym i makroekonomicznym za pomocą modelu przepływów międzygałęziowych, w ramach projektu ewaluacyjnego „Barometr Innowacyjności”*, SIWZ, Warsaw 2017.

Essentially, the analysed PARP aid measures under OP-IE had 2 types of purposes<sup>162</sup> which were conditional upon a specific theory regarding changes on the market<sup>163</sup>. The measures were to support the production sector and pro-innovation activities, related to, in particular, research and development (R&D&I). The first type (87% of total PARP financing under the analysed OP-IE measures) covered financing projects introducing solutions based on relatively well-established technologies or available market knowledge (e.g. purchase of equipment to increase the production efficiency) to companies. The second type (10% of PARP aid funds) was connected with generating new ideas capable of potentially shifting the technological boundaries (such as new inventions, new industrial designs) and delivering groundbreaking innovations<sup>164</sup>.

## Macroeconomic impact

On a macroeconomic level, the scale of aid granted by PARP was relatively small. In 2008–2016, entrepreneurs received PLN 14.3 billion which accounted for merely 0.1% of the cumulated Gross Domestic Product (GDP) for the period (ca. PLN 14 trillion). Annual public expenditure for the analysed measures was not distributed evenly, with a cumulation reaching 0.3% of annual GDP in 2015. It should be noted that the share of micro and small enterprises in the financed group is relatively high (54%) and that the share of companies based in richer regions of the country (in particular the group enjoying pro-innovation aid) is higher. Nonetheless, the modelling results show that injecting these funds into the economy generated an additional PLN 92 billion of GDP in 2007–2017<sup>165</sup> and increased labour productivity, profits and wages in enterprises. This was primarily due to the increase in the capital labour ratio (enhanced capital productivity in supported companies and, in broader terms, in the entire economy) which resulted in the creation of qualified jobs

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<sup>162</sup> The third type, aid to promote SME exports, accounted for barely 3% of the total value of subsidies granted by PARP under the analysed group of OP-IE measures (1.4, 4.1, 3.3.2, 4.2, 4.4, 5.4.1, 6.1, 8.1 and 8.2 PO-IE), therefore it is not discussed in detail here.

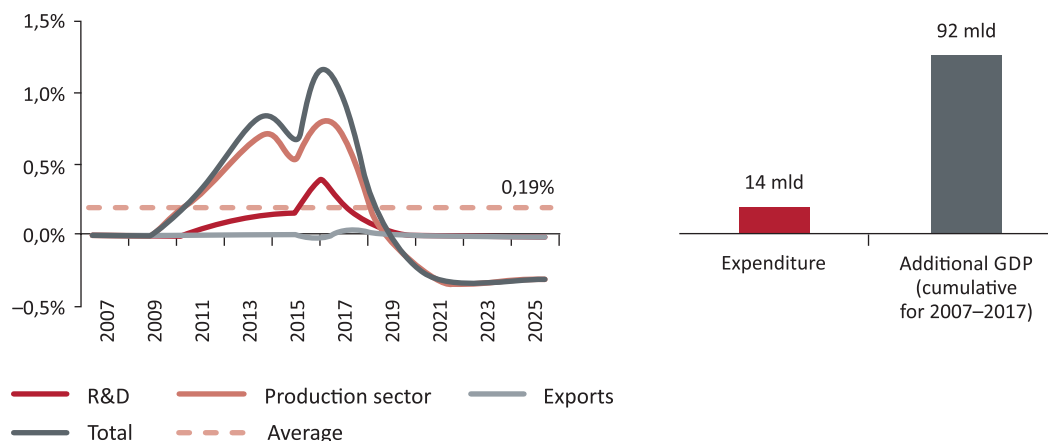
<sup>163</sup> The extent of change in the value of indicators and its spread over time depends on the type of intervention. For example, indicators react differently to R&D&I aid than they do to direct aid to the production sector (M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit., p. 10).

<sup>164</sup> M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit., p. 9.

<sup>165</sup> *Ibidem*, p. 10.

and an additional motivation to accumulate human and organisational capital in companies (modern know-how)<sup>166</sup>.

**Figure 4.** Impact of PARP interventions on GDP in a given year split into categories of aid (deviation from the no-intervention scenario in % – right; cumulative value in PLN – left)



Source: M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit.

The additional GDP generated in 2007–2017 as a result of interventions augmented the volume of PARP co-financing under the analysed OP-IE 2007–2013 measures over six times (6.4). The average annual growth of additional GDP (net effect) in the analysed period amounted to 0.19% of GDP, with the effect exceeding 1% of GDP in 2017.

The additional GDP of 92 billion should be associated with the programme's positive impact on companies' investments which increased by nearly PLN 69 billion in total in the analysed period 2007–2017. Moreover, the implemented measures also influenced foreign trade. In the first phase, that is during the project execution financed from OP-IE, imports surged rapidly. This was a natural phenomenon - entrepreneurs bought new machines, services and components, choosing the most advanced solutions (including foreign ones). (...) The case is different for exports. The first few years of implementing (...) PARP measures resulted in a marginal increase in exports. However, a significant increase in export dynamics has been observed since 2011. By 2017, the export cumulative value was 38 million higher than the baseline scenario. By 2025, the export cumulative additional value (the effect

<sup>166</sup> Ibidem, p. 12.

of OP-IE measures implemented by PARP) should amount to approximately PLN 120 million<sup>167</sup> (Figure 5).

**Figure 5.** Cumulative additional exports and imports value in a given year (PLN million)



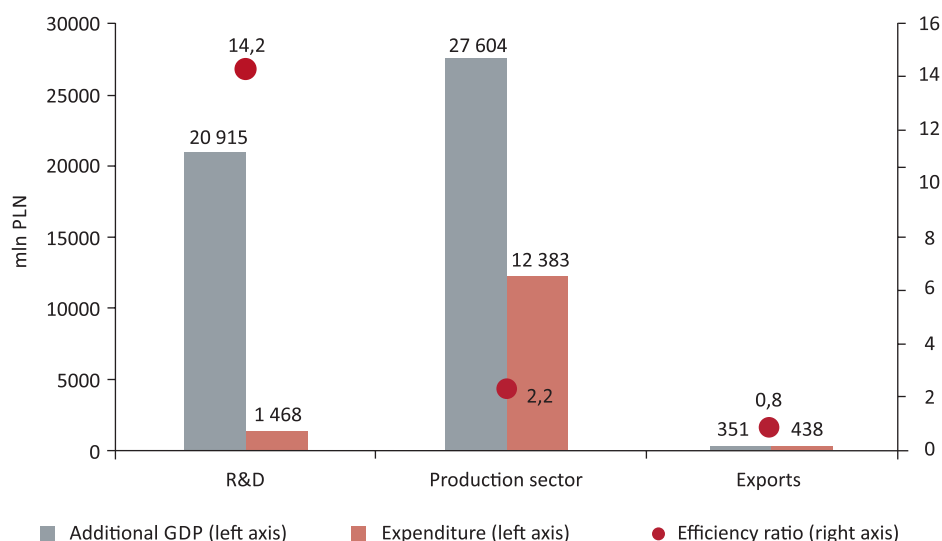
Source: M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit.

The labour market also benefits from the aid granted to enterprises under OP-IE. In 2007–2025, the average annual rise in employment of 0.16% is a net effect of PARP’s aid programme under OP-IE. In the short period of direct exposure to the programme, from 2007 to 2017, the economy was generating 45,000 new jobs annually. In the counter-factual situation of no intervention in the economy, these jobs would not have been created at all. The cumulative employment effect of the programme occurred in 2016–2017. Subsequently, the model signals possible minor negative deviations from the reference scenario, which means phasing out effects in that area. PARP interventions also led to a slight increase in labour productivity (+0.03% on average in the period) and wages (+0.08% on average in the period). The simultaneous increase in these two indicators points to a reorientation of the economy towards technological advancement<sup>168</sup> (i.e. an economy creating well-paid jobs, also linked to higher productivity).

<sup>167</sup> While this value is not very high in relation to the value of total exports of the entire Polish economy, it should be noted that measures which, in their vast majority, were not directly aimed at stimulating exports have influenced them positively (ibidem).

<sup>168</sup> Ibidem, p. 12.

**Figure 6.** Expenditures on the various categories of aid vs GDP generated by the aid allocated to the different categories (cumulative value for 2007–2025)



Source: M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit.

Investments in the production sector had the strongest impact on the presented macroeconomic effects, which, to a large extent, is related to the amount of aid provided to that sector. In the summary, similar effects in the innovation sector (R&D&I), in nominal values, turned out to be lower. It should be noted, however, that the effects in the production sector were temporary. The positive effects either phased out or significantly diminished post-intervention. Direct aid to the innovation sector (R&D&I) produced less spectacular results, but it is more stable over time. As a result of R&D&I activity support, the long-term productivity of Polish companies increased (due to the spread of knowledge and industrial commons<sup>169</sup><sup>170</sup> (Figure 6). This signals high efficiency of the aid provided to the innovation sector. The return on investment in terms of additional GDP in the sector was estimated at over 14 times the original input (in the long term, PLN 1 million of financing for R&D&I generated 14.2 million of additional GDP in the economy). In this regard, positive effects (positive, yet markedly lower) were also observed in the production sector, where, in general, no new ideas or breakthrough solutions were developed and internal

<sup>169</sup> Essential knowledge and capabilities (technical, design and operational) shared within an industrial sector, such as know-how, R&D&I, advanced process development and engineering skills or production competence relevant to a specific technology (ibidem).

<sup>170</sup> Ibidem.

changes in companies consisted in adapting to the market. In this sector, the PLN 1 million of financing provided to companies certainly helped them not to remain passive in the face of the competition and generated over 200% return on investment (PLN 2.2 million) as additional GDP in the economy. Considering the structure of PARP's aid programme (10% expenditure on R&D&I vs 87% on production-related investments), in the long term, both forms of aid and the generated effects proved to be complementary, so to speak. The gradual phasing out of the effects of production investments synchronised with the growing and lasting benefits from the effects of R&D&I activities.

Considering the analysed effect categories, the direct and indirect effects of interventions related to the increase in capital and labour productivity in the group of beneficiaries and entities included in their supply chains were of key importance. The induced effects, indirectly affecting households, resulting from the increase in profits of companies and income of their employees, turned out to be much less significant<sup>171</sup>. Moreover, the modelling results allowed to estimate the fiscal effect related to the distribution of these OP-IE funds. In 2007–2017, higher employment and wages in enterprises subject to the measures contributed nearly PLN 15 billion to the State Treasury in PIT and social security contributions. In addition, this means that the short-term fiscal effect has already covered the expenditure linked with the development activities borne by PARP (PLN 14.3 billion).

## Impact on economic sectors and regions

The most significant impact of OP-IE was noted in information and communication technology-related sectors (ICT), creative and automotive industries. The high effectiveness of the programme observed in these fields is attributable to a higher share of R&D expenditure and innovative projects which positively stimulated labour productivity in these sectors. It has also led to increased cross-sectoral cooperation and movements of workers between sectors. However, irrespective of the sector, support for start-ups and relatively new companies yielded disproportionately low effects in relation to expenditure<sup>172</sup>.

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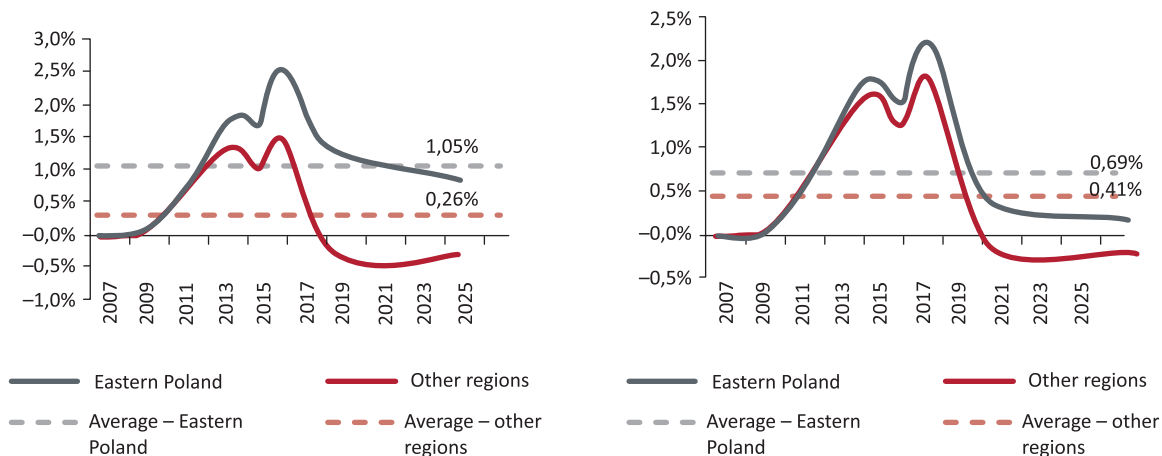
<sup>171</sup> In this respect, the intervention scale turned out to be insufficient to have a stronger impact on the labour market and wages across the economy (ca. 16 million employees).

<sup>172</sup> Cf. K. Makarski, *Recenzja naukowa raportu „Analiza wybranych działań POIG [...]”*, Warsaw 2017, p. 6.

According to VESPA model estimates, in 2007–2025, gross value added in these sectors of the economy will be, on average, 1.6% higher than in other sectors. Moreover, the construction and transport sectors were also the ‘winners’ in the group of OP-IE beneficiaries from various sectors. Nominally, they received the largest amount of PARP aid funds (in particular in voivodeships of the Eastern Poland macro-region, as discussed below).

The evaluation of PARP measures also proved the impact of OP-IE on increasing the economic cohesion of the country by reducing the gap between wealthier and poorer regions. Modelling at the regional level indicates that the most significant effects of aid are observed in the eastern regions of Poland. Substantial expenditures on industry have led to a boost in the construction and transport sectors, dominated by workers from poorer regions. Therefore, the increase in employment stemming from OP-IE interventions is higher in the eastern part of Poland, however labour productivity shows an inverse relationship. The increase in labour productivity in western regions results from the fact that the newly employed persons are mostly highly qualified employees from the innovation sector<sup>173</sup>.

**Figure 7.** Impact of interventions on global production (left) and gross value added (right) in a given year in Eastern Poland and the other regions of Poland (deviation from the no-intervention scenario, %)



Source: M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit.

<sup>173</sup> M. Bukowski, M. Feldy et al., *Analiza wybranych działań POIG [...]*, op. cit., p. 13.

## Conditions for effective aid to companies – conclusions on innovation and competitiveness policy

According to PARP report “*Analizy wybranych działań POIG 2007–2013 na poziomie sektorowym i makroekonomicznym, za pomocą modelu przepływów międzygałęziowych*”, the effectiveness of R&D&I support programmes and major business modernisation programmes is strongly affected by:

- Minimizing the substitution effect, i.e. directing the aid to companies that will replace their own funds (or funds borrowed from the financial sector) with financing obtained under the programme to a limited extent.
- Supporting significant modernisation of productive capital resources in companies, i.e. substantively increasing labour productivity by increasing the capital labour ratio.
- Addressing the issue of mutual complementarity of the different programme elements – aid is more effective if companies supported, directly and indirectly, not only increase their own productivity, but also positively influence the productivity of sub-suppliers and subcontractors.
- Joining the broader industrial commons already functioning in the economy and boosting their development to maximise externalities of the aid and thus its indirect impact on the widest possible group of enterprises<sup>174</sup>.

The above-mentioned conclusions, other than the results of macroeconometric modelling, were formulated based on complementary qualitative studies involving entrepreneurs and macro-economists. Interpretations derived from interviews indicated that the success factors of PARP measures were, in particular, spillover effects (spillovers of the impact of the aid onto a broader group of actors, such as organisations linked in a common value chain or distribution network). These effects were particularly evident in projects involving research and development, stimulating companies to initiate and consolidate business and scientific-technological cooperation. This often results in reusing project results to develop further innovative solutions and enhance cooperation which makes it possible to multiply the impact scale of developed innovations in the economy<sup>175</sup>.

<sup>174</sup> Ibidem, p. 15.

<sup>175</sup> Ibidem, p. 14.

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# VII. Application of DSGE models with frictional labour markets to evaluating public policies enhancing territorial cohesion of the EU countries

Marcin Woźniak

## Introduction

The recent years saw development of many interesting and advanced methods for analysing public policy effectiveness in different areas of the functioning of the economy. These may include new advanced econometric methods, development of spatial models<sup>176</sup>, and an ever growing application of Bayesian techniques<sup>177</sup>. Moreover, the so-called multi-agent models<sup>178</sup>, which violate the classic paradigm of market equilibrium being the result of the interaction of supply and demand, are becoming more and more important.

As this (r)evolution of economic sciences methodology is taking place, its classic doctrine has lost some of its significance, while the mainstream economic analysis methods have encountered criticism. Some of the most often indicated problems included the fact that they were out of touch with reality, required a number of unrealistic assumptions

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<sup>176</sup> A. Bhattacharjee, S. Roy, "Abnormal Returns or Mismeasured Risk? Network Effects and Risk Spillover in Stock Returns", *Journal of Risk and Financial Management* 2019, vol. 12, no. 2, pp. 1–13.

<sup>177</sup> G. Baio, "Bayesian models for cost-effectiveness analysis in the presence of structural zero costs", *Statistics in Medicine* 2013, vol. 33, no. 11, pp. 1900–1913.

<sup>178</sup> M. Richiardi, "The future of agent-based modelling", *Economics Papers* 2015, W06, Economics Group, Nuffield College, University of Oxford.

to be met<sup>179</sup> or that they described the economy with abstract equations requiring complicated numerical procedures. Another element which further increased the scepticism towards the classic methods was their inability to foresee the 2008 financial crisis despite the distressing data originating in the economy<sup>180</sup>.

A large part of this criticism was addressed to the Dynamic Stochastic General Equilibrium (DSGE) models – one of the major tools of the contemporary mainstream economic analysis. Modelling of that type is widely used by many prominent institutions, i.e. central banks of the European Union, the International Monetary Fund or the US Federal Reserve. At the national level, DSGE models are usually used to produce forecasts of the business cycle and to analyse the impact of specific public interventions and policies on the economy<sup>181</sup>. However, the critique of the DSGE models has cast a shadow over the method, questioning the relevance of its further application<sup>182</sup>.

The very name Dynamic Stochastic General Equilibrium models refers to their key features, which are worth noting at this point. The term “general” means that the model is applicable to the economy as a whole; “equilibrium” indicates a tendency of demand and supply to reliably and instantaneously adjust to a common value; “dynamic” means that the model refers to economic processes in time and “stochastic” assumes a certain element of randomness which may, however, be managed and allows for an introduction of unexpected events to the modelled economy (e.g. price shocks).

The classic DSGE models usually consist of three related blocks of equations, i.e. demand block (households), supply block (companies) and a block related to monetary policy issues or, generally, political conditioning<sup>183</sup>. The equations are constructed based on theoretical

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<sup>179</sup> Examples of the very little realistic assumptions of economic models include: 1) there is perfect competition on the markets; 2) prices instantaneously adjust to any equilibrium changes on the markets; 3) there is no information asymmetry; 4) companies are identical; 5) households are identical, 6) the modelled units last indefinitely.

<sup>180</sup> G. Kenny, J. Morgan, *Some lessons from the financial crisis for the economic analysis*, European Central Bank 2011.

<sup>181</sup> F. Smets, K. Christoffel, G. Coenen, R. Motto, M. Rostagno, “DSGE models and their use at the ECB”, *Journal of the Spanish Economic Association*, Spanish Economic Association 2019, vol. 1, no.1, pp. 51–65.

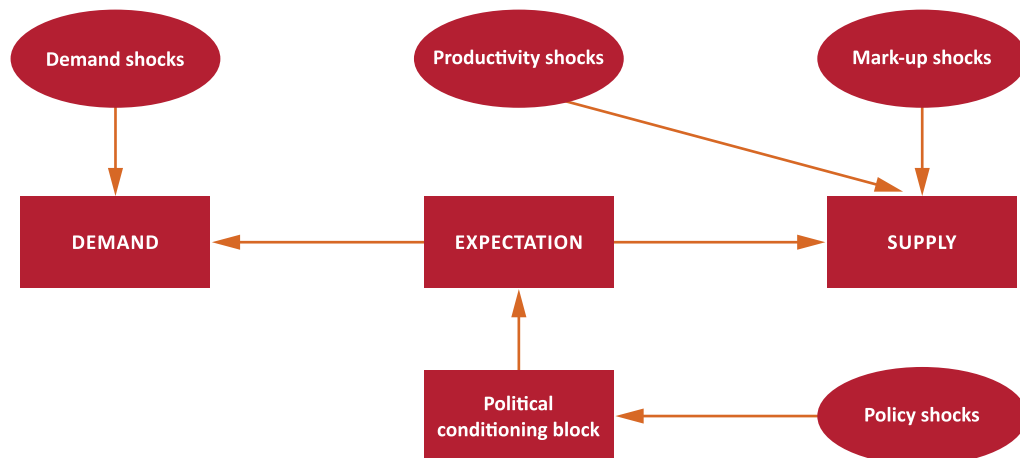
<sup>182</sup> This critique was presented in a synthetic form in: O. Blanchard, *Do DSGE Models Have a Future?*, Peterson Institute for International Economics 2016.

<sup>183</sup> J. Fernández-Villaverde, “The econometrics of DSGE models”, *International Review of Economics* 2010, vol. 1, no. 1, pp. 3–49.

assumptions on consumer and producer behaviour. Expectations about the future constitute the key channel of transmitting state intervention to the economy (Figure 1). The way future is perceived affects the current national policy. For example, the unemployment rate expectations for the next year shape the current labour market policy.

At the moment, one of the modifications to the DSGE models being developed are models with frictional labour markets. This section presents the application possibilities of these research tools in a reliable public policy evaluation. The aspect of territorial cohesion becomes significant in this context: calibrating the model to regional specificities allows to compare and optimally adjust the state policy to compensate for the regional disparities. Such differences currently occur and significantly affect the economy parameters in most of the EU states. This chapter presents both the theoretical material on DSGE models with frictional labour markets and the empirical analysis results for selected EU states, including Poland and its regions in particular.

**Figure 1.** Basic structure of DSGE models



Source: own elaboration based on EconReporter, *What is New Keynesian Dynamic Stochastic General Equilibrium Models?*, 2016.

## DSGE models with frictional labour markets

In response to the wide criticism of the classic DSGE models, attempts are made to improve them and develop their versions with more realistic assumptions. One of the possibilities involves including different types of frictions in the models – friction equivalents

as in physics. From the economy perspective, labour market frictions seem crucial<sup>184</sup>. An efficiently functioning labour market is a basis for economic development, its condition translates into economic parameters and the condition of employees and households<sup>185</sup>.

Contemporary DSGE models of this type, where frictional labour markets are combined with a number of political conditions, are resistant to the Lucas critique, as they are based on microeconomic assumptions and their parameters are the so-called deep parameters related to preferences and decisions of consumers and companies – economic system participants. Hurtado<sup>186</sup> indicates an important role of DSGE models calibration (selection of parameter values). The right choice of parameters based on empirical data significantly improves model precision and its forecasting properties. In times when policy is evidence-based, it becomes an important argument for classic methods, allowing to reject the accusation of excessive discretion in economic models calibration.

DSGE models with frictional labour markets differ from the traditional DSGE models in the manner of modelling the relationships on the labour market. The little realistic classic approach was replaced by a mechanism proposed by Peter Diamond from the *Massachusetts Institute of Technology*, Dale Mortensen from *Northwestern University*, and Christopher Pissarides from the *London School of Economics*.

The three economists, the Bank of Sweden's 2008 Nobel Prize winners for economic sciences, developed a complete labour market analysis environment in the course of ample research conducted first by Diamond<sup>187</sup>, Mortensen<sup>188</sup>, Mortensen and Pissarides, and finally by Pissarides<sup>189</sup>. The concept created by the Nobel Prize winners was nested in the so-called labour market search theory. Its accuracy and wide applicability is confirmed by numerous and, at the same time, significant labour market analyses conducted in many countries,

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<sup>184</sup> V. V. Chari, *Testimony*, House Committee on Science and Technology, Subcommittee on Investigations and Oversight 2010.

<sup>185</sup> A. Pápai, "A DSGE Model of Slovakia with Frictional Labor Market and Monetary Regime Switch", *Review of Economic Perspectives* 2017, ISSN 1804-1663, De Gruyter, Warsaw, vol. 17, no. 3, pp. 287–313.

<sup>186</sup> S. Hurtado, "DSGE Models and the Lucas Critique", Banco de Espana *Working Paper* no. 1310, 2013.

<sup>187</sup> P. Diamond, "A model of price adjustment", *Journal of Economic Theory* 1971, 3, no 2, pp. 156–168.

<sup>188</sup> D. T. Mortensen, "The Matching Process as a Noncooperative Bargaining Game", NBER Chapters, in: *The Economics of Information and Uncertainty*, National Bureau of Economic Research 1981, pp. 233–258.

<sup>189</sup> Ch. Pissarides, *Equilibrium Unemployment Theory*. wyd. 2, The MIT Press, Cambridge – Massachusetts – London 2000.

including Poland<sup>190</sup>. The core element of the theory is the assumption of the existence of costly labour market frictions, which hinder the process of matching an individual searching for employment with a corresponding workplace. Strong heterogeneity (diversity) of workplaces and the unemployed<sup>191</sup> as well as incomplete information on those searching for employment and on vacancies<sup>192</sup> are among the most often indicated causes of frictions. As a result, in order to effectively match an employment searching individual with the employer, the process requires time and resources (e.g. financial)<sup>193</sup>. The theory reasonably explains simultaneous existence of vacancies and unemployment and combines microeconomic analysis of individual's behaviour with macroeconomic effects of their interaction.

For the time-consuming process of searching the labour market, the authors use the concept of the so-called adjustment function<sup>194</sup> – a double-argument relationship which represents the number of newly filled jobs as a result of matching vacancies with the unemployed. Another module of the friction labour market model is wage negotiation based on the Nash arbitrary equilibrium of the game theory<sup>195</sup>. Following that concept, should the employment searching employee be matched with the employer (matching function), wage negotiations begin (Nash equilibrium). During the negotiations, the participants divide a certain surplus between themselves, which for the employment searching individual becomes their wage and for the employer – the company's profit. The cooperation lasts as long as it is profitable for both parties. When the cooperation ceases to bring profit, the employment contract is terminated, the employee embarks on searching for a new job and the employer either abolishes the position or resumes recruitment.

<sup>190</sup> Among other publications: S. Roszkowska, "Aggregate matching function. The case of Poland", *Central European Journal of Economic Modelling and Econometrics* 2009, vol. 1, no. 2, pp. 157–177; M. Woźniak, "Can the Stochastic Equilibrium Job Search Models Fit Transition Economies?", *Acta Oeconomica* 2015, vol. 65, no. 4, pp. 567–591.

<sup>191</sup> D. T. Mortensen, *Wage Dispersion: Why Are Similar Workers Paid Differently?*, MIT Press 2005.

<sup>192</sup> Information on vacancies is spread in the form of job offers through different distribution channels. It should, however, be highlighted that not all recruitment information is made public, and by different estimates only 30–50% of all offers are published.

<sup>193</sup> R. Shimer, "The cyclical behavior of equilibrium unemployment and vacancies", *American Economic Review* 2005, vol. 95 no. 1, pp. 25–49.

<sup>194</sup> Apart from modelling the matching of vacancies with employees, the matching function was successfully applied, i.a., to analysing marriages as a result of matching single women and men.

<sup>195</sup> J. F. Nash, "Equilibrium points in n-person games", *Proceedings of the National Academy of Sciences* 1950, vol. 36, no. 1, pp. 48–49.

The above mechanism was successfully implemented in the DSGE models. In that case, households actively participate in the labour market: they provide labour in exchange for remuneration. The environment is dynamic, vulnerable to external economic shocks (Figure 1). Apart from increasing plausibility, expanding the classic DSGE models by a frictional labour market provides a deeper insight to the labour market situation and allows for an analysis of the introduced shocks (including financial public interventions). The mechanism becomes particularly significant when you want to inspect the labour market policy and its often subtle influence on economic entities in general.

## Labour market policy – the problem of tools’ effectiveness

Labour market policy is an important element of social policy, i.e. wider state actions aimed at solving social problems. The labour market policy is targeted to improve the functioning of the labour market. The policy can be either active or passive. The active part is the key element of the labour market policy. It aims at improving the employment opportunities of job-seekers and to better match job offers (vacancies) to the skills of potential employees. Active Labor Market Policies (ALMP) may, therefore, have a significant influence on the economy as a whole, through increasing employment and, hence, increasing GDP, as well as through decreasing the number of those who depend on social benefits<sup>196</sup>. The Active Labor Market Policies which are applied most often in the EU states include<sup>197</sup>:

- actions targeted to maintain employment. These are temporary programmes which more often than not concern jobs and companies in danger of liquidation;
- actions targeted to create new jobs. Incentives for employers to increase employment at their companies. They can take the form of subsidies lowering labour costs and be oriented on specific groups of the unemployed (e.g. the long-term unemployed);
- actions targeted to maintain employment by low-paid, unqualified employees;
- actions targeted to develop human capital of the unemployed. Includes courses and training for the unemployed;

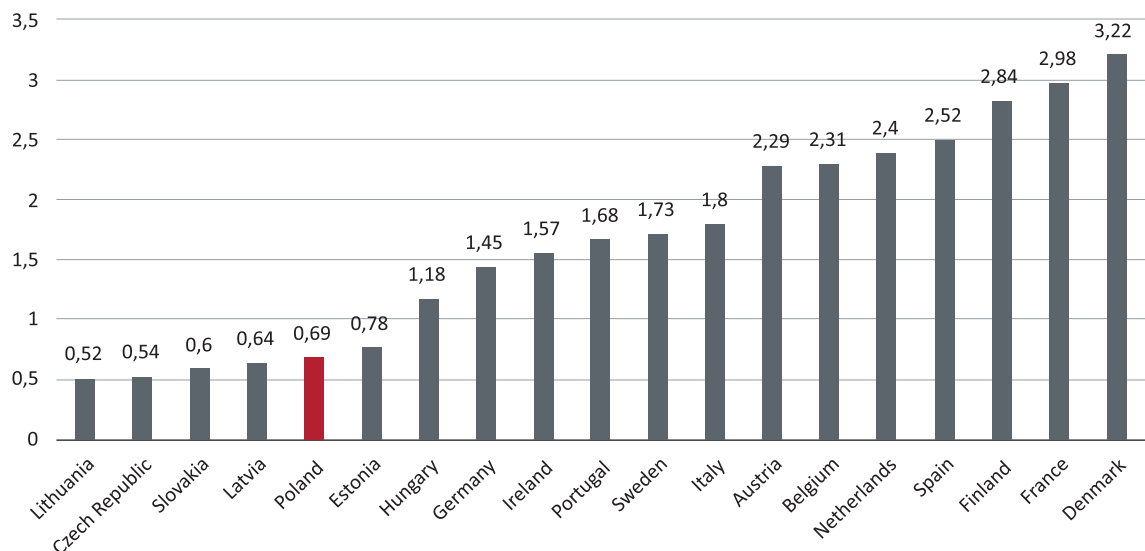
<sup>196</sup> J. P. Martin, “Activation and Active Labour Market Policies in OECD Countries: Stylized Facts and Evidence on their Effectiveness”, *IZA Policy Paper* no. 84, Bonn 2014.

<sup>197</sup> D. Card, J. Kluge, A. Weber, “Active Labor Market Policy Evaluations: A Meta-Analysis”, Bonn 2015.

- actions targeted to improve the matching process on the labour market. Job placement, career advisory or assisting the unemployed in seeking employment are the most common among the wide range of instruments in this category.

On the other hand, Passive Labour Market Policies mostly include benefits and insurance for the unemployed as well as their early pensions. In general, active instruments are to support the integration of the unemployed with the labour market, while passive instruments are to provide financial transfers ensuring that job seekers have certain financial security<sup>198</sup>.

**Figure 2.** Expenditure on Active Labor Market Policies as % of GDP in 2016



Source: own elaboration based on OECD, *Public spending on labour markets (indicator)*, 2019. doi: 10.1787/911b8753-en (access: 15.05.2019).

Currently, ALMP, whose financing is strongly supported by the EU, are becoming popular also among the new Member States. However, the funding for that purpose in countries such as Poland, Czech Republic or Lithuania still lags behind that of the ‘old’ EU15 countries (Figure 2).

<sup>198</sup> P. Auer, U. Efendioğlu, J. Leschke, “Active labour market policies around the world. Coping with the consequences of globalization”, International Labour Office, Geneva 2008.

Due to the large funding allocated to labour market programmes in the EU<sup>199</sup> and to the uncertain economic situation, it is worth identifying the financing areas which effectively and optimally contribute to a better functioning of the labour market. Macroeconomic analysis provides tools for that.

Each evaluation study begins with a dilemma of choosing the most adequate method and research techniques for a given public intervention. This is also the case with evaluation of state policy effectiveness on the labour market. Unfortunately, the current methods of analysing effectiveness applied by employment offices must be considered highly insufficient. They typically focus on counting individuals who found employment upon completing the programme, and do not show a full picture of the effects of the conducted actions. In the source literature, this type of evaluation is referred to as “gross evaluation” (or evaluation of gross effects, as opposed to various types of strict evaluations attempting to assess net effects of an intervention). Calmfors<sup>200</sup> stresses that a gross evaluation may serve to capture direct effects of labour market policy. Direct effects are related to improving the matching process, enhancing labour supply quality or increasing labour demand. Meanwhile, a state intervention on the labour market may trigger a number of indirect effects which may be difficult to capture and often non-obvious (unobservable). In their 2015 publication, Brown and Koettl<sup>201</sup> indicate the following phenomena among this type of effects:

- Deadweight effect. Refers to a group of labour market programme participants who would find jobs despite their participation in the programme. This effect leads to a lower cost-effectiveness of Active Labour Market Policies.
- Cream-skimming effect. Refers to a situation where only the most promising participants are selected into the programme. This is often the case when programme managers need to deliver a particular employment rate of participants.
- Displacement effect. Refers to the fact that employment generated by labour market policy may at the same time crowd programme non-participants out of the market.
- Substitution effect. Refers to a situation where employees may be let go and substituted by programme participants, e.g. due to subsidies or tax exemptions.

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<sup>199</sup> On 17 November 2017, the Parliament of the European Union passed the European Pillar of Social Rights. Many of its provisions refer to labour market policy, such as the statement that everybody has the right to individualised support and assistance in finding employment, to help in job searching, to training, courses and retraining. All these should be included in labour market policy.

<sup>200</sup> L. Calmfors, “Labour market policy and unemployment”, *European Economic Review* 1994, vol. 39, no. 3–4.

<sup>201</sup> A. J. Brown, J. Koettl, “Active labor market programs – employment gain or fiscal drain?”, *Journal of Labor Economics* 2014, pp. 4–12.

- Locking-in effect. Refers to a lower intensity of job search among the labour market programme participants due to co-benefits related to participation.

Measurement of the above effects using traditional observation methods and based on participants' declarations ("gross evaluation") is limited. Advanced macroeconomic techniques come to the aid when it comes to reliable labour market policy and attempting to estimate the indirect effects of intervention. They fall within the evaluation referred to in the source literature as "net evaluation" (or evaluation of net effects)<sup>202</sup>. It allows to assess the real impact e.g. of programmes for the unemployed on the situation of the labour market participants. DSGE models with frictional labour markets are one such method.

## Macroeconomic effects of labour market policy

Significant regional diversification of Poland with respect to economic parameters is a fact. However, it should be pointed out that the role of the labour market in shaping the economic cycle in all regions in Poland is crucial, as confirmed e.g. by Skibińska<sup>203</sup>. To illustrate this, Figure 3 presents regional GDP per capita and unemployment rates. The first indicator may be associated with the economic situation of the regions, while the other reflects the condition of regional labour markets. When analysing the figure, one can notice that regions with higher GDP per capita (such as Mazowieckie, Wielkopolskie, Dolnośląskie Voivodeships) are also characterised by a better labour market situation (lower unemployment) compared to the regions with lower GDP per capita (such as Podkarpackie, Podlaskie, Świętokrzyskie Voivodeships). This confirms Poland's economic dichotomy between the East and West.

Fredriksson<sup>204</sup> suggests that a state intervention, including labour market policy, should incorporate regional disparities and respond to particular needs of the regions to a larger extent. It is easy to make an analogy to Poland, where e.g. the indicator of professional activity in Warmińsko-Mazurskie Voivodeship is as low as 51%, while in Wielkopolskie

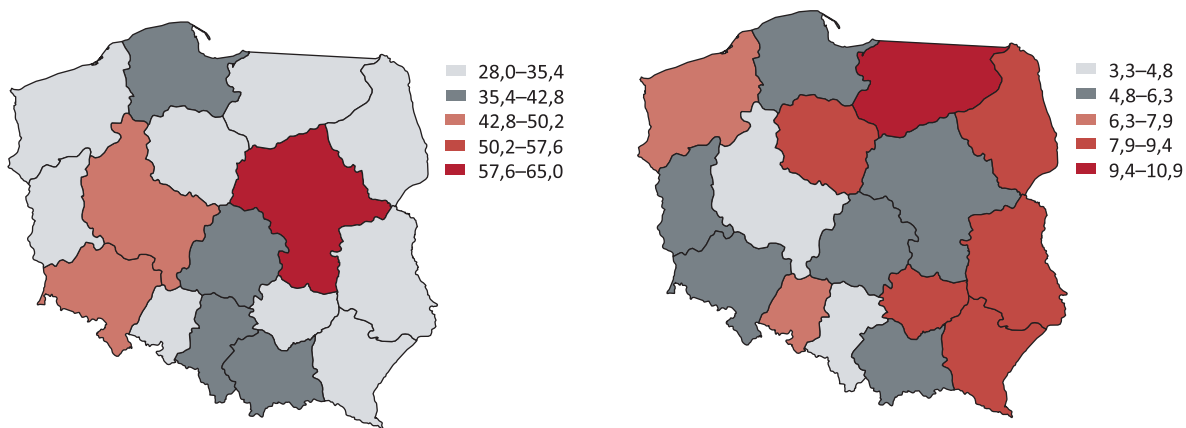
<sup>202</sup> E.g. B. Van der Linden, "Equilibrium Evaluation of Active Labor Market Programmes Enhancing Matching Effectiveness", *IZA Discussion Paper* 2005, no. 1526.

<sup>203</sup> M. Skibińska, "What drives the labour wedge? A comparison between CEE countries and the Euro Area", *IBS Working Paper* 14/2015.

<sup>204</sup> P. Fredriksson, "The Dynamics of Regional Labor Markets and Active Labor Market Policy: Swedish Evidence", *Oxford Economic Papers* 1999, Oxford University Press, vol. 51, no. 4, pp. 623–648.

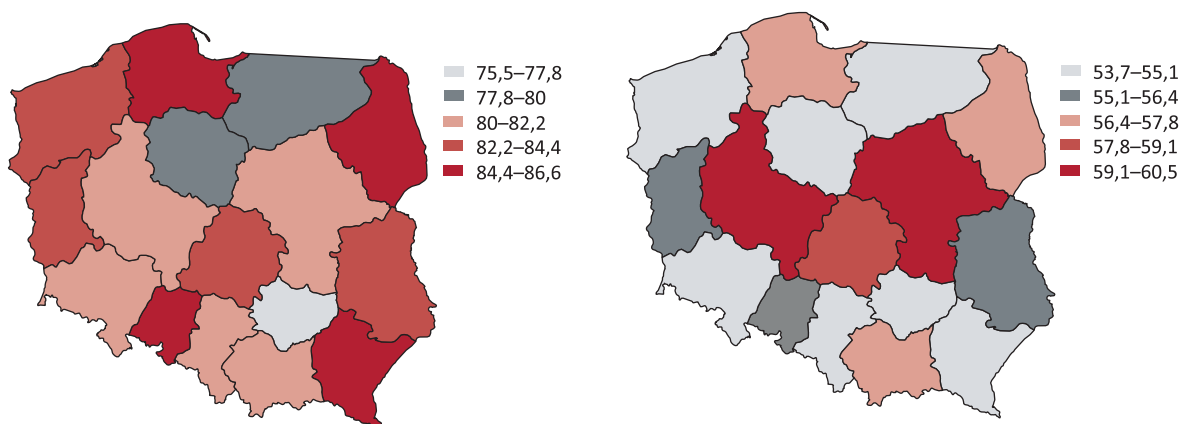
Voivodeship it is 59%. Therefore, the former region requires activities targeted at activating the inactive persons to a much larger degree (e.g. intensified career advisory, paid internships with employers). Currently, activities in that area are to a larger extent developed countrywide on a national level, hence their regional effectiveness falls. Figure 4 shows results of the labour market policy evaluation conducted by the public employment service (gross evaluation) and the regional labour force participation rate.

**Figure 3.** GDP per capita as % of the European Union average in 2018 (map on the left-hand side) and unemployment rate by voivodeship in January 2019 (map on the right-hand side)



Source: own elaboration based on Eurostat and Statistics Poland Local Data Bank data.

**Figure 4.** Employment effectiveness of Active Labor Market Policies as % in 2018 (map on the left-hand side) and the labour force participation rate as % in 2018 (map on the right-hand side)



Source: own elaboration based on Statistics Poland Local Data Bank and Ministry of Family, Labour and Social Policy data.

(Gross) evaluation of labour market policy at a regional level indicates that voivodeships in eastern and north-western Poland experienced the highest employment effectiveness. When comparing the maps in Figure 4, one can also notice that a high value of the aforementioned indicator is also correlated with a low level of GDP per capita, low level of labour force participation and high unemployment rate. This justifies greater support for regions facing a difficult economic situation. However, such comparisons do not allow for estimating real and implicit effects of a state intervention on the labour market. DSGE models with frictional labour markets can be successfully implemented in this area as they may help to estimate the effects of actions also at the regional level. Despite offering potential opportunities and benefits, the available net evaluations of labour market policy for Poland are scarce and usually leave the regional aspect out, hence it was impossible to directly compare research results under both approaches.

An extensive 2017 analysis by Bukowski et al.<sup>205</sup> presents estimates of the DSGE model with frictional labour markets based on the search mechanism and matching mechanism by Mortensen and Pissarides<sup>206</sup>. In their research, the authors consider the influence of selected Operational Programme Innovative Economy actions<sup>207</sup> addressed directly at enterprises, among other things, on the labour market. It should be mentioned that a share of EU funds was allocated to improving the labour market situation and the intervention focused on the most often applied actions. Bukowski's team devised two versions of the model: national and macro-regional (7 macro-regions). The calculations show that thanks to the EU funds, the peak (2016) employment in Poland was higher by 114,000 individuals and between 2007 and 2017, the number of workplaces rose on average by 45,000. The largest effect occurred towards the end of the programme, i.e. at the moment of concluding the largest number of projects. The authors also indicate a strong spacial diversification of the intervention effects. As a result of the intervention, employment in the south-western macro-region declined. Central, north-western and southern macro-regions saw little change in employment, while the northern, north-eastern and south-eastern macro-regions reported an increase in employment. The highest surge in workplaces was

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<sup>205</sup> M. Bukowski, J. Gąska, O. Mazurowska, K. Pastor, U. Siedlecka, Ł. Widła-Domaradzki, *Wpływ polityki spójności 2007–2013 na konkurencyjność przedsiębiorstw i rozwój przedsiębiorczości w Polsce*, WiseEuropa, Warsaw 2017.

<sup>206</sup> D. Mortensen, Ch. Pissarides, "New Developments in Models of Search in the Labour Market", in: O. Ashenfelter, D. Card (eds.), *Handbook of Labour Economics*, Elsevier 1999, pp. 2567–2627.

<sup>207</sup> The authors of the analysis indicate that the following Operational Programme Innovative Economy actions were covered in the evaluation: 1.4, 4.1, 3.3.2, 4.2, 4.4, 5.4.1, 6.1, 8.1 and 8.2.

reported for private and public services sectors. It is worth pointing out that in this case eastern Poland experienced more significant benefits of the EU policy than other areas of the country.

Antosiewicz et al.<sup>208</sup> developed a multi-sectoral DSGE model for Pomorskie Voivodeship. The main objective of the analysis was to evaluate the regional operational programme, also in the context of its influence on the regional labour market. The authors argue that the intervention had a direct influence on increasing employment (by approximately 8,500–9,700 workplaces) and decreasing the unemployment rate (by approximately 0.2%). Employment increased the most in the building and construction, energy and manufacturing sectors. Antosiewicz and Lewandowski<sup>209</sup>, on the other hand, create a DSGE model with the aforementioned matching function mechanism proposed by Mortensen<sup>210</sup> and Pissarides<sup>211</sup> for 8 EU states to compare shock absorption capacity of national labour markets. The authors point to the vulnerability of the Polish market to generate higher than average unemployment fluctuations, as well as to employee empowerment and potential rise in wage pressure. It is worth noting that the conclusions reached in 2014 based on the model are still up-to-date today (the increase in the enterprises sector between 2014 and 2018 amounted to nearly 25%<sup>212</sup>).

In his 2015 article, Woźniak<sup>213</sup> used a key element of DSGE models with frictional labour markets, i.e. the matching function, to analyse the impact of selected Active Labor Market Policies at the regional level. The data collected point to a large diversity of regional labour markets. The probability of taking up a job is correlated with the labour market

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<sup>208</sup> M. Antosiewicz, J. Frankowski, M. Ośka, A. Regulski, J. Zawistowski, *Ocena efektów realizacji Regionalnego Programu Operacyjnego dla Województwa Pomorskiego na lata 2007–2013*, Instytut Badań Strukturalnych 2017.

<sup>209</sup> M. Antosiewicz, P. Lewandowski, "What if you were German? – DSGE approach to the Great Recession on labour markets", *BS Working Paper 01/2014*.

<sup>210</sup> D. T. Mortensen, "The Persistence and Indeterminacy of Unemployment in Search Equilibrium. Scandinavian", *Journal of Economics* 1989, vol. 91, no. 2, pp. 347–370.

<sup>211</sup> Ch. Pissarides, *Equilibrium Unemployment Theory*. wyd. 2, The MIT Press, Cambridge – Massachusetts – London 2000.

<sup>212</sup> According to Statistics Poland, the average wage in March 2014 was PLN 4017, whereas in March 2019, it was PLN 5194.

<sup>213</sup> M. Woźniak, „Aktywne programy rynku pracy: szacunki funkcji dopasowań dla Polski z wykorzystaniem danych regionalnych”, *Ekonomista* 2015, no. 1, pp. 15–43, Polskie Towarzystwo Ekonomiczne, Warsaw.

restrictiveness index<sup>214</sup> in all voivodeships but the index itself shows high regional diversity. The lowest index values were reported for Podlaskie, Lubelskie and Świętokrzyskie Voivodeships, while the highest – for Wielkopolskie, Śląskie and Opolskie Voivodeships. This means that finding a job is the most difficult in regions with the lowest restrictiveness index values and in regions with higher index values, it is easier. Moreover, the results suggest a special, negative contribution of a group of individuals above 50 to the stream of persons taking up jobs. This group surely requires particular attention on all regional labour markets. The analysis also indicates that training programmes addressed to the unemployed are inefficient, although they constitute a most frequently used form of intervention on the labour market.

DSGE models with frictional labour markets are also used by the National Bank of Poland for its own research. One of such analyses was discussed in the 2018 article by Borys et al.<sup>215</sup>. The authors devised a DSGE model with frictions on the labour market and product market and with labour market institutions. The results show that, in general, an increase in unemployment benefits raises volatility of the unemployment rate and contributes to maintaining higher unemployment in the long term. On the other hand, increasing costs of dismissing and recruiting an employee contribute to a fall in unemployment rate in the long term.

Evaluating state policy on the labour market using DSGE models with frictional labour markets was also a case for other European Union states and regions, leading to the drafting of interesting reports and articles in prestigious magazines. Studies of that type were also produced by organisations such as the International Labour Organisation or the European Central Bank. Regarding the ex-eastern block countries, research based on the aforementioned models (similarly as in the case of Poland) is scarce. There are far fewer analyses of that type at the regional level.

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<sup>214</sup> Labour market restrictiveness index is a relationship between vacancies and the number of the unemployed. The higher the index value, the higher the probability of finding a job.

<sup>215</sup> P. Borys, P. Doligalski, P. Kopiec, “Labor market institutions in a shopping economy”, *NBP Working Paper* no. 275, Warsaw 2018.

Work by Gawthorpe and Safr<sup>216</sup> belongs to the exceptions, as the authors devise an extensive DSGE model for 8 regions and 8 sectors of the Czech economy. The model comprises 15,000 equations and allows for an analysis of political and economic links both on the interregional and intersectoral level. In the case of the Czech economy, the results of the state intervention are very diverse and noticeable to a much larger extent at the level of individual sectors than at the regional level. The study is of a preliminary nature and one of the directions for development might involve an introduction of asymmetry at the level of regional labour markets.

Another study concerning the eastern European countries was described in the article by Pápai<sup>217</sup>. The author presents a complete DSGE model with frictional labour markets for the economy of Slovakia. Labour market changes are reflected in the differences in the number of working hours and agent's decisions on participating in the labour market or contributing to the inactivity area. Based on the simulation results, an increase in household consumption and in costs of opening a new workplace has led to a decline in elasticity of the Slovak labour market. In practice, this means that companies may adapt<sup>218</sup> to the changes occurring on the labour market (caused e.g. by an economic cycle) for a longer period of time. Moreover, the results highlight a strong connection between European economies, especially in the case of such a small country as Slovakia.

Another study worth mentioning is the 2015 report by Presidente<sup>219</sup>, which presents a DSGE model with extensive, frictional labour markets in the framework known from the labour market search theory. The state intervention was divided into four modules: labour market policy, unemployment benefits, trade unions and the so-called firing taxes. The model focuses on the four largest economies of the EU (Germany, France, Italy and Spain). The results point to the key role of time scheduled for intervention. Despite the significant differences between the presented economies, what they have in common is that an increase in labour taxation and firing taxes may in the long run result in lowering the

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<sup>216</sup> K. Gawthorpe, K. Safr, "Regional & multi-sector input-output model for the Czech Republic", 20th International Scientific Conference AMSE Applications of Mathematics and Statistics in Economics 2017.

<sup>217</sup> A. Pápai, "A DSGE Model of Slovakia with Frictional Labor Market and Monetary Regime Switch", *Review of Economic Perspectives*, ISSN 1804-1663, De Gruyter, Warsaw 2017, vol. 17, no. 3, pp. 287–313.

<sup>218</sup> This primarily involves matching employment in companies with the economic situation and thus developing an optimum production structure.

<sup>219</sup> G. Presidente, "Labour market reforms in the Euro area: A DSGE approach", *ILO Research Paper*, no. 12, Geneva 2015.

unemployment rate. On the other hand, in the short run, those reforms may not have any impact on the unemployment level in any of the analysed countries. Furthermore, Presidente points to the fact that it is not the intervention of the EU states, but the economic situation that plays the key role in shaping the labour market situation in Europe.

## Conclusion

DSGE models with frictional labour markets have become one of the classic tools extensively used for social and economic analyses in many European countries and worldwide. Evaluation of the state intervention on the labour market is one of the research areas. Application of DSGE models in that field enables assessing the implicit mechanisms and feedback linked to the intervention and measuring their real impact on macroeconomic variables.

Despite their high degree of usefulness, studies applying this type of model at the regional level of EU states are rare. With respect to Poland, only one study was identified as using the complete DSGE model with frictional labour markets to analyse the influence of a state intervention on the labour market and territorial cohesion. This was the 2017 report by Bukowski et al. dedicated to a larger extent to evaluating union programmes than analysing the impact of national policy, which referred to seven macro-regions of Poland.

The research included in the 2017 OECD report<sup>220</sup> suggests an increase in disparities at the regional level in most UE states. This process also concerns the labour markets and has been ongoing since the 1980s. It affected in particular the wage distribution, investment allocation and workplaces, as well as the share of wealthy residents. As it turns out, the regional disparities in these areas increased on average eightfold. One cannot but reflect on these conclusions at least in the context of the EU Cohesion Policy which has been implemented in Poland for many years. They require taking another perspective of the state intervention's impact on the economy and its evaluation since, as it turns out, the actions undertaken up to date to decrease regional disproportions proved futile.

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<sup>220</sup> OECD, *Understanding the socio-economic divide in Europe*, Centre for Opportunity and Equality, Paris 2017.

Having regard to the above, the issues of frictions on the labour market and their impact on the effectiveness of public interventions become even more significant. The possible added value of the DSGE models with frictional labour markets to evaluation studies of territorial cohesion lies in:

- the possibility of analysing in detail the individual regional labour markets and their economic diversity in the context of the intervention. It is all the more important as according to the research the impact of the policy differs depending on the specificities of a region,
- the possibility of assessing the links and relationships between regions and sectors as the key channels for transmitting economic shocks to the labour market which is omitted in the classic large-scale DSGE models,
- the possibility of combining different elements of the state intervention and the economy in a single model and realistic assumptions based on the behaviour of the economic system participants. Studies which apart from labour market policy also include social policy, trade unions or the black economy in the model are more and more frequent. All those elements seem to be equally important also in the context of regional disparities and the effectiveness of public policies.

This chapter may contribute to a wider application of this type of models for evaluating the effects of public policies on regional labour markets. The results of simulations using DSGE models with frictional labour markets may become a valuable addition to socio-economic cohesion analysis in Poland. The issue of legitimacy of redefining labour market policy so that it becomes more adjusted to the dynamics of contemporary labour markets is a general conclusion drawn from the presented analyses. Perhaps it is worth considering a reconstruction of the system of the public employment service to be based more on economic sectors and the specificities of regions, and not on the fixed administrative division. The quoted research suggests a significant sensitivity of industries and sectors in their geographic dimension to the implemented labour market policy. This may be a valuable guideline for creating evidence-based state intervention on the labour market.

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# VIII. A wider role for quantitative modelling in policy design, evaluation and business strategy model

John Bradley

## Introduction

Economic models of all kinds are widely used in forecasting and policy analysis by regional, national and international agencies such as the EC, the OECD and the FRB as well as by large private and state enterprises and organisations. Typically, the analysis derives from the operation of formal quantitative models, i.e., from computer simulations where a range of assumptions are fed into a model and the consequences are derived. To a greater extent than is desirable, the relevance of these complex models and the credibility of the results that they produce have to be taken on trust since few, if any, of the consumers of the analysis will ever in a position to validate the behaviour of the models in the manner, say, of an academic referee.

In reality, model simulation outputs are never used in their raw state. Results that look implausible are modified by “fixes” to the model structure or by making changes to the assumptions used. The final published analysis is usually a hybrid of formal model-based simulations and imposed off-model informal, intuitive judgement. Consequently, economic analysis, even when based on large-scale mathematical models, has more similarity to psychology than it has to “hard” sciences like physics. An admission of this truth does not invalidate the use of models for policy analysis. But it should alert policy analysts to the need to use models in a way that embeds their insights into a wider economic context that is largely absent from macroeconomic and microeconomic models. Economic modellers sometimes hide behind their often impenetrable model structures, but may need a reality check if they are to retain credibility.

As an indicator of the desirability of exploring what that wider economic context might look like, we should recall that the classics of economic literature have almost always been written in plain and precise language, without much assistance from mathematics. One thinks of Adam Smith's *The Wealth of Nations*; John Maynard Keynes' *General Theory*; Joseph Schumpeter's *Capitalism, Socialism and Democracy*; Edith Penrose's *Theory of the Growth of the Firm*. It is not that the great innovators in economics were mathematically challenged. On the contrary, many were highly skilled in mathematical and statistical theory. Rather, they were driven by the realisation that economics does not lend itself to the exactitude and determinism that characterise the hard sciences, however much modern economists wish to believe the contrary. The behaviour of humankind, be they producers or consumers, can at best be only approximately described by imprecise laws, but can often confound even these laws by behaving in ways that are unanticipated, driven by motivations that are poorly understood and find no place in "standard" economic theories.

The move to quantification and formal economic modelling dates from the post WW2 period and is associated with Paul Samuelson. He regarded mathematics as the "natural language" for economists and contributed significantly to the mathematical re-formulation of economics with his seminal 1947 book *Foundations of Economic Analysis*. This recast the insights of economics in a narrow and elegant framework of agents who always behaved optimally, subject to a range of constraints. Firms maximised profits subject to production function constraints. Consumers maximised their utility subject to budget constraints. These activities took place within a national accounting framework that linked income, expenditure and output into three equivalent measures of aggregate GDP. All that was needed to formulate the main ideas of economic theory in a quantitative model format was the availability of national accounting data, the development of econometric techniques, and the advent of computers to crunch the numbers and simulate the models. The happy conjunction of all three developments in the post WW2 years made it easy to estimate the parameters that would convert theoretical models into operational applied models and to run these models on computers. This held out the promise of being able to guide policy makers and forecasters in the real world of policy analysis.

Although the first econometric model had been constructed by Jan Tinbergen in 1936<sup>221</sup>, large-scale complex modelling as we know it today only took off in the 1950s and 1960s

<sup>221</sup> J. Tinbergen, „An Economic Policy for 1936“, w: L.H. Klaassen, L.M. Koyck, H.J. Witteveen (red.), *Jan Tinbergen, Selected Papers*, Amsterdam 1959, s. 37–84 (original in Dutch).

under the influence of Lawrence Klein, a student of Samuelson. However, the subsequent massive growth in modelling activities and the ever increasing technical sophistication of models have not been without controversy. In the hard sciences theory is tested by exposure to data and if the theory fails to reproduce and explain patterns in the data, then the theory must be reformulated. The classic case is the evolution of the pre-scientific Ptolemaic models of planetary motions into the scientific Newtonian paradigm, followed then by the evolution of Newtonian theories into the encompassing Special and General Theories of Relativity in order to explain mounting discrepancies in observations. No such orderly evolution has occurred in economics. Models are often based on different theoretical assumptions and recourse to data and testing in order to resolve paradigm disputes has been of very limited use.<sup>222</sup> This is an unsatisfactory situation whose seriousness has failed to be acknowledged honestly. It needs to be addressed if the policy insights that come from using quantitative models are to retain credibility.

In this paper we will use the somewhat loose term “standard” economics in order to identify the kind of economic theories that are used in building policy models. We can then point to the gulf that exists in the economics profession between behavioural theories based on narrow and prescriptive assumptions of optimising agents and a more descriptive and investigatory approach that attempts to examine actual economic behaviour in a less rigid and more eclectic way. The former attempts to capture knowledge in the form of calibrated computer models and then uses these models to interpret real world behaviour. This mirrors the modelling approach used in the hard sciences. The latter puts aside the theorising and prescriptive model frameworks and attempts to understand the full complexity of the economy without prescriptive mathematical models getting in the way. The reluctance of the economics profession to go down this “unscientific” route is driven by a strongly held but misguided belief that economics resembles the hard sciences and must adopt similar “scientific” methodologies. High status in the economics profession is often associated with close proximity to complex mathematical models. Economic researchers who are interested in the inner workings of enterprises tend to be banished to business schools.

Too often there is a failure, or even a refusal, to recognise that a “standard” model is at best an approximation to reality and is forced to leave out or ignore many of the complications

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<sup>222</sup> See L.H. Summers, „The Scientific Illusion in Empirical Macroeconomics”, *The Scandinavian Journal of Economics* 1991, vol. 93, no. 2, Proceedings of a Conference on New Approaches to Empirical Macroeconomics, s. 129–148.

of real life. For example, the complexities of enterprises are summarised in simple production functions where aggregate factor inputs (capital, labour, energy, materials) are used to produce an aggregate output, and where the consequences of innovation and internal structure and organisation are subsumed into a trend “technical progress” parameter which is regarded as a measure of our ignorance rather than as a potentially vital explanation of productivity growth that urgently needs to be unpacked. The justification usually advanced to support the “standard” model is that all the essential details are taken into account and that any neglected aspects are minor and of second order importance.

A first step in addressing these matters is to examine how models are used in practical policy analysis. It is not our purpose to grapple with the technical details of how “standard” theory is used to design “standard” policy models. Our analysis will apply to any model but will serve to highlight aspects of model use that are of questionable credibility or robustness. To this end, in Section 2 we outline the kind of systematic guidance framework within which any model-based policy analysis ought to be executed. To make this discussion more concrete, we take a specific policy analysis challenge, namely the design and evaluation of EU cohesion policy. Our reason for taking this example is that it presents challenges that clearly expose limitations in conventional modelling that can be addressed by augmenting model-based analysis with insights drawn from a more exploratory approach that focuses mainly on the production sector of the economy. Of course, we recognise that the requirement that this framework be followed in all cases, particularly when time is of the essence and resources are limited, would be unrealistic. But the least that one can demand is that the implications of cutting corners and ignoring any stages of the framework are properly understood and that the possible implications for policy analysis and advice are taken into account.

In Section 3 we focus more narrowly on aspects of the guidance framework that take us outside of what we might call the field of “standard” macro modelling. This is a crucial issue and only comes to light when models are pushed into service in the investigation of questions that cannot be handled internally within and exclusively by “standard” models. The point here is that the internal consistency of models, particularly the more recent ones that are based on the DSGE approach, is only part of the story.<sup>223</sup> One can be internally

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<sup>223</sup> Dynamic stochastic general equilibrium modelling (abbreviated as DSGE) is an approach in macroeconomics that attempts to explain economic phenomena, such as economic growth and business cycles, and the effects of economic policy, through econometric models based on applied general equilibrium theory and microeconomic principles.

consistent while also being entirely wrong! Another, often neglected, point is that many of the underlying forces that drive the production sector are not contained within the “standard” economic paradigm, as embedded in models. In many cases “standard” models have evolved in a way that neglects some important real causes of growth.<sup>224</sup> The drivers of sustained increases in growth take place largely on the supply side of the economy through organisational, investment and innovation actions taken by enterprises and governments. The insights into these forces currently lie largely outside the “standard” macro modelling paradigm and this has serious consequences for modelling activities. However, there are no neat mathematical modelling ways of incorporating the insights from outside the “standard” modelling paradigm into “standard” model frameworks. But the effort has to be made to take this kind of knowledge into account when using models if model-based policy analysis is to be useful and retain credibility.

Section 4 concludes with some suggestions for a way in which the benefits of using formal models can be enhanced by embedding their use in a framework that tries to avoid the problems resulting from ignoring insights derived in less formal ways and where two different approaches can be mutually enhancing. The “standard” modelling approach will continue to focus on macro growth and stability issues that affect the economy as a whole, while the less formal micro and structural approach will continue to focus on understanding the issues that drive the internal dynamics of the enterprise sector and the implications of wider economic governance and strategy issues. The fact that both sides of this research “divide” have seldom talked to each other in the past is unfortunate, but needs to change in the future.

## A guidance framework for the use of policy models

A useful way of identifying potential problems with the routine application of models in policy analysis is to select a very challenging policy issue that pushes modelling to the boundaries of current knowledge and expertise. An example of relevance to Poland is the issue of EU cohesion policy within which integrated programmes of very large-scale

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<sup>224</sup> For example, see: M. Best, *How Growth Really Happens: The Making of Economic Miracles through Production, Governance and Skills*, Princeton University Press, 2018.

public and private investment are designed with the goal of accelerating growth and catch-up within the EU.

Since 1989, the European Commission has implemented cohesion policies that now absorb over one third of its available annual budgetary resources.<sup>225</sup> These policies are embedded in a sophisticated system of public investment planning that represents a creative partnership between the national governments of the recipient states and the Commission authorities. The large size of the financial resources devoted to implementing EU cohesion policy demands that detailed and searching evaluations of the likely policy outcomes be carried out. These exercises are done at the policy design stage (*ex-ante*); during the actual implementation of the programmes (*mid-term*); and after the programmes terminate (*ex-post*).

The challenge of evaluating the impacts of a national cohesion policy programme lies in the extreme complexity of the public policy instruments being used, in terms of individual projects, wider measures, operational programmes and the entire investment package taken as a whole. The goal of cohesion policy – to promote accelerated growth and development in lagging EU member states and regions – is ambitious, and draws on economic and other research that is still at an early stage of its evolution. Economic models have been widely used to deal with these complex evaluation challenges. But the context within which cohesion policy is designed, implemented and evaluated is also complex, and this should serve as a warning against simplistic evaluations and premature judgements.

We attempt to stand back from the technical aspects of the analysis of cohesion policy impacts in order to be able to identify and describe the logical stages of the whole process. These include the nature of the challenge of the EU cohesion policy, the policy design stage, the different steps to be taken to implement the programmes, and finally the execution of impact evaluation. In an effort to identify the wider framework of cohesion policy formation and analysis, we set out a series of thirteen separate logical steps. These can then be organised into four main stages involved in the analysis of the impacts of cohesion policy, as follows:

Stage 1: The cohesion policy challenge (step 1)

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<sup>225</sup> Cohesion policy programmes have been variously called Structural Funds (SF), Cohesion Funds (CF), Community Support Frameworks (CSF), Single Programming Documents (SPD) and National Strategic Reference Frameworks (NSRF). In this paper we use the term “cohesion policy” (or CP) to refer to all of the above.

Stage 2: Designing cohesion policy interventions (steps 2–4)

Stage 3: The methodology of cohesion policy impact evaluation (steps 5–10)

Stage 4: The presentation and interpretation of results (steps 11–13)

The structure and interrelationships of these fourteen steps and four stages are now described.

## Stage 1: The cohesion policy challenge

**Step 1: The cohesion challenge:** Before embarking on model-based analysis, we need to explore and understand the main characteristics of the lagging economies, compared with the “advanced” or “mature” EU economies. Prior to the 2004 and subsequent enlargements that brought in new member states, the lagging states had consisted of the economies of the EU’s southern and western periphery (Greece, Portugal, Spain and Ireland).<sup>226</sup> The challenge of cohesion suggests some questions that need to be asked as part of the preparation for design of policies. Why were these states lagging? To what extent could they catch up simply through participating in the integrated Single Market and Monetary Union? What are (if any) the specific barriers to convergence that require an EU policy initiative like cohesion policy? How much need we learn about the structure and performance of these economies before we commit to specific macro-modelling frameworks?<sup>227</sup>

## Stage 2: Designing cohesion policy interventions

**Step 2: Cohesion policy guidelines:** This step deals with the role of the development planning process in each recipient state as it prepares to receive and use EU aid. It is a combination of the identification of national priorities and is heavily influenced by guidelines issued by the Commission. In each case, one has to examine carefully how

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<sup>226</sup> The re-unification of Germany brought in the eastern Länder from the early 1990s, but this region was also the recipient of massive internal transfers within Germany. It is difficult to single out the separate role of EU cohesion policy. The *Mezzogiorno* region of southern Italy was also in receipt of cohesion aid. In our discussion we focus on national economies, but our guidance framework also applies to regions.

<sup>227</sup> The documentation that accompanies cohesion policy design programmes usually contains some pro-forma analysis of structure and performance. But few if any go deep into the analysis that would be needed to identify the real barriers to growth. This has knock-on consequences for the subsequent model-based impact analysis.

a country has carried out this task. What techniques (if any) were used to select measures within the investment programmes within the overall policy package? Were formal micro-evaluation techniques applied (e.g., cost-benefit analysis, micro-scoring, etc.)?<sup>228</sup> How good is the local institutional capacity likely to be? How did the authorities proceed towards implementation?

**Step 3: Cohesion policy financial inputs:** This step deals with the formal financial plan, where the ex-ante funding allocations are set out in terms of different administrative categories of public investment. It also reviews how the administrative investment categories are mapped into “economic” categories of investment, such as physical infrastructure, human resources and direct aid to firms (including R&D). One needs to identify carefully the main economic categories of investment that are likely to be drivers of faster convergence, since different types of investment will influence an economy in different ways, in different sectors and through different mechanisms. This step tends to be somewhat neglected in past evaluations and evaluation designs.

**Step 4: Economic classification of policy instruments:** This step examines how the investment flows financed by cohesion policy are transformed into stocks of physical infrastructure, human capital and R&D. Although the flow of investment expenditures impact on the demand side of the economy during implementation, it is the improved stocks that actually produce the improved economic performance of the economy, even after the investment flows cease.<sup>229</sup>

## Stage 3: Evaluating cohesion policy interventions: methodology

**Step 5: Economic theory and public investment:** Modern theoretical advances in trade theory, growth theory and economic geography provide insights that can be drawn on for

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<sup>228</sup> For a review of commonly used micro-evaluation techniques, see: J. Bradley i in., „How can we know if EU Cohesion Policy is successful? Integrating micro and macro approaches to the evaluation of Structural Funds”, GEFRA Working Paper March 2006, Muenster.

<sup>229</sup> It should be recalled that EC cohesion policy aid is not open-ended. The aid programmes tend to run for periods of from five to seven years, and are renegotiated when the programming period ends.

the planning and analysis of cohesion policy.<sup>230</sup> These theoretical advances tell us something about the role of investment in physical infrastructure, human resources and R&D. In particular, they suggest ways in which these policies could promote growth.

**Step 6: Empirics of investment impacts:** Given the theoretical insights that are provided in the trade, growth and spatial literatures, we can then seek to establish what the international empirical literature tells us about the strength of these drivers. This literature is still at an early stage, and it is easy to become agnostic!<sup>231</sup> What is important is to draw lessons from empirical studies that provide guidance as to how these driving forces can be related to model mechanisms and equations that trace through the consequences for changes in sectoral output and productivity.

**Step 7: Why are models needed:** The complexity of cohesion policies means that models must be used to evaluate their impacts. Without models, one is unable to isolate the influences of cohesion policy from all the other factors that drive a small open economy.<sup>232</sup>

<sup>230</sup> E. Helpman, P. Krugman, *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy*, MIT Press, Cambridge, Massachusetts; R. E. Lucas, „On the Mechanics of Economic Development”, *Journal of Monetary Economics* 1988, vol. 22, no. 1, s. 3–42; G. Grossman, E. Helpman, *Innovation and Growth*, The MIT Press, Cambridge 1991; P. Romer, „The Origins of Endogenous Growth”, *The Journal of Economic Perspectives* 1994, vol. 8, no. 1, s. 3–22; P. Krugman, *Development, Geography, and Economic Theory*, The MIT Press, Cambridge, Massachusetts 1995; M. Fujita, P. Krugman, A. Venables, *The Spatial Economy: Cities, regions and international trade*, The MIT Press, Cambridge 1999; P. Aghion, P. Howitt, *Appropriate Growth Policy: A Unifying Framework*, 2005, <http://www.economics.harvard.edu/faculty/aghion/papers.html>

<sup>231</sup> D. Aschauer, „Is Public Expenditure Productive?”, *Journal of Monetary Economics* 1989, vol. 3, s. 177–200; A. Munnell, „An assessment of trends in and economic impacts of infrastructure investment”, w: *Infrastructure policies for the 1990s*, OECD, Paris 1993; O. Bajo-Rubio, S. Sosvilla-Rivero, „Does public capital affect private sector performance? An analysis of the Spanish case, 1964–1988”, *Economic Modelling* 1993, vol. 10, no. 3, s. 179–185; H. J. Schalk, G. Untiedt, „Regional Investment Incentives in Germany: Impacts on Factor Demand and Growth”, *The Annals of Regional Science* 2000, vol. 34, s. 173–195; D. Acemoglu, J. Angrist, „How Large are Human Capital Externalities? Evidence from Compulsory Schooling Laws”, w: B. Bernanke, K. Rogoff (red.), *NBER Macroeconomics Annual*, 2000, MIT Press, Cambridge (MA) 2000; B. Sianesi, J. van Reenen, „The Returns of Education: Macroeconomics”, *Journal of Economic Surveys* 2003, vol. 17, s. 157–200; Congressional Budget Office, *R&D and Productivity Growth*, The Congress of the United States 2005; W. Romp, J. de Haan „Public Capital and Economic Growth: A Critical Survey”, *Perspektiven der Wirtschaftspolitik* 2007, vol. 8 (Special Issue), s. 6–52.

<sup>232</sup> *Monitoring* should be clearly distinguished from *impact evaluation*. Monitoring indicators can be used to show (for example) how much motorway has been constructed, but cannot identify the role of roadway improvements in boosting output and/or productivity.

In addition, the financial injections are usually so large that there will be macroeconomic consequences that will affect all aspects of the economy, and not just the areas that are directly influenced by the investments (e.g., output and productivity).

**Step 8: What kind of macro model:** One then has to ask the important question of what kind of model is appropriate for the evaluation of cohesion policy impacts. This will be influenced by insights into what are the key characteristics of the recipient countries (step 1 above). What kind of paradigm best captures these characteristics and gives an appropriate description of the supported country? What level of sectoral disaggregation is required? It is important to stress a methodological point here. Economic models are very imperfect representations of the real world. Modern modelling practice has tended to assign high status to frameworks that incorporate complete rational optimising behaviour and perfect foresight.<sup>233</sup> Such models are elegant but may trap policy analysts into interpreting policy impacts on the basis of models that do not represent the realistic behaviour of agents in the real world<sup>234</sup>. The price of realism may be a lack of complete optimising elegance!

**Step 9: Demand versus supply impacts:** It is well known that cohesion policy investments have demand impacts during implementation, and supply impacts both during and long after the programmes have terminated. One must be careful to ensure that this distinction is captured in the models. A wide range of other questions also becomes important. In particular, how are we to handle demand and supply impacts that arise during implementation and after termination? The recipient states sometimes have rather specific characteristics. Given the known characteristics of the recipient states, what could be expected? Total crowding out of private sector activity by the rise in public sector activity? Partial crowding out? Crowding in? Ricardian equivalence? The answers to these questions will be heavily influenced by the known facts about the economies being aided.

**Step 10: Sectoral issues in modelling:** A specific and very important issue arises with models concerning the level of disaggregation of sectoral production. One needs to be aware of how

<sup>233</sup> Bayoumi (2004) describes the IMF DSGE model, GEM (T. Bayoumi, „A New International macroeconomic Model”, Occasional Paper 239, International Monetary Fund, Washington 2004); Ratto et al. (2005) describe DG-ECFIN’s DSGE implementation of QUEST III (M. Ratto i in., „An Estimated New Keynesian Dynamic Stochastic General Equilibrium Model for the Euro Area”, European Economy Economic Papers, no. 220, Brussels 2005).

<sup>234</sup> G. E. Akerlof (red.), *Explorations in Pragmatic Economics: Selected Papers of George A. Akerlof (and Co-Authors)*, Oxford University Press, Oxford and New York 2005; G. E. Akerlof, „The missing motivation in Macroeconomics”, *American Economic Review* 2007, vol. 97, no. 1, s. 5–36.

each different model addresses questions of sectoral disaggregation on the production side of the economy. Can these differences be subjected to empirical testing? Which approach to sectoral disaggregation is the most useful and informative? What is the best level of sectoral disaggregation? Will this differ between countries?

## Stage 4: Evaluating cohesion policy interventions: results

**Step 11: The “no cohesion policy” counterfactual:** The notion of a “no-cohesion policy” baseline simulation is not trivial. In using a macro-model to quantify the impacts of cohesion policy shocks, all models must go through the following stages:<sup>235</sup>

- a) Project all non-cohesion policy (CP) exogenous variables out to the terminal year of the simulation (i.e., world, domestic policy instruments, etc.). For the 2014–2020 cohesion policy analysis, this year could be taken to be 2030. The point here is that we need to let the simulation run on for at least ten years after the financial injections terminate so that we can identify the longer term impacts of the benefits of increased stocks of physical infrastructure, human resources and R&D.
- b) Set all CP instruments to the appropriate counterfactual values. This tries to capture the “no policy” situation. But setting the CP instruments at zero is not the whole story (see below).
- c) Simulate the model out to 2030.
- d) Re-set the cohesion policy instruments to the appropriate actual (or projected) values.
- e) Re-simulate the model to 2030.
- f) Compare results obtained from stage (e) to results from stage (c), to evaluate CP impacts.

However, a range of different “no-cohesion policy” counterfactuals is possible. We distinguish three main cases: the “zero” substitution case; the “full” substitution case; and the “partial” substitution case. We explain each below.

<sup>235</sup> Hanging over step 11 is the spectre of the so-called Lucas critique (R. Lucas, “Econometric Policy Evaluation: A Critique”, w: K. Brunner, A. Meltzer (red.), *The Phillips Curve and Labor Markets*, Carnegie-Rochester Conference Series on Public Policy, vol. 1, American Elsevier, New York 1976, s. 19–46.). However, most models used for the analysis of cohesion policy are based at least to some extent on micro-foundations, albeit in different ways and to different degrees. They have come a long way from the reduced form, time-series models that Lucas convincingly destroyed in the 1970s!

**The “zero substitution” case:**

In this case domestic authorities do not substitute the missing CP financial injections with domestic finance. This is usually selected as the default case. In many cases the fiscal imbalances in a recipient economy are likely to be so serious as to preclude any expansions of domestically financed public investment. However, in other cases the national authorities might have the option of stepping in and funding the cohesion policy investment programme purely out of local resources.<sup>236</sup> Of course, in the latter situation, there would be more severe fiscal consequences for the public sector budget balance compared to the case of EU-funded cohesion policy.

**The “full substitution” case:**

Domestic authorities fully implement original CP investments, but financed entirely out of own resources (see discussion above). This could be a mixture of public funding re-allocation to the kinds of public investments involved in cohesion policy. It might also involve borrowing and tax increases, the consequences of which would be included in the baseline simulation results.

**The “partial substitution” case:**

Domestic authorities implement only part of the original CP investments, but financed out of their own resources.

Very different implications arise from these three counterfactual options. For example, in the “zero” substitution case, impact analysis would attribute to cohesion policy the entire economic benefits of the CP investments, treating the funding as a grant. In the “full” substitution case, impact analysis in this case would be identical to the “zero substitution” case, except for the negative impacts (such as higher tax rates, offsetting cuts in expenditure, higher interest rates, exchange rate effects, etc.) of the need to raise finance domestically. Finally, the “partial” substitution case would be evaluated in a similar way. If the cancelled cohesion policy investments were genuine barriers to growth, the outcome might fall well below “full” substitution. If the cancelled investments were poorly designed (high dead-weight/crowding out), then this case might be actually better than the case of “full” substitution.

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<sup>236</sup> Countries are expected to grow out of the need for EU development aid. For example, the Irish cohesion policy funding effectively ended in 2014, having run from 1989 to 2014. But the Irish authorities have continued with multi-year national programmes that are funded mainly out of local sources.

**Step 12: Policy Impacts for the entire economy:** The results presented need to be detailed and disaggregated sufficiently enough to provide a wide range of information aimed at interpreting the analysis. The kind of information reported should include:

- stylised facts about the performance of the economy, usually derived by drawing on the historical database used in model calibration;
- the no-cohesion policy baseline under different assumptions, e.g., zero substitution and full substitution;
- sensitivity analysis with respect to important model parameters, e.g., the so-called externality parameters that link changes in stocks of infrastructure, human capital and R&D to changes in sectoral output and productivity. The discussion would also need to cover the consequences in terms of judgements about the “quality” of the CP planning and implementation;
- design of the presentation of the results for a given country in a way that facilitates comparisons with other countries.

**Step 13: Drawing conclusions.** One needs to discuss what the evaluations tell about the influences of the initial structure and characteristics of the economies. How might the initial structure influence the post-CP outcome? Would a different allocation of CP financial injections produce a better outcome?

When evaluating any model-based evaluation of cohesion policy, the above check-list can be used to see if any different evaluations that were derived using different models can be explained in terms of model structure or analysis methodology. To that end, the thirteen points can be classified into two different groups. In the first, there ought to be no strong differences of approach between different evaluators if the evaluation guidelines have been specified clearly and implemented correctly by the modellers. In the second, differences of approach can and do legitimately arise. In an ideal situation these differences should give rise to interesting discussions aimed at understanding their causes and revisiting the simulations if the conclusions send people back to their models. In practice, the reasons for selecting one result over others is often made on administrative grounds or pragmatically.

## Areas of the framework where one expects broad agreement between modellers

Within the range of different impact evaluation studies, there are likely to be areas within the above 13 steps where one would expect broad agreement. The most obvious cases for agreement might be the following:

**Step 2: Cohesion policy guidelines:** Although there may be differences between the modelling groups with respect to the underlying characterisation of the cohesion challenge (step 1, to which we will revert below), the cohesion policy guidelines – as set out by the Commission - have to be accepted. The bottom line is that the modellers are usually asked to evaluate the Commission’s policy, and not any alternative or hypothetical policy package.

**Step 3: Cohesion policy financial inputs:** These public investment policy instrument settings must also be accepted by all modelling groups. However, an issue does arise with the period after the cohesion programme terminates, which we deal with below.

**Step 4: Economic classification of policy instruments:** Only very minor differences of opinion can exist between different modelling groups concerning how the administrative categories of investment are to be reclassified into economic categories. Most modelling groups adopt a three-way classification into physical infrastructure, human resources and direct aid to firms (of which R&D is a sub-component), although a higher level of disaggregation might be more desirable.

**Step 7: Why are models needed:** All modelling groups tend to accept that the role of models is to place the cohesion policy interventions in a wider macro context, where macro and other spillover impacts can be examined.

**Step 11: The “no cohesion policy” counterfactual:** There should be little or no differences between modelling groups on the policy counterfactuals. However, the counterfactuals are seldom discussed explicitly (see previous material on Step 11 above), and there may be differences of opinion as to the most appropriate counterfactual to adopt as a standard. Pragmatically, the default option of the “zero substitution case” (a) of Step 11 is usually adopted.

## Areas of the framework where difference can and will arise

**Step 1: The cohesion challenge:** The nature of the cohesion challenge could be regarded as having certain ambiguities. For example, Greece, Portugal and Spain experienced dramatic convergence in the 1960–1980 period, without any trans-European policy interventions. The Baltic States experienced double-digit growth before joining the EU, before any credible role for cohesion policy could be asserted. Some authors display an almost ideological distaste for cohesion policy, and the book by Herve & Holtzman is a catalogue of the potential evils of policy intervention, untroubled by much actual empirical analysis of the situation in individual countries or the conduct of cohesion policy<sup>237</sup>. Research by the Dutch CPB failed to find any significant cohesion policy impacts, but was largely based on data that preceded the 1989 expansion of cohesion funding and its narrower focus on Objective 1 countries<sup>238</sup>. Although they are largely subliminal and seldom the subject of open discussion, there are probably major differences of interpretation between modelling groups, and these interpretations of the actual situation in the recipient countries and regions may influence the choices of scientific modelling strategies adopted.

**Step 5: Economic theory and public investment:** Faced with the challenge of analysing cohesion policy impacts, all modelling groups dip into new growth theory and economic geography in order to articulate the theoretical roles of physical infrastructure, human capital and R&D in promoting faster growth and catch-up. There is likely to be some common ground here, but deeper examination of the structure of the enterprise sector is likely to lead to a divergence of interpretation as to how the CP is likely to influence growth.

**Step 6: Empirics of investment impacts:** It is possible that different modelling groups may have a common interpretation of the role of theory in exploring the drivers of growth and catch-up. However, there may be differences between groups as to the strength of these

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<sup>237</sup> Y. Herve, R. Holtzmann, *Fiscal Transfers and Economic Convergence in the EU: An Analysis of Absorption Problems and an Evaluation of the Literature*, NOMOS Verlagsgesellschaft, Baden-Baden 1998.

<sup>238</sup> S. Ederveen i in., *Funds and Games: The Economics of European Cohesion Policy*, CPB Netherlands Bureau for Economic Policy Analysis, The Hague 2002. See J. Bradley, G. Untiedt, „Do Economic Models Tell Us Anything Useful about Cohesion Policy Impacts?“, in: U. Stierle-von Schutz, M. Stierle, F. Jennings, A. Kuah (red.), *Regional Economic Policy in Europe: New Challenges for Theory, Empirics and Normative Interventions*, Edward Elgar, Cheltenham, UK 2008, s. 159–180) for a critique of the Ederveen et al. work and R. Rodrik, „Why we learn nothing from regressing economic growth on policies“, *Working Paper*, Harvard University 2005 for a more general critique of using growth regressions to investigate policy interventions.

relationships. Here we are focusing on the immediate relationship between (say) improved physical infrastructure and (say) manufacturing output or manufacturing productivity. We refer to these as “spillover parameters” since they map specific increases in the stocks of physical infrastructure, human resources and R&D into specific increases in sectoral productivity and output. We are not referring to the wider macro-economic outcome that is obtained when the immediate relationships are embedded in large-scale models. The literature presents a wide range of possible parameter choices emerging from empirical studies, and is fraught with methodological and conceptual difficulties. However, even if there was agreement on what to take from the rather confused empirical literature, there would still be problems. The structures of the different models often impose differences in the underlying cohesion mechanisms.

**Step 8: What kind of macro model:** The most important difference between the three main groups, QUEST, RHOMOLO and HERMIN, probably lies in their choice of the modelling framework. This is not to say that there are any deep, fundamental paradigmatic differences between the models. All three draw in varying degrees from recent advances in modelling within the neo-Keynesian and CGE traditions. All three have a significant degree of micro underpinnings and are probably reasonably robust to the so-called Lucas critique.

The origins of QUEST in the analysis of the economies of the “old” EU member states may have led to a stance on crowding out that may be appropriate for fiscal policy interventions in developed economies that are attempting to stabilize about given concept of capacity output.<sup>239</sup> However, the carryover of these mechanisms to the relatively less developed new member state economies, many of which are operating at low rates of utilization of already low levels of capacity, run the risk of being problematic or inappropriate.

RHOMOLO is the spatial computable general equilibrium model of the European Commission focusing on EU regions.<sup>240</sup> It was developed and is maintained by the Regional Economic Modelling team at the Joint Research Centre (JRC) in Seville in cooperation with 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 the EU policy on investments as well as reforms covering a wide array of objectives. The complexity of the model derives from the simultaneous treatment of 27 EU member states,

<sup>239</sup> Ratto et al, 2005.

<sup>240</sup> Di Comite et al, 2015.

further disaggregated into 267 NUTS 2 regions and the inclusion of 5 production sectors in each national model. The equations are calibrated on a single year (e.g., 2010).

The HERMIN modelling framework was derived originally as a simplified version of the original EC HERMES model. It consists of separate national models of all 27 EU member states which can be simulated in a linked system if required. Five production sectors are used. Calibration of the behavioural equations is by econometrics using time series.<sup>241</sup>

In general, the larger the model (in terms of the number of equations included), the more likely it is to include the most relevant mechanisms. But a problem with a large complex model like RHOMOLO is that it becomes very difficult to trace through impact mechanisms in an intuitive way. In the absence of the publication of extensive testing, one has to take the policy analysis results at face value. Smaller model frameworks like HERMIN have to make choices concerning what to include and what to exclude. But their simpler structure makes it easier to trace impact mechanisms and to relate these to the known characteristics of the economy as captured in the model.

In an ideal situation one would operate at least a two-model evaluation strategy: for example, a complex model like RHOMOLO, but also a smaller, simpler model like HERMIN. The comparison of the policy impact analysis produced by each model would at least provide a check on the performance of both.

**Step 9: Demand versus supply impacts:** Although the need to distinguish demand (implementation) effects from long-lasting supply (post-implementation) effects is accepted by all groups, the empirical analysis can lead to dramatically different outcomes, mainly due to the issues mentioned in Step 8 above. For example, the structure of QUEST is such as to produce strong crowding out of any positive demand-side benefits of increased public expenditure. HERMIN produces smaller crowding out effects. It is not possible to say which is more likely to be correct without a much deeper investigation.

**Step 10: Sectoral issues in modelling:** Under this heading we draw attention to the fact that any detailed examination of cohesion policy impacts needs to be performed at a level of sectoral disaggregation that permits – at the very least – the separate analysis

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<sup>241</sup> Bradley and Untiedt, 2007.

of manufacturing, market services, building and construction, agriculture and government. With few exceptions, the main sectoral driver of growth has been manufacturing, or sub-sectors of manufacturing. The rise of market services from a very low base has been a common characteristic of the post-Communist transition of the new EU member states of the CEE area, with internationally traded services playing an increasing role. Also, the agricultural sector has very specific characteristics that may serve to distort cohesion policy analysis unless the sector is isolated. For example, it is conceivable that the one sector approach used by QUEST, compared to the modestly disaggregated approach of HERMIN and the highly spatially disaggregated approach of RHOMOLO, may distort the comparisons of their results.

**Steps 12–13: Policy impacts:** Any different analyses of cohesion policy impacts derived from the different models (e.g., QUEST, RHOMOLO and HERMIN) will need to be interpreted in terms of all the divergences in the modelling framework that are outlined above.

We conclude with the observation that the impact analysis of cohesion policy interventions is very complex and the final results can be determined by a series of decisions taken by the modellers which are seldom obvious but are influential for the outcome. To be able to use and judge the results it is absolutely necessary to be fully transparent concerning the exact set-up of the framework within which the models are used in any policy analysis exercise. Otherwise, macro-economic policy impact analysis will continue to be an impenetrable “black-box”. If that remains the case, then the obvious theoretical advantage claimed for macro-models, i.e., to be able to look at policy impacts in a way that takes into account the specific and realistic economic relations within the recipient countries and their linkage to the rest of the world, will not be realised in practice.

## Extending the modelling approach: quantification and description

In Section 2 we set out a systematic framework to guide the use of models when they are applied to evaluate the likely consequences of a complex policy initiative, namely EU cohesion policy. The objective was to try to isolate all the individual stages of the policy evaluation process where decisions need to be taken that may have important consequences

of the evaluation outcomes. In operational practice, this framework is usually drastically truncated and the evaluation report often consists merely of a short account of the policy shock being studied; the execution of a series of model simulations where only the most cursory description of the model is included; and a write up of the results. In the case of our CP example, this might consist of only three of the thirteen stages of the framework:

**Step 3: Cohesion policy financial inputs:** These public investment policy instrument settings must also be accepted by all modelling groups.

**Step 11: The “no cohesion policy” counterfactual:** Here, option (a), the “zero substitution” case is almost always taken, with no examination of options (b) and (c).

**Step 12: Policy Impacts for the entire economy:** These are often, but not always, confined to the presentation of impacts on aggregates like total GDP, total employment, etc.

A disturbing aspects of such a truncated approach is that a partial application of the wider modelling framework can easily give rise to distorted and misleading policy conclusions. In particular, any failure to examine the national enterprise strategy context within which the cohesion policy is being implemented calls into question the credibility and robustness of the impact results. In light of the fact that EU cohesion policy is intended to have its main impact on the performance of the productive side of the economy rather than on the more transient demand side, any neglect of the structure and characteristics of the enterprise sector and the background national enterprise strategy will have serious consequences.

The reaction of macro modellers to such a criticism, when it is even acknowledged as a problem, is usually to assert that the required information on the structure and characteristics of the enterprise sector is included in the parameters of the production functions used in the model and in the spillover elasticities that translate improvements in the stocks of physical infrastructure, human resources and R&D into enhanced sectoral productivity through altering the characteristics of the production functions. But such an explanation is not convincing since due to data difficulties, the research from which production function and spillover parameters can be derived is often of poor quality and of questionable relevance.

An example can illustrate the relevance of this point. During an ex-post evaluation undertaken by the author of the cohesion policies implemented during the budgetary period 1994–1999 in Greece, Ireland, Portugal and Spain, it became clear that there were some serious differences between these states as to the size, efficiency and modernity of their

respective manufacturing sectors. This came from a very detailed examination of the sectors at a very high degree of sectoral disaggregation, reviewing aspects such as the production technology; the distribution of sectors between high-tech, medium-tech and traditional; productivity trends by sector; and export orientation. Nothing by way of econometric studies of any practical use for the models was available or could be carried out other than rather crude calibration of two-factor CES production functions for aggregate manufacturing in each state. In the analysis lower spillover elasticities were applied in the case of the least developed state, but these had to be selected judgements rather than derived from econometric studies. In the preliminary report the results for that state suggested that the rate of return from the cohesion policy programme was likely to be low, a conclusion that derived directly from the imposed low spillover elasticities and the small overall size of the manufacturing sector in the state in question. However, the authorities in that state objected to these preliminary results. Since there was no formal way of justifying the parameter selections other than judgements, the results had to be adjusted by using a common set of spillover elasticities for all four states.

What this example illustrates is that there can often be situations where insights can be obtained from looking closely at how the economy actually functions and how enterprises actually perform. To gain these insights one usually has to go to a granular level of internal detail that examines individual enterprises or clusters of enterprises, against a background of the overall enterprise strategy within which the enterprise sector in any state functions. At this granular level of detail it is usually possible to form judgements about the current and likely future performance of the enterprise sectors and how that performance is likely to be affected by policy initiatives such as EU cohesion policy. Models are usually constructed at a more aggregate level and firms of very different potential mixed together. Very little can be learned from production functions or factor demand equations calibrated using such aggregate data.

We can further illustrate the importance of taking into account the kind of investigatory and contextual information that can often illuminate important aspects of a policy evaluation, but which is usually ignored in formal model-based analysis. A case in point is a study of the port of Gioia Tauro in Southern Italy (Centre for Industrial Studies, 2011b).<sup>242</sup> This study

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<sup>242</sup> This study, and similar studies commissioned by DG-REGIO, were innovative and experimental evaluations designed to explore post implementation impacts over a time scale during which policy outcomes would have time to “stabilize”.

illustrates the problem with neglecting to generate a comprehensive and coherent description of the regional economic context into which a major project is inserted as well as the wider encompassing economy of which a specific region is only a part. Regional development perspectives tend to be partial because there is a natural tendency to focus almost exclusively on the role of public policy-makers and neglect private sector actors and actions. They are distorted because from a mainly public policy perspective it is difficult to understand the true potential and structural characteristics of regional economies and how they evolve and grow in an organic way. They are poorly organised, not for lack of regional enthusiasm, but because it often proves to be extremely difficult to co-ordinate the many actors and layers of decision making that need to be involved. Finally, they can often be ineffective because there is usually a strong preference to rely on national strategic development frameworks with the hope that centralised policies will generate sufficient spillover and trickle-down effects from core densely populated regions to peripheral, sparsely populated regions.

The example is the evaluation of the port of Gioia Tauro in the southern part of the Italian Mezzogiorno<sup>243</sup>. An interesting finding highlighted in the study was that the expected “energising” role of the port in stimulating development in its underdeveloped hinterland never happened. But the report itself was silent on how the project promoters justified the project in terms of a wider spillover development role. Nor did the report spell out the nature of any ex-ante analysis of the structure of the local and adjoining economies that might have been carried out in a way that would have sounded an early warning about the over-ambitious goals of the project.

In planning this project and in the subsequent impact evaluation study there was a need to stand back from the detail of the actual project and to take a wider view of the economic context into which the project benefits fed. In the case of the Port of Gioia Tauro, it was the micro-structural analysis of the local and adjoining economies that was missing, both in the original project planning and – to a lesser extent – in the ex-post impact evaluation study. This left the port project completely dependent on winning a large share of international transshipment activity, in a business that had many lower-priced alternative international competitors.

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<sup>243</sup> Centre for Industrial Studies, *Ex-post evaluation of investment projects co-financed by the European Development Fund (ERDF) and Cohesion Fund (CF) in the period 1994–1999: The Port of Gioia Tauro*, Report prepared for the European Commission, DG-REGIO, Centre for Industrial Studies, Milan 2011 (CSIL). ([http://ec.europa.eu/regional\\_policy/sources/docgener/evaluation/pdf/projects/Port\\_of\\_Gioia-Tauro\\_IT\\_def.pdf](http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/projects/Port_of_Gioia-Tauro_IT_def.pdf), access on: 15.05.2019 r.).

## The need for policy frameworks

Systematic policy frameworks can help nations and their regions to be smart with limited resources. They are essential in order to bring focus and synergy to the disparate policies that make up any modern national or regional development strategy. However, such frameworks usually emerge as ex-post explanations of outcomes of policies that were designed (or which emerged) in a less formal, eclectic fashion. This is not an ideal situation, but is probably no less desirable than a slavish adherence to a rigid and prescriptive strategy that might turn out ex-post to be completely inappropriate. Nevertheless, strategic frameworks have an important role to play in identifying potential barriers to development or in distilling the lessons of development experience in nations and regions that may share some common characteristics.

In general, there have been three broad approaches to developing such frameworks, the first of which - macro modelling - has already been discussed. The second might be termed the 'descriptive' or "geographical" approach and is based on the history of nations and regions, their geographical features, the quality of their physical infrastructure, the characteristics and standards of their human resources (or 'human capital'), the nature of their main economic activities, and their socio-demographic features. This 'soft' approach is popular, but tends to end up as a confusing mix of praise for great unrealised potential and a call for something to be done about its serious problems.

The third approach might be described as 'analytical' but not "quantitative" and is based on an explicit framework that identifies and makes use of systematic information to examine critically underlying economic mechanisms. In a narrower focus on the enterprise sector of the economy, the work of Michael Porter on competitive advantage has been influential in the reformulations of many national industrial strategies<sup>244</sup>. Porter asked how a nation or a region can achieve international success in any particular industry or in groups of industries. His answers identified four broad attributes (the competitiveness 'diamond') that shape the environment in which firms compete:

- a) **factor conditions:** the availability and quality of the factors of production such as skilled labour, infrastructure etc.,

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<sup>244</sup> M. Porter, *The Competitive Advantage of Nations*, Macmillan Press, London 1990.

- b) **demand conditions:** the nature of local and external demand for the industry's product or service, where local demand can play a vital role in encouraging product innovation and improvement,
- c) **related and supporting industries:** the presence or absence of supplier industries and related industries that are also internationally competitive,
- d) **firm strategy, structure and rivalry:** the national conditions governing how companies are created, organised and managed.

Porter also suggested that there were different stages of competitive development during which different elements of the 'diamond' come into play. At the early stages, competitive development is driven by factor conditions, and draws on low cost labour and/or abundant natural resources. The next stage is investment driven, drawing from factor conditions and demand conditions as well as firm strategy, structure and rivalry (i.e. from three of the four diamond elements). In the final stage, competitiveness is driven by innovation and draws from the entire diamond.

Another framework to emerge from a business research perspective is the 'capability triad' of Michael Best<sup>245</sup>. The capability triad contains probably the most synergistic combination of insights drawn from the economic theory of the firm and the detailed history of the structural evolution of business practices. It is based on the interaction of three elements: a business model, production capabilities and governance (including issues of human capital and skill formation). The most crucial policy implication to emerge from Best's framework is that any overall programmes of change in the area of industrial policy require the close integration of the change programmes in each of the elements of the triad:

"Rapid growth involves coordinated organizational changes in each of three domains: the business model, production capabilities, and skill formation. ... The three domains are not separable and additive components of growth, but mutually interdependent sub-systems of a single developmental process. ... No one of the three elements of the Capability Triad can contribute to growth independently of mutual adjustment processes involving all three elements."<sup>246</sup>

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<sup>245</sup> M. Best, *The New Competitive Advantage*, Oxford University Press, Oxford 2001; M. Best, *How Growth Really Happens...* op. cit.

<sup>246</sup> *Ibid.*

The business model element of the triad describes how entrepreneurial firms can grow, based on the creation of new firms through technology diversification, inter-firm networks within open systems, and regional specialisation based on technological capabilities. The production capabilities element of the triad integrates ideas from operations management and strategy into a logical system of production models that drives home the lesson that competitive strategy and productive systems are bound together. The skill formation element of the triad provides a vital input to innovation and serves to facilitate the synergistic interaction and reinforcement of all three elements. Finally, an important implication to emerge from Best's analysis is that overall programmes in the area of industrial strategy require the close integration over time and space of the change programmes that need to take place within each of the elements of the triad.

The above two policy analysis frameworks together with a formal modelling framework are analytical to varying degrees. The most analytical – the macroeconomic modelling framework – can be incorporated into formal computer models that can be used to carry out forecasting and policy impact analysis. The Porter and Best frameworks are more like systematic taxonomies that provide ways of organising facts into sequences that are easier to link together in a policy-useful way. The insights that arise from the Porter/Best frameworks need to feed into the formal model-based analysis, if not in terms of equations and model mechanisms, then in terms of modification and reinterpretation of supply-side performance.

## Towards a synthesis of approaches to policy design and analysis

One can plan and analyse policy actions (such as cohesion policy) in many different ways. Indeed, the diversity of approaches is a kind of strength if a proper effort is made to examine links between the elements of this diversity. Research suggests that there are likely to be three critical dimensions to the optimal planning and analysis of investment actions undertaken within Structural Fund programmes. The first dimension is **spatial**, to characterise the regional consequences of cohesion policy. The second dimension is **sectoral**, to identify a range of sectors which are uniquely suitable and adaptable for promotion within the economy. The third dimension is **institutional**, to identify the kinds

of co-operative policy frameworks and actions that are needed in the targeted economy if it is to have a greater prospect of participating in EU-wide prosperity.

The combination of these three aspects – spatial, sectoral and institutional – provide a sound and coherent basis for dealing with the exceptional challenges of lagging economies. For example, the identification of specific infrastructural deficits is best carried out where the **spatial** dimension is explicit, the **sectoral** issues are a key justification, and the **institutional** dimensions are supportive and facilitating. The three objectives provide the natural context within which to generate specific development proposals, to do so in a way that facilitates the objective evaluation of likely achievable benefits, and to ensure that the appropriate institutional framework is in place to implement policy decisions.

These three dimensions (spatial, sectoral and institutional) are also relevant to both micro and macro impact analysis, which have their own specific objectives and methodologies. Analysis of the impact and effectiveness of cohesion policy can proceed at different levels of investment aggregation, where the essential difference between these levels is the extent to which the rest of the economy is assumed to remain unaffected or unchanged while a specific policy initiative is investigated. These stages are usually denoted **micro**, **meso**, and **macro** in evaluations of cohesion policy.

In the case of an individual project (e.g., a new harbour like the Port of Gioia Tauro; a targeted training scheme, etc.), a conventional cost-benefit analysis can be carried out, with competing projects ranked in terms of increasing internal rate of return. Such **micro** analysis, however, can give rise to obvious difficulties in relation to the need to evaluate the impact of complementarities, spillover effects and externalities in the context of the overall programme. For micro impact analysis to be valid, the investment projects need to be sufficiently small and self-contained so that spillovers and externalities can be assumed to be second order. However, the results from such micro policies cannot be added up.

Moving up the scale of aggregation, a grouping of, or the totality of projects targeted at a general or systemic problem (say, long-term unemployment or industrial competitiveness), could be evaluated in terms of how successful they were in attaining their designated priority objective (such as lowering the incidence of long-term unemployment or boosting domestic and export sales). Here the assumption that **meso** impact analysis can be carried out purely, or even mainly, in terms of its internal focused objectives is more

difficult to sustain. Meso impact analysis can be carried out, but it leads inexorably to the need for complementary macro impact analysis.

Finally, the effectiveness of large Operational Programmes or of the entire programme can be evaluated as an integrated whole. Given the often large size of the funding in relation to the size of the economy, and the obvious implications for domestic fiscal, monetary, industrial and regional policy, evaluation of the impact of any large scale programmes must be done in a context that includes economy-wide feedbacks and interactions, attempting to account for all complementarities, spillover effects and externalities. In other words, it requires a macroeconomic perspective, and demands formal national or regional economy models: input-output (I-O), macro-econometric, computable general equilibrium (CGE), growth, etc.

Table 1 below sets out a schema that focuses on some of the distinctions between micro and macro impact analysis and characterises the different emphasis each of the two approaches has over ten stages of the evaluation process.<sup>247</sup> Many of these stages are self-explanatory and are determined by the fundamental characteristics of micro and macro approaches to policy research. But some stages require explanation. For example, in Stage 3 we suggest that for policy interventions at the level of individual projects or measures (i.e., a series of closely related projects) can be analysed using microeconomic approaches since spillovers and externality effects can reasonably be assumed to be of second order. But above that level, for Operational Programmes or for the entire Cohesion Policy programme, the large size of the policy interventions forces one to adopt macro approaches to design and impact analysis since spillover and externality effects can also be very large and cannot be ignored.

Turning to Stage 9, the crucial issue of the appropriate policy counterfactual arises. This is probably the most contentious issue in both micro and macro policy impact evaluation. The micro approach draws on techniques commonly used in experimental design in areas of science and medicine. But the formal implementation of the “scientific” approach is fraught with difficulties. For example, it is seldom possible to design cohesion policy interventions at the project or measure level in the same fashion as in scientific experiments (i.e., one region gets a bridge while another, similar and equally deserving region, does

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<sup>247</sup> Table 1 does not include the meso approach to policy impact analysis since this is an uneasy blend of elements from both micro and macro approaches. Our objective is to try to clarify the distinctive features of the “purer” micro and macro approaches so that the appropriate mix can be derived for any meso analysis on a case by case basis.

not). But an approximate application is sometimes possible in order to identify with an adequate degree of precision “a population ‘similar’ to the target population”<sup>248</sup>. In the macro approach, on the other hand, a formal counterfactual scenario can be defined fairly precisely by means of a “policy-off” model simulation. However, its reliability depends on the acceptability of the macromodel being used as a true and accurate portrait of how economies function and how policy instruments affect economic processes.

**Table 1.** Stages in Cohesion Policy Impact Evaluation: Micro and Macro Approaches

	Stages	Micro (bottom-up)	Macro (top-down)
1	First steps	Narrative description of regional economic context of intervention	Macro-sectoral description of national, regional, sub-regional economies
2	Nature of data	Use whatever are available and gather the rest	Requires access to published national and regional accounting data
3	Aspects of Cohesion Policy	Individual projects and measures	Operational programmes and aggregate programme
4	Main formal techniques	Cost-benefit analysis (CBA)	Macro-sectoral policy modelling
5	Timing	Mainly used ex-ante, but can be used ex-post (as in the CSIL studies)	Ex-ante, mid-term and ex-post
6	Necessary inputs	Measured costs and benefits of Cohesion Policy investments	Model calibration plus inputs from micro research
7	Nature of outputs	Informed value judgements based on CBA results	Quantification of impacts on macro-sectoral indicators using model simulations
8	Treatment of externalities	Handled informally or ignored	Formalised, but needs inputs from micro research to link analysis to CP instruments
9	Approach to identifying a policy counterfactual	Uses data of good quality and the robustness of the method to identify a population “similar” to the target population. <sup>249</sup>	Counterfactual is defined in terms of a “policy off” model simulation <sup>250</sup>
10	Presentation of results	Narrative presentation with CBA inputs; focus on organisational aspects and efficiency of implementation	Uses macro-sectoral framework to describe impacts on the economy during implementation and post-implementation phases

<sup>248</sup> F. Barca, *An Agenda for a Reformed cohesion policy. A place-based approach to meeting European Union challenges and expectations*, Independent Report prepared at the request of Danuta Hübner, 2009. ([http://ec.europa.eu/regional\\_policy/policy/future/seminars/barca\\_sem\\_220609\\_en.htm](http://ec.europa.eu/regional_policy/policy/future/seminars/barca_sem_220609_en.htm), access on: 15.05.2019 r.).

<sup>249</sup> F. Barca, *op. cit.*, s. 47.

<sup>250</sup> J. Bradley, „Evaluating the Impact of European Union Cohesion Policy in Less-developed Countries and Regions”, *Regional Studies* 2006, Special Issue: The Evaluation of European Union Cohesion Policy, (red.) J. Bachtler and C. Wren, s. 189–199.

Such a table might suggest that the micro and macro impact evaluation approaches can be treated in isolation from each other, and behave like ships passing in the night. Review of the older literature on cohesion policy evaluation tends to confirm that this separation was a fact of life and the specialists in the two areas almost never talked to each other.<sup>251</sup> But if the quality and effectiveness of policy design and evaluation is to improve, this methodological apartheid needs to end.

Regional development appears to work best when national and regional, micro and macro perspectives are in harmony; when national policy makers realise that the nation is simply the sum of its regions, and regional policy makers accept that co-operation is a two-way process. The knowledge gaps on the macro side (in particular, the calibration of policy externality effects) can only be treated if better and more focused micro research is carried out, perhaps along the lines of the CSIL Italian study referred to earlier. On the other hand, the appropriate economic context in which policies are designed and evaluated can only be understood if some attempt is made to explore it using insights from macro-regional research, even if this is obliged to stop well short of constructing formal macro-regional models. In terms of the methodologies used in planning and evaluating regional policy initiatives, Irish experience suggests that the use of weak methodologies or none at all tend to lead to poor policy outcomes<sup>252</sup>. A better balance between top-down (macro) and bottom-up (micro) analysis is essential if the scarce investment resources being devoted to EU Cohesion Policy are to be used to best advantage. These are not competing perspectives, but are essential complements.

## Back to basics in evaluation

There are many other aspects of evaluation that need to be emphasised. For example, cohesion policy is an intrinsically strategic and long term process that spans many separate

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<sup>251</sup> A further complicating factor was that the different modelling groups on the macro side of evaluation tended to fight among themselves about the appropriate modelling methodology (J. Bradley, G. Untiedt, „Do Economic Models Tell Us Anything Useful about Cohesion Policy Impacts?“, in: U. Stierle-von Schutz, M. Stierle, F. Jennings, A. Kuah (red.), *Regional Economic Policy in Europe: New Challenges for Theory, Empirics and Normative Interventions*, Edward Elgar, Cheltenham, UK 2008, s. 159–180).

<sup>252</sup> See: J. Bradley, *The Economy of the Atlantic Economic Corridor: A Study of County Mayo*, Report prepared for the AEC Business Forum, Westport, Ireland 2019 ([http://www.sligochamber.ie/wpcontent/uploads/2019/05/The-Economy-of-the-AEC-Mayo-Study-Final\\_compressed.pdf](http://www.sligochamber.ie/wpcontent/uploads/2019/05/The-Economy-of-the-AEC-Mayo-Study-Final_compressed.pdf), access on 15.05. 2019 r.).

EU budget programme periods. Yet the EC and DG-Regional Policy continue to insist that each EU budget period be evaluated in isolation from all others, even though there is – or ought to be - considerable continuity as one programme leads to the next. In addition, there is a tendency to evaluate the different cohesion policy investment elements as completely separate exercises. For example, the evaluation of the ERDF impacts is carried out separately from the evaluation of the ESF impacts as if they had no inter-relationships with each other! The Commission approach might make some sense in narrow, accounting terms. It makes no sense at all in economic policy terms and distorts the whole design and evaluation process.

Many previous attempts to evaluate cohesion policy impacts do not distinguish between “implementation” impacts and “post-implementation” impacts. While programmes are being implemented, and investment expenditures supported by cohesion policy are being made, there can be significant demand-side (or Keynesian) impacts.<sup>14</sup> When the programme ends, and expenditures are assumed to cease, only supply-side impacts remain and can continue to benefit the economy for many years if “good” policies were implemented. Evaluation reports regularly confuse these two kinds of different impacts and risk drawing distorted and misleading conclusions. As an extreme example, if a funding injection from the EU were to be used entirely to boost employment in the public sector of the recipient state, it would have a much bigger demand-side “implementation” impact than the alternative case where such funds were used to purchase capital equipment from abroad in order to modernise the manufacturing and service sectors. However, the post-implementation impacts of the former would be almost zero, while significant positive impacts would be likely to flow from the latter.

Perhaps cohesion policy impact evaluation is still at its weakest in the microeconomic area. The Commission has been slow to adopt a rigorous and logical micro analysis framework such as that set out in Honohan<sup>253</sup>, and elaborated by Bradley<sup>254,255</sup>. The “place-based”

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<sup>253</sup> P. Honohan, „EU Structural Funds in Ireland. A Mid-Term Evaluation of the CSF 1994–99”, *Policy research series 1997*, Paper no. 31.

<sup>254</sup> J. Bradley et al., „How can we know if EU Cohesion Policy is successful? Integrating micro and macro approaches to the evaluation of Structural Funds”, *GEFRA Working Paper 2006*, Muenster

<sup>255</sup> The Commission’s Competence Centre on Microeconomic Evaluation (<https://ec.europa.eu/jrc/en/microeconomic-evaluation>, access on: 15.05.2019 r.) has moved to address the deficit in micro evaluations. But the approaches adopted are not linked effectively to the more common macro modelling evaluation approaches.

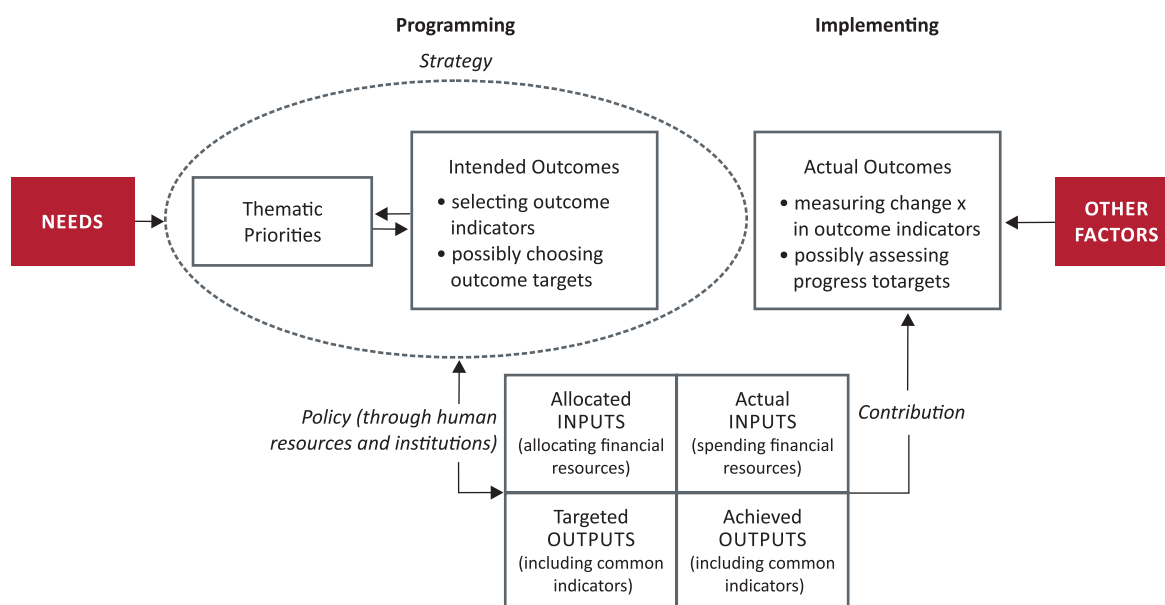
approach advocated by the Barca team<sup>256</sup>, is a poor substitute for the absence of economic rigor and rationale at both the microeconomic and macroeconomic levels. And however useful the further elaboration of “target” indicators is, as set out in Barca and McCann<sup>257</sup>, the fact remains that, in the absence of rigorous economic examination, we continue to be in the dark about how actual policy actions might be related to targeted outcomes.

In very simple terms, policy impact evaluation addresses the following question.

If we implement policy action X, what impact is it likely to have on economic target Y?

If policy action X happened to be: “increase the rate of VAT by one percentage point”, then the implications for VAT revenue would be reasonably easy to approximate. But when we try to predict the likely impacts of Cohesion Policy, we enter a far more complicated world.

**Figure 1.** Barca and McCann, 2011: Cohesion Policy - Input, Output and Outcome Framework



Source: F. Barca, P. McCann, Outcome indicators and targets: Towards a performance oriented EU cohesion policy, Brussels 2011, p. 24.

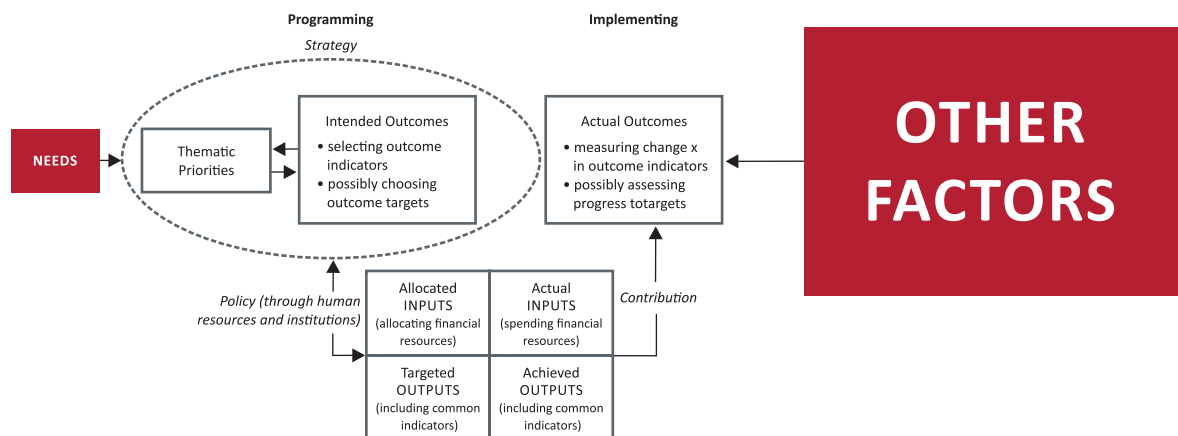
To illustrate the basic problem with existing approaches to evaluation, in Figure 1 we reproduce a schematic diagram of the process of evaluation from a paper by Barca

<sup>256</sup> F. Barca, *An Agenda for a Reformed...* op. cit.

<sup>257</sup> F. Barca, P. McCann, *Outcome indicators and targets: Towards a performance oriented EU cohesion policy*, Paper prepared for High level group reflecting on future cohesion policy, Brussels 2011.

and McCann<sup>258</sup>. This might be termed an “insiders” view of the evaluation process, where Cohesion Policy is the centre of attention. Focus is on an elaboration of indicators, of which 62 are listed in an annex to the Barca and McCann paper. Standing back from the details of Cohesion Policy in order to get some perspective, we have re-sized the Barca and McCann diagram in a way that we consider more accurately indicates what are the dominant drivers of economic development and cohesion. What we emphasise in Figure 2 is the simple fact that Cohesion Policy actions, however worthy or effective, are simply a very small part of the forces that bring about cohesion. To be effective, any methodology used to evaluate the impacts of a complex Cohesion Policy programme must also be able to disentangle these modest effects from the much larger impacts of what the diagram calls “other factors”. If we do not understand the “other factors”, we cannot understand the Cohesion policy impacts. And these “other factors” only lie partially within the scope of the “standard” economic approach.

**Figure 2.** Barca and McCann re-scaled to represent driving forces of cohesion processes



Source: own elaboration based on F. Barca, P. McCann, op. cit., p. 24.

In the methodology described by Barca<sup>259</sup> and elaborated in Barca and McCann<sup>260</sup>, evaluation becomes a kind of ritualistic and elaborated monitoring procedure that tells us very little about what is being achieved. For example, we may learn how many small and medium sized

<sup>258</sup> *Ibid.*

<sup>259</sup> F. Barca, *An Agenda for a Reformed... op. cit.*

<sup>260</sup> F. Barca, P. McCann, *Outcome indicators and targets: Towards a performance oriented EU cohesion policy*, Paper prepared for High level group reflecting on future cohesion policy, Brussels 2011.

enterprises (SMEs) introduced product or process innovations by asking them directly, but in the absence of searching microeconomic analysis, we will still have little idea about how and in what way this outcome might be considered as a direct benefit of cohesion policy actions.

The serious weakness of microeconomic evaluation of cohesion policy actions has knock-on consequences for their macroeconomic evaluation. This kind of top-down evaluation needs structural macro models of various kinds. Economists still argue about which model design is best for purpose, but there is wide agreement on many modelling questions and where model-based impact evaluations differ from each other, the differences can usually be reduced to differences of emphasis, interpretation of research and even ideological preferences, as discussed in Section 2 above. However, all macro model-based evaluations suffer from the paucity of good micro-based evaluation research and are forced to use approximations to quantify specific relationships between policy instruments (say, investment in physical infrastructure) and macro-sectoral impacts (say, increases in sectoral output or sectoral productivity). The paper by Bradley et al., 2006 develops these issues in more detail, but lack of a microeconomic approach to evaluation remains a serious barrier to improved and more robust evaluation of cohesion policy.

Turning to the national level, there is an urgent need to integrate cohesion policy more closely into the full set of domestic policy actions, national and regional, that are likely to affect economic development. In this process, it will be important for governments to recognise that cohesion policy actions, however vital, are by no means the major policy input into promoting faster, sustainable development. It is often the case that responsibility for cohesion policy is separated into a specific policy group and isolated from more “mainstream” domestic policy considerations. There are even cases where responsibility is hived off to a line “spending” Ministry that runs the risk of being seen by the Finance Ministry as a “suppliant” rather than as a main actor in promoting development.

At the national level, the integration of cohesion policy with other relevant aspects of domestic policy carries the requirement to place the evaluation of cohesion policy firmly in the context of a wider framework of domestic policy evaluation. The obvious challenges to be faced in attempting to achieve this synthesis should not prevent an effort being made, since the likely benefits of an integrated policy framework could be very great.

Turning to the regional level, we need to explore politically and socially acceptable ways of acknowledging that some regions are likely to develop earlier and grow faster than others. This essentially comes down to the need to reconcile the increasing emphasis placed by DG-Regional Policy on “place-based” development policy with the rather different insights and evidence from analysis of “people-centred” policy, and this is a huge political challenge for both the EC and for national governments. It does not imply that national governments should ignore the obvious benefits – social as well as economic – of subsidiarity, i.e., devolving power to local actors. Nor does it imply that the unsustainable growth of huge metropolitan areas at the expense of impoverished rural hinterlands is inevitable or desirable. But governments who manage to leverage national development by initially harnessing the development potential of their most favoured regions will quickly be able to generate the resources and the skills necessary to bring their less favoured regions into line.

Initially, favoured regions are likely to include cities with their sophisticated education establishments; existing successful enterprise agglomerations; regions with good communication links to external markets, etc. But it would be wrong to uncritically devolve too much policy making power down to regions that may have conflicting priorities. However, it would also be wrong for the centre to try to retain all policy-making power and address cohesion issues exclusively by means of income re-distribution between regions, since this can engender long-term dependency of weak regions and hamper the resource-generating power of strong regions. For better or worse, “place-based” and “people-centred” policies have to act jointly and getting that crucial balance right will generate synergies that will best promote the achievement of the EU cohesion objective.

If there continues to be an unwillingness to ground cohesion policy design and impact evaluation in the best available economic policy research and methodologies, the credibility of the Commission’s actions and efforts are likely to be greatly weakened and the net donor states, who have to carry the burden of financing Cohesion Policy through higher taxes on their citizens, may come to believe that in a time of fiscal austerity their resources could be better directed elsewhere. This would be an unfortunate and misguided conclusion on a policy that will be crucial in promoting renewed long-term development when the current fiscal and financial crisis passes.

## Concluding issues

It would be very useful if we had a single conceptual framework for policy analysis related to growth and development. This would be a big advance as it would get around the serious methodological problem of switching from a macroeconomic conceptual framework organized around (for example) macro models, to a micro (or, more correctly, firm level) framework central to the Porter's diamond and Best's Capability Triad, as one transited from top-down to bottom-up. In other words it would make it less likely that macro oriented economists would simply write off production organization issues as external or irrelevant to macro growth dynamics, and force them to look at production organization issues as part of a continuum that runs from the performance of individual firms and clusters of firms up to the level of the economy as a whole.

The criticism can obviously be made that such an extended production organisation framework is indifferent to agents (workers, managers, society at large) and the standard macro and micro frameworks where firms are regarded as entities that maximize profits subject to production function constraints and demand labour, while households maximize utility and supply labour. But the point of the production frameworks is that it is not useful to assume optimizing behaviour by representative entities as the core explanatory framework in the economy. In the production framework a growing economy would be one that manages to get its production side sorted out. The framework goes right down to the factory level. Successful firms in economies are no longer regarded merely as better "optimizers" than unsuccessful firms. Rather, in the framework, they are better "organizers". There is a world of difference between the notion of "optimizer" and "organizer". Every level of the economy, including government policy, can be examined in light of production capabilities, education/skill programs, business organization, although this may have to be extended or elaborated. What we find with low income countries and regions are underdeveloped production capabilities, low investments in skill development and education institutions, and poorly organized and under-developed business models.

In the case of a poorly performing manufacturing sector in an economy, it is not useful to talk in terms of sub-optimizing behaviour by representative firms or, if skilled labour is in short supply, to talk of problems with the work/leisure trade-offs. Rather, we find underdeveloped production capabilities, unenlightened management practices, unskilled workers, under-funded education institutions, screwed up tax systems, etc. Furthermore, we find

governments that are not addressing market failures by promoting open-systems business models or worse, enacting policies that undermine the conditions which make such business models viable. We find low productivity as a consequence not of lazy or indifferent workers but of poorly organized factories and counter-productive government policies.

The point about developing a production-focused perspective is not that proponents of neoclassical growth theory have to be rejected but that the production-focused approach is a more practical and useful way to look at the underlying sources of growth. It accepts that some insights can be gained from examining the work/leisure, saving/consumption, capital/labour incentive relationships of market-clearing, equilibrium (or even Keynesian) economics. It does not take away from the critical need for stability of money supply and prices. It does not assert that keeping the public finances balanced over the business cycle is unimportant. These last two might be referred to as “hygiene” policies, i.e., essential for survival but not the whole story.

Absent the production perspective and the role of the public sector as “strategic organizer” is crucially undermined. For example, government failure to enact advanced production policies is the source of slow growth, not just the lack of correct fiscal policy. The lack of government effectiveness in addressing production issues can be seen as market failure using the neoclassical framework. But a better way to see the problem is within a production framework, where the underlying drivers of growth are actually located. Macro insights are primarily summary statements or to do with external conditions and policy stances. They are very partial frameworks for characterizing why exactly firms in some economies grow faster than in others. The production framework characterizes a parallel universe to the world of conventional macro-policy and micro-policy analysis, in which the parts are organized in a very different way, at the levels of business and government. When we find a mess at the company level, we can expect related messes at the government policy and economic performance levels. The company level is the proper place to look first. And the lessons learned need to be incorporated into policy macro models.

## About the Author

**John Bradley** was Research Professor at the Irish-based ESRI and has published extensively on the island economy of Ireland, EU cohesion policy, industrial strategy and economic modelling. He developed techniques to evaluate the impacts of Structural Funds on the Irish economy from 1989, and worked with the European Commission to apply these to Greece, Portugal, Spain, the East German regions and the Italian Mezzogiorno. After the 2004 EU enlargement he designed analytic tools for DG-REGIO to evaluate the impact of Structural Funds in promoting the objectives of cohesion in all 28 member states. In 2012 he co-authored with Michael Best a study entitled Cross-Border Economic Renewal: Re-thinking Regional Policy in Ireland. He has acted as a consultant to the European Commission, the European Parliament, the OECD, the World Bank, many EU member state governments and has carried out research and training projects in the EU, Western Balkans and Africa.

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## II. Development of macroeconomic HERMIN models in Poland in the context of evaluation research

**Logo 1.** European Founs Logo

**Logo 2.** Republic of Poland Logo

**Logo 3.** PARP Logo

**Logo 4.** European Union Logo  
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**Figure 1.** Diagram of the HERMIN model.

The name “HERMIN” is placed in the middle of the diagram, and subsequent elements are arranged around it. The elements of the diagram are written below.

**1. National accounts:** Production, Expenditure, Income.

**2. Production:**

Industry (T) – Industrial processing, Mining and quarrying, Electricity, gas, steam, sewage;  
Market services (N) – Public utilities, Other service activities; Agriculture (A) – Agriculture, Forestry, Fisheries and fishing; Non-market services (G) – General government, Health care, Education;  
Construction (B).

**3. Expenses:** Private consumption, Public consumption, Investments, Changes in capital resources, Export, Import.

**4. Income:**

Public sector – Income, Expenditure, Demand for loans, Public debt; Private sector – Enterprise sector, Household sector.

**5. Model as an integrated system:**

Production = Expenses, used to determine net trade balance ( $NTS = GDP + GDA$ )

where  $GDA = C + G + I + DS$ ;

Production = Revenue, used to determine corporate profits ( $YC = GDP - YW$ )

**6. Behavioral and identity equations:**

Behavioral equations: based on theoretical foundations – Consumption function, Wage negotiations, Demand factors;

Identity equations: summation, definition, final – GDP (GDP), Productivity, Public sector demand for loans (PSBR)

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**Figure 2.** The evolution process of HERMIN models in Poland

The diagram consists of three parts, which are written below. National models (subsequent stages of the process are placed along one long arrow indicating the passage of time):

2002 – HPO4

2005 – HPON

2008 – HPL5 CSHM (AMECO)

2010 – HPL5 CSHM (GUS)

2015 – HPL5 with a monetary module

Regional models (at each stage there is a short arrow indicating the passage of time):

2005 – HPO4REG (I generation)

2010 – HPL5REG (II generation)

2015 – HPL5INTERREG (III generation)

City models (at the following stage there is one arrow indicating the passage of time):

HPL5WAW

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**Figure 3.** Impact of POIŚ, OP IE and POKL 2007–2013 on the level of GDP per capita in PPS (EU-28 = 100) for Eastern Poland (percentage points)

//Data from the line chart was saved in the table. All values except those recorded on the chart are approximate.//

	POKL 2007–2013	POIŚ 2007–2013	POIG 2007–2013
2008	0,0 p.p.	0,0 p.p.	0,0 p.p.
2009	0,1 p.p.	0,05 p.p.	0,0 p.p.
2010	0,2 p.p.	0,1 p.p.	0,3 p.p.
2011	0,25 p.p.	0,25 p.p.	0,9 p.p.
2012	0,3 p.p.	0,6 p.p.	2,2 p.p.
2013	0,35 p.p.	0,7 p.p.	2,5 p.p.
2014	0,45 p.p.	0,75 p.p.	2,6 p.p.
2015	0,4 p.p. (value recorded on the chart)	0,8 p.p. (value recorded on the chart)	2,7 p.p. (value recorded on the chart)
2016	0,3 p.p.	0,7 p.p.	2,75 p.p.
2017	0,2 p.p.	0,55 p.p.	2,4 p.p.
2018	0,2 p.p.	0,45 p.p.	2,2 p.p.
2019	0,2 p.p.	0,4 p.p.	2,0 p.p.
2020	0,2 p.p. (value recorded on the chart)	0,3 p.p. (value recorded on the chart)	1,9 p.p. (value recorded on the chart)

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**Figure 4.** Results of RPO WM 2014–2020 impacts on GDP at constant prices in the Warmian-Masurian Voivodeship, broken down into 9 development scenarios of the region (PLN million)

//Data from line charts were saved in tables. Values are approximate.//

**Chart 1.** – optimistic scenarios

	<b>INNO_opt</b>	<b>INFR_opt</b>	<b>RPO_opt</b>
<b>2014</b>	0 mln zł	0 mln zł	0 mln zł
<b>2015</b>	0 mln zł	0 mln zł	0 mln zł
<b>2016</b>	200 mln zł	200 mln zł	200 mln zł
<b>2017</b>	700 mln zł	350 mln zł	350 mln zł
<b>2018</b>	1300 mln zł	1150 mln zł	1100 mln zł
<b>2019</b>	1500 mln zł	1250 mln zł	1200 mln zł
<b>2020</b>	1550 mln zł	1300 mln zł	1200 mln zł
<b>2021</b>	1300 mln zł	1100 mln zł	1000 mln zł
<b>2022</b>	1100 mln zł	900 mln zł	800 mln zł
<b>2023</b>	900 mln zł	800 mln zł	650 mln zł
<b>2024</b>	750 mln zł	700 mln zł	600 mln zł
<b>2025</b>	650 mln zł	650 mln zł	550 mln zł
<b>2026</b>	550 mln zł	600 mln zł	500 mln zł
<b>2027</b>	500 mln zł	600 mln zł	500 mln zł
<b>2028</b>	450 mln zł	600 mln zł	450 mln zł
<b>2029</b>	400 mln zł	550 mln zł	450 mln zł
<b>2030</b>	350 mln zł	400 mln zł	400 mln zł

**Chart 2.** – pessimistic scenarios

	<b>INNO_pes</b>	<b>INFR_pes</b>	<b>RPO_pes</b>
<b>2014</b>	0 mln zł	0 mln zł	0 mln zł
<b>2015</b>	0 mln zł	0 mln zł	0 mln zł
<b>2016</b>	250 mln zł	250 mln zł	250 mln zł
<b>2017</b>	1000 mln zł	750 mln zł	750 mln zł
<b>2018</b>	2000 mln zł	1600 mln zł	1600 mln zł
<b>2019</b>	2400 mln zł	1900 mln zł	1900 mln zł
<b>2020</b>	2450 mln zł	1900 mln zł	1900 mln zł
<b>2021</b>	2100 mln zł	1500 mln zł	1500 mln zł
<b>2022</b>	1600 mln zł	1100 mln zł	1100 mln zł
<b>2023</b>	1300 mln zł	900 mln zł	850 mln zł

	<b>INNO_pes</b>	<b>INFR_pes</b>	<b>RPO_pes</b>
<b>2024</b>	1100 mln zł	750 mln zł	700 mln zł
<b>2025</b>	1000 mln zł	700 mln zł	650 mln zł
<b>2026</b>	900 mln zł	650 mln zł	600 mln zł
<b>2027</b>	800 mln zł	625 mln zł	575 mln zł
<b>2028</b>	750 mln zł	600 mln zł	550 mln zł
<b>2029</b>	700 mln zł	575 mln zł	525 mln zł
<b>2030</b>	600 mln zł	550 mln zł	500 mln zł

**Chart 3.** – moderate scenarios

	<b>INNO_mod</b>	<b>INFR_mod</b>	<b>RPO_mod</b>
<b>2014</b>	0 mln zł	0 mln zł	0 mln zł
<b>2015</b>	0 mln zł	0 mln zł	0 mln zł
<b>2016</b>	250 mln zł	250 mln zł	250 mln zł
<b>2017</b>	1000 mln zł	750 mln zł	750 mln zł
<b>2018</b>	1750 mln zł	1450 mln zł	1450 mln zł
<b>2019</b>	2000 mln zł	1600 mln zł	1550 mln zł
<b>2020</b>	2050 mln zł	1650 mln zł	1600 mln zł
<b>2021</b>	1750 mln zł	1400 mln zł	1350 mln zł
<b>2022</b>	1400 mln zł	1100 mln zł	1000 mln zł
<b>2023</b>	1200 mln zł	900 mln zł	800 mln zł
<b>2024</b>	1000 mln zł	850 mln zł	750 mln zł
<b>2025</b>	900 mln zł	800 mln zł	700 mln zł
<b>2026</b>	800 mln zł	750 mln zł	675 mln zł
<b>2027</b>	750 mln zł	750 mln zł	650 mln zł
<b>2028</b>	650 mln zł	700 mln zł	600 mln zł
<b>2029</b>	550 mln zł	650 mln zł	550 mln zł
<b>2030</b>	525 mln zł	600 mln zł	525 mln zł

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**Figure 5.** Impact of cohesion policy implemented in 2014–2020 in fifteen voivodeships on the GDP level of the Dolnośląskie voivodeship in current prices (average from 2014–2030) in PLN billion

The graphic presents a map of Poland divided into voivodeships. Voivodeships were divided into three groups depending on the prices.

> PLN 10 billion:

province. Masovian – 23.9 billion

province. Silesia – 20.4 billion

province. Greater Poland – 14.4 billion

province. Lesser Poland – 12.7 billion

PLN 5–10 billion:

province. łódzkie – 9.3 billion

province. pomorskie – 7 billion

province. Podkarpackie – 6.2 billion

province. Kuyavian-Pomeranian – 5.3 billion

< 5 billion PLN:

province. Lower Silesia – 4.8 billion

province. Warmian-Masurian Voivodeship – 4.4 billion

province. Lublin – 4.4 billion

province. West Pomeranian – 4 billion

province. Świętokrzyskie – 3.6 billion

province. Lubuskie – 3.3 billion

province. Opole – 2.6 billion

province. Podlasie – 2.2 billion

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**Figure 6.** Impact of cohesion policy implemented in 2014–2020 in the Dolnośląskie voivodeship on the level of GDP in current prices of other regions of Poland (average from 2014–2030) in PLN million

The graphic presents a map of Poland divided into voivodeships. Voivodeships were divided into three groups depending on the prices.

DL – province Lower Silesia – 104,030 million

> PLN 200 million:

province. Silesia – 506 million

province. Masovian – 460 million

province. Greater Poland – 335 million

province. Lesser Poland – 293 million

province. Łódź – 206 million

PLN 100-200 million:

province. Pomeranian Voivodeship – 119 million

province. Kuyavian-Pomeranian – 117 million

< PLN 100 million:

province. Podkarpackie – 89 million

province. Lublin – 86 million

province. Opole – 76 million  
province. Świętokrzyskie – 65 million  
province. Warmian-Masurian Voivodeship – 60 million  
province. West Pomeranian – 53 million  
province. Lubuskie – 46 million  
province. Podlasie – 46 million  
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**Figure 7.** Impact of actual (2004–2014) and forecasted (2015–2030) investment expenditure on Warsaw’s GDP in current prices in 2004–2030 (in%) – option I “demand and supply effects”

//Data from the line chart was saved in the table. The values have been read approximately.//

	real scenario	alternative scenario I	alternative scenario II	alternative scenario III
2004	1 %	1 %	1 %	1 %
2005	1,5 %	1,5 %	1,5 %	1,5 %
2006	2 %	2 %	2 %	2 %
2007	4 %	4 %	4 %	4 %
2008	5 %	5 %	5 %	5 %
2009	6 %	6 %	6 %	6 %
2010	9,5 %	10 %	9,5 %	9 %
2011	10 %	10,5 %	10 %	9,5 %
2012	11 %	11 %	10,5 %	10 %
2013	11 %	10,5 %	10,5 %	9,5 %
2014	12,5 %	10,5 %	10,5 %	10 %
2015	14 %	11 %	11 %	10,5 %
2016	15 %	12,5 %	12 %	11,5 %
2017	17 %	12,5 %	13 %	12,5 %
2018	18 %	13 %	13,5 %	13 %
2019	18,5 %	12 %	13,5 %	13 %
2020	19 %	11,5 %	13,5 %	13 %
2021	19,5 %	11 %	13,5 %	13 %
2022	20 %	10,5 %	13 %	12,5 %
2023	20 %	10,25 %	12,5 %	12,25 %
2024	20 %	10 %	12,25 %	12 %
2025	20,25 %	9,75 %	12 %	11,75 %
2026	20 %	9,5 %	11,5 %	11,5 %
2027	19,75 %	9,25 %	11 %	11,25 %
2028	19,5 %	8,5 %	10,5 %	11 %
2029	19 %	8 %	10 %	10,5 %
2030	18,5 %	7,5 %	9,5 %	9,75 %

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**Figure 8.** Impact of actual (2004–2014) and forecasted (2015–2030) investment expenditure on Warsaw’s GDP in current prices in 2004–2030 (in%) – option II “demand effects”  
 // Data from the line chart was saved in the table. The values have been read approximately.//

	real scenario	alternative scenario I	alternative scenario II	alternative scenario III
2004	1 %	1 %	1 %	1 %
2005	1,5 %	1,5 %	1,5 %	1,5 %
2006	2 %	2 %	2 %	2 %
2007	3,5 %	3,5 %	3,5 %	3,5 %
2008	4,5 %	4,5 %	4,5 %	4,5 %
2009	6 %	6 %	6 %	6 %
2010	9 %	9,5 %	9 %	8,5 %
2011	10 %	10,5 %	10 %	9 %
2012	11,5 %	11,5 %	11 %	10 %
2013	11,5 %	11 %	10,5 %	9,5 %
2014	13 %	11 %	11 %	10,25 %
2015	12,5 %	11 %	11 %	10,25 %
2016	12 %	11,25 %	11 %	10,25 %
2017	11,5 %	11,25 %	11 %	10 %
2018	11 %	11 %	10,5 %	9,75 %
2019	10,5 %	10,75 %	10 %	9,5 %
2020	9,75 %	10,5 %	9,75 %	9 %
2021	9 %	10 %	9 %	8,5 %
2022	8,5 %	9,5 %	8,5 %	8,25 %
2023	8 %	9 %	8,25 %	8 %
2024	7,50 %	8,5 %	8 %	7,75 %
2025	7,5 %	8,25 %	7,75 %	7,5 %
2026	7 %	8 %	7,5 %	7 %
2027	6,5 %	7,5 %	7 %	6,75 %
2028	6,25 %	7 %	6,5 %	6,5 %
2029	6 %	6,75 %	6,25 %	6,25 %
2030	5,75 %	6,5 %	6 %	6 %

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### III. The importance of analyzing inter-regional effects of EU policies – the application of the RHOMOLO model for Poland

**Figure 1.** Investments implemented from the European Structural and Investment Funds as a share of GDP in Polish NUTS-2 regions (%)

//Information from the bar chart is saved in the table. The values have been read approximately.//

	share of GDP in Polish NUTS-2 regions
Łódzkie	0,225 %
Mazowieckie	0,075 %
Małopolskie	0,23 %
Śląskie	0,17 %
Lubelskie	0,36 %
Podkarpackie	0,34 %
Świętokrzyskie	0,33 %
Podlaskie	0,33 %
Wielkopolskie	0,18 %
Zachodniopomorskie	0,26 %
Lubuskie	0,25 %
Dolnośląskie	0,18 %
Opolskie	0,26 %
Kujawsko-Pomorskie	0,25 %
Warmińsko-Mazurskie	0,37 %
Pomorskie	0,2 %

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**Figure 2.** Investment under cohesion policy as a share of GDP (bar chart) and the impact of cohesion policy on GDP as a % deviation from base GDP (solid line)

//Data from the charts are saved in the table. The values have been read approximately.//

	share in GDP	% deviation from base GDP
2014	0,75 %	0,1 %
2015	1,45 %	0,4 %
2016	2,1 %	0,9 %

	share in GDP	% deviation from base GDP
2017	2,5 %	1,4 %
2018	2,75 %	1,9 %
2019	2,9 %	2,4 %
2020	3 %	3 %
2021	2,4 %	3,4 %
2022	1,5 %	3,6 %
2023	0,25 %	3,5 %
2026		2,75 %
2029		2,3 %
2032		2 %
2035		1,6 %
2038		1,4 %
2041		1,3 %
2044		1,2 %
2047		1,1 %
2050		1 %
2053		0,9 %
2056		0,8 %
2059		0,7 %
2062		0,6 %

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**Figure 3.** Impact of cohesion policy on GDP (red chart) and employment (gray chart) in Polish voivodeships (as % deviation from baseline) in a very long term perspective (2063)  
 //Information from bar charts is saved in the table. The values have been read approximately.//

	GDP	employment
Łódzkie	0,7 %	0,5 %
Mazowieckie	0,4 %	0,25 %
Małopolskie	0,7 %	0,45 %
Śląskie	0,6 %	0,4 %
Lubelskie	0,8 %	0,55 %

Podkarpackie	0,95 %	0,7 %
Świętokrzyskie	0,9 %	0,65 %
Podlaskie	0,9 %	0,6 %
Wielkopolskie	0,55 %	0,4 %
Zachodniopomorskie	0,7 %	0,45 %
Lubuskie	0,65 %	0,4 %
Dolnośląskie	0,6 %	0,4 %
Opolskie	0,65 %	0,45 %
Kujawsko-Pomorskie	0,8 %	0,55 %
Warmińsko-Mazurskie	0,9 %	0,6 %
Pomorskie	0,65 %	0,45 %

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**Figure 4.** Impact of cohesion policy on exports of Polish voivodeships (as % deviation from baseline)

//Information from the line chart is saved in the table. Approximate values for the whole country and extreme values from provinces have been read.//

	min	Poland	max
<b>2014</b>	-1,7	-0,5	-0,2
<b>2016</b>	-3	-1	-0,5
<b>2018</b>	-2	-0,5	0,1
<b>2020</b>	-1	0,5	2
<b>2022</b>	1,5	3,5	8
<b>2024</b>	2	3	7
<b>2026</b>	1,5	2,75	5
<b>2028</b>	1,25	2,5	4,5
<b>2030</b>	1,2	2,25	4
<b>2032</b>	1,1	2	3,5
<b>2034</b>	1	1,8	3
<b>2036</b>	0,9	1,6	2,75
<b>2038</b>	0,8	1,5	2,5
<b>2040</b>	0,7	1,35	2,25
<b>2042</b>	0,6	1,2	2

	min	Poland	max
2044	0,55	1	1,9
2046	0,5	0,9	1,8
2048	0,5	0,85	1,7
2050	0,45	0,8	1,6
2052	0,4	0,75	1,5
2054	0,35	0,7	1,4
2056	0,3	0,65	1,3
2058	0,25	0,6	1,2
2060	0,2	0,55	1,1
2062	0,2	0,5	1

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**Figure 5.** Discounted cumulative differences in Poland's GDP between two scenarios: scenario assuming the implementation of cohesion policy throughout the EU minus the scenario assuming the implementation of this policy only in Poland (million euros).  
 //Information from the line chart is saved in the table. The values have been read approximately.//

	differences between the scenarios
2014	0
2017	-500
2020	-1100
2023	-1750
2026	-1500
2029	-1200
2032	-800
2035	-500
2038	-250
2041	0
2044	50
2047	100
2050	150
2053	200
2056	250

	differences between the scenarios
2059	250
2062	250

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**Figure 6.** Impact of cohesion policy implemented in Poland in the period 2014–2020 on the GDP growth of EU regions in the short term (2014 – left map) and in the long term (2063 – right map) as a % deviation from the baseline scenario

The figure shows two maps of the European Union countries.

// Information from the graphic is saved in the table. Values for individual countries were read, without division into regions.//

	2014 r.	2063 r.
Poland	0 – 0,352	0,006 – 0,932
Austria	-0,002 – 0	0 – 0,006
Belgium	-0,004 – -0,002	0 – 0,004
Bulgaria	-0,001 – 0,068	0,004 – 0,932
Croatia	-0,002 – 0,001	0 – 0,004
Cyprus	-0,004 – -0,003	0,002 – 0,003
Czech Republic	-0,002 – 0	0,006 – 0,932
Denmark	-0,001 – 0	0 – 0,002
Estonia	-0,001 – 0	0,006 – 0,932
Finland	-0,016 – -0,002	0,006 – 0,932
France	-0,016 – -0,001	0 – 0,006
Greece	-0,003 – -0,002	0 – 0,006
Spain	-0,004 – 0	0 – 0,006
Holland	-0,003 – 0	0 – 0,004
Ireland	-0,003 – -0,002	0,003 – 0,006
Lithuania	-0,001 – 0	0,006 – 0,932
Luxembourg	-0,003 – -0,001	0 – 0,003
Latvia	0,068 – 0,118	0,006 – 0,932
Malta	-0,016 – -0,004	0 – 0,002
Germany	-0,004 – 0	0,002 – 0,932
Portugal	-0,016 – -0,004	0 – 0,004
Romania	-0,004 – 0,068	0,003 – 0,932

	2014 r.	2063 r.
Slovakia	-0,002 – 0	0,006 – 0,932
Slovenia	-0,002 – -0,001	0,003 – 0,004
Switzerland	-0,003 – -0,001	0,003 – 0,932
Hungary	-0,003 – 0,001	0,003 – 0,932
UK	-0,016 – -0,003	0 – 0,932
Italy	-0,016 – -0,002	0 – 0,932

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**Figure 7.** Net present value of investments implemented in Poland under the cohesion policy for the EU

//Information from the line chart is saved in the table. The values have been read approximately.//

	net present value
2014	-2500 mln euro
2017	-15000 mln euro
2020	-22000 mln euro
2023	-12000 mln euro
2026	0 mln euro
2029	6000 mln euro
2032	10000 mln euro
2035	11000 mln euro
2038	9000 mln euro
2041	7500 mln euro
2044	7000 mln euro
2047	6000 mln euro
2050	5000 mln euro
2053	4000 mln euro
2056	3500 mln euro
2059	2500 mln euro
2062	2000 mln euro

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## IV. Quantitative foresight analysis at regional level – macroeconomic MASST model

**Figure 1.** Investment trends in three groups of countries before and after the financial crisis  
//Information from line charts is written in the tables. The values have been read approximately.//

### Low growth countries

	pre-crisis trend (1995–2008) TREND pre	post-crisis trend (2012–2017) TREND post	E_IFK annual investments
15-95	75000	50000	75000
15-96	78500	52500	78500
15-97	82500	54500	82500
15-98	86000	57000	86000
15-99	90000	59000	90000
15-00	93500	61500	73500
15-01	97000	64000	97000
15-02	101000	66000	101000
15-03	104500	68500	104500
15-04	108500	70500	108500
15-05	112000	73000	112000
15-06	115500	75500	115500
15-07	119500	78000	119500
15-08	123000	82000	120000
15-09	127000	84500	100000
15-10	130500	87000	96000
15-11	134000	89000	94000
15-12	138000	91500	91500
15-13	141500	94000	85000
15-14	145500	96000	80000
15-15	148000	985000	70000
15-16	149000	990000	80000
15-17	150000	100000	280000

## Medium growth countries

	pre-crisis trend (1995–2008) TREND pre	post-crisis trend (2012–2017) TREND post	E_IFK annual investments
4-95	150000	75000	150000
4-96	154500	80500	152000
4-97	159000	86500	155000
4-98	163500	92000	163500
4-99	168000	98000	170000
4-00	172500	103500	175000
4-01	177000	109000	177000
4-02	181500	115000	180000
4-03	186000	120500	184000
4-04	190500	126500	188000
4-05	195000	132000	192000
4-06	199500	137500	199500
4-07	204000	143500	206500
4-08	208500	149000	208500
4-09	213000	155000	177500
4-10	217500	160500	178500
4-11	222000	166000	180000
4-12	226500	172000	178500
4-13	231000	177500	177500
4-14	235500	183500	182000
4-15	240000	189000	185000
4-16	235000	195000	195000
4-17	250000	200000	225000

## High growth countries

	pre-crisis trend (1995–2008) TREND pre	post-crisis trend (2012–2017) TREND post	E_IFK annual investments
3-95	10000	-5000	12000
3-96	11500	-3500	13500
3-97	13000	-2000	1500
3-98	14000	0	1600
3-99	15500	1500	17500
3-00	17000	3000	17000
3-01	18500	4500	17500
3-02	20000	6000	17500
3-03	21000	8000	18000
3-04	22500	9500	20000
3-05	24000	11000	22000
3-06	25500	12500	25500
3-07	27000	14000	27500
3-08	28000	16000	28000
3-09	29500	17500	24000
3-10	31000	19000	24500
3-11	32500	20500	25000
3-12	34800	22000	24500
3-13	35000	24000	24000
3-14	36500	25500	25500
3-15	38000	27000	27000
3-16	39000	28500	28500
3-17	40000	30000	30000

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**Figure 2.** Average annual rate of regional GDP growth in 2018–2035 in the scenario reference (%)

The graphic shows a map of European Union countries. Shades of gray are designated for individual regions of the countries, according to the legend written below.

// Regions marked on the map with extreme values have been saved within the legend.//

Legend:

Average regional GDP growth rate:

1.  $< 0$ : northern Spain, southern France, small areas in southern England

2. 0.01 – 1.02

3. 1.03 – 1.95

4. 11.96 – 3.25

5.  $> 3.25$ : Ireland, eastern England, small areas in the south and north of France, central Sweden, northern Germany, northern Poland, small areas in Austria, Italy and Hungary, eastern Romania and Bulgaria.

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**Figure 3.** Differences between the average GDP growth rate (2008–2035) in the reference and “integration” scenarios at the regional level (percentage points)

The graphic shows a map of European Union countries. Shades of gray are designated for individual regions of the countries, according to the legend written below.

// Regions marked on the map with extreme values have been saved within the legend.//

Legend:

Average regional GDP growth rate:

1.  $< 0$ : none of the areas on the map are marked this way

2. 0.01 – 0.17

3. 0.18 – 0.28

4. 0.29 – 0.45

5.  $> 0.45$ : south-western Spain, a large part of Belgium and the Netherlands, Luxembourg, central Germany, eastern Bohemia, western Slovakia, eastern Bulgaria

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## V. The use of macroeconometric modelling in the evaluation of innovation policy

**Figure 1.** Impact of R&D support on EU GDP

//Information from the bar chart is saved in the table. Values are approximate.//

	GDP
2007	-0,005
2008	-0,01
2009	-0,015
2010	-0,02
2011	-0,015
2012	-0,01
2013	-0,005
2014	0,005
2015	0,01
2016	0,025
2017	0,03
2018	0,035
2019	0,045
2020	0,05

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**Figure 2.** An alternative scenario regarding the level of expenditure on innovation activities in enterprises – the scenario assuming the continuation of the lack of support in the following years.

//The information from the plane chart was saved in the table. The values have been read approximately//

	support in the years 2008–2016	long-term support
2008	0 %	
2009	-6 %	
2010	-12 %	
2011	-14 %	
2012	-14 %	
2013	-14 %	
2014	-15 %	
2015	-17 %	-18 %
2016	-10 %	-19 %
2017	-4 %	-19,25 %
2018	-1 %	-19,5 %
2019	-1 %	-19,75 %
2020	-1 %	-20 %
2021	-1 %	-20,25 %
2022	-1 %	-20,5 %
2023	-1 %	-20,75 %
2024	-1 %	-21 %
2025	-1 %	-21,5 %

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## VI. Innovation and competitiveness policy in the light of the VESPA model 3

**Figure 1.** National and regional models in VESPA

// The block diagram was saved as a numbered list. Additional information is written in square brackets.//

1. Poland [National model, national intervention]
    - 1.1. Aggregation module [Taking into account exchanges between regions]  
[Agreement on top-down and bottom-up analyses]
      - 1.1.1. Region 1 [Regional model, regional intervention]
      - 1.1.2. Region 2 [Regional model, regional intervention]
      - ...
      - 1.1.16. Region 16 [Regional model, regional intervention]
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**Figure 2.** Structure of the VESPA3 model

The graphic has a complex block diagram.

The main elements are:

**households, companies, government**

**Households and companies** are two-way connected by elements:

Labour market, Capital market, Goods market.

Capital and goods markets are connected with the Foreign component.

**The government** transfers contributions to the EU budget, from which European funds flow into the **government**. The second element dealt with by the **government** is the budget and other policies.

Other connections between schematic elements:

from European Funds to **Households** – Investments in human capital

from Budget, other policies to **Households** – Transfera

from **Households** to Budget, other policies – PIT, pod. kap.

from European Funds to **Companies** – Investments in capital and R&D, public infrastructure

from Budget, other policies to Goods market – Cons. publ.

from Goods Market to Budget, other policies – VAT

from Budget, other policies to the **Company** – Subsidies

from **Company** to Budget, other policies – CIT

from Budget, other policies to Capital market – Bonds

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**Figure 3.** Causal model of the effects of intervention in the economy

//The block diagram was saved as a numbered list.//

- 1. Direct effect:** The producer receives PLN 1 million in subsidies for implementing innovative production methods:
  - a new factory is being built
  - production increases

**2. Indirect effect:** Benefits are noted by entities in the beneficiary's supply chain:

- 500 thousand PLN goes to construction companies
- 500 thousand PLN goes to machine suppliers
- companies increase production and employment

**3. Induced effect:** Demand for products of all industries increases due to the increase in the remuneration of employees of the beneficiary and its suppliers:

- employment growth triggers companies competing for employees and pay rise
- an increase in wages results in an increase in consumption (spreading effects to a larger number of sectors of the economy and households)

**4. Fiscal effect:** Tax revenues increase as a result of increased activity or efficiency of the economy.

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**Figure 4.** Impact of PARP interventions on GDP in a given year, broken down by categories of support (deviation from the scenario without intervention in % – right figure, and cumulative value in PLN – left figure)

//Information from the charts is recorded in two tables. Line chart a) deviation from the scenario without intervention and bar chart b) cumulative value. In chart a) all values except the average are approximate.//

**a)**

	R+D	Production Sector	Export	Total	Average
2007	0 %	0 %	0 %	0 %	19 %
2009	0 %	0 %	0 %	0 %	19 %
2011	0 %	0,2 %	0 %	0,2 %	19 %
2013	0,1 %	0,6 %	0 %	0,8 %	19 %
2015	0,18 %	0,5 %	-0,05 %	0,6 %	19 %
2017	0,4 %	0,7 %	0,05 %	1,2 %	19 %
2019	0,1 %	0,1 %	0 %	0 %	19 %
2021	0 %	-0,3 %	0 %	-0,3 %	19 %
2023	0 %	-0,3 %	0 %	-0,3 %	19 %
2025	0 %	-0,3 %	0 %	-0,3 %	19 %

**b)**

expenditures	14 bn
Additional GDP (cumulated for the period 2007–2017)	92 bn

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**Figure 5.** Accumulated additional value of exports and imports for a given year (in PLN million)

// Information from the bar chart is saved in the table. The values have been read approximately.//

	Export	Import
2007	0 mln PLN	0 mln PLN
2009	0 mln PLN	0 mln PLN
2011	4 mln PLN	8 mln PLN
2013	5 mln PLN	20 mln PLN
2015	15 mln PLN	35 mln PLN
2017	40 mln PLN	65 mln PLN
2019	60 mln PLN	65 mln PLN
2021	80 mln PLN	50 mln PLN
2023	100 mln PLN	30 mln PLN
2025	120 mln PLN	5 mln PLN

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**Figure 6.** Expenditures under individual support categories vs. effect in the form generated thanks to the support classified into individual categories of GDP (cumulative value for the period 2007–2025)

//Bar (Extra GDP and Expenditure) and point (Performance Index) charts are recorded in the table.//

	R+D	Production Sector	Export
<b>Additional GDP</b>	20915 mln PLN	27604 mln PLN	351 mln PLN
<b>Expenditures</b>	1468 mln PLN	12383 mln PLN	438 mln PLN
<b>Performance indicator</b>	14,2	2,2	0,8

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**Figure 7.** Impact of intervention on output (left picture) and gross value added (right picture) in a given year, broken down by Eastern Poland and the rest of the country (deviation from the scenario without intervention, %)

//Information from the charts is recorded in two tables. Line chart a) impact of intervention on output and line chart b) impact of intervention on gross value added. All values except average values are approximate.//

**a)**

	Eastern Poland	Average – PL East	Rest of the country	Average – rest
<b>2007</b>	0 %	1,05 %	0 %	0,26 %
<b>2009</b>	0 %	1,05 %	0 %	0,26 %
<b>2011</b>	0,25 %	1,05 %	0,25 %	0,26 %
<b>2013</b>	1,8 %	1,05 %	1,3 %	0,26 %
<b>2015</b>	1,6 %	1,05 %	1 %	0,26 %
<b>2017</b>	2,5 %	1,05 %	1,5 %	0,26 %
<b>2019</b>	1,2 %	1,05 %	-0,4 %	0,26 %
<b>2021</b>	1,05 %	1,05 %	-0,5 %	0,26 %
<b>2023</b>	0,8 %	1,05 %	-0,4 %	0,26 %
<b>2025</b>	0,7 %	1,05 %	-0,3 %	0,26 %

**b)**

	Eastern Poland	Average – PL East	Rest of the country	Average – rest
<b>2007</b>	0 %	0,69 %	0 %	0,41 %
<b>2009</b>	-0,05 %	0,69 %	0 %	0,41 %
<b>2011</b>	0,5 %	0,69 %	0,5 %	0,41 %
<b>2013</b>	1,7 %	0,69 %	1,5 %	0,41 %
<b>2015</b>	1,5 %	0,69 %	1,2 %	0,41 %
<b>2017</b>	2,1 %	0,69 %	1,7 %	0,41 %
<b>2019</b>	0,3 %	0,69 %	-0,3 %	0,41 %
<b>2021</b>	0,2 %	0,69 %	-0,4 %	0,41 %
<b>2023</b>	0,2 %	0,69 %	-0,3 %	0,41 %
<b>2025</b>	0,15 %	0,69 %	-0,2 %	0,41 %

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## VII. Using DSGE models with frictional labour markets to evaluate public policies that strengthen territorial cohesion of EU countries

**Figure 1.** The basic structure of DSGE models

The block diagram shows the structure of DSGE models. At the centre of the diagram are the main elements: EXPECTATIONS that affect DEMAND and SUPPLY. EXPECTATIONS arise from blocks of political determinants that are influenced by political shocks. Demand, in turn, is affected by demand shocks, and supply is affected by supply shocks and productivity shocks.  
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**Figure 2.** Expenditure on active labour market programs as a% of GDP in 2016

//Information from the bar chart is saved in the table.//

	% Of GDP in 2016
Lithuania	0,52
Czech Republic	0,54
Slovakia	0,6
Latvia	0,64
Poland	<b>0,69</b>
Estonia	0,78
Hungary	1,18
Germany	1,45
Ireland	1,57
Portugal	1,68
Switzerland	1,73
Italy	1,8
Austria	2,29
Belgium	2,31
Holland	2,4
Spain	2,52
Finland	2,84
France	2,98
Denmark	3,22

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**Figure 3.** GDP per capita as% of the European Union average in 2018 (left map) and the unemployment rate in individual voivodeships in January 2019 (right map)  
 The drawings show the map of Poland divided into voivodeships.  
 // Data from drawings are saved in the table.//

Voivoidship	GDP per capita as a% of the European Union average in 2018	unemployment rate in individual voivodeships in January 2019
dolnośląskie	42,8 – 50,2	4,8 – 6,3
kujawsko-pomorskie	28,0 – 35,4	7,9 – 9,4
lubelskie	28,0 – 35,4	7,9 – 9,4
lubuskie	28,0 – 35,4	4,8 – 6,3
łódzkie	35,4 – 42,8	4,8 – 6,3
małopolskie	35,4 – 42,8	4,8 – 6,3
mazowieckie	57,6 – 65,0	4,8 – 6,3
opolskie	28,0 – 35,4	6,3 – 7,9
podkarpackie	28,0 – 35,4	7,9 – 9,4
podlaskie	28,0 – 35,4	7,9 – 9,4
pomorskie	35,4 – 42,8	4,8 – 6,3
śląskie	35,4 – 42,8	3,3 – 4,8
świętokrzyskie	28,0 – 35,4	7,9 – 9,4
warmińsko-mazurskie	28,0 – 35,4	9,4 – 10,9
wielkopolskie	42,8 – 50,2	3,3 – 4,8
zachodniopomorskie	28,0 – 35,4	6,3 – 7,9

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**Figure 4.** Employment efficiency of active labour market programs in% in 2018 (left map) and professional activity rate in % in 2018 (right map)  
 The drawings show the map of Poland divided into voivodeships.  
 //Data from drawings is saved in the table.//

Voivoidship	Employment efficiency of active labor market programs in% in 2018	activity rate in% in 2018
dolnośląskie	80 – 82,2	53,7 – 55,1
kujawsko-pomorskie	77,8 – 80	53,7 – 55,1
lubelskie	82,2 – 84,4	55,1 – 56,4
lubuskie	82,2 – 84,4	55,1 – 56,4
łódzkie	82,2 – 84,4	57,8 – 59,1
małopolskie	80 – 82,2	56,4 – 57,8
mazowieckie	80 – 82,2	59,1 – 60,5
opolskie	84,4 – 86,6	55,1 – 56,4
podkarpackie	84,4 – 86,6	53,7 – 55,1
podlaskie	84,4 – 86,6	56,4 – 57,8
pomorskie	84,4 – 86,6	56,4 – 57,8
śląskie	80 – 82,2	53,7 – 55,1
świętokrzyskie	75,5 – 77,8	53,7 – 55,1
warmińsko-mazurskie	77,8 – 80	53,7 – 55,1
wielkopolskie	80 – 82,2	59,1 – 60,5
zachodniopomorskie	82,2 – 84,4	53,7 – 55,1

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## VIII. On the role of quantitative research tools in shaping and assessing development policy

**Figure 1.** Diagram of the functioning of cohesion policy according to Barca and McCann  
The figure shows a block diagram divided into two main parts: Programming and Implementation.

### I. Programming

The strategy's needs. The strategy is mutually influencing thematic priorities and expected results (selection of program objectives, selection of result indicators). The strategy is influenced by politics through human resources and institutions. This impact is determined by the allocated FINANCIAL RESOURCES and expected products (outputs).

### II. implementation

Expended FINANCIAL RESOURCES and expected products (outputs) affect the achieved results (measurement of value change, price of progress in achieving goals). Other factors may also affect the results at this stage.

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**Figure 2.** A modified diagram of the functioning of cohesion policy

The information is presented in the same block diagram as in Figure 1. The only difference is the size of the elements – in this diagram the last element “Other Factors” is significantly enlarged, it covers about 40% of the entire drawing.

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