Investigaciones Regionales

asociación española de ciencia regional

N.º 29 • Special Issue 2014
ISSN: 1695-7253
E-ISSN: 2340-2717

Rhomolo and The European Cohesion Policy

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INTRODUCTION

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Section ARTICLES

Rhomolo and other methodologies to assess The European Cohesion Policy

Jesús López-Rodríguez *, Andrés Faíña **

ABSTRACT: The funds committed to cohesion policy are the second highest category of expenditure in the European Union budget and this policy is among the most evaluated. There are different tools and methodologies to carry out the evaluation each of them with their own merits and also their flaws and biases. This special issue explores the three main types of approaches, theory-based evaluation, counterfactual (econometrics) and macroeconomic models, to assess cohesion policy by presenting a set of contributions within these methodologies. The first set of contributions focus on the assessment of cohesion policy by means of macro models putting a special emphasis on the European Commission newly developed model RHOMOLO. The second set of contributions is linked to the econometric evaluations of different aspects of cohesion policy and finally a theory-based evaluation exercise closes this special issue.

JEL Classification: R11; R13; C54; C68.

Keywords: European Union; Cohesion Policy; regional development; macroeconomic models.

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* European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Knowledge for Growth Unit, Edificio Expo. C/ Inca Garcilaso 3, 41092 Seville, Spain. jesus.lopez.rodriguez@udc.es

** Grupo Jean Monnet de Competencia e Desenvolvemento na UE, Departamento de Analise Economica e ADE, Facultade de Economia e Empresa, Universidade da Coruña, Campus de Elviña s/n, 15071 A Coruña, Spain.

Guest editors Jesús López-Rodríguez and Andrés Faiña acknowledge the funding received from the Institute for Prospective Technological Studies (IPTS), Knowledge for Growth Unit to support the publication of this special issue. We are particularly grateful to Xabier Goenaga (Knowledge for Growth Head of Unit) and Andries Brandsma, (REMO project leader) for their specific support to produce this special issue. The first author also acknowledges the support received from the Spanish Ministry of Science and Innovation through the project ECO2011-28632 and Xunta de Galicia through the project EM2014/051. We also thank the organizers of the XXXIX annual meeting of the Spanish Regional Science Association which took place in Oviedo on 21-22 November 2013 and very specially Fernando Rubiera Morollón and Esteban Fernandez Vazquez for granting us with two special sessions to present and discuss some of the papers which end up contributing to this special issue. The inestimable collaboration, valuable comments and contributions of the reviewers is also gratefully acknowledged. The first author also wants to thank his IPTS colleague Wouter Torfs for the exchange of ideas and fruitful discussions we had while drafting this introduction. Finally, we would like to express our gratitude to Juan Ramon Cuadrado, the editor-in-chief of the journal, who has offered his support since the very first instances we started to draft and work on this special issue. The views expressed here are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Received: 1 july 2014 / Acepted: 1 septembre 2014.

Rhomolo y otras metodologías para evaluar la Política de Cohesión Europea

RESUMEN: La política de cohesión es la segunda más importante en el presupuesto de la Unión Europea y es una de las políticas más evaluadas. Existen diferentes herramientas y metodologías para realizar esta evaluación, cada una de ellas con sus propios méritos pero también con sus sesgos y fallos. Este número especial explora las tres aproximaciones más importantes para evaluar la política de cohesión, evaluación fundamentada en la teoría, análisis *counterfactual* (econometría) y modelos macroeconómicos, presentando un conjunto de contribuciones dentro de cada una de estas metodologías. El primer conjunto de contribuciones se centra en la evaluación de la política de cohesión a través de modelos macroeconómicos con una dedicación especial al nuevo modelo desarrollado por la Comisión Europea llamado RHOMOLO. El segundo conjunto de contribuciones se basa en evaluaciones econométricas de diferentes aspectos de la política de cohesión, y finalmente el monográfico se cierra con un ejercicio de evaluación fundamenta en la teoría.

Clasificación JEL: R11; R13; C54; C68.

Palabras clave: Unión Europea; política de cohesión; desarrollo regional; modelos macroeconómicos.

1. Introduction

The European Cohesion Policy (ECP) is one of the major investment tools in the European Union (EU). Roughly a third of the EU budget is assigned to this policy domain with the objective of supporting job creation, enhancing competitiveness and economic growth and improving quality of life and sustainable development (EU Commission, 2010). The cohesion policy is one of the most evaluated policies, however capturing both ex-ante and ex-post macroeconomic impacts of ECP is intrinsically a very complex exercise.

A variety of different tools and methodologies have been developed and used by scholars and institutions to carry out such evaluations, each of them with their own merits but also with their flaws and biases. The three main approaches to assess the effect of EU financial transfers on the key magnitudes of growth, investment and employment are the theory-based evaluation (see for recent contributions Bachtler *et al.,* 2013; Faíña *et al.,* 2013a, 2013b), the counterfactual analysis including the econometric exercises (Cancelo *et al.,* 2009; Dall'erba *et al.,* 2009, Rodríguez-Pose and Fratesi, 2004 and Villaverde and Maza, 2010) and the use of macroeconomic models (Bradley *et al.,* 1995; Cardenete *et al.,* 2013, Márquez *et al.,* 2010; Sosvilla, 2009, Varga and in 't Veld, 2011).

This special issue brings together the three main approaches to the analysis of the impact assessment of European cohesion policy by presenting some of the most recent contributions within these methodologies. The first set of contributions focus on the assessment of cohesion policy by means of macro models putting a special emphasis on the European Commission newly developed model RHOMOLO. The second set of contributions is linked to the econometric evaluations of different aspects of cohesion policy and finally a theory-based evaluation exercise closes this special issue. The interest of this issue is to prompt new reflections and debate among the academic community and public policy makers on the techniques used for measuring the economic impact of EU funds. Taking into account that this evaluation is a complex process a particular attention to the techniques used to carry out the evaluation should be taken. The need to ensure the existence of enough available data to carry out the exercises and prompting the collaboration with research institutes and universities should also be considered among the top priorities for achieving the success in this important task.

The rest of the paper is structured as follows: section 2 briefly summarizes the main contributions to the monograph which are based on the use of the RHOMOLO model, section 3 does the same for the contributions based on other macro models, and econometric exercises and finally section 4 comments on the theory-based evaluation exercise.

2. The Rhomolo model as a tool to assess the impact of the European Cohesion Policy

The evaluation of the Cohesion Policy by the European Commission (DG Regio) has been largely based on two macroeconomic models: HERMIN (Bradley et al., 1995) and QUEST (Varga *et al.,* 2011, Varga and in ‘t Veld, 2011). These models have different theoretical underpinnings and sector coverage. QUEST belongs to the class of Dynamic Stochastic General Equilibrium (DSGE) models and has only one sector producing intermediate inputs, whereas HERMIN is a system of macroeconomic models which offer much higher level of disaggregation. However, these models are applied at the level of EU Member States (MS) and cannot be employed to analyse economic developments at regional level, according to the European Nomenclature of Territorial Units for Statistics (Eurostat, 2006). One important shortcoming when using these macroeconomic models for the evaluation of cohesion policy is that they lack the ability to produce results at regional level. This shortcoming was pointed out in a special report made by the European Commission Court of Auditors in 2006 (Special Report No 10/2006) on the ex post evaluations of the former objectives 1 and 3 programmes 1994 to 1999. It became even more pressing with the Barca 2009 report emphasizing the place-based nature of European cohesion policy. The RHOMOLO model developed by the DG REGIO with the collaboration of JRC-IPTS fulfils the shortcoming previously mentioned since it is a general equilibrium model which produces results at the level of EU NUTS2 regions.

The lead article of this special issue by Brandsma *et al.* uses the RHOMOLO model to estimate the ex-ante impact of the cohesion policy over the period 2014-2020 on GDP in the 267 NUTS 2 regions of EU27. After a brief overview of the

2014-2020 ECP financial envelope, the paper outlines the main building blocks of the RHOMOLO model. Then it describes the four scenarios which represent the main channels over which the structural funds flow: increase human capital through investment in training and other related policies, provide public funding assistance to the private and public sectors via R&D and Non-R&D subsidies thus increasing factor productivity and increase investment in order to improve the physical infrastructure as a basis for stimulating private sector productive activity. These financial expenditures are assumed to affect a set of parameters including factor productivity and transport costs that determine the model outcomes. The results of the simulations show that the overall effect of the four set of investments can clearly be expected to be positive, especially for most of the regions in the Member States which joined in the past decade. This fact is correlated with the distribution of Cohesion Policy support which is much higher for less developed regions.

Di Comite and Potter's investigation proposes one extension of the RHOMOLO model devoted to the study of knowledge creation, investment decisions and economic growth by capturing the interactions between researchers, investors and final good producers. The starting point for the design of their knowledge production block and its integration with the rest of the economy comes from the formulation in Romer (1990). This formulation was later implemented in QUEST III a macroeconomic DSGE model for the Eurozone (Varga and in 't Veld 2010). The future updates of RHOMOLO and its simulation results will greatly benefit from this theoretical piece of research since full endogenous knowledge production and investment decisions at the regional level could be incorporated to the current model's structure. However as the authors clearly point out, some challenges could arise at the implementation phases due to data constraints and the model's large dimensions (267 EU regions and 6 sectors).

RHOMOLO would fall short of a full-fledged equilibrium model without a well-modelled labour market. Regional labour markets serve as important adjustment channels to macro-economic shocks. In the third contribution of this special issue, Persyn *et al.* address this concern by describing the functioning of RHOMOLO's labour market. In a standard labour market setting, regional demand shocks are translated into changes in local employment. Local employment changes can in turn be decomposed into three components: changes in labour force participation, changes in unemployment and changes in migration. The authors elaborate on how each of these channels are modelled. First, RHOMOLO incorporates the participation decision of workers, both at the extensive and the intensive margin. Second, regional unemployment is pragmatically modelled by means of wage curve, which inversely relates wage to unemployment. Finally, interregional migration decisions are based on a discrete-choice framework, in which the migration elasticities are estimate econometrically. The paper additionally discusses possible paths for future development.

The evaluation of the macro-economic impacts of innovation activities induced by R&D is by now well established in the CGE and DSGE frameworks (Bye *et* *al.,* 2006, Křístková, 2013, Varga *et al.,* 2011). However innovation can take place through activities which do not require R&D *senso stricto* such as the purchase of licenses, patents and software. Diukanova and López-Rodríguez's investigation deals with the analysis of the impact of the ECP 2014-2020 financial investments allotted to innovation activities other than R&D (non-R&D) in the EU regions using the RHOMOLO model. Assuming that these innovation activities increase total factor productivity and that the RHOMOLO model requires externally elasticities to be supplied from other specific studies, they use López-Rodríguez and Martínez (2014) elasticity estimations to perform their simulations. The main results show that the biggest impact of the funds is reached in the regions belonging to the Central and Eastern European countries.

3. Other macro models and econometric studies to assess the European Cohesion Policy

De Miguel e*t al.*'s paper focus their analysis of the impact of the European cohesion policy on the specific case of the Extremadura region. Specifically the paper aims to evaluate the effects that an increase of public final demand financed with the European funds may have in the economy of Extremadura. These effects are measured using a SAM (Social Accounting Matrix) model, which is an extension of Input-Output models and uses a SAM as database. The database is the SAM for Extremadura in 2000 (SAMEXT2000) elaborated by de Ramajo *et al.* (2009). After presenting an overview of two macro variables, GDP (Gross Domestic Product) and employment, and the evolution of population in the region in 2000-13, they evaluate the effects of raising investment demand. The main conclusions are that agriculture and market services are the most affected sectors, especially the former, in line with the main source of European funding. Regarding employment, Market services capture the biggest effects. According to their results, every million euros invested in Extremadura with European funds in the period 2007-13 generated around 67 new jobs in the region.

Álvarez-Martínez manuscript reviews a rather small set of literature that has examined the response of Spanish regions to European Structural Funds. It does so by first laying out the priority objectives of the funds and then pointing to regions in Spain that have received them (and how much). In doing the latter, it discusses why some regions have phased into and out of receiving the funds over time.

From this base, the paper moves to a discussion of the general equilibrium effects of the Structural Funds and immediately identifies the four papers that have used regional CGE models. The analyses are all recent and are limited to Madrid and Andalusia. Interestingly the author finds that the existing studies strictly examine the short-run effects of the investment spending of the Structural Funds. That is, all four papers fail to examine the true purpose of the structural funds, which is to improve long-run productivity by investing in human capital and key elements of public infrastructure. As the present author notes «we do not build roads... for their impacts on construction jobs but rather because they enable the delivery of products and people at lower cost... we do not fund [education and training] programs to enhance universities and schools, but rather to improve the capabilities... of workers».

Subsequently, the author cleverly uses the misguided analysis of the reviewed studies as a springboard to discuss new official Spanish databases on gross fixed capital formation.

The Maza *et al.*'s paper studies the impact of R&D investment, measured by the number of patents per million inhabitants, in Spanish growth and convergence at the level of NUTS3 regions (Spanish provinces). After a review of the theoretical and empirical literature on the topic, the authors started their econometric exercise by estimating an absolute beta-convergence equation for the Spanish provinces over the period 1996-2009 which was used as a benchmark for the subsequent estimations. Then, this equation is modified in subsequent stages to incorporate the effect of patents on the income growth in the Spanish provinces and also several control variables in order to test for the robustness of the results. The authors also report results using spatial econometric techniques to control for the existence of spatial dependence in their beta-convergence estimations. The results of this investigation show that first, patents have acted as a growth driver in the Spanish economy over the period 1996-2009. Second, no presence of spatial spillovers for the period under analysis is found. And, third, the effect of patents on growth seems to be higher for developed than for less developed provinces. These results can be used as a lesson for the design of future cohesion policy programmes since a big share of the ECP financial investments go to finance innovation related activities in the European regions. In view of the authors' findings, major efforts should be devoted to promote a cohesion policy focused on R&D investment in the less developed territories.

It is well known that a great heterogeneity exists regarding the endowment of public and private, material and immaterial assets across EU regions. Within this context, Fratessi and Perucca's paper assesses the role of these specific territorial endowments labelled as «territorial capital»[1] on the efficient implementation of Cohesion policies in Central and Eastern European NUTS3 regions. The authors overall results postulate that regions more endowed with territorial capital are more able to benefit from the policy support of structural funds investment and that for a substantial number of territorial capital assets, increasing returns are present and therefore regions more endowed with specific types of territorial capital are more able to gain from policy investment in related fields. These results, as the authors state, pose a trade-off between the effectiveness of the European cohesion policy and the convergence and catching up stimulus they can achieve, i.e., investing cohesion funds in regions with more «territorial capital» leads to greater returns than investing them in poorer regions. The authors' suggested way out of this dilemma is to use the structural funds to build this type of capital which eventually will end up in enhancing the long run growth of the poorest regions.

[1] See Camagni (2008) for a taxonomy on the types of territorial capital.

Disparities in the levels of regional development are a well-established feature of the European economies. These disparities are largest within Central and Eastern European countries when comparing capital and non-capital city regions. Foreign direct investment could be an off-setting factor for regional disparities if it is channelled towards second tier city regions. The Dogaru *et al.*'s paper analyses the locational choices of multinational corporations (MNCs) in Central and Eastern Europe (CEE) between 2003 and 2010 focusing particularly on the location choices of capital city regions versus second tier city regions in the networks of foreign direct investments. The econometric exercise carried out by the authors (conditional logit regression) found that the most important location factors for FDI are market accessibility, strategic assets, institutional quality and agglomeration. These factors, at the present stage, cannot be offered simultaneously in CEE second-tier city regions and consequently competitiveness opportunities are difficult to obtain. The paper emphasizes the need for more European involvement in redirecting financing towards secondary city regions. According to the authors' view cohesion policy should partly shift its support from offsetting deficient regional growth to encouraging secondary growth centres. EU guidelines should recognize the importance of more decentralized regional development.

4. Theory-based evaluations on the European Cohesion Policy: The case of Andalucía

Romero and Fernández-Serrano's investigation closes this special issue by discussing the significance, trends and achievements of entrepreneurship promotion in Andalusia within the framework of the European cohesion policy financial investments carried out in the regions since the launching of the first programming period, the Delors I package (1989-1993) until the recently finished one (2007-2013). After a thorough discussion of the European Union cohesion policy and ERDF initiatives regarding to entrepreneurship in Andalucía in sections two and three, the authors move on to present an evaluation of the impact of these initiatives. This evaluation is made using several regional indicators such as business density, demography and total entrepreneurship activity, among others. The analysis of the experience of Andalusia allows the authors to draw some lessons and make recommendations for a more effective and efficient design of cohesion policy in support of entrepreneurship, which go beyond the particular case under study. Some of these recommendations are already incorporated in the current design of the ECP programmes. Among them it is important to underline *a)* the need of having a productive system with enough absorption capacity for an efficient use of the European Structural and Cohesion instruments, *b)* the need of a long run view for this type of policy actions since it is not possible to substantially change the entrepreneurial culture in a region with structural deficiencies in the short or medium run, *c)* the need of taking demand considerations into account and to apply a bottom-up approach granting an important role to private and intermediate agents, *a)* the need of moving away from a «subsidy» culture and potential rent-seeking behaviour by using other type of instruments such as reimbursable funds, credit guaranties or loans.

5. Conclusions

The interest of this issue was to prompt new reflections and debate among the academic community and public policy makers on the techniques used for measuring the economic impact of EU funds. The evaluation of the European Cohesion policy is a complex process and we believe that this special issue of Investigaciones Regionales contributes to its general understanding. It provides an overview of the progress that has been accomplished over the past decades, and highlights present day state-of-the-art techniques that are currently used in the evaluation process. The different contributions stress the need to keep the academic debate alive, since many hurdles are still to be overcome. It is our hope that this special issue paves the way for new collaborations between research institutes and universities, which should be considered to be a top priority for future progress on the subject.

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ARTICLES

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Section ARTICLES

Assessing policy options for the EU Cohesion Policy 2014-2020

Andries Brandsma *, Francesco Di Comite *, Olga Diukanova *,
d'Artis Kancs *, Jesús López Rodríguez *, Damiaan Persyn *
and Lesley Potters *

ABSTRACT: In this paper we analyse the possible impact of Cohesion Policy 2014-2020, putting together the investments supported by EU funding in all NUTS2 regions and running a set of simulations. We make use of RHOMOLO, a spatial CGE model tailored for economic analysis at the subnational level, which is described in the paper. We do so by first considering infrastructure investment, human capital development and innovation climate support, including environmental amelioration, separately and then run a combined simulation of the three categories to give an impression of the pattern and time profile of the overall effect. The results of the simulation show substantial heterogeneity in the effects across the regions, which are not a mere image of the differences in input. The concentration of EU funding on the less developed regions, and on energy saving, innovation and social inclusion in the more developed regions receiving support, could be a fruitful mix for lifting the standards of living in the whole of Europe.

JEL Classification: R13; R58; H54; O32.

Keywords: *RHOMOLO; multiregional spatial CGE; Cohesion Policy.*

Evaluación del impacto de la Política de Cohesión de la UE 2014-2020

RESUMEN: En este trabajo analizamos el posible impacto de la Política de Cohesión de la UE 2014-2020, teniendo en cuenta todas las inversiones financiadas con los fondos estructurales europeos en el conjunto de las regiones NUSTS2 de la UE y simulando un conjunto de perturbaciones. Para ello se usa el modelo RHOMOLO, un modelo espacial de EGC que está diseñado para el análisis económico

* *European Commission, DG JRC-IPTS.*
The authors acknowledge helpful comments from Philippe Monfort, participants of the XXXIX conference of Regional Studies in Oviedo, as well as participants of seminars and workshops at the European Commission. The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Received: 06 january 2014 / Accepted: 16 september 2014.

a nivel subnacional. El conjunto de simulaciones considera primero y de forma separada los impactos de las inversiones en infraestructura, capital humano y el apoyo a los temas de innovación incluyendo las mejoras medioambientales. En una segunda fase se realiza una simulación conjunta de las tres categorías de gasto para tener una impresión del patrón y del perfil temporal de los efectos totales. Los resultados de la simulación muestran una sustancial heterogeneidad en cuanto a los efectos en las distintas regiones, los cuales no son una mera imagen de las diferencias en términos de *inputs*. La concentración de la financiación de la UE en las regiones menos desarrolladas, y en ahorro energético, innovación e inclusión social en las regiones más desarrolladas podría ser una mezcla exitosa para elevar los niveles de vida en el conjunto de Europa.

Clasificación JEL: R13; R58; H54; O32.

Palabras clave: *RHOMOLO; EGC multirregional y espacial; Política de Cohesión.*

1. Introduction

Greater scrutiny over the performance of Member States and regions benefiting from the European Structural and Investment Funds (ESIF) is part of the design of the EU cohesion policy for 2014-2020, distinguishing it from previous rounds. This goes together with concentration of funding on 11 main lines of support and, geographically, on the less developed among the 271 regions. Each region is expected to have a strategy for using the funds, identifying both the starting point and the potential for economic and social development, and indicating the region-specific targets that have been set. Quantification is essential and required. In principle, funds could be withheld, or the allocation for the next period lowered, when these conditions are not met.

This paper presents the spatial computable general equilibrium (CGE) model that has been developed by the European Commission for assessing the impact of the regional policy choices, taken together rather than individually. The main purpose of the paper is to show the pattern of impacts across the regions for the two broad options of investing in the infrastructure connecting the regions and investing in the economic potential of the less developed regions. Although this can be refined to simulate the impact of the more detailed policy choices of individual regions, it will remain problematic to establish, ex post, to what extent a deviation from the targeted impacts is caused by not implementing the policies as intended and to what extent by external effects beyond the control of the region concerned, including those induced by the strategies of other regions.

The use of models in policymaking is often justified by the multitude and complexity of interaction between agents, and some arguments for regional modelling put forward in this paper are no exception. However, it needs to be recognised upfront that it is precisely the objective that all regions should benefit from the single market, primarily by improving the competitive position of the less developed regions, which makes evaluating cohesion policy so difficult. In their own right, the number of regions and the challenges to multilevel governance do not constitute convincing arguments for modelling. What needs to be captured foremost is the high degree of interdependency between the deepening of economic integration and the increased potential of the regions to benefit from integration.

From its inception in 1988, EU cohesion policy has been accompanied by a growing literature, concerned with the process and its evaluation [1]. The most recent overview is in Bachtler, Méndez and Wishlade (2013). Their analysis challenges the view that cohesion funding is just another battleground for Member States fighting over EU spending. Earlier rounds of cohesion policy are covered in volumes edited by Cuadrado and Parellada (2002), Bachtler and Wren (2006), Cuadrado and Marcos (2005) and Garrido *et al.* (2007).

In the absence of a regional model, the Commission has had to rely on macroeconomic and multi-sector models for its assessment of the impact of cohesion policy. The use of the QUEST III endogenous *R&D* model is set out in Varga and In't Veld (2011). This is the Commission's in-house dynamic general equilibrium model linking the economies of the Member States and the rest of the world, but no deeper than at the national level. Economic development may be reflected by the sectoral composition of national output. In order to capture the sectoral shift induced by regional policy the Commission has made use of the HERMIN model for a subset of the Member States (Bradley *et al.,* 2003). The analysis is laid out in Gakova, Grigonyte and Monfort (2009), also considering possible extensions to a system of models at sub-national level. In essence, after taking into account conceptual difficulties and computational limitations, this has led to the construction of the spatial CGE model at NUTS2 level presented in this paper [2].

The current version of RHOMOLO covers 267 NUTS2 regions of the EU27 [3], with total production divided into six sectors. Goods and services from home and abroad, that is to say other regions within the same country and (the regions of) other countries, are consumed by households, government and firms. The households in each region receive income from labour, capital and transfers. The geographic interrelations between pairs of regions are obtained through a matrix of asymmetric bilateral transport costs for trade between regions derived from the transport model TRANSTOOLS (Burgess *et al.,* 2008; Petersen *et al.,* 2009).

The CGE approach allows for the interaction between regions to be captured within a fully consistent framework solving for simultaneous equilibrium in the goods, services and factor markets, but may run into computational limitations if the number of regions and sectors becomes very large. It therefore needs to be imposed

[1] For more information on the evaluation of past Cohesion Policy measures and on the future and on the strategies and plans for the next programming period, see the Sixth report on economic, social and territorial cohesion (European Commission, 2014).

[2] Ferrara, A., Ivanova, O. and Kancs, D. (2010) provide a formal description of the prototype.

[3] The full inclusion of the two Croatian regions is waiting for the data to become available. The impact on the country as a whole is simulated with the help of the QUEST model.

that each sector produces just one composite good and the usual Dixit-Stiglitz and Armington assumptions are made to keep the system of equations manageable. More fundamentally, although the model is derived from optimization by representative economic agents, forward-looking expectations consistent with model outcomes cannot be handled within the current set-up. Bradley (2006) already recognised the challenge of reconciling bottom-up micro-analysis with top-down macro-analysis. The approach taken in this paper is to align the RHOMOLO results with the aggregate impact generated with QUEST under model-consistent expectations. To the extent possible the two models are made to share the microeconomic foundations, whereas the rich dynamics of the QUEST III endogenous *R&D* model are superimposed on the sequence of solutions over time of the spatial CGE model.

The paper is organised as follows. First, Section 2 provides some further background on EU cohesion policy and the changes that are envisaged. Section 3 gives a brief technical description of RHOMOLO, touching upon its structure, characteristics and dynamics. Section 4 describes in detail the design of the four main scenarios that have been simulated (Human Capital, *R&D*, Non-*R&D* and Infrastructure investments) and Section 5 presents the outcomes of these simulations as deviations from the baseline without cohesion policy interventions. Finally, Section 6 concludes.

2. Concentration of funding under EU cohesion policy

EU cohesion policy has its roots in the Treaty of Rome, but it was on the waves of the single market and the European Union's enlargement that the policy got its present size and shape. All together, the ESIF are the second largest comprehensive part of the EU budget, absorbing roughly one third of the expenditure[4].

The ESIF are three different funds with their own objectives and stakeholders:

— The Cohesion Fund available to Member States with a *GDP* per capita of less than 90% of the EU average supports investment aimed at fulfilling the convergence objective. Its main activities are directed at improving the trans-European transport (TEN-T) networks and the environment, notably in the fields of energy or transport (e.g., supporting energy efficiency, the use of renewables, public transport, inter-modality);

— The European Social Fund (ESF) is the EU's main financial instrument for investing in people. It increases the employment opportunities of European citizens, promotes better education and helps containing the risk of poverty. The ESF covers measures aimed at fostering lifelong learning schemes, reducing search and matching costs in the labour market, promoting social

[4] There are two additional funds that fall under the Commission's Common Strategic Framework: the European Maritime and Fisheries Fund (EMFF) and the European Agricultural Fund for Rural Development (EAFRD). They are not taken on board in the analysis of this paper since, strictly speaking —and although they serve structural reform purposes— they are generally not considered to be part of EU cohesion policy.

integration, combating discrimination and strengthening human capital by reforming education systems;

— The European Regional Development Fund (ERDF) aims to strengthen economic, social and territorial cohesion in the EU by correcting imbalances between regions. The ERDF supports regional and local development, including actions in the field of sustainable urban development.

The combination of the Structural Funds (ESF and ERDF) and the Cohesion Fund amounted to 347 billion euros, equivalent to roughly 0.3% of EU-27 *GDP*, in the programming period 2007-2013. For individual regions, the financial support can be as high as 4% to 5% of their *GDP*. The support is provided under the principles of additionality and partnership. Concentration and multi-annual programming are the tools for aligning the use of the funds to EU objectives and priorities. Additionality refers to the requirement that contributions from the structural and cohesion funds are not simply substituted for national expenditures already planned. Partnership requires a collective process involving authorities at European, regional and local level, social partners and organisations from civil society[5].

The funds are the EU's instruments for channelling the contributions of the Member States into investments in infrastructure, people and the environment, primarily through financial support provided at the regional level. In the words of the Treaty of Lisbon, in order to promote its overall harmonious development, the Union shall develop and pursue its actions leading to the strengthening of its economic, social and territorial cohesion. The Union aims at reducing disparities between regions with a particular focus on the backwardness of the least favoured regions.

2.1. How to model EU cohesion policy

Over the years, the emphasis of cohesion policy has shifted from an attempt to shield the countries and regions from the consequences of fiercer competition within the single market to a strategy of enhancing the potential of the regions to take greater advantage of European integration. What this means for the approach followed in this paper is that RHOMOLO should be able to capture both the lowering of barriers between regions, reflected in shifts in inter-regional and cross-border trade, and the increased potential of the regions resulting from the access to the ESIF. The model is set up to deal with the broad strokes of policies to stimulate growth, employment and competitiveness at the regional level, rather than the detailed channels of financial support of the structural and cohesion funds.

RHOMOLO as it stands has three major handles for putting in the interventions under cohesion policy:

— the reduction of transport cost resulting from the investment in infrastructure, differentiated for the bilateral connections between each pair of regions;

[5] See *http://ec.europa.eu/regional_policy/index_en.cfm* for more detailed information about Regional Policy.

— the shifts in labour productivity resulting from the investments in human capital, which have a distinct profile with highly positive effects in the long term and possibly negative in the short run; and
— the improvement in total factor productivity, outside the labour-capital bundle, which represents technical progress and innovation among other factors behind regional economic growth.

In addition, it would be possible to assign some interventions to sectors of economic activity and to use the cost of newly built-up physical capital as a parameter. For instance, the sector of construction may benefit heavily from particular investments in infrastructure. However, it is far from obvious in which region the companies benefiting from such investments would be located. The demand effects in the simulations of this paper are therefore left to the inner workings of the model, including the input-output relations embedded in the production structure.

Table 1 shows the result of grouping the lines of expenditure into macro categories for the purpose of the simulations.

Table 1. Details on Cohesion Policy expenditures (in € millions). *GDP* values are reported for 2007 because that is the year used for the calibration of the model due to data availability at the regional level

Region type[1]	*#*	*GDP 2010*	*RTDI*	*Aid to private sector*	*Infras-tructure*	*Human Capital*	*Techni-cal Assis-tance*	*Total*	*%*
Less Developed Regions	65	1,199,595	25,250	27,127	129,128	38,408	12,162	232,075	68
Transition Regions	51	1,466,019	5,772	6,218	14,339	10,201	1,585	38,115	11
More Developed Regions	151	9,539,148	10,916	9,101	24,167	24,196	2,954	71,335	21
Total	267[2]	12,204,762	41,938	42,447	167,634	72,805	16,701	341,525	100
% of total CP			12%	12%	49%	21%	5%	100%	

[1] The less developed regions have a GDP per capita that is less than 75% of the EU-27 average. The GDP per capita of the transition regions is between 75% and 90% of the EU-27 average and for the more developed regions this is above 90%.
[2] The EU27 has a total of 271 NUTS2 regions, but 4 French regions are left out because of their very particular characteristics: Guadalupe, Martinique, Guyana and Réunion. The two Croatian regions are not included yet because of limited data availability.

Funds designated to *Human Capital* aim at bringing improvements to the labour markets by investing in training and education of employees. As can be seen, the vast majority (68%) of the funds is allocated to the less developed regions. The joint human capital expenditures are assumed to translate into an improvement of labour productivity in the model. The full setup of the simulation is discussed in section 4.1.

Funding for *Research, Technical Development and Innovation* (*RTDI*) is aimed at supporting firms with the uptake of novel research findings in the actual implementation of innovations. The *RTDI* related expenditures are assumed to affect the innovation capacity of the economy, which is translated into changes in the total factor productivity (*TFP*) parameter of the model. Section 4.2 discusses the set-up of the *TFP* simulations in greater detail.

The category *Aid to Private Sector* covers support to activities that are not immediately associated with *R&D*. They nevertheless can play an important role in the economic development of countries and regions that are at a considerable distance from the technology frontier by easing the way towards that frontier and raising *TFP*. These non-*R&D* innovation activities consist e.g. of technology and know-how acquisitions, such as machinery and other equipment patents, trademarks, designs, etc. In Europe, about 40-60% of the industrial value-added and 50% of all industrial employees are engaged in the non-*R&D* intensive sector (Som, 2012). Moreover, more than half of all innovating firms in the EU are non-*R&D* performers (Arundel *et al.*, 2008). Therefore, considering the high shares of funding devoted to the non-*R&D* activities and the importance of these activities in the promotion of innovation and *TFP* growth in Europe, it is important to evaluate the ex-ante effects of the planned regional non-*R&D* investments across EU regions. More details are provided in Section 4.3.

Funds aimed at investment in *Infrastructure* mainly support regions in improving connectivity within the region and with other regions. The main focus is on railways, motorways and airports, as well as on improving the environmental and social infrastructure of the regions. The investments can be expected to lead to a decrease in transport costs, as well as in the general cost for doing business. For instance, they may lower the cost of communication, making it easier to sell final goods or source intermediates. These investments will be modelled as a reduction of the transport costs. The setup is discussed more in detail in Section 4.4[6].

The envelope is spread over the years based on the experience of past Community Support Frameworks. In addition, the N+3 rule[7] is applied, so that the *expenditures* run from 2014 to 2023. The assumed time profile is shown in Figure 1. The same profile applies to all regions and they are expected to be able to increase their absorption capacity as compared to the 2007-2013 programming period. It is assumed that by 2018 more than 50% of the allocated funds will have been spent and up to 80% by 2020.

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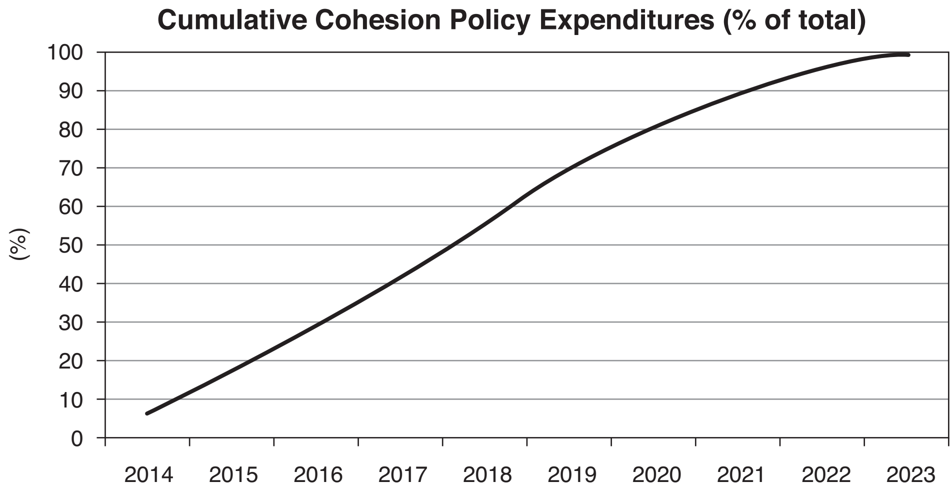
[6] Given its relatively small size in the overall budget and the difficulty to model it in a consistent way, the category *Technical Assistance* has not been modelled. It mostly concerns technical support provided to regions or local authorities for streamlining bureaucratic procedures, public programming and auditing.

[7] The Commission shall automatically «decommit» any part of a commitment which has not been settled by the payment on account or for which it has not received an acceptable payment application by the end of the third year following the year of commitment.

Figure 1. Time Profile of Cohesion Policy expenditures



2.2. The main themes of EU cohesion policy for 2014-2020

The 2014-2020 round of cohesion policy is characterised by a concentration of funding, geographically as well as thematic. It mirrors closely the EU 2020 objectives with their focus on sustainable growth, creating jobs within an inclusive society. In comparison with the previous round, the number of lines of expenditure under which structural and cohesion funding is spent has been concatenated, partly reversing the proliferation of projects. The eleven thematic objectives for delivering Europe 2020 through ESIF are:

1. Strengthening research, technological development and innovation.
2. Enhancing access to, and use and quality of, information and communication technologies.
3. Enhancing the competitiveness of small and medium-sized enterprises, the agricultural sector and the fisheries and aquaculture sector.
4. Supporting the shift towards a low-carbon economy in all sectors.
5. Promoting climate change adaptation, risk prevention and management.
6. Protecting the environment and promoting resource efficiency.
7. Promoting sustainable transport and removing bottlenecks in key network infrastructures.
8. Promoting employment and supporting labour mobility.
9. Promoting social inclusion and combating poverty.
10. Investing in education, skills and lifelong learning.
11. Enhancing institutional capacity and an efficient public administration.

Looking more closely at this list, it appears that only items 9-11, and perhaps 3, are clearly related to improving the economic and social situation of the least favoured regions. Themes 4-6 are directed at making the European economy more resource efficient —less energy dependent— and contributing to climate change targets. Regions may learn some lessons on best practices from one another and from light competition on environmental attractiveness between them, but air pollution and global warming are not contained within regional borders and typically need to be sorted out at the supranational level. The use of structural and cohesion funds for environmental purposes is mostly related to urban development, nature, water and waste. Other themes —focusing on research and innovation (1), ICT (2), transport (7) and mobility (8)— have as much to do with the interconnection of regions as with remedying their backwardness, and assigning them to the regions, as in Table 1, is somewhat arbitrary.

From a modelling point of view, there would be no need to have a full allocation of funds to the regions. The model itself generates the regional distribution of the returns on the investment, some of which will be tied to the region and another part to the connections between the regions. This is in fact the way it has been implemented in RHOMOLO for the purpose of the exercises in this paper. The budget for cohesion policy post-2013 amounts to 380 billion euros in total, including 40 billion euros for the Connecting Europe facility for transport, energy and ICT. The latter is clearly spent on the networks connecting the regions and is modelled through a reduction in transport costs which is estimated with the help of the TRANSTOOLS model using detailed data on the TEN-T investments in roads, rail and waterways.

For the 2014-2020 period, the Cohesion Fund is dedicated to investment in climate change adaptation, energy saving and risk prevention in Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. Some 10 of the nearly 70 billion euros reserved for the Fund are ring-fenced for the Connecting Europe facility. All in all, the broad thematic decomposition in Table 1 shows that nearly half of the ESIF can be attributed to investment in infrastructure, not counting the 40 billion for the facility itself.

The other half of the ESIF is spent on education and training, that is investing in human capital, and support to research and innovation in enterprises, including SMEs in the regions. Relatively little goes to *R&D* activities proper; the category Aid to the private sector consists of such things as financial support for acquiring new equipment and know-how and for applying for patents, trademarks and designs with local/regional content. It is envisaged that part of the ESIF may be dedicated to assisting researchers in Horizon 2020 participation and providing enterprises with easier access to the results of earlier Framework Programs, mainly to the benefit of countries that joined the EU since 2004.

The calculations in Table 1 show that in terms of geographical allocation roughly two thirds of the ESIF, including the Cohesion Fund, go to the less developed regions. The remaining third goes to the more developed regions and the regions in transition, with a *GDP* per capita between 75 and 90 per cent of the EU-28 average. The transition arrangements apply in particular to the regions that passed the 75% threshold recently, either of their own account or because the EU average fell as a result of the recent enlargements.

2.3. The 2014-2020 allocation of funding

It is interesting to consider the matrix of thematic and geographical allocation from a political angle. Bachtler and Méndez (2007) made a careful assessment of the governance of EU cohesion policy at the start of the 2007-2013 round. They argue that the doubling of the funding in 1988 accompanying the single market initiative has been followed by largely unsuccessful attempts, at each review and renegotiation of the allocation and spending, to shift the decision power on the spending of the structural funds back to the Member States. In terms of geographical allocation, half of the funding continues to go directly to the less developed regions. The battle is mainly over the remaining part of the structural funds, and in particular the European Social Fund (ESF). On the proposal of the Commission, maximum co-financing rates have been set, which range from 50% for the most developed regions to 85% covered by the EU contribution from the Cohesion Fund. Some of these rates have been increased in response to the economic and financial crisis.

The Commission has raised its leverage even further by setting minimum shares for categories of spending under each Fund. For example, under the ERDF, at least 80% of the spending in the more developed and transition regions, aggregated by Member State, should be devoted to the use of natural resources, innovation and SME support. At least one quarter of this is expected to go to energy efficiency improvements and renewables. Less developed regions have greater leeway in setting investment priorities, reflecting more diverse needs in catching up with EU average standards, but will have to spend at least 50% of ERDF resources on energy saving, innovation and SME support.

Minimum shares have also been established for the use of ESF support as a percentage of total EU funding: 25% for the less developed regions; 40% for the regions in transition; and 52% for the more developed regions. The upshot of all this is that the bulk of the ESIF is going to the least favoured regions, with investment in infrastructure and human capital as the two biggest categories. More developed regions receiving support are very much restricted in their use of the funds, which should be spent mostly on promoting energy efficiency and innovation and enhancing job opportunities and social inclusion.

With its proposal for the 2014-2020 round, endorsed by Council and Parliament, the Commission has reinforced the conditions under which funding will be released. Ex ante, the Commission looks at whether the regulatory and institutional frameworks for making investments effective and implementing them efficiently are all in place. It can also impose requirements regarding the thematic objectives, such as submission of a smart specialisation strategy. Ex post conditionality looks at whether regional performance and the results of using the funds are in line with the EU 2020 objectives. A total of 5% of the ESIF envelope is set aside for allocation at a later point of time, after the mid-term review has taken place. Failure to reach the targets agreed with the Member State concerned and fulfil the requirements may lead to the suspension or cancellation of EU funding.

3. Brief description of RHOMOLO

The RHOMOLO model is calibrated to the regionalised Social Accounting Matrices (SAMs) of the EU member states that were extracted from the World Input-Output Database (Timmer, 2012). SAMs for the NUTS2 regions were constructed using the data of regional production by sector, bilateral trade flows among the NUTS2 regions, and trade with the rest of the world (ROW), as described by Potters *et al.* (2013). The version of the model used for this paper includes 6 NACE[8] Rev. 1.1 industries: Agriculture (AB), Manufacturing (CDE), Construction (F), Transport (GHI), Financial Services (JK) and Non-market Services (LMNOP).

EU regions are modelled as small open economies that accept EU and non-EU prices as given, which is consistent with the regional scope of the model. In this perspective, EU external relations involve only one non-EU trading partner that is represented by the ROW aggregate

Interregional trade flows are estimated based on prior information derived from the Dutch PBL dataset (Thissen *et al.,* 2013). Data on bilateral transport costs per sector are provided externally by the TRANSTOOLS model[9], a model covering freight and passenger movements around Europe. The costs of different shipments are calculated in terms of share of the value shipped, based on the time needed to reach the destination using alternative modes of transport. Transport costs thus differ by type of good and depend on the distance between the regions and the variety and characteristics of modes of transport connecting them, which also means that they can be asymmetric. The representation of trade and transport flows among the NUTS2 regions gives the model a spatial dimension, indicating that EU regions differ not only in their stocks of production factors but also in geographic location.

Mobility of capital and labour is assumed to occur within regions, but international or intra-regional migration of production factors is not considered in the core model version.

All agents of the model are assumed to have myopic expectations and do not anticipate future changes in relative prices or make choice between consumption and savings depending on the interest rate. Using a perpetual inventory method (OECD, 2001), the sum of interest rate and depreciation rate are employed to estimate the regions' capital stocks from the value of their operating surplus, as available in the SAMs. The interest rate is set at the level of 5% and the capital depreciation rate at

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[8] See *http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:NACE.*

[9] See Burgess *et al.* (2008) or visit *http://energy.jrc.ec.europa.eu/TRANS-TOOLS/TT_model.html.*

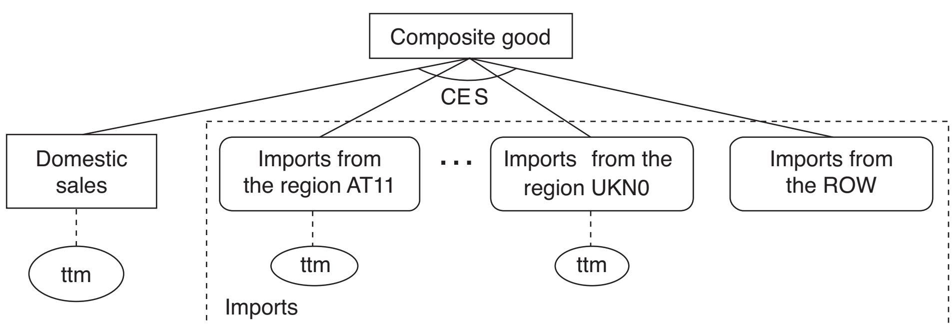
6% per annum[10]. In order to keep the model baseline «clean» of trade spillovers that change relative prices and induce sectorial changes, we apply a uniform 2% annual growth rate to all regions.

The model solves for the sequence of equilibrium states when all time periods are connected with the equation of capital accumulation: each year in each region a portion of capital stock depreciates and gets augmented by the previous year investments, so that capital stock and investments grow at the same rate with the rest of economy. Values of investments in each region are adjusted in order to achieve consistency among the observed investments, the estimated capital stock and the required replenishment of the capital stock. Therefore, there are no changes in regions' economic structures over the steady-state baseline period. All prices remain constant; only the quantities grow at the same constant rate. This enables the comparison of the after-shock results with the baseline values[11].

3.1. Composite of domestic and imported varieties

Domestically produced and imported varieties are combined with a CES function. Trade and transport margins are applied to imports from other NUTS2 regions and to domestic sales (*ttm*). Following this specification, the structure of composite good is depicted in Figure 2.

Figure 2. Composite of domestically produced and imported varieties of the same good



Composite goods are consumed by industries, households, government, and the investment sector.

[10] In reality, interest rates may change over time, but for modelling standard values are assumed in the literature.

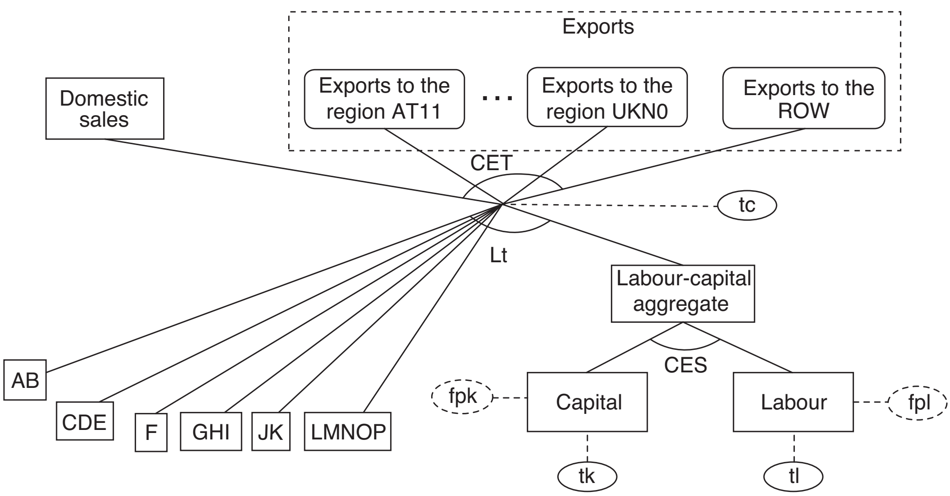
[11] The core model equations are specified in the calibrated share format proposed by Rutherford (1999), programmed in GAMS as a mixed complementarity problem (Mathiesen, 1985) and solved using a PATH solver.

3.2. Industries' nested cost function

In a core model version the CET function defines the sectors' choice between sales on the domestic market and exports to other regions as function of relative prices on these markets. However, in order to introduce imperfect competition, the CET function has to be removed. Taking into account that sectors' export supply to the NUTS2 regions is determined by import demand of these regions (see Figure 2), we can dismiss the constant elasticity of transformation (CET) function of output transformation to regional markets. However, the aggregate of non-EU economies (ROW) cannot be treated as one of model's regions. Even though a SAM for ROW can be constructed using a GTAP database (Badri Narayanan *et al.*, 2012), adding the ROW region to a RHOMOLO would create computational difficulties, as model would be calibrated to the SAMS of 270 small regions that have relatively small values of economic transactions and one ROW region with large values. Hence, following the approach of Whalley and Yeung (1984), export supply to the ROW is modelled with a function of export demand from the Rest of the World.

A Leontief function is employed on the top level of the sectors' production functions in order to define complementarity between the intermediate inputs and the labour-capital aggregate. The lower level of the sector's production function features the possibilities of trade-offs between labour and capital services that were specified with the CES function; intermediate inputs are assumed to be non-substitutable. Coefficients of factor productivity improvements are assigned to labour (*fpl*) and capital (*fpk*). With this specification, producers can maintain the same levels of output using less production factors. The same structure of nested production functions is adopted for all sectors (see Figure 3).

Figure 3. Sector's nested production function

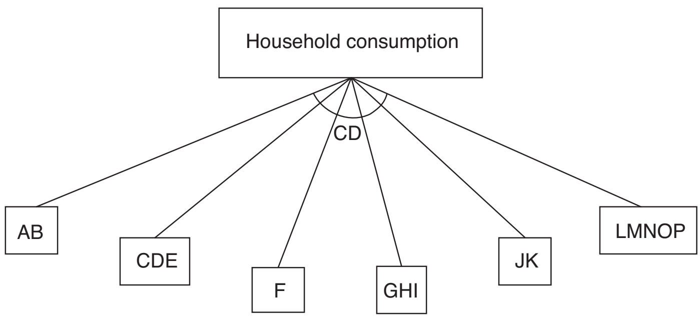


3.3. Budget balance and structure of household consumption

According to the information, which was provided in the regional SAMs, regional households supply labour and capital services, pay income taxes, receive net transfers from the public sector, and also net transfers from abroad. Households save a fixed proportion of their income.

After deducting taxes, transfers and savings, the disposable income is used to maximize utility of households' consumption. The final goods that are consumed by households are combined, allowing for substitutability among inputs. The structure of regional household consumption is described in Figure 4.

Figure 4. Structure of regional household expenditures and public expenditures



3.4. Budget balance and structure of Public consumption

According to the SAMs, income of regional government consists of taxes on sectors' output, sectors' consumption of labour, capital services, taxes on regional investment good, income taxes, net transfers from abroad and net transfers from regional households. In the model we assume fixed tax rates and constant public consumption of final goods. Hence, public savings are determined as a residual.

The structure of regional public consumption was specified in a similar manner to that of households (Figure 4).

3.5. Savings-investment balance

Investment sector combines Armington goods in fixed proportions. Savings-investment balance is achieved by household savings, public savings and also savings from the EU and ROW.

3.6. Market clearing conditions

Since model is formulated in a calibrated share format, demand and supply of goods were defined by differentiating the profit or cost function by the price of that good (Hotelling's and Shephard's lemmas).

3.7. ROW closure

Following the (small open economy) SOE assumptions, any of the NUTS2 regions doesn't influence prices in the non-EU market. Therefore, we formulated the EU balance of trade as net exports to the ROW. We fix the ROW savings keeping the real exchange rate flexible, so that ROW price adjusts to bring about equilibrium. Savings from the EU are set exogenously and valued using a producer price index

4. Scenario construction

4.1. Human capital related policies

The budget line Human Capital under cohesion policy covers a wide variety of expenditures. Some aim at fostering re-integration of long-run unemployed on the labour market, while others pertain to improving life-long learning or on the job training. To simulate the effects of cohesion policy on human capital in RHOMOLO, the expenditures are aggregated into a single exogenous shock by assuming that they all lead to an increase in regional labour productivity (the *fpl* parameter), at the cost of a temporary decrease in the local labour supply.

Next, it needs to be specified how efficient the policy is in improving regional labour productivity. For this, it is assumed that the percentage increase in the human capital stock of the region induced by cohesion policy equals cohesion expenditure on human capital relative to the total expenditure on education in the region, taken from EU KLEMS (Timmer *et al.,* 2007). Next, in accordance with the estimates in the empirical literature, it is assumed that increasing the stock of human capital by 1% leads to an increase of 0.3% in output per worker (Sianesi and Van Reenen, 2003).

In the initial years of the policy implementation, labour supply simultaneously is assumed to decrease and remains subdued during the programming period. After the programming period, labour supply recovers to its original level.

Future work will focus on the stark assumptions made for these simulations. Firstly, the homogeneity of the labour productivity increase between countries for a given percentage increase relative to local education expenditure will be relaxed, as it seems likely that not all countries and regions would benefit equally from an increase in the human capital stock. Secondly, policies will be separated out which may be expected to operate not through increasing labour productivity, but rather e.g. through improving labour market efficiency.

4.2. *R&D* investments

For the 2014-2023 period, 42 billion euros have been allocated to lines of expenditure related to support to *RTDI*. This is 12% of the grand total of Cohesion Policy funds; 60% of this goes to the less developed regions, a lower percentage than the 70% across all budget lines.

In order to depart from a framework with simplified growth dynamics à la Solow (1956), the current version of RHOMOLO introduces an endogenous growth mechanism à la Howitt (2000). López-Bazo and Manca (2014) use a specification in which *TFP* growth is determined by a combination of *RTDI* investment and catching up with other regions. There is considerable empirical evidence of the effect of *R&D* on *TFP*, very well elaborated in Hall *et al.* (2009). The investment in *RTDI* under cohesion policy is first expressed as an increase in the *R&D* intensity compared to the baseline and subsequently a *TFP* equation is used to model the increase in *TFP* resulting from *R&D*. This is the most standard formulation derived in Hall *et al.* (2009) which is reproduced here in a distributed lag format, reflecting that it takes time for an investment in *R&D* to be turned into innovation and consequently a productivity improvement. The *TFP* equation is as follows:

$$TFP_{reg,t} = \gamma * TFP_{reg,t-1} + (1-\gamma) * \\ * \left(b_0 + b_1 * \frac{RTDI_{reg,sec,t}}{GDP_{reg,t}} + b_2 * \frac{RTDI_{reg,sec,t}}{GDP_{reg,t}} * TFPgap_{reg,reg,t*} + b_3 * TFP \text{ elsewhere}_t \right) \tag{1}$$

where TFP_{reg} represents the level of regional *TFP* at a given point of time that subsequently has an impact on the total output. The term $\frac{RTDI_{reg,sec}}{GDP_{reg}}$ is the *R&D* intensity for each sector in each region. The second explanatory variable is the combined interaction between the average *R&D* intensity and the gap in *TFP* with the leading region. It should be noted that the further away is the region from the technology frontier the faster it will catch up given the same *R&D* intensity. This is because there is a greater potential for closing the gap by borrowing from the existing stock of knowledge and know-how.

The third term between brackets represents possible spillovers from *TFP* increases in other regions and sectors (*TFP*elsewhere). These spillovers are the key reason why the social return on *R&D* exceeds the private return, and thereby would justify public investment and support to *R&D* in the private sector. This is a topic of empirical research taken up by Belderbos and Mohnen (2013), who propose a patent citation-based indicator to measure the presence of intra- and inter-sectoral knowledge spillovers, nationally as well as cross-border. This could possibly at a future stage be transformed into a spatial structure for the spillovers between regions but for the moment b3 is set to zero.

Hall *et al.* (2009) conclude that *R&D* rates of return in developed economies are strongly positive and may be as high as 75%, although they are more likely to be in the 20% to 30% range. This estimate is introduced in the model by setting a rate of return. This is close to the estimate used in QUEST III (McMorrow and Röger, 2009).

The empirical evidence on the spillover effect and catching-up is not as strong, but it is likely that the farther away from the technology frontier the greater the potential for catching up, conditional on the ratio of *R&D* to *GDP*. This is introduced in the model by a multiplicative term expressing that the higher the *R&D* intensity the greater the part of the *TFP* gap that is closed every year. An increase in *RTDI* expenditure compared to the baseline will set in motion this process, which is assumed to operate with the same distributed time lag and coefficient as the *R&D* effect on its own. This would approximate a doubling of the rate of return on *RTDI* for regions which are *TFP* = 1 at compared to the technology frontier (*TFP* = 2)[12]. The estimates behind this specification are confirmed by the econometric research of López-Bazo and Manca (2013).

4.3. Support to innovation other than through *R&D*

Innovation can take place through activities which do not require *R&D* such as the purchase of advanced machinery, patents and licenses, training related to the introduction of new products or processes, etc. These forms of acquiring knowledge and technology are referred to here as non-*R&D* (*NR&D*) innovation activities. From a policymaking point of view, it is important to analyse the impact of *NR&D* measures since a sizable portion of the cohesion policy budget is devoted to such support. In the 2014-2020 round, some 40 billion euros are devoted to *NR&D* activities. The current version of RHOMOLO analyses its impact considering that the main channel of influence of these activities is through their impact on *TFP*. López-Rodríguez and Martínez (2014) estimate an elasticity of *TFP* with respect to the *NR&D* investments of $\left(\gamma_3 + \gamma_1 \overline{Ird}\right)$[13]. Mathematically, the following expressions have been used to estimate the shifts on *TFP* due to *NR&D* funds:

$$gTFP_{reg,t} = \left(y_3 + \gamma_1 \overline{Ird}\right)\left(\frac{NR\,\&\,D_{t-1,reg}}{GDPbau_{t-1,reg}}\right) \tag{2}$$

$$TFP_{reg,t} = gTFPbau_{reg,t} + gTFP_{reg,t_3}) \tag{3}$$

where $gTFP_{reg,t}$ is the annual regional growth rate in *TFP* in region *reg* in year due to *NR&D* innovation expenditures; $\gamma_3 + \gamma_1$ *Ird* is the elasticity of *TFP* improvements with respect to *NR&D* investments, taken from López-Rodríguez and Martínez (2014); $NR\&D_{t-1,reg}$ is the amount of *NR&D* innovation expenditures assigned in the

[12] Luxembourg, Brussels and Greater London are excluded from the frontier, because they are financial centres with a very high *TFP* in the data

[13] This expression takes values in the range [0.15-0.18].

year $t-1$; $GDPbau_{t-1,reg}$ is the forecasted *GDP* region in the year is the baseline annual regional *TFP* growth in the region *reg* during the year *t*; $TFP_{reg,t}$; is the growth rate induced by the *NR&D* investments.

For the purpose of this exercise not only the values of allocated funds are introduced but also the planned annual absorption of non-*R&D* investments for each region during the compliance period of 2014-2023. It should be noted that regional *NR&D* investments are not distributed homogenously in the plans for the period of 2014-2023, but show fluctuations from one year to the next. Given that the model baseline was projected assuming a steady-state 2% annual growth rate, region's values of *TFP* growth can double or triple from one year to another.

4.4. Infrastructure investments

In a first step, an aggregate measure of the total expenditure on transport infrastructure under cohesion policy is derived for each region. For this purpose, all policy instruments directly affecting transport infrastructure are aggregated in one category, INF[14].

In a second step, an attempt is made to impute the spatial dimension of the transport infrastructure funds based on region-specific expenditures as calculated in the first step by estimating how region-specific expenditure translates into region-pair-specific expenditure. The spatial dimension is important, because transport infrastructure improvement affects not only the region in which the investment is made, but also all regions with which it trades goods and services. The following formula is used to impute a spatial matrix of bilateral transport investments, $ECP^{INF}_{reg,regg}$:

$$ECP^{INF}_{reg,regg} = \phi_{reg,regg}\left(\frac{ECP^{INF}_{reg} + ECP^{INF}_{egg}}{2}\right) \tag{4}$$

where ECP^{INF}_{reg} and ECP^{INF}_{rerg} are *ECP* transport infrastructure expenditures in regions *reg* and *regg*, respectively, and $\phi_{reg,regg} \equiv \tau^{1-\sigma}_{reg,regg}$ is the freeness of trade, which ranges from zero, when trade is perfectly un-free (bilateral trade costs are prohibitive between *reg* and *regg*), to unity, when trade is perfectly free and bilateral trade costs are zero (Baldwin *et al.,* 2005). $\tau^{1-\sigma}_{reg,regg}$ denotes bilateral trade costs between pairs of regions as measured by TRANSTOOLS.

The bilateral measure of transport infrastructure investments (4) takes the expenditure in the regions at both ends as well as the proximity of the regions into account. The second term on the right-hand side in equation (4) calculates the average transport investment for every pair of regions. The first term on the right-hand side

[14] Note that no weights are applied at this stage of aggregation, although, according to the theoretical literature (European Commission, 2011), the aggregation of different policy measures should account for differences in their expected impact. This will be introduced in future simulations.

introduces a spatial structure (economic geography) in the bilateral measure of transport infrastructure investment by weighting the proximity (integration) of regions. The farther away the trading regions are (trade is more costly), the less weight will be attributed to the transport infrastructure improvements between the two regions. The weighting implies that the further away are the two regions, the lower impact will have a fixed amount of expenditure (1 km of road can be improved much better than 10 km of road with the same amount of funds).

In a third step, $ECP^{INF}_{reg,regg}$, which is a bilateral measure of expenditures, is transformed into changes in bilateral trade costs between regions, which are measured as a share of trade value. This is done by pre-multiplying the bilateral measure of transport infrastructure investments $\left(ECP^{INF}_{reg,regg}\right)$ by a coefficient measuring the effectiveness of transport infrastructure investments. The elasticity of trade costs with respect to the quality of infrastructure is retrieved from studies on TEN-T infrastructure (European Commission, 2009), since no comparable elasticities are available for Cohesion Policy investments in transport infrastructure. The result is a transport infrastructure scenario that can be readily implemented in the model.

5. Simulation results

Given the complexity of interactions and spillovers in RHOMOLO, regional shocks induced by cohesion policy are quickly transmitted across regional and national borders. In fact, EU regions are interconnected through a dense network of trade in goods and services and technology transfers which make the model and the interpretation of its results not easily tractable. In order to fully capture the effects of each expenditure item and the role played by interconnections, the simulated impact of each measure is shown in in isolation and then combined. Following the order proposed in the scenario construction (Section 4), first human-capital related policies are presented below, then *R&D* investments, followed by non-*R&D* support and infrastructure investments. Finally, the possible overall impact of cohesion policy is put together in a combined simulation illustrating the extent of spatial interrelations.

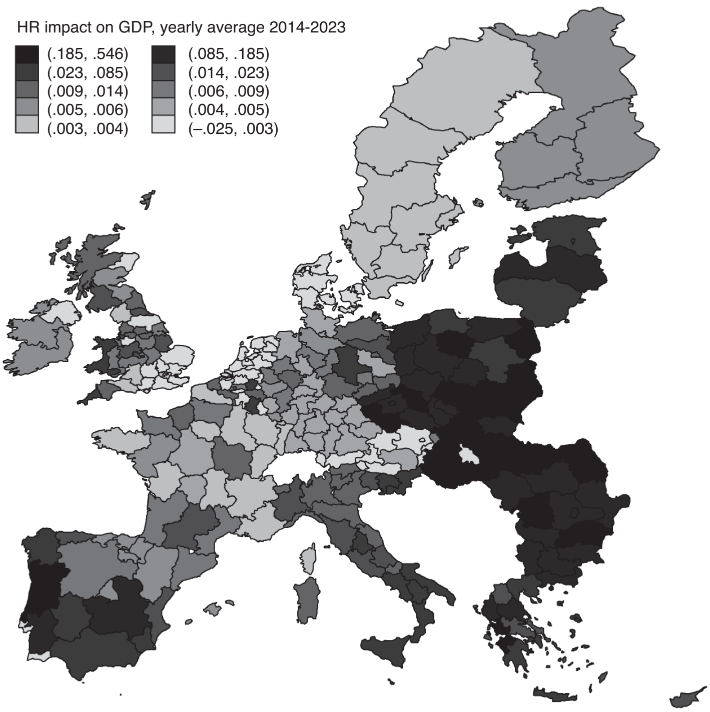
5.1. Interventions in the field of Human Capital

Cohesion policy expenditures on human capital are projected to account for about 20% of total cohesion policy expenditures for the 2014-2020 round. To simulate the effects on human capital in RHOMOLO, the expenditures are assumed to lead to an increase in labour productivity, however at the cost of a temporal decrease in the regional labour supply. Formally, an expenditure on human capital of 1% relative to local education expenditures is assumed to increase local labour productivity by 0.3% [15].

[15] This elasticity is taken from the literature (Sianesi and Van Reenen, 2003).

Increase in regional labour productivity implies an increase in regional *GDP* but also an increase in labour demand and wages. The following map displays the yearly average impact of investments in human resources under cohesion policy over the 2014-2023 period.

Map 1. Impact of interventions in the field of human resources on NUTS 2 regions *GDP* in 2023, % deviation from baseline



As Map 1 suggests, the overall effect of investment in human resources is clearly positive, especially in most of the Central and Eastern European Member States. This reflects the distribution of cohesion policy support which is much higher for the less developed regions than for the transition and more developed regions.

However, the difference in regional impact also stems from other factors. First, investment in human resources is likely to produce a larger impact on *GDP* in regions where the level of local expenditure on education is low. These are indeed places where cohesion policy support will significantly change the level of public support provided to human resources. Second, RHOMOLO includes six industrial sectors which have varying degrees of labour intensity. Regions in which the industrial fabric has a larger proportion of labour intensive industries (such as for instance manufacturing) are likely to benefit more from an increase in labour productivity.

Finally, investment in human resources also generates spatial spillovers. As for infrastructure investments, the increase of *GDP* in the regions receiving support benefits other regions because of the interregional trade links.

5.2. Interventions in the field of *R*&*D*

R&D is another key sector of intervention for cohesion policy and accounts for approximately 12% of the total cohesion policy budget (or some 40 billion euros) which is to be allocated to lines of expenditure associated with support to research, technological development and innovation (*RTDI*) during the 2014-2020 programing period. More than 60% of this is allocated to the less developed regions.

As discussed in Section 4.2, in RHOMOLO support to *RTDI* is assumed to increase *TFP*. An increase in *R&D* affects *GDP* in several ways. First, *GDP* increases due to the fact that *R&D* leads to an increase in total factor productivity. This implies a reduction in the prices of intermediate inputs and hence of production costs which also contributes to the increase in *GDP*. Finally, the price of consumption goods decreases which encourages demand and hence the level of economic activity. As for other fields of intervention, other regions benefit from a rise in *GDP* due to increased demand from the regions receiving *RTDI* support.

The model accounts for spatial spillovers specific to *R&D*. Formally, it is assumed that the farther away a region from the technology frontier, the greater the potential for absorption and imitation of technological progress produced elsewhere. This not only implies that lagging regions are catching up on more advanced ones in terms of technology but also that an increase in *R&D* produces a bigger impact on factor productivity in regions where the level of technology is originally low.

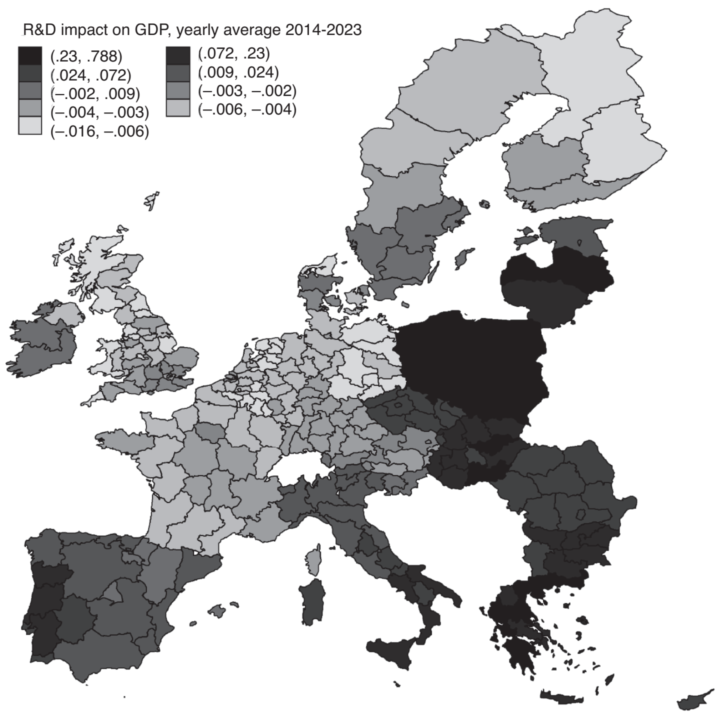
The results of the simulation show positive effects in all regions, with very few exceptions due to the intensification of competition from catching-up regions (see Map 2). Czech, Hungarian, Polish and Portuguese regions benefit the most, with impacts on regional *GDP* of 1-2% above the baseline on average in the 2013-2023 period. The impact on *GDP* in the less developed regions on average is somewhat higher than 1.2% on average in the 2014-2023 period. A renewed/continued increase in *RTDI* would be needed to keep the regional economies on a higher growth path.

In general, the impact is higher in less developed regions than in transition regions. This is explained by the fact that less developed regions receive more support under cohesion policy than the two other groups and that *R&D* investment has a higher impact on *TFP* in lagging regions in terms of technology.

5.3. Interventions in the field of non-*R*&*D* support to innovation

As explained in Section 4.3, and described at length by Diukanova and López-Rodríguez (2014), non-*R&D* support can be another key component of EU cohesion

Map 2. Impact of interventions in the field of *R&D* on NUTS 2 regions *GDP* in 2023, % deviation from baseline



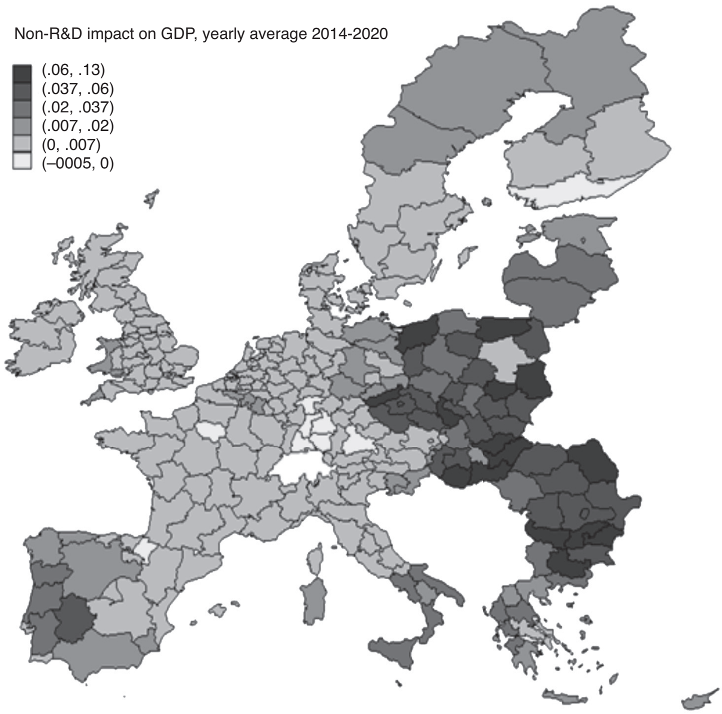
policy. Map 3 shows the average impact of non-*R&D* measures on *GDP* across the NUTS2 regions in EU-27 in 2014-2023. The impact on non-*R&D* support is positive in all regions although their magnitude varies considerably between regions. The most benefiting regions are those located in the Eastern parts of Europe and the Southern European periphery (Greece, Southern Italy, Spain and Portugal). Central European regions are expected to benefit only mildly. The results of the simulations are highly correlated with the amount of non-*R&D* funds received.

5.4. Interventions in the field of infrastructure

Finally, investments in infrastructure are planned to be nearly 170 billion euros, almost half of the total funding available.

However, there are large differences between regions concerning cohesion policy expenditure on infrastructure. Indeed, larger amounts are allocated to less developed regions. In addition, the share of infrastructure in the allocation is also higher than in more developed regions. Accordingly, cohesion policy expenditures on infrastructure

Map 3. Impact of interventions in the field of non-*R&D* on NUTS 2 regions *GDP* in 2023, % deviation from baseline

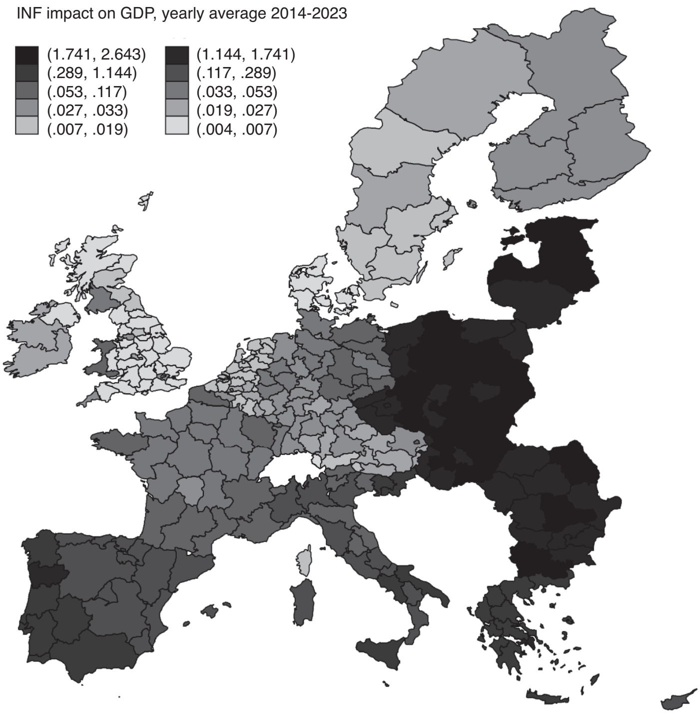


allocated to the less developed regions are considerably higher than to the transition and more developed regions.

In order to simulate the impact of cohesion policy investment in the field of infrastructure, the corresponding expenditure needs to be «translated» into changes in some of the model's parameters. Infrastructure investments are assumed to reduce transport costs between regions and the parameters representing transport costs are adjusted accordingly. Bilateral transport costs can be used to calculate an indicator of each region's accessibility. There are significant differences in transport cost reductions between regions and the largest improvements in accessibility take place in the less developed regions which reflects the expenditure pattern of Cohesion Policy.

Improvement in transport infrastructure means that regions get better connected within the single market which increases their exports and hence boosts the level of economic activity. The lowering of transport costs also implies a reduction in the price of imported intermediate goods and of consumption which contributes to a reduction reduce in firms' production costs and an increase in the disposable income of households. All these effects lead to an increase in regional *GDP* in the 2013-2023 period, as shown in Map 4.

Map 4. Impact of interventions in the field of infrastructure on NUTS 2 regions *GDP* in 2023, % deviation from baseline



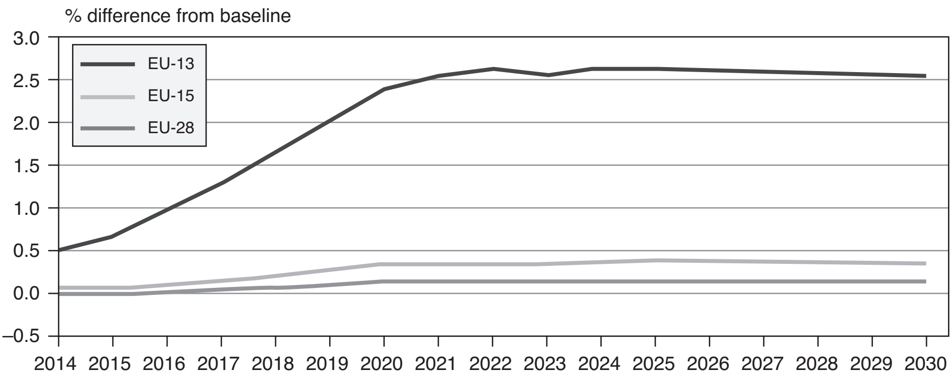
The largest returns on investment in accessibility are found in the less developed regions of the EU. It is in these regions that accessibility is lacking and where transport infrastructure has the greatest potential for improvement.

The impact of investment in the field of infrastructure does not only materialise in the regions where the investment takes place. A region benefiting from enhanced accessibility increases its imports of goods from the other regions which in turn also experience an increase in their exports and hence their *GDP*. The impact of local intervention therefore has a tendency to progressively disseminate in space through the numerous trade links existing between the EU regions.

5.5. Simulating Cohesion Policy 2014-2020

The full cohesion policy package for the period 2014-2023 consists of investment in the three categories discussed above, disregarding technical assistance. RHOMOLO has been calibrated to the results of QUEST at the national level for each year and each Member State. This means that RHOMOLO's main use is in the disaggregation of the results obtained with QUEST to the NUTS2 level. Figure 5 shows the estimated impact of cohesion policy for the 2014-2020 period on *GDP* based on simulations with the QUEST III endogenous *R&D* model (Varga and in 't Veld, 2011). These results are also reported in the Sixth report on economic, social and territorial cohesion (European Commission, 2014). They are split into the results for the EU-13, the new Member States that joined the Union since 2004, the EU-15, the other Member States, and the entire EU.

Figure 5. Estimated impact of Cohesion Policy for the 2014-2020 period on *GDP* based on QUEST III endogenous *R&D* simulations



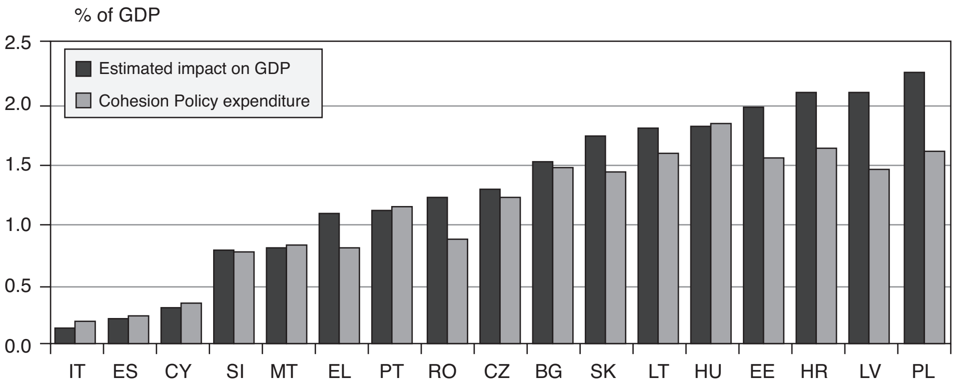
Source: Figure 8.10 in the *Sixth report on economic, social and territorial cohesion* (European Commission, 2014).

The percentage deviations are obtained by adding up national impacts and expressing them relative to the corresponding aggregate in the baseline.

Figure 6 shows the national deviations from the baseline in terms of *GDP* (purple bars on the back) confronted with the Cohesion Policy expenditures in the country (orange bars on the front). On average, the impact of the Cohesion Policy spending is estimated to be around 0.4% of *GDP* for the EU as a whole, with a substantially higher impact in the EU-13 (2.6% deviation from baseline *GDP* in 2023) than in the EU-15 (whose corresponding figure is 0.2%), much of the difference being explained by the differences in the allocation of funding.

The impact of Cohesion Policy on each individual region is then simulated using RHOMOLO in the set-up described above and yielding the results illustrated in Map 5. It shows the annual impact of the 2014-2020 package over the period 2014-2023, averaged over the ten years. The impact is particularly large for regions located in Central and Eastern Europe. It is the highest in the Polish regions of Śląskie, Podkarpackie, Małopolskie and Lubelskie as well as in Východné Slovensko (Slovakia) where, compared to the baseline scenario with no policy interventions, Cohesion Policy is expected to increase *GDP* by more than 3% per year on average between 2014 and 2023. A number of regions in Southern Europe also benefit from a large positive impact of cohesion policy on their *GDP*. For instance, between 2014 and 2023 *GDP*

Figure 6. Cohesion Policy expenditure for 2014-2020 and impact on *GDP* in main beneficiary countries based on QUEST 3*R&D* simulations



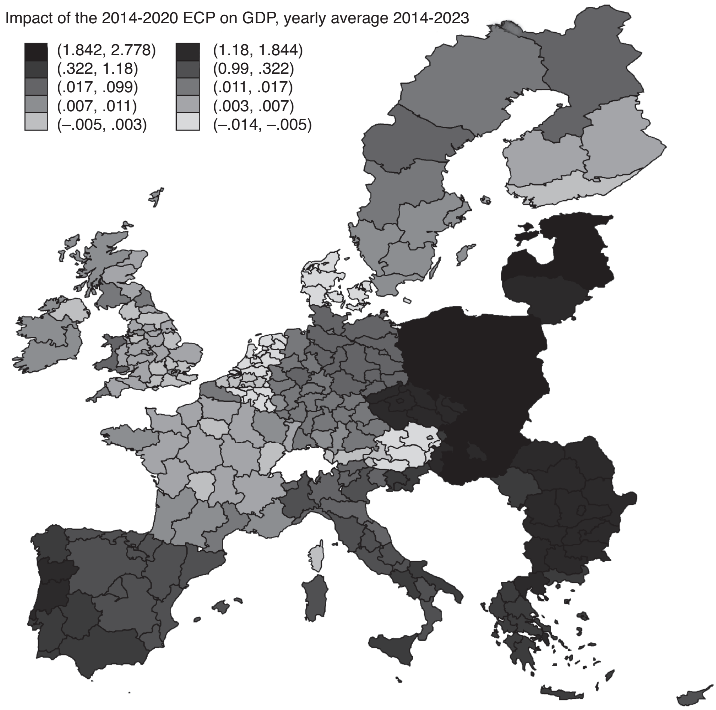
Source: Figure 8.12 in the *Sixth report on economic, social and territorial cohesion* (European Commission, 2014) based on QUEST II endogenous *R&D* simulations, DG REGIO Cohesion spending projections and DG ECFIN Spring 2013.

is expected to increase on average by 1.7% per year in Norte (Portugal) and by 1.5% per year in Kentriki Makedonia (Greece).

These regions are all major beneficiaries of funding under cohesion policy. As resources allocated to these regions are generally high, one can expect to also observe a higher impact in terms of *GDP*. These regions are also generally lagging behind in terms of infrastructure and hence are in a situation where investment in this field is likely to produce a particularly large impact. In addition, cohesion policy support in the fields of human resources adds much more to the total amounts dedicated to education in these regions than in regions of more developed Member States. Finally, the less developed regions tend to be more specialised in labour intensive industries, which implies that they benefit from investment in human capital and the increase in labour productivity that is generated.

Even if regions located in the Member States with *GDP* per capita close to or above the EU average get much less financial support, the impact of the policy still remains significant in a number of more developed regions. For instance, *GDP* is expected to increase on average by 0.11% per year in Lazio (Italy) and by 0.12% per year in West Wales and The Valleys (UK) during the implementation period. The impact is obviously smaller in regions where the allocation of cohesion funds is modest and which are already well endowed with infrastructure, human capital and technology. These more developed regions not only benefit from their own cohesion policy programmes but also from those implemented in the group of less developed regions to which the greatest part of the ESIF is directed.

Map 5. Impact of the 2014-2020 Cohesion Policy programmes on NUTS 2 regions *GDP* in 2023, % deviation from baseline



6. Conclusions

This paper presented RHOMOLO, the European Commission's spatial CGE model used for ex-ante impact assessment at the NUTS2 level. It covers 267 (of the 271) NUTS2 regions of the EU-27 and 6 NACE Rev. 1.1 industries (sectors) through a simulation of planned cohesion support for the years 2014-2020. The cohesion policy expenditures were grouped into four main categories, covering Research, Technical Development and Innovation (*RTDI*), Infrastructure, Human Capital, and Aid to Private Sector. These expenditures are assumed to affect a set of parameters including factor productivity and transport costs that determine the model outcome.

Using a spatial CGE model at the regional level is essential for capturing the effects of cohesion policy, in view of its convergence objective, but has its limitations. The main dynamics in RHOMOLO are the long-term effects of capital accumulation that continue even after the funding has ended. As inter-temporal optimisation and forward-looking expectations are not currently included, inter-temporal dynamics of the simulations are not always reliable. Therefore, RHOMOLO has been calibrated to the European Commission's QUEST III endogenous *R&D* model to obtain consistent results for each year and each Member State. What can also be done is to filter the input of the simulations through a module which incorporates more sophisticated dynamics than currently imposed upon the model.

Another possible refinement of the approach taken in this paper concerns the detail of incorporating the investments in the Connecting Europe facility and ICT networks. It is a bit of a detour to first assign the investments in infrastructure to the regions and then use a weighted average of the investments in the regions at both ends of a new or improved connection by road, railway or waterway to estimate the reduction in interregional transport cost. In principle, a model such as TRANSTOOLS would allow for the investments to be directly tied to the piece of transport infrastructure at which they are directed, but awaiting the operational programmes such detail is not yet available. What RHOMOLO does allow for is mapping the effect of all bilateral transport cost reductions between regions. In addition, the reductions in intra-regional transport cost, which depend only on the investment in the infrastructure of the region itself, are taken into account.

Finally, it would be useful to do more work on estimating the parameters in the total factor productivity relation, which this paper uses as the vehicle for transmitting the effects of cohesion policy on the regional potential for catching up. It accounts for *R&D* as well as non-*R&D* related support to innovation and entrepreneurship. To some extent, the catching up is pre-programmed by the specification of the estimated total factor productivity equation in that the effect of a given increase in *R&D* intensity is greater the farther away is the region from the technology frontier. There are also indications that the availability of high-skilled labour in the region can be a constraint on the effect of *R&D*, as has been built into the QUEST III endogenous *R&D* model at the country level. Going deeper into these interrelations and dependencies could be highly relevant for the design of a smart policy mix for each type of region.

Acknowledgements

Jesús López-Rodríguez acknowledges the support received from the Spanish Ministry of Science and Innovation through the project ECO2011-28632 and Xunta de Galicia through the project EM2014/051.

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Section ARTICLES

Modelling knowledge creation, investment decisions and economic growth in a spatial CGE setting

Francesco Di Comite*, Lesley Potters*

ABSTRACT: The expansion of knowledge is commonly understood as a key driver of economic growth. Yet, while knowledge production and economic growth have been extensively studied in isolation, few studies have tried to formalise the mechanism connecting the two elements from a spatial general equilibrium perspective. To fill this gap, in this paper we propose a model of knowledge creation building upon the multiregional spatial CGE model RHOMOLO to allow for endogenous knowledge production and investment decisions at the regional level. The innovation process is modelled through the interaction between researchers, investors and final good producers. Specifically, researchers in each region use their human capital together with local R&D-embedded capital and intermediates to produce ideas, enhanced by knowledge spillovers crossing regional borders. These ideas are then purchased by local investors and combined with their human capital and intermediate goods to be turned into new R&D-embedded capital, which adds up to the existing stock after having replaced the obsolete one. Lastly, after having paid a fixed entry cost, in each region firms produce goods for final and intermediate consumption by renting local R&D-embedded and human capital and combining it with an interregional bundle of intermediate goods, their productivity being enhanced by the availability of local public goods and services. The model is designed to be calibrated using a regionalised version of standard Social Accounting Matrices, such as the ones provided by the World Input Output Database.

JEL Classification: R13; R58; H54; C68; D58.

Keywords: multiregional spatial CGE; Endogenous R&D; Endogenous investment decisions.

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* *European Commision, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS).*

We thank participants of the "IPTS Workshop on Spatial Computable General Equilibrium Modelling for the Assessment of Cohesion Policy" (Seville, 12/2013), the «XXXIX Reunión de Estudios Regionales» (Oviedo, 11/2013) and «Geography of Innovation conference 2014» (Utrecht, 01/2014). We are also grateful to Stefan Boeters, Mark Thissen, Martin Christensen and two anonymous reviewers for useful comments and suggestions. The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission. Corresponding author: Francesco Di Comite, *francesco.di-comite@ec.europa.eu.*

Received: 14 january 2014 / Accepted: 6 august 2014.

Modelización de creación de conocimiento, decisiones de inversión y crecimiento económico en un modelo espacial de equilibrio general computable

RESUMEN: La creación del conocimiento es habitualmente entendida como un vector clave de crecimiento económico. Mientras que la producción de conocimiento y el crecimiento económico han sido estudiados extensamente por separado, pocos estudios han intentado formalizar el mecanismo conectando los dos elementos desde la perspectiva de un modelo de equilibrio general espacial. Para rellenar este vacío, proponemos un modelo de creación de conocimiento aprovechando el modelo CGE multirregional RHOMOLO para la producción endógena de conocimientos y decisiones de inversión a nivel regional. El proceso de innovación se modeliza teniendo en cuenta la interacción entre investigadores, inversores y productores de bienes de consumo. Más en detalle, los investigadores en cada región usan su capital humano junto a activos que incorporan I+D y bienes intermedios para la producción de nuevas ideas, las cuales son mejoradas por la transferencia de conocimientos desde otras regiones. En la siguiente etapa, estas ideas son adquiridas por inversores locales y se combinan en el proceso de generar nuevos activos que incorporan I+D junto al capital humano y bienes intermedios, así aumentando el *stock* existente después de haber reemplazado la parte obsoleta. Por último, después del pago de los costes fijos de entrada, empresas regionales producen tanto bienes intermedios como bienes de consumo, alquilando capital humano y activos que incorporan I+D, combinándolos junto con un conjunto interregional de bienes intermedios en el proceso de producción, donde la disponibilidad de bienes y servicios públicos influye en su productividad. El modelo ha sido diseñado para ser calibrado con las versiones regionalizadas de matrices de contabilidad social, como son las que se pueden obtener de la base de datos World Input Output.

Clasificacion JEL: R13; R58; H54; C68; D58.

Palabras clave: CGE multiregional espacial; I&D endógeno; decisiones de inversión endógenas.

1. Introduction

What drives growth? Of the many institutional and economic factors interacting in bringing economic development about, including labour market participation, capital accumulation, good institutions and product market regulation, the focus in developed economies is increasingly turning to the expansion of knowledge. There is indeed a growing consensus, in both policy-oriented (Veugelers and Mrak, 2009) and academic (Bröcker and Soltwedel, 2010) literature, that the entire society is expected to benefit from the creation of marketable innovations, which foster investments, augment human capital and increase productivity and product variety. As stressed in the endogenous growth literature (as for example in Romer, 1994, or in Aghion and Howitt, 1998), the technological progress resulting from commercial innovation is the most straightforward way to endogenise the process of productivity growth, which has otherwise to be assumed exogenous. In practice, in these models one part of the economy is assumed to be working on expanding the technological frontier, with the rest of the economy benefitting from the improved production capabilities (see Jones, 1995, or Romer, 1990). Economic growth then feeds back into knowledge creation by increasing its efficiency, in addition to the standard spatial spillovers capturing the positive externalities associated with neighbours' progress (Grossman and Helpman, 1991).

The objective of this paper is to bring this mechanism into a multiregional spatial CGE model setting. For this exercise, we build upon RHOMOLO, the European Commission's model used for the ex-ante impact assessment of EU Cohesion Policy at the regional level (Brandsma *et al.,* 2014), to present the possibility of including a mechanism of endogenisation of innovation and investments based on the accumulation of R&D-embedded capital.

A number of CGE models have applied a similar approach to the endogenisation of the R&D investment decision. In European Commission's QUEST III model realised by DG ECFIN (see Varga and In 't Veld, 2011, or Ratto *et al.,* 2009, for a detailed description), for example, a part of the skilled workers is employed in a specific R&D sector where new designs (blueprints) are invented as a function of previous technological stock, foreign technological stock and skilled workers in the R&D sector. In a more recent development of the model, non-liquidity constrained households buy the patents and rent it to the intermediate producing sector (see Varga and In 't Veld, 2011). Bye *et al.* (2009) describe a CGE model for measuring the implications of innovation policies in the small open economy of Norway. Here, the R&D sector produces patents to be acquired by capital firms for the production of a new capital variety. The production of new patents is a function of labour and is enhanced by the endogenous domestic spillovers from the accumulated stock of knowledge embodied in patents. However, most of the CGE models including explicitly an R&D sector lack a geographical dimension to determine spillovers and interactions between sectors of different economies, which are important dimensions to account for empirical validation and impact assessments (see Varga, 2015). Christensen (2013), for example, describes the development of a multi-sector dynamic general equilibrium model with R&D-driven growth with multiple nations. We also aim at merging an explicit accounting of the innovation process and the introduction of a spatial dimension of analysis, but we focus on a more disaggregated geographical unit of observation, which includes all the EU NUTS2 regions.

As for the structure of the paper, first a non-technical description is provided to describe the general framework of the model we build upon, RHOMOLO (Section 1.1), to present a preliminary explanation of the process of endogenisation of R&D (Section 1.2) and to outline the model (Section 1.3). Section 2 explains the knowledge-creation process. Section 3 focuses on how this knowledge is used in the production of R&D-embedded capital stock which is consequently used in the production of final and intermediate goods (Section 4). After that, the role of Households (Section 5) and Government (Section 6) are described. A discussion on the endogeneity of the R&D process ensues and, finally, we present conclusions and ideas for future development.

1.1. A description of RHOMOLO

The point of departure for the model presented in this paper is RHOMOLO, a spatial Computable General Equilibrium (CGE) model designed to work at the regional level (see Brandsma *et al.,* 2013). We present the current version of RHOMOLO in this Section and then, in the rest of the paper, we propose one possible way to include a knowledge-creation process based on R&D-embedded capital accumulation. RHOMOLO currently consists of 267 NUTS2 regions of the EU27 and 6 NACE Rev. 1.1 industries (agriculture, manufacturing, construction, transport, financial services and public services). Each region is inhabited by households that receive income from labour (in the form of wages), capital (profits and rents) and transfers (from national and regional governments). The income is split between savings, consumption and taxes.

Each region contains 6 sectors that produce goods that are consumed by households, government or firms (in the same sector or in the others) as an input in their production process. Transport costs for trade between and within regions are assumed to be of the iceberg type and sector and region specific. This implies a 267 x 267 asymmetric trade cost matrix derived from the transport model TRANSTOOLS (Burgess *et al.* 2008; Petersen *et al.,* 2009).

The national government levies taxes on the income of households, firms and production factors and pays social contributions to the households. Due to its high dimensionality, the model is solved following a recursive static rather than in a full dynamic approach. It contains a sequence of short-run equilibria that are related to each other through the build-up of physical and human capital stocks.

In the current version of RHOMOLO productivity growth and R&D are currently modelled based on an empirical approach, which is explained in Lopez-Bazo and Manca (2012)[1]. They follow an approach à la Solow (1956) where R&D expenditures at the regional level are linked to Total Factor Productivity (TFP), which can be measured as the part of productivity increases that are not explained by the main inputs to the production process, which are labour and capital in RHOMOLO. The main elements assumed to explain the growth in regional TFP levels are R&D expenditures, technology transfers (as a measure of absorptive capacity), distance from the technological frontier and non-R&D expenditures. The role played by regional R&D investments in the RHOMOLO specification is therefore dual. First, by investing in R&D a region is able to catch-up faster with the technological frontier (the region with highest TFP). The catching-up term is based on models of economic growth that are widely used in the literature in a leader-follower context of economic development (see e.g. Barro and Sala-i-Martín, 1997; Howitt, 2000). Second, a higher level of regional R&D implies a higher level of regional innovation, which in turn has a positive effect on TFP. Although this way of semi-endogenising R&D brings some

[1] A similar approach has been taken for analysing the impact of non-R&D innovation expenditures. See Lopez-Rodriguez and Martinez (2014) for the empirical estimation of the impact of non-R&D innovation on TFP and Diukanova and López-Rodríguez (2014) for its implementation in RHOMOLO.

regional interaction dynamics in the form of productivity convergence, there are also reasons to explore alternative modelling approaches where decisions on how much to invest in capital and R&D are endogenous too[2].

1.2. Non-technical description of R&D endogenisation

This paper deviates from RHOMOLO by proposing an endogenous R&D sector and a corresponding endogenous capital investment sector. This Section gives a short overview of the main components of the model and how R&D is endogenously modelled. The sections hereafter describe the sectors, agents and market transactions in a more detailed and rigorous way.

The first step of the innovation process is undertaken by researchers involved in the creation of knowledge. Their output can be interpreted as ideas to develop new products or processes, which may be captured by patents when the model is taken to the data. Researchers combine their ingenuity (approximated by their human capital) with intermediates and rented R&D-embedded capital to produce ideas, this process being enhanced by the accumulated stock of available knowledge. This modelling approach amounts to assuming positive spillovers in research activities, as the creative process benefits from the observation of past and present ideas produced in their own region and in the others, following a spatial decay function. Section 2 describes the creation of knowledge more in detail.

Researchers can either work in the public domain, producing ideas that only augment the stock of knowledge, or sell their ideas to the private sector to investors willing to turn those ideas into productive capital. In terms of calibration, public research is determined by the level of public expenditure in R&D and the production of ideas in both the public and private domain is approximated by filings for patents. The existing stock of knowledge increases with the production of new ideas, after replacing older ideas, which are assumed to depreciate at a constant rate. The absorption of ideas from other regions is discounted by a measure of distance rooted in the economic geography's gravity literature.

Turning to investors, in order to turn ideas into productive capital they combine their own human capital with existing R&D-embedded physical capital in the region and a bundle of intermediate goods that are produced by the final goods sectors in all the regions. The new units of R&D-embedded capital generated as a result of this process are used to replace the obsolete capital and increase the regional stock, which is then rented for productive and innovative purposes. Section 3 gives a detailed explanation of the R&D-embedded capital price setting mechanisms, its production process and the accumulation of its stocks.

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[2] For example, R&D expenditures in RHOMOLO are currently exogenously given and do not feed back into the model to define future R&D intensities. Data on R&D and non-R&D expenditures come from EUROSTAT and the regional R&D intensities (R&D over GDP) are constant over time. For simulations on Cohesion Policy Funds committed to increasing R&D expenditures, the R&D intensities are shocked with the additional funds.

Firms in the final goods sector rent the R&D-embedded capital from investors within the region and use it as an input in their production function. This non-tradable aspect of the capital stock is one of the driving forces of heterogeneity across regions in the model. In the final goods sector, the regional stock of R&D-embedded capital is combined with human capital, intermediate goods and public goods and services to produce specific varieties of a tradable differentiated good for final and intermediate consumption. The production process of the final goods sector and its consumption is described in Section 4.

Households play a key role in the model. First, they provide high-skilled labour which can be turned into researchers, investors or labour in the intermediate/final goods sector, which also employs low-skilled workers. Second, they consume final goods shipped from all the regions and, third, they put aside savings that form a stock which is used as an investment for setting up firms in the final goods sector. The savings are aggregated at the EU level and flow freely to EU firms across all the regions in the form of equity that is needed to set up a final goods firm, as described in Section 5.

The inter-temporal stocks connecting one period to the other are physical R&D-embedded capital and human capital endowments in each region plus a national knowledge stock augmenting productivity in the R&D sector.

Different levels of government are assumed: regional, national and supranational (the European Union). Their role consists in taxing or subsidising certain activities; providing productivity enhancing public services; undertaking public research; and realising transfers across regions or nations. The combination of transfers across levels of government on one hand, and taxes and subsidies on the other, allows us to fine-tune redistributive policies in the model. For example public research can be funded at the national level by taxing ideas at the regional level, which amounts to subsidizing the production of ideas is specific regions. To maintain the model as simple as possible, we abstract from inter-temporal government optimisation and assume all the agents (public and private) to have balanced budgets.

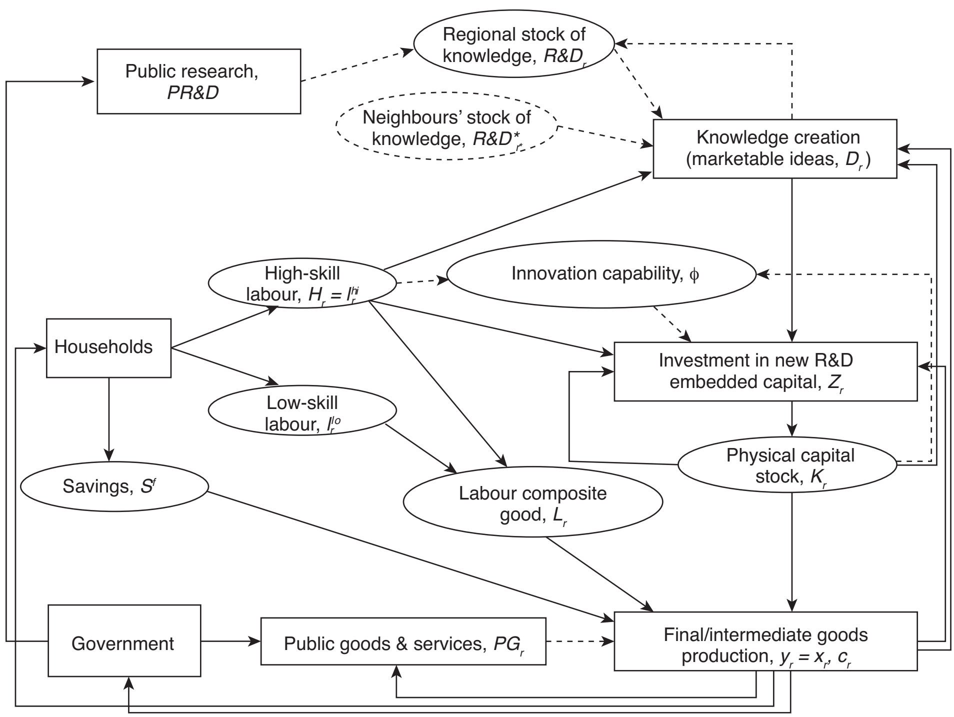
1.3. General outline of the model

Turning to the general setting of our model, we take the general structure of a multi-region, multi-sector computable general equilibrium model whose inter-temporal dimension is granted by the presence of stocks, such as knowledge and physical capital stocks, built over time. Knowledge creation drives growth by increasing the availability of productive R&D-embedded capital in the regions, which are then rented to produce goods, knowledge and new R&D-embedded capital. The model is meant to cover all the EU regions, plus a region accounting for the rest of the world. Each region is inhabited by a representative household which consumes final goods, supplies high- and low-skilled labour and provides equity to final and intermediate goods producers through her savings. Each region is populated by final and intermediate goods producers, investors and researchers. The government in each country and region is allowed to collect taxes, pay out transfers and subsidies, fund public research and supply public goods and services (at the regional level).

Finally, turning to the geographical and sectorial dimension of the model, different industries are considered in the economy (six in the current version), each being characterised by an innovation and production process split into three parts: knowledge creation, R&D-embedded capital accumulation, and goods production. The ideas generated in the regional knowledge-creation process are assumed to be sold to investors only within the region, even if the accumulation of knowledge resulting from these ideas is assumed to spill over to the other regions. The R&D-embedded capital in which the local ideas are turned by regional investors are also not assumed to be traded, but they increase the knowledge stock available to firms located in the region. Final and intermediate goods are instead freely traded across regions. Finally Household savings are perfectly mobile across sectors and regions. Human and physical capital are assumed region-industry specific, but can move across sectors within a region. Figure 1 provides a schematic overview of the model.

Notice that for the sake of exposition the innovation and production processes are assumed to be carried out by independent actors (researchers, investors, goods producers) in a decentralised market equilibrium, but it may well be that the different

Figure 1. Schematic representation of the economy in RHOMOLO



activities are undertaken by agents within the boundaries of the same organisation (for example, a large innovative firm). Indeed, as shown in the following sections, the exchanges between researchers and investors and between investors and goods producers are assumed to happen under perfect competition, which means that prices emerging from the transactions equal costs and thus the process can be equally interpreted as describing transfer pricing within the same company. This approach has the advantage of allowing us to abstract from the differences between innovations and investments happening within firms and accounted at the cost value or purchased from specialised firms, which is a type of information often not available in input/output tables. The incentives for researchers, investors, goods producers to create ideas, capital and final goods are depend on the remuneration of their human capital provision, which equalises in the three processes in each region.

2. The knowledge-creation process

The economy consists of R regions referred to as r or q, that are part of M countries referred to as m. In each industry *ind* and region r, the knowledge creation activity is carried out by researchers (part of the high-skilled workforce), producing ideas (whose empirical proxy is patents), D_r and selling them to local investors[3]. The production of ideas requires the use of human capital ($H_{R\&D,r}$), intermediates ($X_{R\&D,r}$) and R&D-embedded capital ($K_{R\&D,r}$), augmented by regionally available stock of knowledge in the region, ρ_r, which includes locally accumulated knowledge, $R\&D_r$, and spillovers from other regions, $R\&D_{r*}$, approximated by cross-citations in patent applications, so that

$$\rho_r = \sum_{r^*=1}^{R} (R\&D_{r^*})^{\frac{1}{d_{r,r^*}}} \tag{1}$$

where the stock of knowledge from other regions is weighted by a gravity parameter related to a measure of the extent of knowledge spillovers between each pair of regions, d_r (equal to 1 for local knowledge, i.e. $r^* = r$)[4]. The process of creating new knowledge is modelled as a production function such as the following:

$$D_r = \zeta_{R\&D,r} (\rho_r)^{\omega_{R\&D}} (H_{R\&D,r})^{\in_{H_{R\&D}}} (X_{R\&D,r})^{\in_{H_{R\&D}}} \tag{2}$$

where $H_{R\&D,r}$ represent the part of regional high-skilled labour employed as researchers, and $K_{R\&D,r}$ and $X_{R\&D,r}$, respectively, the *R&D-embedded capital stock* rented and

[3] Notice that region-level elements by the subscript r and country-level elements are signalled by the subscript m throughout the text. Activities concerning knowledge production and investment have subscripts $R\&D$ and I, respectively. For a full list of parameters, identifiers and variables used in the paper, see Annex I to IV.

[4] There are different ways in which knowledge spillovers can be measured, ranging from direct knowledge exchange measures such as cross citations in patents to indirect measures such as volumes of bilateral trade or transport costs.

intermediates consumed for creating knowledge. The parameters $\in_{H_{R\&D}}$, and $\in_{X_{R\&D}}$ can be calibrated using the Community Innovation Survey (CIS)[5] data and Social Accounting Matrices (SAMs)[6], which can be used also to estimate the productivity level of the regional knowledge creation process as captured by the parameter $\zeta_{R\&D,r}$. The parameter $\omega_{R\&D}$ can be interpreted as the regional absorptive capacity of the immaterial knowledge stock, ρ_r, which can be approximated by the stock of ideas of each region, calculated by applying the Perpetual Inventory Method on the number of patent applications as provided at Eurostat. For the different skill levels of human capital by region, the ISCED levels[7] of the employees are applied, where ISCED levels 5+6 represent the high-skilled labour force. As for the bundle of intermediates, they can be measured as

$$X_{R\&D,r} = \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R_m} \sum_{i=1}^{N_r} (\beta_{r,ind})^{\sigma} (x_{R\&D,r}^{i,q,ind})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{3}$$

where $x_{R\&D,r}^{i,q,ind}$ is the quantity of (R&D) intermediates used by researchers in region and bought from firm in industry of region and the relative importance of each industry's output in the production process is $\beta_{r,ind}$.

The ideas generation function at the regional level D_r can then be seen as a Cobb-Douglas production function of high skilled labour $H_{R\&D,r}$, R&D-embedded capital $K_{R\&D,r}$, and intermediates $X_{R\&D,r}$. This means that returns to scale are decreasing in each factor, taken in isolation (such as the R&D stock), but constant with respect to the combination of all the factors, as ensured by the condition

$$\in_{H_{R\&D}} + \in_{K_{R\&D}} + \in_{X_{R\&D}} = 1. \tag{4}$$

The ideas produced in the private domain are then sold to investors located in the region where they are produced (i.e., there is no interregional trade of ideas comparable to intermediates and final goods)[8]. This assumption, combined with the lack of barriers to entry in creating knowledge, implies that each idea is sold at its marginal

[5] The CIS offers country level data —obtained from questionnaires for individual firms— on the total innovation inputs per country: internal R&D (proxy for, since the main share for internal R&D consist of wages for researchers), external R&D (both outsourced R&D activities and acquisition of external knowledge and a proxy for) and acquisition of machinery and equipment (proxy for). For the missing countries we applied average shares. For DK we took the average of FI, SE and NO. For GR the average shares of ES, IT and PT. For the UK the average shares of DE, NL and FR were taken.

[6] See Potters *et al.* (2014) and Thissen *et al.* (2014) for a more detailed description of the construction and regionalisation of the Social Accounting Matrices for RHOMOLO.

[7] International Standard of Classification of Education (ISCED) levels are go from level 0 (pre-primary education) to level 6 (tertiary education —e.g. PhD). For the distinction between low, medium and high skilled labour we will refer respectively to the levels 0-2, 3+4 and 5+6.

[8] Since the aim of the model is to capture an innovation process that can happen either inside the boundaries of a firm or in a competitive market environment, ideas are implicitly assumed to be perfectly substitutable, which is of course a simplification but it allows us to keep the model general and tractable. In addition, there are no extensive, comparable datasets on the market value of patents.

costs of production and the quantity supplied depends on the availability of researchers, whose human capital has to be remunerated equally in the different activities in which it can be employed (i.e., as researchers, investors or employee in the final goods sector). This means that the supply of regional ideas ultimately depends on the skill level of the inhabitants of the region, on its R&D-embedded capital and access to intermediates, in addition to the available stock of knowledge.

The knowledge stocks in each region are assumed to increase with the development of marketable ideas produced in the private domain, D_r, and from ideas issued from public research, DP_r, with region-time-specific efficiency u_r. In addition, to capture the idea that old productive ideas may become obsolete and need to be replaced by new ones, the stock of ideas is assumed to depreciate at a constant rate, $\delta_{R\&D}$, assumed invariant across time and countries for simplicity. Formally, adding the time dimension, t:

$$R\&D_{r,t} = (1-\delta_{R\&D})\ R\&D_{r,t-1} + D_{r,t} + u_r DP_{r,t}. \tag{5}$$

Notice that the R&D stock so computed directly enters into the flow of new knowledge generated in region and in the neighbouring regions with decreasing returns. Also the flow of new ideas from public research, $DP_{r,t}$, is produced using the same technology as the flow of ideas in the private sector, scaled down by a region-specific parameter u_r capturing heterogeneities in the efficiency of public research as for example from the Quality of Government indicators (Charron *et al.*, 2012) or the Regional Innovation Scoreboard (2014). As for public research, the total amount invested in each region in hiring researchers, buying intermediates and renting R&D-embedded capital to produce ideas is financed by the national and regional government budgets, the former indicated as $PR\&D_r^m$ and the latter as $PR\&D_r$. Hence, for a given level $PR\&D$ the total output of public research is

$$DP_r = \frac{(PR\&D_r + PR\&D_r^m)\ u_r\ \zeta_{R\&D,r}(\rho_r)^{\omega_{R\&D}}}{\left(\dfrac{w_{R\&D,r}(1+t^w_{r,R\&D})}{\in_{H_{R\&D}}}\right)^{\in_{H_{R\&D}}}\left(\dfrac{p^k_{R\&D,r}(1+t^k_{r,R\&D})}{\in_{K_{R\&D}}}\right)^{\in_{K_{R\&D}}}\left(\dfrac{P^x_{R\&D,r}(1+t^x_{r,R\&D})}{\in_{X_{R\&D}}}\right)^{\in_{H_{R\&D}}}} \tag{6}$$

, where $w_{R\&D,m}$ and $p^k_{R\&D,r}$ are the rental price of labour and capital. In addition, $t^{\,w}_{r,R\&D}$, $t^{\,k}_{r,R\&D}$ and $t^{\,x}_{r,R\&D}$ are regional taxes or subsidies correspondingly on researchers' wages, rented capital and consumed intermediates. Regional governments are thus allowed to tax or subsidise inputs and outputs in the R&D sector. $P^{\,x}_{R\&D,r}$ is the price index of the bundle of intermediates:

$$P^x_{R\&D,r} = \left(\sum_{ind=1}^{IND}\sum_{r=1}^{R_m}\sum_{i=1}^{N_{ind,q}}(\beta_{r,ind})^{\sigma}(p^{x,ind}_{R\&D,i,r})^{1-\sigma}\right)^{\frac{\sigma-1}{\sigma}} \tag{7}$$

where $\beta_{r,ind}$ is the relative importance of each industry's output in the production process and $p^{\,x,ind}_{R\&D,i,r}$ the price of intermediate used by researchers in region r and bought from firm *i* in industry *ind* of region *q* and the relative importance of each industry's output in the production process is $\beta_{r,ind}$.

Since in equilibrium private researchers are indifferent between working in the knowledge-creation process or in other activities of the economy and a competitive market for ideas drives profit to zero, profit maximization of the knowledge-creation process yields the following price:

$$P_{D,r} = \frac{\left(\frac{w_{R\&D,r}(1+t^{w}_{r,R\&D})}{\in_{H_{R\&D}}}\right)^{\in_{H_{R\&D}}} \left(\frac{p^{k}_{R\&D,r}(1+t^{k}_{r,R\&D})}{\in_{K_{R\&D}}}\right)^{\in_{K_{R\&D}}} \left(\frac{P^{x}_{R\&D,r}(1+t^{x}_{r,R\&D})}{\in_{X_{R\&D}}}\right)^{\in_{X_{R\&D}}}}{\zeta_{R\&D,r}(\rho_r)^{\omega_{R\&D}}} \tag{8}$$

where $p_{D,r}$ is the price of ideas in region *r*. Regional governments are thus allowed to tax or subsidise inputs and outputs in the R&D sector.

3. The R&D-embedded capital production process

Turning to the regional investors, after having purchased the ideas, they use an interregional bundle of intermediates and rent local R&D-embedded capital and human capital to generate new R&D-embedded capital, increasing the regional stock. Since capital is not traded across regions but used for production and is rented only to the productive sectors of the regions where it is created, it represents one of the key sources of heterogeneity of economic outcomes across regions (together with human capital and the geographic location of the region).

In order to produce new R&D-embedded capital, investors buy all the ideas produced in the region, *Dr*, even if only a part of them are successfully transformed into successful ideas, $V_{I,r}$, depending on an endogenous regional innovation capacity ϕ_r:

$$V_{I,r} = D_r^{\phi_r}. \tag{9}$$

The rate of success in turning an idea into new R&D-embedded capital is determined by

$$\phi_r = \frac{KP_r}{KP_{EU}} \frac{HP_r}{HP_{EU}} \left(\frac{K_r}{K_{EU}}\right)^{\lambda} \left(\frac{H_r}{H_{EU}}\right)^{1-\lambda} \tag{10}$$

where is the amount of R&D-embedded capital in region $r(K_r)$ and in the whole EU (K_{EU}); is the number of high-skilled workers (approximated by the number of employees with education level ISCED 5+6) in region $r(H_r)$ and in the EU (H_{EU}). In addition, regional human capital and R&D-embedded capital endowments are also considered in per capita terms (HP_r and KP_r), where per capita variables are expressed as follows:

$$KP_r = \frac{K_r}{Pop_r} \;\; ; \;\; HP_r = \frac{H_r}{Pop_r}. \tag{11}$$

This specification is used to capture the key role played by the social interactions and a critical mass of investments in the innovation process by taking into account the relative endowment and absolute concentration of human and physical capital in a particular country vis-à-vis the rest of the EU[9]. The intuition is that absolute concentration may matter per se, as it increases the probability of productive interactions, imitation and productive complementarities, however also the relative endowment is important because richer regions (hosting a more than proportional share of capital and skilled labour vis-à-vis the rest of the EU) may still be very innovative because of factors related to the higher factor availability which are not captured in the model (as for example better education system because of a higher pool of skilled workers, or a more effective allocation of investments due to successful entrepreneurship history in the region).

Regional investors produce new R&D-embedded capital *Zr,* which increases the regional R&D-embedded capital stock, K_r, depreciating at rate δ_K[10]. The stock is thus assumed to be owned by the investors, who rent it to final goods and producers. At time *t*, the regional capital stock owned by investors can then be computed as:

$$K_{r,t} = K_{r,t-1}(1-\delta_K) + Z_{r,t}. \tag{12}$$

The investors in each region produce new capital by combining a bundle of inputs that can be traded across regions and locally available inputs. Considering all the investors in the region, the production of new R&D-embedded capital can be written as:

$$Z_r = V_{I,r}\zeta_{I,r}(K_{I,r})^{\epsilon_{K_I}}(H_{I,r})^{\epsilon_{H_I}}(X_{I,r})^{\epsilon_{X_I}} \tag{13}$$

where $K_{I,r}$, and $H_{I,r}$ are the amounts of local R&D-embedded and human capital rented to the investors $X_{I,r}$ and captures the quantity of intermediate goods used by the investors in region *r*. The shares of each type of input are estimated based on the SAMs. The productivity level is captured by the parameter $\zeta_{i,r}$, which can be estimated based on micro-level studies such as Ortega-Argilés *et al.* (2011). The bundle of intermediates is computed as:

$$X_{I,r} = \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R_m} \sum_{i=1}^{N_r} (\beta_{r,ind})^{\sigma} (x_{I,r}^{i,q,ind})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{14}$$

[9] For detailed analyses and literature of the impact of social agglomeration and clustering on the innovation capability, see Crescenzi *et al.* (2007), Storper and Venables (2004), Porter (2000) and Varga (2000).

10 The initial capital stock is calculated from the regional Social Accounting Matrices by assuming that the new capital generated is exactly what is needed to keep the system on a steady state growth path.

where $x_{I,r}^{i,q,ind}$ is the quantity of intermediates used by investors in region r and bought from firm i in industry *ind* of region q and the relative importance of each industry's output in the production process is $\beta_{r,ind}$. Constant returns to scale in the inputs are ensured by the condition:

$$\in_{K_I} + \in_{H_I} + \in_{X_I} = 1. \tag{15}$$

R&D-embedded capital is assumed not to be differentiated and therefore the competitive market price investors are able to charge $p_{I,r}^{z}$ equals their marginal costs of production plus the amortisation over the expected quantities produced in the $1/\delta_{NI}$ periods of the fixed cost of purchasing the idea[11]. For the sake of tractability, the rental price of new R&D-embedded capital is assumed to be equal to the rental price of the existing stock, i.e. $p_r^k = p_{I,r}^k$ [12]. The price of the newly produced units of capital consistent with zero profits at the industry level can then be written as:

$$p_{I,r}^{z} = \frac{\left(\dfrac{p_{I,r}^{k}(1+t_{I,r}^{k})}{\in_{K_I}}\right)^{\in_{K_I}} \left(\dfrac{w_{I,r}^{hi}(1+t_{I,r}^{w})}{\in_{K_I}}\right)^{\in_{H_I}} \left(\dfrac{p_{I,r}^{x}(1+t_{I,r}^{x})}{\in_{K_I}}\right)^{\in_{X_I}}}{\zeta_{I,r}(1+t_r^z)} + \frac{p_m^D D_r (1+t_r^D)\phi_r \delta_{N_I}}{Z_r(1+t_r^z)} \tag{16}$$

where the first terms accounts for the marginal costs of production and the second term for the fixed costs of buying D_r ideas, at p_r^D price, with a probability of turning them into R&D-embedded capital of ϕ_r. These fixed costs are then distributed over Z_r new units of R&D-embedded capital produced for $1/\delta_{N_I}$ periods, net of taxes and subsidies. Concerning the first term, $p_{I,r}^{z}$ is the price of renting the R&D-embedded capital ($K_{I,r}$) used in the production process, $w_{I,r}^{hi}$ is the wage of investors in region r and $P_{I,r}^{x}$ is the price index of the bundle of intermediates ($X_{I,r}$) bought as inputs from the different industries. The price index of the intermediates reflects the factory prices of individual intermediate goods, $p_{i,I}^{x,q,ind}$, their trade costs incurred to ship goods from region q to r, $\tau_{q,r,ind}$, and the relative importance of each industry's output in the R&D-embedded capital production process, $\beta_{q,r,ind}$:

$$P_{I,r}^{x}\left(\sum_{ind=1}^{IND}\sum_{q=1}^{R}\sum_{i=1}^{N_{ind,q}}(\beta_{r,ind})^{\sigma}(p_{i,I}^{x,q,ind}\tau_{q,r,ind})^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{17}$$

The regional government can tax or subsidise inputs and outputs used in process. The new R&D-embedded capital can be taxed or subsidised at rate $t_{Z,r}$, investors' labour at rate $t_{w,I,r}$, R&D-embedded capital rental at rate $t_{k,I,r}$, intermediates' purchase at rate $t_{x,I,r}$ and ideas at rate $t_{R\&D,r}$.

[11] Implicitly, this amounts to assuming that the investors can use the operating profits on ideas bought in previous periods to buy the new ones.

[12] In order to keep the model tractable, it is assumed that agents are myopic and expect prices and output to be stable over time, even after temporary shocks.

4. Regional final and intermediate goods production

Firms in each region produce goods for final consumption (for consumers and governments) and intermediate consumption (for other firms, investors and researchers) by employing local labour, R&D-embedded capital and intermediates, the latter being also imported from other regions' producers. Firms producing goods are indicated as i_r, $j_r \in N_r$. Their output ($y_{i,r}$) is defined as $c_{i,r}$ when used for final consumption, when used to produce ideas, $x_{I,r}$, when used to produce R&D-embedded capital, $x_{i,r}$ when used to produce other goods and $x_{G,r}$ when used to produce regional public goods.

The production process is represented by a Cobb-Douglas combination of an aggregate CES bundle of low- and high-skilled regional labour[13], $L_{i,r}$; a bundle of imperfectly substitutable intermediates $X_{i,r}$ from producer $j \neq i$ from within the same region r and other regions q from each industry $ind \in IND$, weighted by an industry-region-specific preference parameter, $\beta_{r,ind}$; and a stock of undifferentiated regional R&D-embedded capital $K_{i,r}$. In addition, each region is associated with a specific manufacturing productivity level, $\zeta_{i,r}$, and has access to different public goods and services provided by the regional government (PG_r) and by the national government (PG_r^m) by combining available intermediates with a region-specific efficiency level. Finally, a fixed amount of financial capital, FCi,r is needed to set up firms. This is financed by the households' savings stock in the EU, which is rented from regional entrepreneurs. The production function for the regional final and intermediate good firms can then be written as follows:

$$y_{i,r} = \zeta_{i,r} GS_{m,r}^{\in_{G_m}} GS_r^{\in_{G_r}} X_{i,r}^{\in_{X_i}} K_{i,r}^{\in_{K_i}} L_{i,r}^{\in_{L_i}} - FC_{i,r} \tag{18}$$

where:

$$L_{i,r} = \left(\sum_{e=lo,hi} \gamma_e (l_{i,r}^e)^\sigma \right)^{\frac{1}{\sigma}} \tag{19}$$

where $l_{i,r}^e$ is the amount of labour of skill level $e = lo, hi$ (respectively, low and high) used in the final goods sector of region r. The term γ_e represents the relative contribution of each skill level in the overall bundle of labour used in the final goods sector;

$$X_{i,r} = \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R_m} \sum_{j=1}^{N_{ind,q}} \left(\beta_{r,ind}\right)^\sigma \left(x_{i,r}^{j,q,ind}\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{20}$$

where $x_{i,r}^{i,q,ind}$ is the quantity of intermediates bought in the final goods sector of region r from firm j in industry of region q and $\beta_{r,ind}$ the relative importance of each industry's intermediate in the production process of regional public goods and services:

[13] Data on low skilled (ISCED level 0-2) and medium skilled (ISCED levels 3-4) come —just as high skilled labour— from the EUROSTAT database.

$$GS_r = \zeta_{G,r} \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R_m} \sum_{i=1}^{N_r} \left(\beta_{r,ind}\right)^{\sigma} \left(x_{G,r}^{i,q,ind}\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{21}$$

where $x_{G,r}^{i,q,ind}$ is the quantity of intermediates bought from firm i in industry *ind* of region q to produce public goods and services, *GS,* in region r. The term $\zeta_{G,r}$ captures the efficiency of public expenditures at the regional level and is approximated by the Quality of Government indicator as developed by Charron *et al.* (2012) [14]. Public goods and services are non-rival and are freely provided to private companies. Their supply depends on an exogenously given amount of resources, $E_{G,r}$, financed by the regional government budget, which is calibrated using government spending as reported in the regional Social Accounting Matrices. The amount of regional public goods and services provided can be computed as

$$GS_r = \frac{E_{G,r}\zeta_{G,r}}{P_{G,r}^{x}\left(1+t_{i,r}^{x}\right)}\ ; \tag{22}$$

where

$$P_{G,r}^{x} = \left(\sum\nolimits_{q=1}^{R} \sum\nolimits_{ind=1}^{IND} \sum\nolimits_{i=1}^{Ng,r} \left(\beta_{r,ind}\right)^{\sigma} \left(p_{G,r}^{i,q,ind}\tau_{q,r,ind}\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{23}$$

As for the provision of goods and services at the national level, a similar logic applies, with

$$GS_m = \zeta_{G,m} \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R_m} \sum_{i=1}^{N_r} \left(\beta_{r,ind}\right)^{\sigma} \left(x_{G,m}^{i,q,ind}\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{24}$$

And, an exogenously given amount of national resources devoted to the provision of public goods and services, $E_{G,r}$, the total amount produced in country m is

$$GS_m = \frac{E_{G,r}\ \zeta_{G,m}}{P_{G,m}^{x}}\ , \tag{25}$$

where

$$P_{G,m}^{x} = \left(\sum\nolimits_{q=1}^{R} \sum\nolimits_{ind=1}^{IND} \sum\nolimits_{i=1}^{Ng,r} \left(\beta_{r,ind}\right)^{\sigma} \left(p_{G,m}^{i,q,ind}\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{26}$$

[14] This QoG indicator has been constructed by combining national indicators on corruption, rule of law, government effectiveness and accountability from the World Bank's World Governance Indicators data with regional indicators obtained from a EU wide survey of 34 000 inhabitants in 172 NUTS1 and NUTS2 regions.

The amount of national public goods allocated to region can thus be measured as

$$GS_{m,r} = GS_m \frac{Pop_r}{Pop_m}, \tag{27}$$

Again, to ensure constant returns to scale in the inputs, the following condition should hold:

$$\in_{G_m} + \in_{G_r} + \in_{X_i} + \in_{K_i} + \in_{L_i} = 1. \tag{28}$$

The preferences of final goods consumers $U(Cr)$ are expressed by a standard CES utility function. For the sake of tractability, the substitutability between varieties is equal to the substitutability between intermediate inputs in the different sectors of the economy:

$$U(C_r) = \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R} \sum_{i=1}^{N_{s,q}} \beta_{r,ind} \left(c_r^{i,q,ind} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{29}$$

where the representative consumer in region $r \in R$ buys $i \in N_r$ varieties from all the EU regions and the rest of the world, $q \in R$, of each $ind \in IND$ industry, each weighted by an industry-region-specific preference parameter, $\beta_{r,ind}$[15]. The budget constraint for household in region r is

$$\sum_{ind=1}^{IND} \sum_{q=1}^{R} \sum_{i=1}^{N_r} \left[p_{c,r}^{q,i,ind} (1 + t_{c,r}) \tau_{q,r,ind} \right] c_r^{i,q,ind} = l_{h,r}^c \tag{30}$$

where $I_{h,r}^c$ is the part of income used for consumption, measured as a constant share of total income $(1 - s_r)$ the rest going to savings:

$$l_{h,r}^c = (1 - s_r) I_{h,r} \tag{31}$$

The resulting price index in region r for final consumption goods (indexed by c), given iceberg bilateral trade costs $\tau_{q,r,ind} > 1$ is:

$$P_r^c = \left(\sum_{ind=1}^{IND} \sum_{q=1}^{R} \sum_{i=1}^{N_{s,q}} \left(\beta_{r,ind} \right)^{\sigma} \left(p_{c,r}^{i,q,ind} \tau_{q,r,ind} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{32}$$

where $t_{r,ind}$ are consumption taxes or subsidies for industry ind in region r. The resulting consumption of variety i produced in region q and sold in region r for industry ind is equal to:

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[15] Notice that the same parameter is used to capture the relative importance of each industry's output in the production process and the industry-region-specific preference parameter. While a simplification, it makes the model more tractable, easier to calibrate and is a standard assumption in the literature with vertical linkages.

$$c_r^{i,q,ind} = \left(\frac{\frac{1}{\beta_{r,ind}} p_{c,r}^{q,i,ind} (1+t_{c,r}) \tau_{q,r,ind}}{P_r^c} \right)^{-\sigma} \frac{I_r^c}{P_r^C} \; . \tag{33}$$

The profit function associated with final and intermediate goods firms in each industry can be written in compact form as:

$$\Pi_r^i \left[p_{c,r}^i (1+t_{c,r}) - MC_r^i \right] y_r^i - f_r^i (1+t_m^f)(1+t_r^f) \tag{34}$$

where —given the functional forms of intermediate and final demand— prices are determined applying a constant mark-up on costs that depends on the level of substitutability (1 – σ),

$$p_{c,r}^i = \frac{MC_{i,r}}{1-\sigma} \tag{35}$$

Marginal costs can be computed as:

$$MC_{i,r} = \frac{\left(\frac{W_{i,r}\left(1+t_{i,r}^w\right)}{\in_{w_i}} \right)^{\in_{w_i}} \left(\frac{p_{i,r}^k\left(1+t_{i,r}^k\right)}{\in_{K_i}} \right)^{\in_{K_i}} \left(\frac{P_{i,r}^x\left(1+t_{i,r}^x\right)}{\in_{X_i}} \right)^{\in_{X_i}}}{\zeta_{i,r} (PG_r)^{\in_{KG}}} \tag{36}$$

where

$$P_{i,r}^x = \left(\sum\nolimits_{q=1}^{R} \sum\nolimits_{ind=1}^{IND} \sum\nolimits_{i=1}^{N_{g,r}} \left(\beta_{r,ind}\right)^{\sigma} \left(p_{i,v,ind}^{x,q} \tau_{q,r,ind} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} ; \tag{37}$$

$$W_{i,r} = \left(\sum_{e=lo,hi} \gamma_e [w_{i,r}^e]^{\frac{\sigma}{\sigma-1}} \right)^{\frac{\sigma-1}{\sigma}} . \tag{38}$$

Therefore, the price equation can be rewritten as:

$$p_{i,r}^c = \frac{\left(\frac{W_{i,r}\left(1+t_{i,r}^w\right)}{\in_{w_i}} \right)^{\in_{w_i}} \left(\frac{p_{i,r}^k\left(1+t_{i,r}^k\right)}{\in_{K_i}} \right)^{\in_{K_i}} \left(\frac{P_{i,r}^x\left(1+t_{i,r}^x\right)}{\in_{X_i}} \right)^{\in_{X_i}}}{(1+t_r^c)\,(1-\sigma)\,\zeta_{i,r} (PG_r)^{\in_{KG}}} . \tag{39}$$

Finally, the remuneration of equity $f_{i,r}$ (which can be seen as an annual fixed costs paid for setting up a firm) is equal to the endogenously determined returns on financial capital r_f times the units of financial capital needed to set up a firms $FC_{i,r}$, which is exogenously given:

$$f_{i,r} = r_{i,f} \ FC_{i,r}. \tag{40}$$

The total remuneration of financial capital per firm per region can be obtained using the zero-profit condition:

$$\Pi_{i,r} = 0 \qquad f_{i,r} = \left[\frac{MC_{i,r}(t_{i,r} + 0)}{(1-\sigma)\,(1+t_m^f)\,(1+t_r^f)} \right] y_{i,r} \tag{41}$$

where $t_{f,m}$ and $t_{f,r}$ are, respectively, national and regional taxes or subsidies on the rental of financial capital.

Returns on financial capital can be computed based on the assumptions that total savings are a fixed share of total income and free mobility of financial capital is assumed across regions in such a way that $f_i = f_{i,r}$. Therefore, a process of bidding up of the scarce resource leads to an equalisation in financial capital remuneration within the EU, net of taxes and subsidies. This leads to:

$$r_{i,f} = \frac{f_i}{FC_i} = \frac{MC_{i,r}(1-\theta)}{\left(1-\sigma\right)\left(1+t_m^f\right)\left(1+t_r^f\right) FC_i} y_{i,r}. \tag{42}$$

The equalisation of capital remuneration in turn determines the share of EU firms hosted by each EU region, as seen in the next section.

5. Households' savings and income

The financial capital sector is composed of savings first pooled from households across all EU regions and then allocated frictionless to final and intermediate goods firms across all the EU regions in the form of equity, equalising returns in all regions. An exogenously defined fixed quantity of capital, FC_i, is needed to set up a final goods firm. Firms then bid up for the units of capital to be employed in the productive process until total savings' returns could not be higher by marginally changing their allocation across regions.

In every period t, households add savings $s_r \ I_{h,r}$ to their total stock, which gets depreciated at rate δ_s (which can be thought of as inflation or deflation, if negative), so that

$$S_{r,t}^f = (1-\delta_s) S_{r,t-1}^f + s_{r,t} \ l_{h,r,t}. \tag{43}$$

The total savings stock, S^f, equals the sum of all regions' savings stocks S_r^f, which follow the accumulation equation as shown in equation (43) and:

$$S^f = \sum_r^R S_r^f . \tag{44}$$

It can be assumed that not all the savings are turned efficiently into equity, but that a transformation parameter ϕ_{FC} accounts for compliance costs, search costs or any other source of inefficiency, so that:

$$F = \phi_{FC} \ S^f . \tag{45}$$

Whereas the total number of firms in the whole EU can then be easily set as

$$N = \frac{F}{FC_i}, \tag{46}$$

the number of firms in each region will depend on the equalisation of financial capital remuneration seen in the previous section. So it will be local characteristics such as the availability of R&D-embedded capital, local public goods and services, firms' productivity and so on to determine the patterns of economic agglomeration and dispersion across regions.

Household income is the sum of wages of researchers, investors and employees in the goods sectors, plus the remuneration received from the rental of financial capital across regions. In addition, regional and national governments can deliver social transfers. Total household income at the regional level can then be computed as:

$$\begin{aligned} L_{h,r} = &\sum_{ind=1}^{IND} w_{R\&D,r} H_{R\&D,r,ind} + \sum_{ind=1}^{IND} w_{I,r}^{hi} H_{I,r,ind} + \\ &+ \sum_{ind=1}^{IND} W_{i,r} L_{i,r,ind} + \phi_{FC} S_r^f + TR_{h,r}^r + TR_{h,r}^m \end{aligned} \tag{47}$$

where TR_h^m are transfers from the national government to households and TR_h^r are transfers from the regional government to households.

6. Government

Finally, we sum up all the leverages of policy intervention observed in the different sectors of the economy analysed so far and thus define the national and regional governments' budget, which is assumed to be balanced.

6.1. National government budget

The national government can tax or subsidise financial capital rental. It is also allowed to transfer resources directly to regions or households. Its budget can then be written as follows:

$$t_m^f \sum_{r=1}^{R_m} \sum_{i=1}^{N_m} f_{i,r} + \left(\sum_{r=1}^{R_m} TR_m^r + TR_m^{EU} \right) - \left(TR_r^m + TR_h^m + TR_{EU}^m \right) - \\ - PR\&D_m - E_{G,m} = 0, \tag{48}$$

where $t_m^f \Sigma_{r=1}^{Rm} \Sigma_{i=1}^{Nr}$ *fi,r* are subsidies or taxes on rental of financial capital of firms i in regions $r \in R_m$; TR_r^m are transfers from the national government to regional governments; TR_h^m are transfers from the national government to households; TR_m^r are transfers from the regions to the national governments; TR_m^{EU} are the ECP funds transferred to each country; $PR\&D_m$ is the national funding of public research, $PR\&D_m$ $\Sigma_{r=Rm}$ $PR\&D_r^m$; $E_{G,m}$ is the budget allocated to the provision of the national public good.

6.2. Regional government budget

The regional government can provide productivity-enhancing public goods and services and tax or subsidise wages, intermediates and financial and physical capital rental. It is also allowed to transfer resources directly to households or to the national government. The regional government budget can then be written as:

$$\left(w_{R\&D,r}^{hi} \tau_{R\&D,r}^{w} H_{R\&D,r} + p_{R\&D,r}^{k} t_{R\&D,r}^{k} K_{R\&D,r} + p_{R\&D,r}^{x} t_{R\&D,r}^{x} X_{R\&D,r} + p_m^D D_r t_r^D \right) + \\ + \left(w_{I,r}^{hi} H_{I,r} t_{I,r}^{w} + p_{I,r}^{k} K_{I,r} t_{I,r}^{k} + P_{I,r}^{x} X_{I,r} t_{I,r}^{x} \right) + \left(TR_r^m + TR_r^{EU} \right) - \left(TR_h^r + TR_m^r \right) + \\ + \left(Wi_{I,r} L_{i,r} t_{i,r}^{w} + p_{i,r}^{k} K_{i,r} t_{I,r}^{k} + P_{i,r}^{x} X_{i,r} t_{i,r}^{x} + t_r^f \sum_{r=1}^{R_m} \sum_{i=1}^{N_r} f_{i,r} \right) - E_{G,r} - PR\&D_r = 0 \tag{49}$$

Here:

— $w_{R\&D,r}^{hi} \tau_{R\&D,r}^{w} H_{R\&D,r}$ are subsidies or taxes on wages of researchers;
— $p_{R\&D,r}^{k} t_{R\&D,r}^{k} K_{R\&D,r}$ are subsidies or taxes on R&D-embedded capital rental by researchers;
— $p_{R\&D,r}^{x} t_{R\&D,r}^{x} X_{R\&D,r}$ are subsidies or taxes on intermediates purchased by researchers;
— $w_{I,r}^{hi} H_{I,r}^{k} t_{I,r}^{hi}$ are subsidies or taxes on wages of investors;
— $p_{I,r}^{k} K_{I,r} t_{I,r}^{k}$ are subsidies or taxes on R&D-embedded capital rental by investors;
— $P_{I,r}^{x} X_{I,r} t_{I,r}^{x}$ are subsidies or taxes on intermediate goods purchased by investors;
— $p_m^D D_r t_r^D$ are subsidies or taxes on the purchase of ideas (bought by investors);
— $W_{i,r} L_{i,r} t_{i,r}^{w}$ are subsidies or taxes on wages of employees in the goods sector;
— $p_{i,r}^{k} K_{i,r} t_{i,r}^{k}$ are subsidies or taxes on R&D-embedded capital rental by goods firms;
— $P_{i,r}^{x} X_{I,r} t_{i,r}^{x}$ are subsidies or taxes on intermediate goods purchased by goods firms;

- $t_r^f \sum_{r=1}^{Rm} \sum_{i=1}^{Nr} f_{i,r}$ are subsidies or taxes on rental of financial capital of firms in;
- TR_h^r are social transfers from the regional government to households;
- TR_h^m are social transfers from the national government to households;
- TR_m^r are transfers from the regional government to the national government;
- TR_r^m are transfers from the national government to the regional government;
- TR_{EU}^m are contributions to the EU budget of each country;
- TR_r^{EU} are the ECP funds transferred to each region;
- $E_{G,r}$ is the money spent on acquiring inputs for the provision of public goods and services;
- $PR\&D_r$ is the regional funding of public research.

6.3. EU budget

The EU receives the contributions to its budget from the countries and redistributes this —in the form of ECP funds— to both national and regional governments, depending on the type of ECP funds. The balanced EU budget is written as:

$$\left(\sum TR_{EU}^r + \sum TR_{EU}^m\right) - \left(\sum TR_r^{EU} + \sum TR_m^{EU}\right) = 0 \qquad (50)$$

7. Discussion on the endogeneity of the knowledge-creation process

In what sense can this model be seen as generating an endogenous knowledge-creation process? And how are changes in the economy going to affect this process? To answer these questions, we should turn to equation (2), describing the regional knowledge production function, and analyse the sources of variation of its inputs: stocks of R&D-embedded capital, knowledge and human capital. For the sake of illustration, we can see the example of what would happen to the determinants of knowledge creation if transport costs are reduced because of an exogenous improvement in transport infrastructures resulting in lower interregional transport costs.

The first order of effects runs through the availability of cheaper intermediates imported from other regions lowering the production cost of new ideas. In fact, the reduction in marginal costs of production will affect prices of ideas, R&D-embedded capital and final goods and trigger reallocation and welfare effects. The second order of effects depends on the geographical knowledge spillovers. If the knowledge spillovers between regions are influenced directly by transport costs (for example, because researchers can travel and meet more often) or indirectly by an increase in trade (assuming that knowledge is embedded in the products and services traded), the impact of a reduction in iceberg transport costs would be associated with more efficient production of ideas, which will momentarily increase the salary of researchers and drive new researchers in the knowledge-creation activities to re-equilibrate high-skilled wages. This would result in more knowledge produced and lower prices for ideas.

A third order of effects runs through the availability of R&D-embedded capital to rent for producing new ideas. Lower transport costs of intermediate goods imported from other regions make the R&D-embedded capital production process in equation (13) more efficient and thus increase its stock [equation (12)], which is assumed to be on a steady growth path before the shock and thus above the trend after the shock. The impact of an increase in this stock to rent would then lower the prices and increase the quantities rented.

Human capital input is exogenously given in the current version and would therefore not be affected by a reduction in transport costs. However, if a production function is assumed also for the provision of the education service and it uses inputs such as intermediates, then also the human capital stock (the relative number of high-skill workers) would behave similarly to the R&D-embedded capital stock and have the same impact on the knowledge-creation process. In addition, it should be noted that even a temporary increase in knowledge production enhances future productivity for the region experiencing the shock and for its neighbours because an increase in the regionally produced stock knowledge as modelled in equation (1) shifts the knowledge production frontier outwards by increasing the stock of ideas available to researchers. This means that even the temporary shocks may have long-lasting effects, reinforced by the spatial spillovers.

Summing up, conditional on the specific technological parameters of the production functions, the endogenous knowledge-creation process of the model may yield self-sustained endogenous growth and allow us to model permanent effects of temporary shocks such as European Structural Funds.

8. Conclusions

This paper has described in detail how an endogenous knowledge-creation process can be embedded in a spatial CGE model. We described how, in each region, high-skilled researchers leverage the existing stock of ideas, R&D-embedded capital and intermediates to produce ideas which are transformed by local investors into R&D-embedded capital that add up to the existing stock which sustains the economy. This stock is indeed used not only to create new idea and regenerate the stock, but also by firms for producing final goods (for consumers) and intermediate goods (for the physical capital sector and the government) by combining regional R&D-embedded capital with labour, intermediates and public goods and services (provided by local governments). Besides consuming local and imported final goods, households provide both the labour input (low- and high-skilled) and the savings that are used as equity for setting up firms.

The main aim of this extension is to provide an analytical tool to deal with the heterogeneous response of European regions to policy intervention. Indeed, both persistence in economic disparities and convergence in income levels can be observed looking at the full sample of European regions. The extension proposed can rationalise economic convergence or the lack thereof though the differences in the accumulation of knowledge and R&D-embedded capital stocks. We showed that even temporary policy shocks —for example due to the availability of Cohesion Policy funds— can have long-lasting effects on the regions involved. These results are in line with the innovation literature finding that the socio-economic conditions of regions play a key role in determining that extent of a successful knowledge-for-growth nexus (Veugelers and Mrak, 2009).

An exogenous shock in a certain region increasing the efficiency of knowledge production has indeed been shown to increase the number of marketable ideas sold to investors, who are then expected to produce more R&D-embedded capital. This in turn increases the availability of the R&D-embedded capital input in the final goods sector, whose output in terms of intermediate and final consumption goods increases and prices lower. This is as far as each region is concerned individually. However, sources of spatial spillovers have been identified in both the knowledge-creation process and the trade of intermediate goods. For example, the efficiency of knowledge creation in each region is increased by the additional stock of knowledge in neighbouring regions. Similarly, the production of cheaper intermediates and final goods in the regions experiencing the positive shocks in knowledge-creation process benefits neighbouring regions by decreasing their costs of purchasing intermediate inputs (which make researchers, investors and firms more efficient) and final goods (which increases the welfare of citizens).

There are different directions in which the model presented here can be enriched. For example, an obvious simplification has been to take human capital stock as exogenous, but it could as well result from an endogenous accumulation process as the other stocks analysed here. Another obvious subsequent step would be to bring the model to the data and see it can indeed be used to rationalise observed growth patterns and impacts of policy intervention. Its implementation will be data-intensive, partly due to the model's large dimensions (267 EU regions and 6 sectors) and due to the detailed knowledge creation process as described in this paper. For comparison, DG ECFINs model QUEST is developed at a country level and has only one productive sector. The model presented in this paper has described the process of knowledge creation, the production of R&D-embedded capital and final and intermediate goods while keeping in mind its actual implementability and calibration at the regional level with available data, which will be done in subsequent work.

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Annex I: Identifiers (subscripts/superscripts)

$r, q \in R$	Regions
$m \in M$	Countries
$j \in N$	Intermediate firms
$ind \in IND$	Industries
$R\&D$	Knowledge-creation activities
I	R&D-embedded capital creation activities
G	Government
h	Households

Annex II: Variables

ci	Consumption of final goods
D	Ideas adding up to the knowledge stock
$DP_{r,t}$	Ideas created using public regional funding
$E_{G,r}$	Regional government expenditures in intermediates to produce public goods
$E_{G,m}$	National government expenditures in intermediates to produce public goods
F	Total effective financial investments
$f_{i,r}$	Remuneration of financial capital needed to set up a firm
f_i	Total remuneration of financial capital
FC_i	Fixed costs of setting up a final goods firm (in terms of units of financial capital)
$H_{R\&D}$	Researchers' human capital
H_I	Investors' human capital
HP_r	Per capita levels of human capital in region
$I_{h,r}$	National household income
I_h^c	Income spent on consumption
$K_{r,t}$	R&D-embedded capital stock at time
K_I	R&D-embedded capital rented to the investments' sector
K_i	R&D-embedded capital rented to the final goods firms
$K_{R\&D,r}$	R&D-embedded capital stock in region
KP_r	Per capita levels of R&D-embedded capital in region

$l_{R\&D}^{hi}$	High-skilled labour force used in the knowledge-creation sector
L_i	Composite bundle of labour employed for goods firms
l_i^e	Labour force with skill level, (respectively low, high)
MC_i	Marginal costs of firm
N_i	Number of final goods firms
p^D	Price of ideas
$p_{I,r}^z$	Price of new R&D-embedded capital produced by investors
p_I^k	R&D-embedded capital rental price in for investors
P_I^x	Intermediates bundle price index for investors
p_I^x	Intermediates' price for investors
P_i^x	Intermediates bundle price index for goods firms
p_i	Price of final goods
p_i^k	Capital rental price for goods firms
p_i^x	Price of intermediates for goods firms
P_r^c	Price index of final goods in consumption bundle in region
GS_r	Public goods and services provided by regional governments
GS_m	Public goods and services provided by regional governments
$P_{G,r}^x$	Intermediates bundle price index for producing public goods and services in region
P_r^c	Price index of final goods in region
Pop	Population
$PR\&D_r$	Regional budget for public research
$PR\&D_m$	National budget for public research
$R\&D_r$	Stock of knowledge in region
ρ_r	Regionally available stock of knowledge
r_i	Remuneration of a unit of financial capital
S^f	Total financial savings stock
TR_h^m	Transfers from countries to households
TR_h^r	Transfers from regions to households
TR_m^r	Transfers from regions to countries
TR_r^m	Transfers from countries to regions
TR_{EU}^m	Transfers from countries to the EU (contribution to EU budget)
TR_m^{EU}	Transfers from the EU to the countries (ECP funds)

TR_r^{EU}	Transfers from the EU to the regions (ECP funds)
$U(C_r)$	Utility of the representative consumer in region r
u_r	Efficiency of public research of region
V_I	Number of ideas successfully turned into new R&D-embedded capital.
$w_{i,r}^e$	Wage of e-skilled labour employed in goods firms, e=lo,hi (low, high)
W_i	Wage index of labour bundle for goods firms
w_I^{hi}	Wages (high-skill) of investors
$X_{R\&D}$	Intermediates' bundle consumption by researchers
$x_{R\&D}$	Intermediates purchased by researchers to produce ideas
X_I	Intermediates' bundle consumption by investors
x_I	Intermediates purchased by investors to produce R&D-embedded capital
X_i	Intermediates' bundle consumption used by goods firms
X_m	Intermediates' bundle consumption used by the national government
X_r	Intermediates' bundle consumption used by the regional government
x_G	Intermediates used by government to produce public goods
x_j	Intermediates used by firms to produce goods
y_i	Output of goods firms
Z	New R&D-embedded capital produced
$\tau_{q,r,ind}$	Trade cost from q to r in industry ind
Π_i	Goods firm 's profits in the sector
ϕ_{FC}	Transformation parameter for savings into financial capital/equity
ϕ_r	Rate of success in turning ideas into R&D-embedded capital

Annex III: Taxes

$t_{r,R\&D}^w$	Regional subsidies or taxes on researchers' wages
t_r^D	Regional taxes or subsidies on ideas' sales
$t_{I,r}^w$	Regional subsidies or taxes on investors' wages
$t_{I,r}^k$	Regional subsidies or taxes on R&D-embedded capital rented by investors
$t_{I,r}^x$	Regional subsidies or taxes on intermediates purchased by investors
$t_{i,r}^w$	Regional subsidies or taxes on employees' wages in the goods sector
$t_{i,r}^k$	Regional subsidies or taxes on R&D-embedded capital rented by goods firms
$t_{i,r}^x$	Regional subsidies or taxes on intermediates purchased by goods firms

t_r^c	Regional subsidies or taxes on goods sales
t_m^f	National subsidies or taxes on rental of financial capital
t_r^f	Regional subsidies or taxes on rental of financial capital

Annex IV: Parameters

d_{r,r^*}	Measure of distance between region and
s_r	Savings rate in region r
β	Preference parameter
γ_e	Relative skill e(=lo,me,hi) weight in the labour bundle for final goods production
δ	Depreciation rate
$\delta_{R\&D}$	Depreciation rate of knowledge stock
δ_K	Depreciation rate of R&D-embedded capital stock
δ_s	Depreciation rate of savings stock
$\in_{H_{R\&D}}$	High-skill human capital share in ideas' production function
$\in_{K_{R\&D}}$	Rented capital share in ideas' production function
$\in_{X_{R\&D}}$	Intermediate consumption share in ideas' production function
$\in_{H_I}$	High-skill human capital intensity in R&D-embedded capital's production function
$\in_{K_I}$	R&D-embedded capital intensity in R&D-embedded capital' production function
$\in_{H_i}$	R&D-embedded capital intensity in final goods production function
$\in_{G_i}$	Relative importance of public goods in goods production function
$\in_{L_i}$	Labour intensity in goods production function
$\in_{X_I}$	Intermediates consumption's intensity in R&D-embedded capital production
$\in_{X_i}$	Intermediates consumption's intensity in goods production function
$\zeta_{R\&D,r}$	Region-specific productivity parameter in the knowledge creation process
$\zeta_{I,r}$	Region-specific productivity parameter in R&D-embedded capital production
$\zeta_{i,r}$	Region-specific productivity parameter in the goods manufacturing process
$\zeta_{G,r}$	Region-specific efficiency in the production of public goods and services
θ	Level of substitutability between varieties
λ	Relative importance of R&D-embedded capital and human capital for innovation capability
σ	Substitution parameter
$\omega_{R\&D}$	Knowledge absorption capacity in the knowledge-creation process

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Section Articles

Modelling regional labour market dynamics: Participation, employment and migration decisions in a spatial CGE model for the EU

Damiaan Persyn, Wouter Torfs, d'Artis Kancs*

ABSTRACT: This paper outlines how regional labour market adjustments to macro-economic and policy shocks are modelled in RHOMOLO through participation, employment and migration decisions of workers. RHOMOLO, being a multi-sectoral, inter-regional general equilibrium model, is complex both in terms of its dimensionality and the modelling of spatial interactions through trade flows and factor mobility. The modelling of the labour market is therefore constrained by the tractability and computational solvability of the model. The labour market module consists of individual labour participation decisions, including the extensive margin (to participate or not) and the intensive margin (hours of work). Unemployment is determined through a wage curve and inter-regional labour migration decisions are modelled in a discrete-choice framework, with backward-looking expectations.

JEL Classification: C68; D58; F22; J20; J61; J64; O15.

Keywords: Participation; unemployment; labour migration; wage curve; CGE; new economic geography.

Modelización de la dinámica en mercados de trabajo regionales: participación, empleo y decisiones de migración en un modelo espacial de EGC para la UE

RESUMEN: Este *paper* describe cómo los ajustes en los mercados de trabajo regionales tanto a los *shocks* de política como macroeconómicos se modelizan en RHOMOLO a través de decisiones de los trabajadores sobre participación, empleo y migración. RHOMOLO, como modelo de equilibrio general multisectorial e interregional es complejo tanto en términos de dimensionalidad como de modelización de interacciones espaciales a través de flujos de comercio y movilidad de factores. La modelización del mercado de trabajo está por ello limitada tanto por

* IPTS, European Commission DG Joint Research Centre, E-41092 Seville, Spain
The authors gratefully acknowledge the helpful comments of two anonymous referees. The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not under any circumstances be regarded as stating an official position of the European Commission.

Received: 10 april 2014 / Accepted: 1 september 2014.

la capacidad computacional como por la facilidad para obtener una solución (en forma de expresión matématica, en forma reducida) del modelo. El módulo del mercado de trabajo consiste en decisiones de participación individuales, incluyendo el margen extensivo (participar o no) y el margen intensivo (horas de trabajo). El desempleo se determina a través de la curva de salarios y las decisiones de migración interregional se modelizan en un esquema de elección discreta basado en expectativas pasadas.

Clasificación JEL: C68; D58; F22; J20; J61; J64; O15.

Palabras clave: participación; desempleo; migración laboral; curva de salarios; CGE; nueva geografía económica.

1. Introduction

Labour markets serve as an important adjustment channel to macro-economic shocks, such as regional integration and economic crises. Changes in regional employment can be accommodated in a model through changes in labour force participation, changes in unemployment, or labour migration. The present paper describes the modelling approach of regional labour markets taken in the newly developed dynamic spatial general equilibrium model RHOMOLO[1]. It is crucial to account for all three adjustment channels of regional labour markets in the modelling framework, as there exist important interactions between them. Failing to model them simultaneously may result in suboptimal policy recommendations (Boeters and Savard, 2012). Therefore, in RHOMOLO, the labour market equilibrium is determined by firms' labour demand, the participation decision of representative households, a wage curve relating wages to unemployment and inter-regional labour migration.

Inclusion of households' participation decisions is desirable, as the empirical evidence has shown that in the EU changes in regional employment opportunities are predominantly absorbed through changes in participation decisions by individuals, rather than migration or changes in unemployment (Decressin and Fatás, 1995). In addition, it is important to distinguish between the intensive and extensive margin of participation. If the change in participation occurs at the intensive margin, workers simply adjust their number of hours worked and unemployment remains unaffected. For given levels of employment however, participation decisions at the extensive margin do alter unemployment. In RHOMOLO the participation decision is modelled both at the intensive and the extensive margin and closely follows the approach by Boeters and van Leeuwen (2010), describing the labour market in WORLDSCAN, a CGE model developed and used by the Dutch Central Planning bureau (CPB).

The empirical evidence suggests that unemployment is not driven by excess labour supply. In contrast, regions and countries with high employment rates have low

[1] For a detailed description of the RHOMOLO model, see Brandsma *et al.* (2013), published in this issue of *Investigaciones Regionales*.

unemployment rates, and there is limited job creation in regions and countries with high unemployment rates, rather than large differences in labour supply. This implies that labour market imperfections must be accounted for, in order to explain the prevalance of unemployment. The modelling of unemployment in RHOMOLO follows Blanchflower (1994) and adopts the wage curve approach —an empirical regularity describing the negative relation between wages and unemployment. This approach allows us to pragmatically introduce unemployment, while avoiding strong assumptions on the underlying labour market imperfections causing it.

Although the importance of international migration as an adjustment channel is only of limited importance in the EU, inter-regional labour migration flows do mitigate demand shocks to a significant extent (Blanchard and Katz, 1992; Decressin and Fatás, 1995; European Commission, 2012), especially over longer time periods. Consequently, interregional migration is also modelled in RHOMOLO. The migration decision of households in RHOMOLO is based on a comparison of expected regional income differences. All parameters governing the elasticity of the migration decision are estimated empirically.

The remainder of the paper is structured as follows. Section 2 introduces the participation decisions of workers, Section 3 describes the wage curve and estimates country-specific wage curve elasticities, and Section 4 details the modelling of inter-regional labour migration in RHOMOLO and the estimation procedure applied to uncover the elasticities determining inter-regional labour migration flows.

2. Labour market participation

The approach taken in modelling participation in RHOMOLO is based on Boeters and van Leeuwen (2010). We introduce participation decisions both at the intensive and extensive margins.

2.1. Modelling participation: intensive margin

The representative individual divides her total available time T between leisure, F, and hours worked, H. As working increases the available income for consumption, the individual faces a trade-off between consumption and leisure in utility when optimising the following CES utility function:

$$V_e = \left[\theta_c \left(\frac{C}{\overline{\overline{C}}} \right)^{\frac{\gamma-1}{\gamma}} + (1-\theta_c) \left(\frac{F}{\overline{\overline{F}}} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \tag{1}$$

Bars above variables denote the observed benchmark values. We use the «calibrated share form» notation of Böhringer *et al.* (2003) to facilitate the practical implementation and calibration of the model additions in GAMS. The only parameter that requires calibration then is θ_c, which is the value share of consumption, at its benchmark point. Write p_c for the price of the consumption good C. The price of leisure F corresponds to its opportunity cost, the wage w. Write p_c for the expenditure required to obtain a unit of utility. Given the CES form of utility, the price of utility is a CES price index of w and p_c:

$$p_v = \left[\theta_c (p_c)^{\frac{1-\gamma}{\gamma}} + (1-\theta_c) \left(\frac{w(1-t_m)}{\overline{w}(1-t_m)} \right)^{\frac{1-\gamma}{\gamma}} \right]^{\frac{1}{1-\gamma}} \tag{2}$$

where t_m is the marginal tax rate on labour.

Consider the extended income Y_D which equals total income plus the initially consumed amount of leisure when valued at the benchmark wage, such that $Y_D = w\big(H(1-t_\alpha) + (T-H)(1-t_m)\big)$. The level of obtainable utility in the benchmark equals $V_e = \dfrac{Y_d}{p_v}$. The optimal demand of consumption and leisure relative to their baseline value are given equations (3) and (4).

$$\frac{C}{\overline{\overline{C}}} = V_e \left(\frac{p_v}{p_c} \right)^{\gamma} \tag{3}$$

$$\frac{F}{\overline{\overline{F}}} = p_e \left(\frac{\overline{w}(1-\overline{t_m}}{w(1-t_m)} \right)^{\gamma} \tag{4}$$

A shift in the budget constraint increases the obtainable level of utility V_e and shifts the demand functions. The number of hours of work supplied then can be readily calculated from the demand of leisure as $H = T - F$.

In order to set the elasticity of substitution between leisure and consumption γ, we make us of the fact that under appropriate assumptions[2] $\gamma = 1 - \dfrac{\eta_{Lw}}{\eta_{LY}}$, with η_{Lw} the wage elasticity of the hours of work supplied, and η_{LW} the income elasticity of the hours of work supplied. The values for these elasticities are set at and $\eta_{LY} = -0.1$ and $\eta_{wY} = -0.1$, which results in $\gamma = 2$. Furthermore, under the appropriate assumption,

[2] See (Boeters and van Leeuwen, 2010) for an elaborate discussion on the assumption underlying this result. A detailed exposition of the complete build up of all elements of the model is beyond the scope of this paper. We restrict ourselves to the intuiting of the mechanisms driving the most important results.

an income elasticity of labour, $\eta_{LY} = -0.1$ implies $T/H = 1.1$ (see (Boeters and van Leeuwen, 2010). Future work will consider setting the parameter values according to recent empirical work on these elasticities, such as Bargain *et al.* (2014).

2.2. Modelling participation: extensive margin

Next, we introduce labour supply decisions along the extensive margin. Our aim is to determine the number N of labour market participants.

Following Boeters and van Leeuwen (2010) we model the combined labour supply decision (intensive and extensive) as a two-step procedure, which is solved backwards by the individuals. Individuals first determining their optimal number of hours worked, assuming a positive participation decision. The expected utility of supplying labour V_l then is compared to a fixed (and individual specific) cost of working, V_0 to determine whether to participate or not. This fixed cost of working, V_0, is assumed to be uniformly distributed across individuals.

In the presence of involuntary unemployment (see Section 3), the assignment of labour market participants between the employed and unemployment is assumed to be random (the individuals are assumed to be identical apart from their idiosyncratic cost of participation V_0). The unemployment rate, u, is assumed to be exogenous from the perspective of the individual, V_u is the utility of an unemployed individual (see below), and V_e is the utility of an employed individual shown above in equation 1. The e$_1$xpected utility of supplying labour for every individual therefore is given by:

$$\bar{V}_l = (1-u)\bar{V}_e + uV_u, \tag{5}$$

where the utility of an unemployed individual is given by:

$$V_u = \left[\theta_c\left(\frac{C_u}{\bar{C}}\right)^{\frac{\gamma-1}{\gamma}} + (1-\theta_c)\left(\frac{T-\delta\bar{L}}{\bar{F}}\right)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}} \tag{6}$$

with $C_u \equiv rwL(1 - t_\alpha)$ the consumption level of the unemployed with a replacement income determined by the replacement rate r. It is assumed that the unemployed can enjoy only a share δ of the total available time T in the form of leisure (due to, for example, time spent searching for jobs). The utility level of the unemployed contains no decision variables and hence is fully determined by model parameters.

Writing h for the value of the density function of V_0's, the number of labour market participants then can be calculated as

$$N = \bar{N} + h(U_l - \bar{U}_l) \tag{7}$$

Assuming the U_l remains within the upper and lower limit of this distribution, the change in the number of participants N in function of wage increases will be higher for a high value of h, the case where individuals have rather similar values of V_0. The value of h therefore determines the elasticity of labour supply at the extensive margin.

More formally, the elasticity of labour supply at the extensive margin which is implied by a specific value for h equals

$$\eta_{Nw} \equiv \frac{\partial \log N}{\partial \log w} = \frac{\partial \log N}{\partial \log V_l} \frac{\partial \log V_l}{\partial \log w} = h \frac{V_l}{N} \frac{\partial \log V_l}{\partial \log w} = h \frac{(1-u)V_e}{N} \frac{wL(1-t_m)}{Y_D}.$$

Note that the value of the elasticity does not only depend on h but also on N and other variables, and therefore is endogenous. We follow Boeters and van Leeuwen (2010) and fix h at the value which correponds to $\eta_{Nw} = 0.2$ at the benchmark level of $N = \overline{N}$. In the simulations, will vary depending on the value of N.

Alternatively, the participation module could be calibrated using country-specific econometric elasticity estimatesy. Some recent empirical estimates are available from Bargain *et al.* (2014).

3. Unemployment

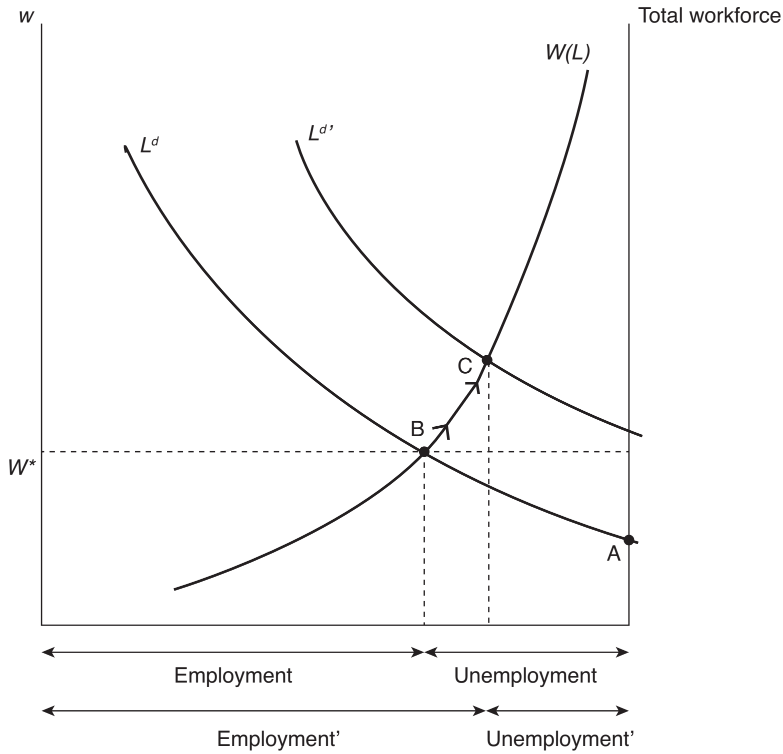
3.1. Conceptual framework of a wage curve

Following Blanchflower (1994), unemployment in RHOMOLO is modelled by means of a wage curve. The fundamental empirical regularity of the wage curve —a negative relationship between the local unemployment to local real wages— can be derived from a number of micro-founded theoretical models (Card, 1995): the implicit contract model, where the local presence of valued amenities compensate for lower wages and higher unemployment; the efficiency wage model, where employers need to be paid a premium to prevent them from shirking on the job and the negative relation arises because the no-shirking premium is lower in times of high unemployment (because the penalty of getting caught shirking increases); and finally, the union bargaining model, where increasing unemployment leads to a worsening of the workers' outside option, reducing their wage demands during negotiations with employers.

Figure 1 illustrates the equilibrium on the labour market in the presence of a wage curve. Take for example a unionised regional labour market, where unions bargain a higher wage during negotiations with employers, albeit at the cost of decreased job creation. The negotiations drive a wedge between the competitive wage level (A) and the bargained wage (B), leading to equilibrium unemployment, a desirable future for a spatial equilibrium model.

Now consider the effect of a regional labour demand shock: in a perfectly competitive labour market with an inelastic labour supply, such a shock would solely

Figure 1. The local labour market equilibrium in the presence of a wage curve and an illustration of the effect of a labour demand shock on wages and (un)employment



affect the wage level and leave employment unaltered at the full-employment level. A wage curve ensures that a labour demand shock is translated into an increase in both employment (decrease in unemployment) as well as the wage level (A→B). Because in the RHOMOLO economy people can migrate between regions, this is not the end of the story. How migration mitigates the initial local wage increase in the change in the unemployment rate is illustrated in section 4.

A key parameter determining the effect of shocks on regional unemployment is the wage curve elasticity. In the current version of RHOMOLO, the slope of all regional wages curves is assumed to be equal to –0.1, a commonly recurring value in the empirical literature (Card, 1995; Blanchflower and Oswald, 1995; Janssens and Konings, 1998; Fagan *et al.*, 2005). Since reported estimates in the empirical literature vary considerably, future research will aim to provide country specific estimates of the wage curve elasticity. Our approach will be based on Baas *et al.* (2007) and Jimeno and Bentolila (1998). The pragmatic approach of using a reduced-form wage curve allows us to avoid explicitly modelling the exact mechanisms generating unemployment and thus circumvent making strong assumptions about parameters driving those models, which are often unobservable. Introducing national variation in the slope of the wage curves, allows the model to capture fundamental differences between countries' labour market institutions. With a more structural approach, this would be difficult to achieve as calibrating such modelling frameworks would place heavy demands on the data requirements.

4. Labour migration

4.1. A discrete choice model of labour migration

The equilibrating effect of migration flows in RHOMOLO is illustrated in Figure 2. Keeping everything else constant, the initial labour demand shock, illustrated in Figure 1, triggers in-migration which causes both wages and unemployment rates to return back to their pre-shock level (B→C). It is important to keep in mind that in a general equilibrium model, as in reality, everything else is not fixed. Firms will be exiting or entering the region which results in additional labour demand shifts and other regions will be affected through trade-links or knowledge spillovers, preventing complete equalisation of regional labour market outcomes.

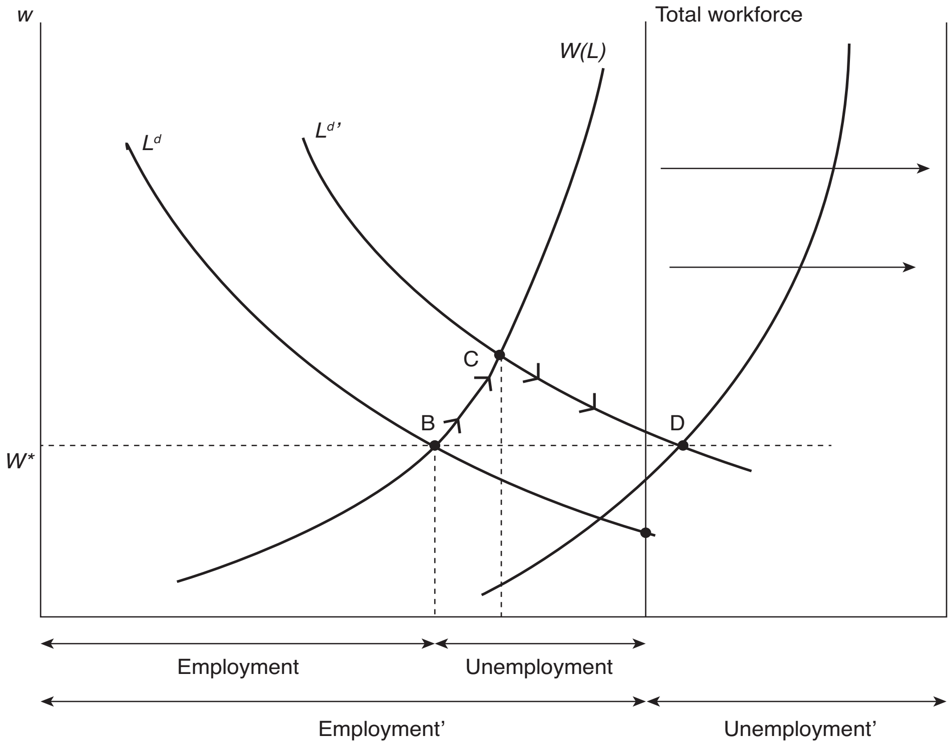
The modelling of migration in RHOMOLO follows the approach of Sorensen *et al.* (2007) and Grogger and Hanson (2011) and is described in detail in Brandsma *et al.* (2013). It starts from the individual migration decision, where worker k from origin region o, maximises indirect utility, V_{kor}, across all possible destinations r. Destination d will be chosen if

$$V_{kod} > V_{kor} \;\; \forall\, r, \qquad V_{kod} = Z_{od}\beta + \xi_{od} + e_{kod}.$$

The indirect utility of V_{kod} worker k migrating from origin region o to destination region d is determined by characteristics V_{od} of regions o and d. These characteristics are pair specific and contain for example bilateral distance. Term $Z_{od}\beta$ represents the utility that workers k associates with these characteristics, so that β is a vector of marginal utilities. Error term ξ_{od} represents unobserved location characteristics. $Z_{od}\beta$ and ξ_{od} assign the same utility level to all workers in o considering migration to d. The idiosyncratic error term e_{kod} varies across both workers and regions and accounts for the fact that not all workers from the same region choose the same destination. The probability that location d is chosen by individual k from region o then equals:

$$\begin{aligned} &Pr(V_{kod} > V_{kor}) && \forall d \neq r \\ &Pr(e_{kod} - e_{kor} > Z_{or}\beta - Z_{od}\beta + \xi_{or} - \xi_{od}) && \forall d \neq r. \end{aligned}$$

Figure 2. An illustration of a single shift in labour demand (A→B), and subsequent in-migration (B→C) on regional wages, employment and unemployment in a *partial equilibrium* setup. The shift only has a temporary effect on the local wage level and unemployment rate, but a permanent effect on the size of the local labour force.



Now assume that the idiosyncratic error term follows an i.i.d. extreme value distribution. McFadden (1973) shows this yields the following probability for a worker k from o to migrate to d:

$$Pr(M_{kod}=1)=\frac{\exp(Z_{od}\beta+\xi_{od})}{\sum_{d=1}^{R}\exp(Z_{od}\beta+\xi_{od})}. \tag{8}$$

Berry (1994) in turn shows that probability (8) of migrating from o to d coincides with the share of workers from o migrating to d. Following Sorensen *et al.* (2007), we therefore write the share of migrants from o to d as:

$$S_{od}=Pr(M_{kod}=1)=\frac{\exp(Z_{od}\beta+\xi_{od})}{\sum_{d=1}^{R}\exp(Z_{od}\beta+\xi_{od})}. \tag{9}$$

and the share of stayers in region *o* as:

$$S_{oo} = Pr(M_{koo} = 1) = \frac{\exp(Z_{oo}\beta + \xi_{oo})}{\sum_{d=1}^{R}\exp(Z_{od}\beta + \xi_{od})}. \tag{10}$$

Dividing equation (9) by (10) and applying a logarithmic transformation yields a simple econometrically estimable migration equation:

$$Ln\left(\frac{s_{od}}{s_{oo}}\right) = \ln\left(\frac{\exp(Z_{od}\beta + \xi_{od})}{\exp(Z_{oo}\beta + \xi_{oo})}\right) = Z_{od}\beta - Z_{oo}\beta + \xi_{od} - \xi_{oo} \tag{11}$$

Next, we allow e_{kod} the to be correlated within countries, while maintaining the i.i.d. assumption between countries. Using the same index *c* for countries (nests) and for the country of destination, the estimable migration equation can then be written as:

$$Ln\left(\frac{s_{od}}{s_{oo}}\right) = (Z_{od} - Z_{oo})\beta + \sigma\ \ln(s_{(od/c_d)}) + (\xi_{od} - \xi_{oo}) \tag{12}$$

4.2. Econometric specification and empirical implementation

The estimation of equation (12) requires an instrumental variable approach due to the endogeneity of the conditional probability (share). Following the common approach in the literature on discrete choice in the context of product demand estimation (Berry *et al.*, 1995), we chose the number of regions in country as an instrument for the probability of choosing a specific region as the destination of choice, conditional on the destination country choice. The share of people choosing a particular region in a country will on average be inversely related to the number of regions in the country. The number of regions in a country is exogenous to the migration decision in itself, as the size of countries and the number of NUTS-2 regions contained in them are clearly unrelated to contemporary migration patterns.

In order to construct a matrix with bilateral regional migration flows, two datasets were merged: Eurostat's data on within-country interregional migration flows and OECD's data on international migration. Data on migration between NUTS2 regions *within* countries is available from Eurostat for most of the EU member states. The first step in constructing an approximate dataset of gross bilateral migration flows between NUTS2 regions consists of calculating migration probabilities between every pair of regions within each country, for each country separately. Secondly, international migration flows without any regional dimension were obtained from the OECD. These international migration flows were subsequently «regionalised», assuming that international migrants distribute themselves between the regions of the country of destination according to the same pattern as within-country migrants do. Similarly, the international migrants are assumed to originate from specific regions of origin in the source country in the same proportions as the within-country migrants originate from different regions in the source country. Obviously, this approach is an approximation, and will introduce errors, if the true distribution of international migrants differs significantly from the observed distribution of within-country migrants.

Explanatory variables. In line with the underlying conceptual framework, we measure the indirect utility for living in region d for an individual from region o, $V_{kod} = Z_{od}\beta + \xi_{od} + e_{kod}$ by the expected real income in destination region d, net of migration costs for migrating between o and d. We approximate the real expected income in region r by $income_r = \frac{W(r)\cdot\left(l-u(r)\right)}{P(r)}$, with the average local wage $W(r)$, the unemployment rate $u(r)$, and the local consumer price index $P(r)$. The migration costs are approximated by a log-linear function of the great circle distance between the geographic centre of the origin and destination NUTS-2 region. A dummy variable $I(intl_{od})$ for international migration equals 1 in case region o and d are located in different countries. The empirical specification of the estimation equation then becomes

$$\ln\left(\frac{s_{od}}{s_{oo}}\right) = \beta_1 \ln(income_o) + \beta_2 \ln(income_d) + \beta_3 \ln(distance_{od}) + \\ +\beta_4 \mathrm{I}(intl_{od}) + \beta_5 \ln(s_{(od|c_d}) + (\xi_{od} - \xi_{oo}). \tag{13}$$

The data on wages, the unemployment rate and consumer price index (CPI) were taken from the Eurostat regional databases. The year 2004 was chosen to perform the analysis, as this year has the best data coverage[3]. Although, according to the underlying conceptual framework, coefficients β_1 and β_2 should be of opposite sign and of equal size, we follow Kancs (2011) and do not impose this restriction in our empirical application. We report the empirical results for specifications including a log-linear distance term to estimate the elasticity of migration with respect to distance. In the simulations using RHOMOLO, however, in order to obtain results which are as realistic as possible a fifth-order polynomial in log-distance will be used to capture non-linearities in the response of migration to distance. We omit these results here.

4.3. Empirical results

Using the imputed interregional migration flows, equations (11) and (12) were subsequently estimated.

Column (I) of Table 1 shows the results of estimating equation (11) using the OLS estimator. Column (II) reports the instrumental variables estimation described above for equation (12). The estimated effect of income in the destination region

[3] Choosing a different year does not materially affect the results.

decreases and the elasticity of distance increases when taking into account the endogeneity of the conditional probability, but overall the results of OLS and IV are rather similar. The size of the effect of the international migration dummy I($intl_{od}$) is remarkable, emphasising the importance of international borders (often corresponding to important cultural and language barriers) on labour mobility. One important point is that the coefficient on the conditional share implies an estimate of σ, the measure of within-country correlation in taste has the opposite sign and is outside of the theoretically consistence range between 0 and 1. In this light, and because the difference between the OLS and IV estimates are quite close, we opted to use the OLS estimates in the simulation analysis.

Table 1. Estimation results

	(I)	*(II)*	*(III)*
lnexpto	0.840***	0.855***	0.758***
	(0.0236)	(0.0234)	(0.0275)
lnexpfrom	–0.465***	–0.461***	–0.488***
	(0.0197)	(0.0196)	(0.0243)
logdist	–1.724***	–1.696***	–1.877***
	(0.0202)	(0.0202)	(0.0330)
lncondshareto		0.228***	–1.221***
		(0.0172)	(0.0423)
_cons	–4.163***	–3.902***	–5.563***
	(0.292)	(0.291)	(0.426)
N	14485	14485	14485

Being rooted in the discrete choice theory, the estimated migration model allows us to infer the structural parameters governing the individual behaviour from observable aggregate migration flows. An important advantage of this approach is that when assessing the effects of policy simulations —to which we turn in the next section— the predicted migration flows will obey key macro-accounting rules. In particular, the predicted increase in migration inflow resulting from an increasing attractiveness of regions must imply an equal increase in outgoing migration from other regions, such that the total EU population is unaffected by migration internal to the EU. Such properties do not hold when modelling migration flows in an ad-hoc way, or as a Poisson process (for a discussion, see Schmidheiny and Brülhart, 2011).

5. Conclusions

This paper describes how regional labour market adjustments to macro-economic and policy shocks through participation, employment and migration decisions of workers are modelled in RHOMOLO, a spatial CGE model. Being a multi-sectoral, inter-regional general equilibrium model, RHOMOLO is complex both in terms of its dimensionality and the modelling of spatial interactions through trade flows and factor mobility. The modelling of the labour market is therefore constrained by the tractability and computational solvability of the model. The labour market module consists of individual labour participation decisions, both at the extensive (to participate or not) and the intensive margin (hours of work). Unemployment is determined through a wage curve. Inter-regional labour migration is modelled in a discrete-choice framework with backward-looking expectations, for which migration elasticities have been estimated econometrically.

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Section Articles

Regional Impacts of non-R&D Innovation Expenditures across the EU Regions: Simulation Results Using the Rhomolo CGE Model

Olga Diukanova, Jesús López-Rodríguez*

ABSTRACT: In the EU, a sizable part of innovation is attributed to the activities other than R&D such as purchases of advanced machinery, licenses, patents and minor modifications in products or processes. These non-R&D innovation activities receive substantial funding from the European cohesion policy (ECP). In this paper we applied the dynamic spatial computable general equilibrium model RHOMOLO to evaluate the ex-ante short and long run economic impacts of 2014-2020 non-R&D innovation subsidies allocated to the EU27 NUTS2 regions. The results of computer simulations show that the most notable welfare improvements (GDP, production and household consumption) were observed in the Eastern EU regions that receive the largest share of funding. Such outcome is in line with the goals of the European Cohesion Policy of stimulating economic convergence of the least developed regions. As was expected, the magnitude of macroeconomic impacts positively correlates with the amount of non-R&D subsidies allotted to the regions.

JEL Classification: R11; R13; C54; C68.

Keywords: Computable General Equilibrium Model; Innovation; European Union; Cohesion Policy.

Impactos en las regiones europeas de los gastos de innovación no considerados estrictamente I+D: Resultados de simulaciones realizadas con el MEGA RHOMOLO

RESUMEN: En la Unión Europea una parte importante de la innovación se atribuye a actividades que no son estrictamente I+D como la compra de maquinaria avanzada, compra de licencias y patentes y modificaciones menores en productos

* European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Knowledge for Growth Unit, Edificio Expo. C/ Inca Garcilaso 3, 41092 Seville, Spain.

Corresponding author. Tel.: +34 9544-88226; fax: +34 954 48 84 34, E-mail address: *jesus.lopez-rodriguez@ec.europa.eu* (J. López-Rodríguez).

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

Received: 10 january 2014 / Accepted: 18 august 2014.

y procesos. Este tipo de actividades reciben una financiación importante por parte de la política de cohesión europea. En este trabajo se utiliza el modelo espacial de equilibrio general RHOMOLO para evaluar tanto a corto plazo como a medio plazo el impacto económico *ex-ante* de los subsidios a este tipo de actividades proporcionados por la política de cohesión europea en el período 2014-2020 a las regiones NUTS2 de la UE27. Los resultados de las simulaciones realizadas muestran que los mayores incrementos en los niveles de bienestar (PIB, producción, y consumo de los hogares) se observan en las regiones de los países del este de Europa que son aquellas que recibieron la mayor proporción de financiación. Además, la magnitud de los impactos macroeconómicos se correlaciona positivamente con la cantidad de subsidios asignados a las regiones.

Clasificación JEL: R11; R13; C54; C68.

Palabras clave: Modelo Computable de Equilibrio General; Innovación; Unión Europea; Política de Cohesión.

1. Introduction

The EU Cohesion Policy (ECP) is one of the major investment tools in the European Union. Roughly a third of the EU budget is assigned to this policy domain with the objective of supporting job creation, enhancing competitiveness and economic growth and improving quality of life and sustainable development (EU Commission, 2010).

Table 1 illustrates the distribution of 2014-2020 ECP funding across the three groups of regions and according to the five main categories of expenditure.

Table 1. Distribution of 2014-2020 ECP funding among the EU regions, mln €

Region type	*Number*	*RTDI*	*non-R&D*	*Infra-structure*	*Human resources*	*Technical assistance*	*Total*	*Share in total ECP funding, %*
Less developed	65	25,250	27,127	129,128	38,408	12,162	232,075	68%
Transition	51	5,772	6,218	14,339	10,201	1,585	38,115	11%
More developed	151	10,916	9,101	24,167	24,196	2,954	71,334	21%
Total	267	41,938	42,446	167,634	72,805	16,701	341,524	
Share in total ECP funding, %		12%	12%	49%	21%	5%		

Source: own elaboration based on simulations with RHOMOLO.

It can be seen that the biggest share of funding is allotted to finance infrastructure projects and human capital related activities (70%). However, the promotion of innovation was a central feature of the Lisbon National Reform Programmes (EU Commission, 2010) and it was very much taken into consideration in the current programming period were around a quarter of the total budget was assigned to promote innovation (RTDI and non-R&D).

There is a general consensus in the economic literature that R&D has a preeminent role in the economic development, being an important driver of innovation and growth (Romer, 1990, Grossman and Helpman, 1991, Aghion and Howit, 2007).

However, in addition to R&D activities, innovation can take place through activities which do not require research and development. These non-R&D activities include the acquisition of advanced machinery, computer hardware and software, patents and licenses, training related to the introduction of new products or processes, market research, feasibility studies, design and production engineering, etc. (see Arundel *et al.,* 2008, Hervas-Oliver and Albors-Garrigos, 2011, Khan *et al.,* 2010 and Martin *et al.*, 2005, among others).

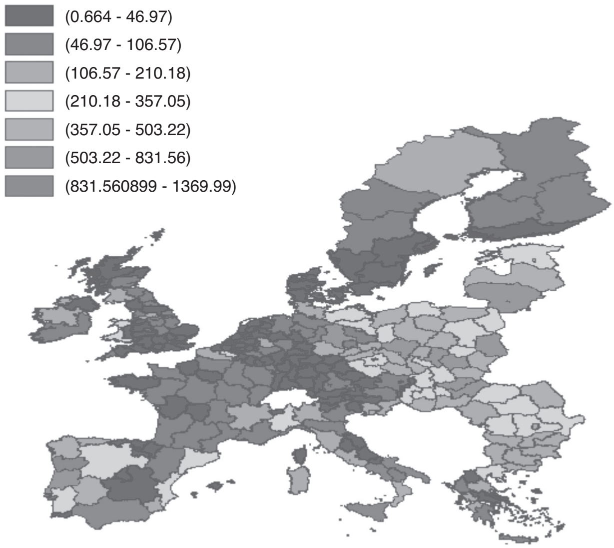
In Europe about 40-60% of the industrial value-added and 50% of all industry employees are engaged in the non-R&D-intensive sector (Rammer *et al.,* 2011, Hirsch-Kreinsen, 2008, Som, 2012). Additionally, more than 50% of all innovating firms in the EU are non-R&D performers (Rammer *et al.,* 2011, Som *et al.,* 2010). These non-R&D performers are found to be prevailing in low technology manufacturing and services sectors and among small and medium sized firms. Firm-level data studies have shown that non-R&D activities have a significant impact on firms' productivity (see, for example Crepon *et al.,* 1998 and Ortega-Argilés and Moreno, 2009). Departing from these firm-level data studies, López-Rodríguez and Martínez (2014) evaluated the impacts of non-R&D activities on total factor productivity (TFP) at a country level for a sample of EU countries showing also their positive contribution to TFP.

Figure 1 illustrates the allocation of cumulative non-R&D expenditures across the NUTS2 regions over the period of 2014-2020 and Figure 2 presents the share of cumulative non-R&D funding in regions' GDP[1].

Considering the high shares of funding devoted to non-R&D activities in the EU budget and the importance of these activities in promoting innovation in Europe, it is important to evaluate the ex-ante short and long run effects of the planned regional non-R&D investments contained in the European Cohesion Policy budget. In essence, EU assistance affects economies through two channels: First, transfers from the EU Structural Funds increase revenues in the recipient regions, producing a so-called Keynesian, or demand effect on output and employment, as the increased income would be spent on goods and services. Second, they are likely to increase productive potential in the region by improving infrastructure, skills of the work force and strengthening local business environment. Some of these impacts are quite difficult to evaluate ex ante, since programmes have full effect on the economy after a number of years.

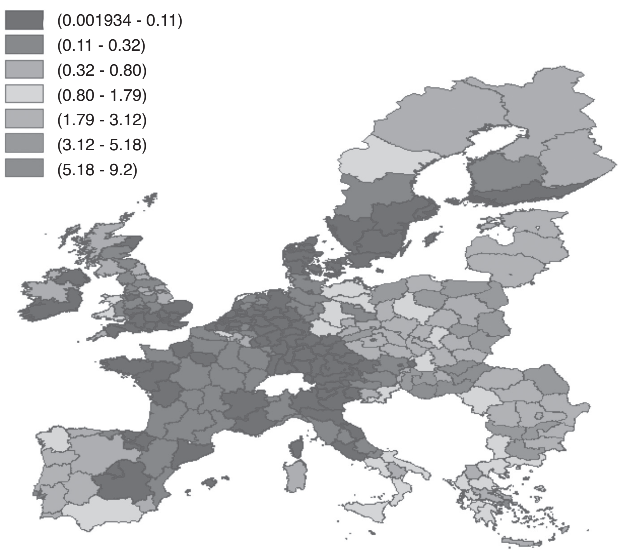
[1] The shares are computed based on 2009 GDP figures.

Figure 1. Non-R&D innovation expenditure allocation by CSF in 2014-2020, min € 2007



Source: own elaboration based on DG Regio data.

Figure 2. The allocated non-R&D innovation expenditures allocation (2014-2020) as % of regional GDP



Source: own elaboration based on DG Regio data (allocation of non-R&D innovation expenditures for 2014-2020) and Eurostat data (regional GDP in 2009).

Although there is no well-established methodology to quantify the economic and social effects of the Structural Funds, there is a consensus about focusing on their long-term or supply-side effects. This task usually requires computer simulations with dynamic macroeconomic models.

The European Commission (DG Regio) has been using two type of macroeconomic models: HERMIN (Bradley *et al.,* 1995) and QUEST (Varga *et al.,* 2009, 2011) to analyse the impacts of EU cohesion programmes. These models have different theoretical underpinnings and sector coverage. QUEST belongs to the class of Dynamic Stochastic General Equilibrium (DSGE) models and has only one sector producing intermediate inputs, whereas HERMIN is a system of macroeconomic models which offer much higher level of disaggregation. However, these models are applied at the level of EU Member States (MS).

A number of studies were devoted to the evaluation of macro-economic impacts of R&D investments within a CGE framework at the level of EU member states (see, for example Bye *et al.,* 2006, Křístková, 2013, Varga *et al.,* 2011). However, these studies did not consider the non-R&D activities and cannot be employed to analyse economic developments at the level of NUTS2 regions, according to the European Nomenclature of Territorial Units for Statistics (Eurostat, 2006).

Even though it has long been acknowledged that invention processes involving R&D is not the only method of innovating, a vast majority of theoretical and applied research focuses almost entirely on R&D partly because of inadequate and segmented information on non-R&D activities.

Aiming to bridge this gap, our paper uses data received from DG Regio on the regional allocation of non-R&D investments (category «Aid to Private Sectors», and on their annual planned consumption by regions during 2014-2023) to explore innovation activities that are not based on R&D. Since non-R&D activities are considered to be productivity enhancing (see, for example, Arundel *et al.,* 2008, Khan *et al.,* 2010, Hervas-Oliver and Albors-Garrigos, 2011), improvements in regions' TFP were considered in RHOMOLO as the main channel through which the ECP funding of non-R&D innovation activities affect regional economies. In order to perform our analysis, we applied a spatial dynamic computable general equilibrium model RHOMOLO to estimate the ex-ante economic impacts of non-R&D innovation subsidies allotted to EU NUTS2 regions within the 2014-2020 ECP budget.

As a point of departure we use López-Rodríguez and Martínez (2014) econometric estimates of TFP elasticities with respect to the non-R&D investments for a sample of EU countries. Using the values of the annual planned allocation of non-R&D investments to the NUTS2 regions contained in the 2014-2020 ECP budget and the computed TFP elasticities, we projected the TFP growth in the EU NUTS2 regions to perform our simulations with RHOMOLO. The results of the simulations carried out have shown that cumulative production in the NUTS2 regions would grow relative to the baseline projections achieving the highest values in the less developed regions of the new member states.

The rest of the paper is structured as follows. Section 2 describes the main building blocks of the RHOMOLO model. Section 3 briefly discusses the economic rationale behind the econometric estimates of the TFP elasticities with respect to the non-R&D investments and explains how TFP projections were introduced into the RHOMOLO model. Section 4 presents the discussion of the results of computer simulations. Finally, Section 5 contains the main conclusions and policy implications.

2. The structure of the RHOMOLO model

RHOMOLO is a spatial dynamic general equilibrium model that was constructed under the Regional Modelling project of the JRC-IPTS on behalf of the DG REGIO with the objective to provide scientific support to the EC policymaking by evaluating the possible impacts of policy instruments available under the Cohesion Policy toolkit (see Brandsma *et al.,* 2013).

Following Mathiesen (1985), the model was formulated as a mixed complementarity problem. The core equations of RHOMOLO were formulated using a calibrated share format which is described in Rutherford (2002), programmed in GAMS and solved using PATH solver.

Since regional structure of the model follows the European Nomenclature of Territorial Units for Statistics at the level two (NUTS2, Eurostat, 2006), RHOMOLO was calibrated to the Social Accounting Matrixes (SAMs) of the NUTS2 regions of the EU. SAMs of the EU member states were built from the World Input-Output Database, WIOD 2010). Construction of SAMs for NUTS2 regions was accomplished using the data of regional production by sector, bilateral trade with the NUTS2 regions, and with the rest of the world. The entropy approach was employed to balance the rest of SAMs' entries.

Transportation costs in RHOMOLO differ by type of good and depend on distance between the regions of origin and destination. Inter-regional trade costs were derived from the TRANS-TOOLS database (JRC IPTS, 2005-2010). Representation of trade and transport flows among the NUTS2 regions allows accounting for regional differences in cost of trade and transportation.

In each region, the model describes behaviour of private households, government and the producers. The latter are represented by production sectors. Because of large spatial dimension which requires much time and computer memory to perform simulations, the current model version included only 6 industries: Agriculture (AB), Manufacturing and energy (CDE), Construction (F), Transport (GHI), Financial services (JK) and Non-market services (LMNOP).

Mobility of capital and labour is assumed to occur across industries within the region but inter-regional migration of production factors is not considered in the current model version.

The EU regions were modelled as small open economies that accept non-EU prices as given. While this assumption might seem contradicting to the European influence on global economy, it is consistent with the regional scope of the model. In this perspective EU's external relations involve only one non-EU trading partner that is represented by the rest of the world aggregate (ROW).

Because of models' large dimensionality, we have selected a rather simple approach to introduce dynamics into RHOMOLO. It rests on the assumptions of exogenous growth, which is in line with Solow's model (Solow, 1956). This type of dynamics does not require time index in the core equations. The model solves for the sequence of equilibrium states, when all time periods are connected with the equation of capital accumulation. Each year in each region a portion of capital stock depreciates at a given rate, and gets augmented by the previous year investments, so that capital stock and investments grow at the same rate with the rest of economy. Using a perpetual inventory method (OECD, 2001), sectors' capital stock was calculated from the operating surplus, as these data were provided in the SAMs. All agents of the model have myopic expectations and cannot anticipate future changes in relative prices or make choice between consumption and savings depending on the interest rate. In order to keep the model baseline «clean» of trade spill-overs that change relative prices and induce sectoral changes, we applied a uniform 2% annual growth rate to all regions. The sum of interest rate and depreciation rate was employed to estimate regions' capital stock from the value of their operating surplus. The interest rate was set at the level of 5%. Capital depreciation rate was assumed to be 6% per annum. Therefore there are no changes in regions' economic structure over the steady-state baseline period. All prices remain constant; only the quantities grow at the same constant rate. In this case we can get more clear insights by comparing the after-shock model results with the baseline values.

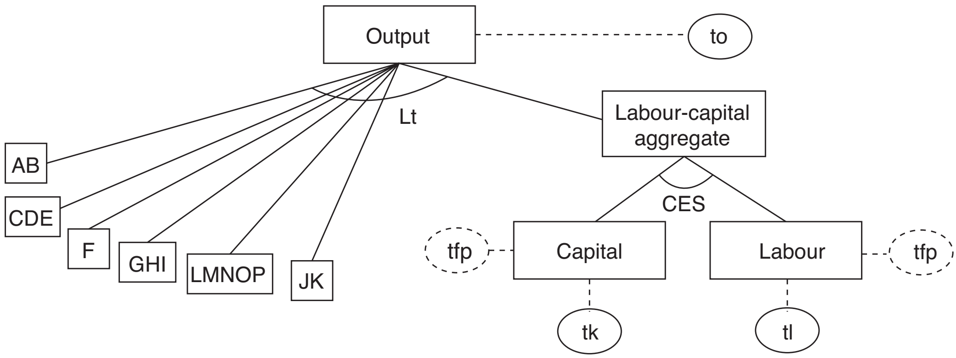
The results were compared with the scenario when regions receive funding within the framework of the EU Cohesion Policy to support non-R&D activities. Taking into account the productivity enhancing nature of non-R&D investments (Arundel *et al.,* 2008, Khan *et al.,* 2010, Hervas-Oliver and Albors-Garrigos, 2011, López-Rodríguez and Martínez, 2014), improvements in regions' TFP were considered as the main transmission channel through which the ECP funding of non-R&D innovation activities affects regional economies. To do so, elasticity estimations of the the impact of non-R&D funding on TFP were taken from López-Rodríguez and Martínez, 2014.

Calculation of regional TFP rates and the approach of their integration into the model equations are explained in the sections 3.1 and 3.2. The core model structure is explained below.

2.1. Sector's production function

According to the structure of regional SAMs, industries' production costs include labour services, operating surplus (capital services), and intermediate inputs. Taxes (or subsidies) are levied on industries' consumption of labour, capital services and also on sectors' output. Proceeds from taxation accrue to the regional government. The same structure of nested production functions is adopted for all sectors, see Figure 3.

Figure 3. Sector's nested production function



where AB-Agriculture, CDE-Manufacturing and energy, F-Construction, GHI-Transport, JK- Financial services and LMNOP-Non-market services.

On the top level of the sectors' production functions a Leontief (Lt) function defines complementarity among the intermediate inputs and the labour-capital aggregate. The lower level of the sector's production function features the possibilities of trade-offs between labour and capital services that were specified with the constant elasticity of substitution (CES) function.

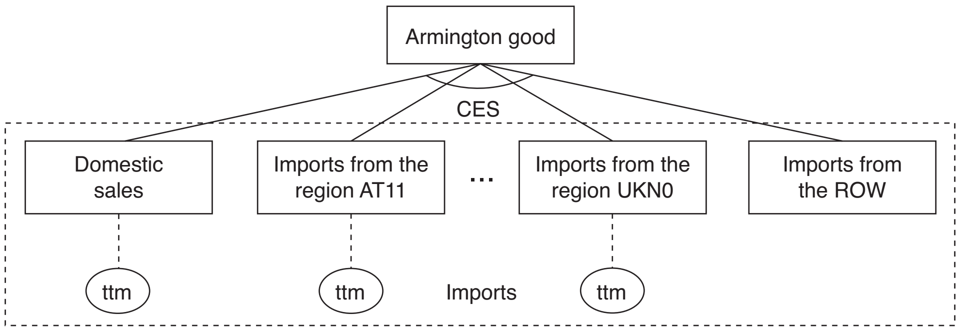
The coefficients of TFP improvements were assigned to the labour-capital aggregate. Taking into account zero substitution between production factors and intermediate inputs,TFP improvements let producers to decrease their consumption of both labour and capital per unit of output. It results in reduction of production costs, gives producers a competitive advantage in terms of price setting and leads to lower prices for consumers. Economy-wide effects arise because improved technologies create new production possibilities and increase economic growth.

Taking into account that sectors' export supply to the NUTS2 regions is determined by import demand of these regions (see Figure 4), we can dismiss the constant elasticity of transformation (CET) function of output transformation to the regional markets. However, the non-EU aggregate cannot be treated as one of model's regions. Even though a SAM for ROW can be constructed using a GTAP database (Badri Narayanan *et al.,* 2012), adding the ROW region to RHOMOLO would create computational difficulties, since model would be calibrated to a SAMs of 270 small regions with small numbers that represent transactions and one ROW region with large numbers. Hence, following the approach of Whalley and Yeung (1984), function of sectors' supply to the ROW was replaced with a function of export demand from the Rest of the World.

2.2. Regional Armington good

Following Armington (1969), commodities of the same type that were produced in different origins are considered to be imperfect substitutes. Therefore, domestically produced and imported goods are combined in a CES function. Trade and transport margins (*ttm*) were applied to the domestic sales and imports from the EU regions. Following this specification, the structure of the regional Armington good is depicted in Figure 4.

Figure 4. Structure of regional Armington good

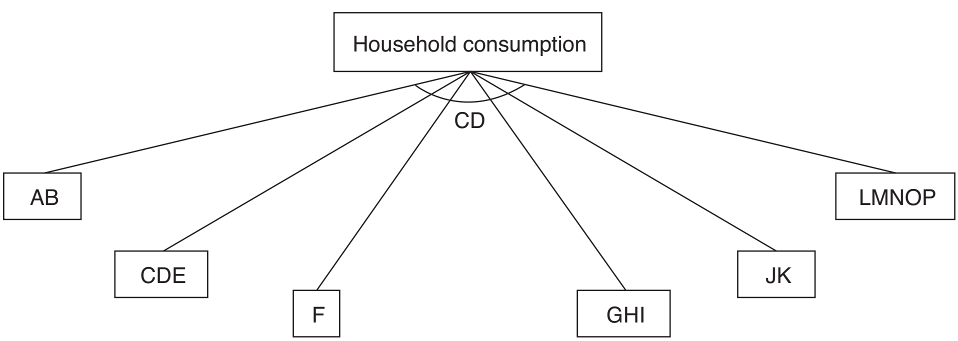


Following the information provided in the regional SAMs, a composite of domestically produced and imported goods is consumed by sectors, as intermediate goods, households, the government, and investment sector.

2.3. Budget balance and structure of household consumption

According to the information, which was provided in the regional SAMs, regional households supply labour and capital services, pay income taxes, receive net transfers from the public sector, and also net transfers from abroad. After deducting taxes, transfers and savings, the disposable income is used to maximize utility of households' consumption. Households save a fixed proportion of their income. The final goods that are consumed by households were combined with the Cobb-Douglas (CD) function that allows substitutability among the inputs. The structure of regional household consumption is described in Figure 5.

Figure 5. Structure of regional household consumption



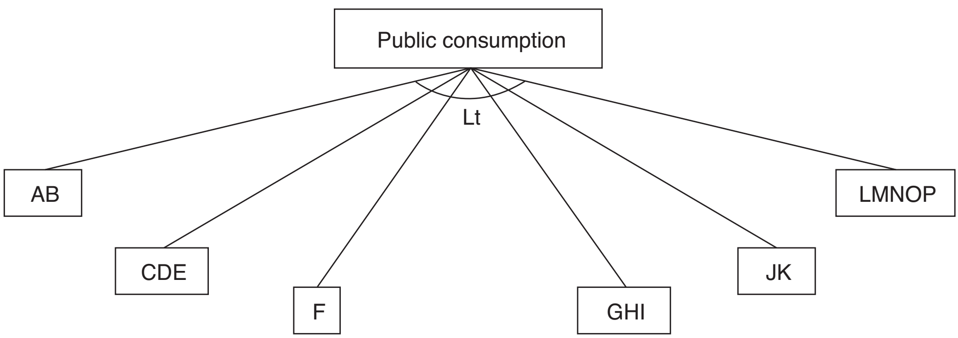
where AB-Agriculture, CDE-Manufacturing and energy, F-Construction, GHI-Transport, JK- Financial services and LMNOP-Non-market services.

2.4. Budget balance and structure of public consumption

According to the SAMs, income of regional government consists of taxes on sectors' output, sectors' consumption of labour, capital services, taxes on regional investment good, income taxes, net transfers from abroad and net transfers from regional households.

The structure of regional public disposable revenue was specified in a similar manner to that of households. In the model we assume fixed tax rates and constant public consumption of final goods. Hence, public savings are determined as a residual. Final goods were combined with a Leontief (Lt) function. The structure of regional public consumption is described in Figure 6.

Figure 6. Structure of regional public consumption



where AB-Agriculture, CDE-Manufacturing and energy, F-Construction, GHI-Transport, JK- Financial services and LMNOP-Non-market services.

2.5. Investment sector

Investment sector combines Armington goods in fixed proportions. Savings-investment balance is achieved by household, public savings and also savings from the EU and ROW.

2.6. ROW closure

Following the (small open economy) SOE assumptions, any of the NUTS2 regions doesn't influence prices in the non-EU market. Therefore, we formulated the EU balance of trade as net exports to the ROW. We fix the ROW savings keeping the real exchange rate flexible, so that ROW price adjusts to bring about equilibrium. Savings from the EU are set exogenously and valued using a producer price index.

3. NR&D-TFP elasticities and their link to RHOMOLO

3.1. Econometric estimations of the influence of non-R&D innovation expenditures on TFP growth across EU countries

A number of studies using firm-level data to evaluate the impact of non-R&D innovation expenditures on firms' productivity have been carried out (see, for example Crepon *et al.,* 1998, Janz *et al.,* 2004, Lööf and Heshmati, 2002). From a macroeconomic perspective, the standard approach to evaluate the impacts of innovation on economic growth is to regress the TFP improvements on R&D endowments. However, this approach does not take into consideration the influence of non-R&D activities on TFP. In the EU, a sizable part of innovation, such as production engineering or design work, purchases of advanced machinery, licenses, minor modifications in products or processes, etc. is attributed to activities other than R&D (non-R&D). Non-R&D activities shift firms' production frontiers upwards and, therefore, have similar impact on TPF compared with the R&D ones.

López-Rodríguez and Martínez (2014) envisaged a way to evaluate the impacts of non-R&D investments on total factor productivity at a country level by combining the micro and macro approaches. The main conceptual departure of López-Rodríguez and Martínez (2014) from the traditional endogenous growth theory is to consider the non-R&D innovation activities as important drivers of TFP improvements. However, the main difficulty of this approach is associated with obtaining the right empirical counterparts for non-R&D endowments in the regression equation.

Linking the Eurostat data on business expenditures on R&D, three issues of the Community Innovation Survey (CIS04, CIS06, and CIS08) for private innovation expenditures and business expenditures on non-R&D and DG Regio data on public funding for non-R&D activities, López-Rodríguez and Martínez (2014) built a proxy for non-R&D endowments at country level. Data on TFP came from the Cambridge Econometrics and EU KLEMS (2011); data for R&D investments and the set of control variables were obtained from the Eurostat.

López-Rodríguez and Martínez (2014) proposed the following structural equation for estimating TFP elasticities with respect to the R&D and non-R&D investments:

$$\frac{\tilde{A}_i(t)}{A_i(t)} = \gamma_0\, Ird_i(t-1) + \gamma_1 \left(IRD_i(t-1)\, IRD_i\,(t-1)\right) + \gamma_2 IRD_i^2\,(t-1)$$
$$= \gamma_3\, IRD_i(t) + \gamma_4\, IRD_i(t)^2 + \mu X_i\,(t) + u_i\,(t),$$

where:

i	= index of EU member states;
t	= one-year time index:
$\frac{\tilde{A}_i(t)}{A_i(t)}$	= TFP growth rate in the year t;

$\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4,$	= the coefficients;
μ	= row vector of coefficients
$IRD_i(t)$	= R&D intensities (R&D/GDP) in the year *t;*
$INRD_i(t)$	= non R&D intensities (NR&D/GDP) in the year *t;*
$X_i(t)$	= colum vector of control variables;
$u_i(t)$	= regression error.

The econometric estimates were conducted for a panel of 26 EU countries for the years 2004, 2006 and 2008 using the pooled least squares approach. The coefficients in the regression can be used to obtain the elasticities of TFP with respect to R&D and non-R&D expenditures.

With the linear specification of the previous equation (that is, without the term $INRD_i(t)$), the non-R&D-TFP elasticity was defined as $\gamma_3 + \gamma_1 \, I\bar{R}D$, where $I\bar{r}d$ is the average value of the R&D intensities across the sample. The paper presents several sets of results, in terms of absorptive capacity linked to R&D, interactions between R&D and non-R&D, the effects of the distance to the technological leader, etc. The result from Lopez-Rodríguez and Martínez (2014) we use in our simulations is the estimation of $\gamma_3 + \gamma_1 \, I\bar{R}D$ which can be referred to as the TFP elasticity with respect to non-R&D investments. This estimation lies in the interval (0.15-0.18). The estimated values of TFP elasticity with respect to R&D expenditures are almost twice as higher and lie in the interval of (0.30-0.33)[2]. The estimated values of elasticities were used to project TFP improvements due to non-R&D innovation expenditures funded by ECP in the NUTS2 regions during 2014-2023. In the next subSection we present the approach to incorporate the TFP elasticities into RHOMOLO.

3.2. Incorporation of TFP elasticities with respect to non-R&D expenditures into RHOMOLO

Several approaches can be used to simulate productivity improvements with a CGE model. When econometric estimates are available, productivity changes can be approximated by changes in labour or capital productivity. However, this approach can produce misleading results, since CGE models assume non-zero elasticities of substitution between labour and capital. For example, decrease in the consumption of capital due to increased productivity of capital can be offset with increased consumption of labour, and vice versa. These effects can render rather unpredictable impacts on simulated economy.

This deficiency can be avoided by considering the measure of total factor productivity improvements which defines how efficiently all production factors are used. The term «total factor productivity» is also called the Solow residual (Solow, 1956) in the growth accounting exercises.

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[2] Similar numbers were obtained in other studies that evaluated the influence of R&D investments on TFP, see for instance Kancs and Siliverstovs (2012).

In order to simulate the shocks on sector's TFP due to the planned European Cohesion Policy investments on non-R&D innovation activities over the period 2014-2023 we employed the López-Rodríguez and Martínez (2014) estimations of TFP elasticity with respect to the non-R&D investments $\gamma_3 + \gamma_1\, I\bar{R}D$). The following formulas were used in the model to estimate the upward shifts on TFP due to non-R&D innovation expenditures:

$$gTFP_{reg}(t) = (\gamma_3 + \gamma_1\, \overline{IRD}) \left(\frac{NR\&R_{reg}(t-1)}{GDPbau_{reg}(t-1)} \right),$$

$$TFP_{reg}(t) = gTFPbau_{reg}\,(t) + gTFP_{reg}\,(t)$$

where:

reg	= NUTS2 region;
t	= one-year time index:
$gTFP_{reg}(t)$	= annual regional TFP growth rate due to non-R&D innovation expenditures;
$TFP_{reg}(t)$	= the growth rate induced by the non-R&D investments;
$\gamma_3 + \gamma_1\, I\bar{R}D$	= elasticity of TFP improvements with respect to non-R&D investments;
$NR\&D_{reg}(t-1)$	= the amount of non-R&D innovation expenditures assigned during the year $t-1$;
$GDPbau_{reg}(t-1)$	= forecasted regional GDP in the year $t-1$;
$gTFPbau_{reg}(t)$	= baseline annual regional TFP growth in the region *reg* during the year *t*.

It is important to mention that regional non-R&D funding was not distributed homogenously among the regions within the period of 2014-2023, but allowed for high spikes from one year to the next. Since DG Regio allocates investments according to the N+3 rule, granting the regional authorities three additional years beyond the programming period to absorb the funds, we present simulation results until the year of 2023. Although we only had information on distribution of non-R&D funds among the regions, and not among the sectors that operate in these regions, we applied same rates of TFP growth to all sectors within each region.

4. Evaluation of 2014-2020 non-R&D innovation expenditures

Overall, the results of the simulations with the RHOMOLO model demonstrated small positive impacts on regions' GDP (see Figure 7) and household consumption (see Figure 8).

On the whole, the magnitude of these impacts positively correlates with the amount of non-R&D investments, received by the regions; see Figure 1 and Figure 2. In fact, the major recipients of ECP funds, belong to a category of less de-

Figure 7. Changes in regional GDP due to the non-R&D innovation funding in 2003, % relative to the baseline projections

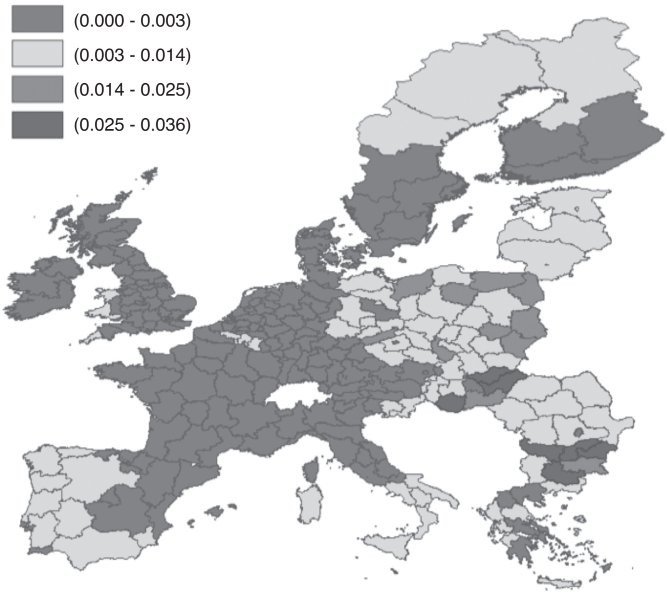
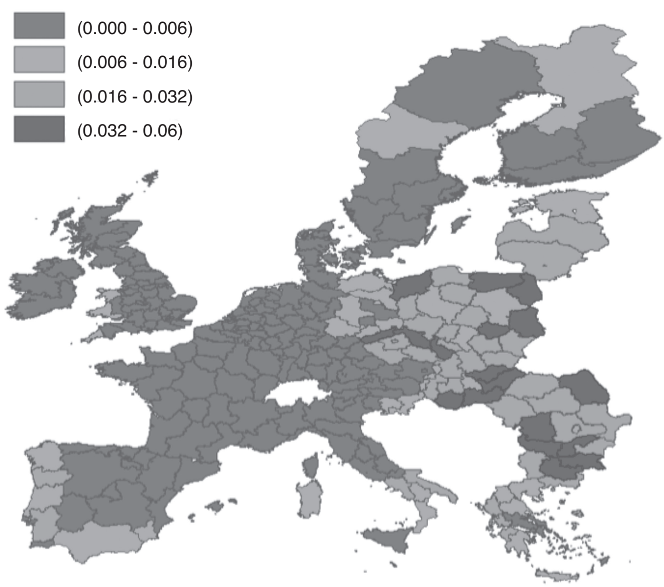


Figure 8. Changes in regional cumulative household consumption due to non-R&D innovation expenditures in 2003, % relative to the baseline projections



Source (Figure 7 and Figure 8): own elaboration based on simulations with RHOMOLO.

veloped (i.e. regions with GDP per capita below 75% of the EU average (European Commission, 2013).

Figure 7 and 8 demonstrate that the most benefited regions are mainly located in Eastern Europe. The results suggest that by 2023, the GDP of the Eastern EU regions would grow up to 0.036% while in the EU-15 regions GDP would increase up to 0.015% relative to the baseline projections. The cumulative household consumption of the NMS regions would grow up to 0.06% by 2023 and in the old member states it will increase up to 0.02% relative to the baseline projections.

Regions with the highest growth of household consumption and GDP are the BG31, BG32, BG33, BG34 and BG42 regions of Bulgaria, HU23, HU31, HU32 and HU33 regions of Hungary, PL31, PL32, PL33, PL34, PL42, PL61 and PL62 regions of Poland, CZ04, and CZ07 regions of Czech Republic, RO21 and RO41 regions of Romania (the European Nomenclature of Territorial Units for Statistics is provided in the Eurostat, (2006)).

Although the model results did not indicate production losses relative to the baseline projections, in reality improvements in comparative advantage of some regions can affect competitiveness of other regions. Clearly, holding everything else equal, if a region receives meagre allocation of non-R&D investments per its GDP, the computed TFP rate would be lower, hence production cost would be higher, and sales would be less competitive compared with the regions that have higher TFP growth rates. As a result, production of a less competitive and more expensive good could decline.

Certainly, when relative prices change, to some extent regions can substitute own production with imports. However, the possibility of such substitution depends on origin of imports which determines trade and transport cost. Clearly, policy at the level of a single EU region may not affect prices, export demand and supply of imports from the non-EU world. Therefore, regions with high intensity of imports and exports from/to the non-EU countries (and especially those that basically re-export imported goods, with little value added) can maintain their levels of welfare even when their intra-EU trading partners lower demands for exports and increase import prices. Of course, the extent of such trade depends on transport costs and on the degree of trade protectionism.

In order to investigate the economic impacts of policy intervention on the production structure in the two groups of new and old EU member states we displayed the results of simulations with RHOMOLO at more aggregate level. The Figure 9 and Figure 10 demonstrate that all sectors in the NMS displayed much higher growth rates compared with the sectors in the EU-15.

In the NMS, the non-R&D funding stimulated the most agricultural production, manufacturing and energy, transport and financial services (the hike in sectors' production during 2018-2021 is induced by the higher allocation of funding during this period). In the EU-15, non-R&D investments had quite smooth and insignificant impact on all industries. As we can see from the charts above, impacts on production growth rates in the NMS during 2015-2023 were within the range of 0.01%-0.6%,

Figure 9. Sectors' production in the new EU member states, % relative to the baseline projections

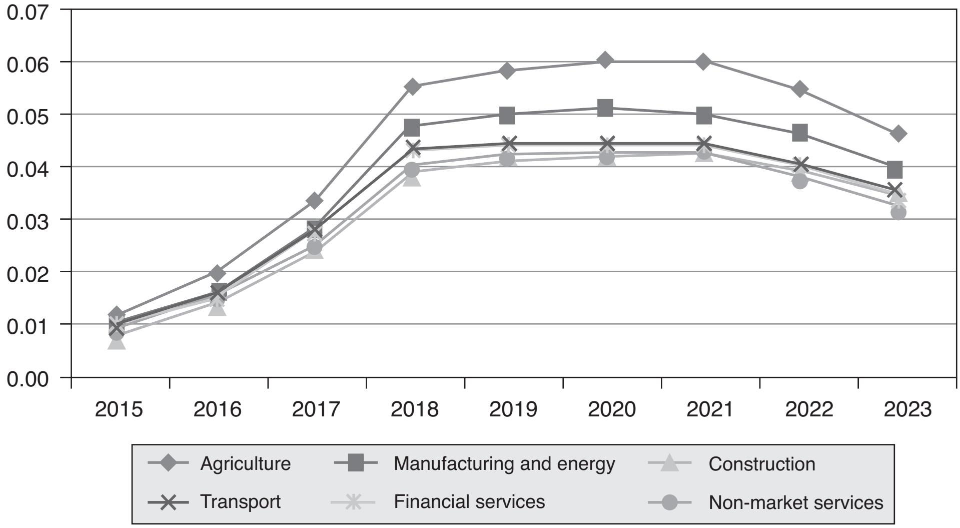
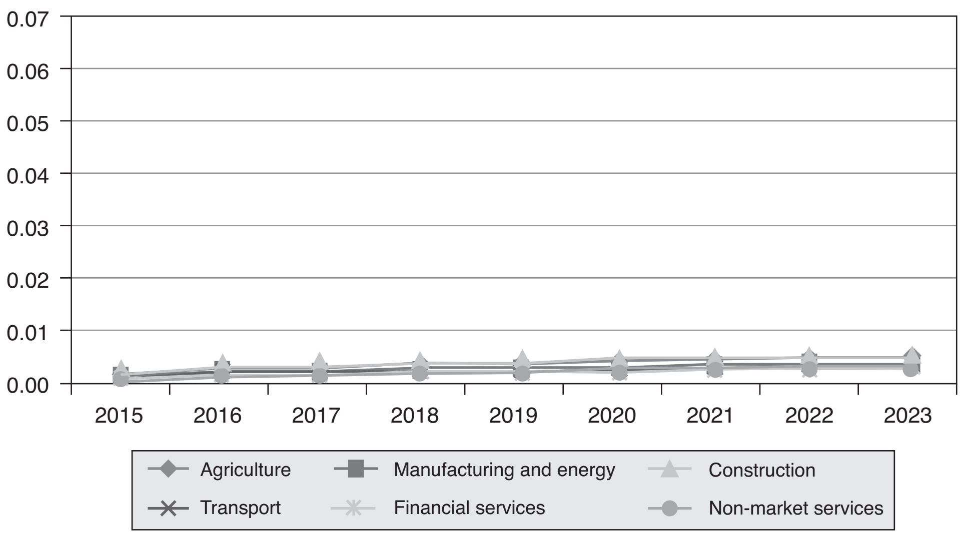


Figure 10. Sectors' production in the EU-15, % relative to the baseline projections



Source (Figure 9 and Figure 10): own elaboration based on computer simulations with RHOMOLO

while in the old member states they ranged from 0.0004% to 0.007% above the baseline.

Analysing the results we should consider that due to the absence of sector-specific estimates, the same rates of TFP growth were applied to all sectors within each region. Such modelling exercise demonstrated improvements in the efficiency of production that were not accompanied with any noticeable structural changes in the NMS and EU-15 country blocks, see Table 2.

Table 2. Shares of sector's output in the total production in the two groups of EU regions in 2007 and in 2023

	Agriculture	*Manufacturing*	*Construction*	*Transport*	*Financial services*	*Non-market services*
EU-15, 2007	**0.02**	**0.32**	**0.08**	**0.20**	**0.23**	**0.16**
Difference between 2007 and 2023	–3.07E-07	1.68E-06	1.13E-06	–4.84E-07	–1.73E-06	–9.03E-07
NMS, 2007	**0.04**	**0.41**	**0.09**	**0.20**	**0.15**	**0.11**
Difference between 2007 and 2023	–3.84E-06	–1.28E-05	3.05E-06	4.78E-06	3.31E-06	5.46E-06

Source: own estimates based on regional SAMs and computer simulations with RHOMOLO.

As shown in Table 2, throughout the model horizon the New Member States have much higher shares of agriculture and manufacturing, and much lower shares of financial and non-market services in the total production compared with the EU-15 countries.

Such production structure was inherited from the period of central planning, which endowed most of the NMS with the oversized and inefficient industrial sector and grossly underdeveloped financial and non-market services (Havlik, 2013).

The inter-dependency between sectoral structure and aggregate economic performance has been widely acknowledged in the economic theory. As postulated in the *structural bonus hypothesis* (Timmer and Szirmai, 2000), during the process of economic development, economies upgrade from industries with comparatively low value added to those with a higher contents of value added. In line with the argument of unbalanced growth introduced by Baumol (1967) and Baumol *et al.* (1985), labour-intensive industries that provide social, cultural and public services have limited capacity to increase labour productivity through technological progress or rise in capital intensity. That explains why services, especially non-market services (i.e. administration, education, research and health services provided by government and non-profit institutions) generally exhibit slower productivity growth compared with producing (manufacturing, construction and energy) sectors.

Taking into account that allocation of labour and capital favours industries with higher productivity, TFP improvements induced by non-R&D innovation subsidies can act as transmission channel through which the ECP policy can affect industry composition and overall economic performance in the NMS. Therefore, differentiated allocation of EU funding among the NUTS2 regions can be viewed as an instrument to reduce the discrepancies in production structure and regional welfare between the NMS and EU-15.

Clearly, other categories of ECP funding have influence on the economic performance of sectors and regions, and policy impacts will also depend on the distribution of the ECP funds among the sectors. However, we don't aim to combine all ECP policies in a single model run. Although this exercise would provide insights about the impact of ECP intervention on regional production or GDP and permits to evaluate the success of ECP funding in general, it is difficult to link the impacts with a specific policy. Apart from economic priorities, allocation of ECP funds within the NUTS2 regions and the overall economic impacts of EU funding largely depend on quality of local public administration.

5. Conclusions and Policy Implications

In this paper we have carried out computer simulations with the RHOMOLO model to evaluate the ex-ante short- and long- run impacts of non-R&D innovation expenditures allotted to the NUTS2 regions of the EU27 within the 2014-2020 EU Cohesion Policy budget.

Improvements in regions' total factor productivity were considered as the main transmission channel through which the ECP funding of non-R&D innovation activities affects regional economies. This assumption was widely acknowledged in the empirical firm's innovation literature. Very recently López-Rodríguez and Martínez (2014) contributed to the macro literature on innovation by estimating the TFP elasticity values with respect to the non-R&D investments. These estimations were used to translate the values of non-R&D funds allotted to the NUTS2 regions during 2014-2020 into their total factor productivity improvements and to run the simulations with the RHOMOLO model.

Model results show that cumulative production in the NUTS2 regions would grow relative to the baseline projections. The highest growth is achieved in the less developed regions of the new member states. This outcome is explained by the fact that regions that belong to Bulgaria, Poland, Check Republic, Slovakia, Slovenia, Romania, Hungary and the Baltic countries receive the largest injection of funds-both in absolute and per GDP terms, and therefore, have the highest rate of total factor productivity improvements.

All sectors in the new member States displayed much higher growth rates compared with the EU-15. In the old member states, non-R&D investments had quite smooth and insignificant impact on all industries. This outcome is in line with the European Cohesion Policy objective of speeding up the convergence of the least developed Member States.

Acknowledgements

The authors are grateful to Andries Brandsma and two anonymous reviewers for their helpful comments and suggestions. The authors would also like to thank the participants of XXXIX Conference of Regional Studies (Oviedo, 2013) and the Geography of Innovation Conference (Utrecht, 2014) for their feedback. The comments made during the seminars and the workshops at Universidad de Granada, Aberystwyth University, Universidad de Las Palmas de Gran Canaria and CERDI at Auvergne University are highly appreciated. The second author also thanks for the financial support provided by the Spanish Ministry of Science and Innovation through the Grant ECO2011-28632. The usual disclaimer applies.

The second author also acknowledges the support received from the Spanish Ministry of Science and Innovation through the project ECO2011-28632 and Xunta de Galicia through the project EM2014/051.

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Section ARTICLES

Economic impact of the European Funds in Extremadura during the period 2007-2013

Julián Ramajo Hernández*, Miguel Ángel Márquez Paniagua**,
Francisco Javier De Miguel Vélez***

ABSTRACT: Although the evaluation of European Union regional policy is necessary to improve the effectiveness of the operational programmes, it is not usual to find studies comparing the efficiency of two programming periods for the case of a particular region. This could be explained by the fact that, at regional level, the study of the efficiency of the European funds during two different programming periods faces many different problems; for example, it entails the consideration of both adequate and homogeneous data, and similar methodology. The goal of this paper is twofold. The first goal is to estimate the economic impact of the European Union structural and cohesion funds received by Extremadura, a Spanish convergence objective NUTS II region, during the programming period 2007-2013. To this end, it is provided a multipliers analysis based on a Social Accounting Matrix (SAM) of Extremadura for the year 2000. Secondly, the paper will compare the returns obtained in terms of output and employment by the European funds received in Extremadura during the periods 2000-2006 and 2007-2013. Our results allow quantifying the effects of the EU regional policy, showing and comparing the efficiency for these two programming periods.

JEL Classification: C67; F35; H50; H54; R58.

Keywords: regional policy; European Funds; social accounting matrix; Extremadura.

Impacto económico de los Fondos Europeos en Extremadura en el período 2007-2013

RESUMEN: Aunque la evaluación de la política regional de la Unión Europea es necesaria para mejorar la eficiencia de los programas operativos, no es común encontrar estudios que comparen la eficacia de dos períodos de programación para el caso de una región. Esto puede deberse a que a nivel regional el estudio de la efica-

* *ramajo@unex.es*. Departamento de Economía (Universidad de Extremadura).
** *mmarquez@unex.es*. Departamento de Economía (Universidad de Extremadura).
*** *demiguel@unex.es*. Departamento de Economía (Universidad de Extremadura).

Received: 27 january 2014 / Accepted: 6 august 2014.

cia de los fondos europeos se enfrenta a problemas de diversa índole; por ejemplo, se necesita disponer de datos adecuados y homogéneos y una metodología similar. El objetivo de este trabajo es doble. El primer objetivo es estimar, para el periodo de programación 2007-2013, el impacto económico de los fondos estructurales y de cohesión recibidos por Extremadura, una región NUTS II española del tipo «convergencia». Para este fin, se utiliza un análisis de multiplicadores basado en una matriz de contabilidad social (SAM) de Extremadura para el año 2000. En segundo lugar, el artículo compara los retornos obtenidos en términos de *output* y empleo debido a los fondos europeos recibidos en Extremadura durante los períodos de programación 2000-2006 y 2007-2013. Nuestros resultados permiten cuantificar los efectos de la política regional europea comparando la eficiencia para esos dos períodos de programación.

Clasificación JEL: C67; F35; H50; H54; R58.

Palabras clave: política regional; Fondos Europeos; matriz de contabilidad social; Extremadura.

1. Introduction

The general objective of the European regional policy is to promote economic and social progress and to help disadvantaged regions adjust to the challenges of the single market, eliminating disparities in living standards. In accordance with these objectives, the gaps among the development levels of the various Regions have to be narrowed. This implies that poorest European regions are the main priority of European Cohesion policy. These regions share some identical economic indicators; among others, higher unemployment rate, poor basic infrastructure and lack of services for businesses and individuals. It is therefore of most critical importance to evaluate the impact of Structural Funds in order to help the European Commission in the design of future policy. Nevertheless, the evaluation of the economic effects of European funds is a complex and difficult task. It is not easy to estimate the full socioeconomic costs and benefits resulting from European Funds since the information needed for a cost-benefit analysis does not exists. Hence, to measure the aggregate effects or European regional policies, the range of evaluation methods uses to apply top-down approaches like econometric models, input-output models and computable general equilibrium models.

In the context of the European NUTS II regions, territories with Gross Domestic Product per capita less than 75% of the EU average were defined as «Objective 1» regions in the 2000-2006 programming period, while in the 2007-2013 programming period, this type of regions were renamed as '«Convergence Objective» regions (European Commission, 2007). One of the great unresolved debates about European regional policy is the extent to which the regions that fall below the 75% of European Union Gross Domestic Product per capita is achieving higher levels of employment and economic growth. Policy makers need answer to these questions. The measure of these achievements would let us assess the effectiveness of the European funds. Nevertheless, although the evaluation of European Union regional policy is necessary to improve the effectiveness of the operational programmes, it is not usual to find studies comparing the efficiency of two programming periods for the case of a particular region. This could be explained by the fact that, at regional level, the study of the efficiency of the European funds during two different programming periods face many different problems; for example, it entails the consideration of both adequate and homogeneous data, similar methodology, and the difficulty to isolate the effects of the programmes.

This paper centers his focus on the analysis of the economic impact of the European Funds in Extremadura, an Autonomous Community in the southwest of Spain. The region of Extremadura was considered as one of the «Objective 1» priority areas for the European Regional Policy during the period 2000-2006, being a «Convergence Objective» region for the programming period 2007-2013. The goal of this paper is twofold. The first goal is to estimate the economic impact of the European Union structural and cohesion funds received by Extremadura, a Spanish convergence objective NUTS II region, during the programming period 2007-2013. Secondly, the paper will compare the returns obtained in terms of output and employment by the European funds received in Extremadura during two programming periods (2000-2006 and 2007-2013). It needs to be emphasized that it is not usual to find empirical contributions about this type of comparison in the literature (see for instance Cancelo *et al.,* 2009). Thus, it is necessary to design a methodological approach that will quantify the economic impacts of European Funds in Extremadura. Concretely, a multisectoral economic model based on a Social Accounting Matrix (SAM) is used to quantify the output and employment effects derived from the structural and cohesion funds that this region received due to its 'Convergence Region' situation. The multipliers analysis was based on a Social Accounting Matrix (SAM) of Extremadura for the year 2000. Our results allow quantifying the effects of the EU regional policy, showing and comparing the efficiency for these two programming periods. For the programming period 2000-2006, and as base of comparison, the results presented in Márquez *et al.* (2010) will be considered. The comparison will provide an interesting information since it will be shown empirical evidence about the efficiency of two programming periods for the case of Extremadura: the only region in Spain considered to be less developed (with a GDP per inhabitant below 75% of the EU27 average) for the next programming period 2014-2020.

The rest of the paper is organized as follows. Section 2 tries to place the Extremadurian region within the Spanish context, and the basic features of the economy of Extremadura are described. Additionally, it is shown a brief description of the EU regional policy for the program period 2007-2013. Section 3 presents the methodological issues and discusses the main results. Finally, Section 4 concludes.

2. Extremadura in the context of the European regional policy

To properly situate Extremadura in the European context, firstly, this section describes the basic features of this regional economy. Therefore, subsection 2.1

analyzes the evolution of the regional economy of Extremadura in the period 2000-2013. More specifically, the evolution of production, employment and GDP per head for both the Spanish economy and the regional economy of Extremadura are presented. Secondly, in subsection 2.2, the main features of the European funds received by Extremadura in the programming period 2007-2013 are briefly shown.

2.1. The economy of Extremadura in the period 2000-2013

Extremadura has an area of 41,634 km^2, which accounts for 8.3% of the Spanish area. Its population in recent years has been around 1,080,000 inhabitants; thus, the population density of Extremadura approaches 26 Inhabitants/Km^2 (less than a third of the Spanish population density). Since the population of Extremadura is distributed sparsely and irregularly along the territory, it is easy to corroborate that the demographic base of Extremadura has got a great weakness. In short, it is possible to infer that domestic demand is not going to be a stimulus when conducting an increase of regional productive activities in Extremadura. Even more, this diagnosis is related to a low birth rate, high aging population and, as it will become clear later, low levels of income.

Gross Domestic Product (GDP) in constant terms (euros of year 2000) for Extremadura reflects a cumulative growth for 2000-2006 of 20.77% (in average terms, Spain grew 22.19%). This increase has its translation in a lost of weight of the economy of Extremadura in terms of share on the Spanish economy, decreasing from 1.62% to 1.60%. In the same way, during the period 2007-2013 Extremadura showed a negative growth of –6.79% (Spain had a negative growth of –5.88%). This fact implies, again, that the economy of Extremadura lost relative importance with respect to the Spanish economy (from 1.60% to 1.59%). Consequently, in terms of GDP, it is not possible to find an advance in the Extremadura economy, since Extremadura lost relative weight within the national context. In addition, Table 1 displays the growth rates of GDP (in constant terms) for Extremadura and Spain in the two programming periods.

With respect to employment, in 2000 Extremadura had about 335,100 employments, and 386,400 in 2006 (an increase of 15.31% in the programming period 2000-20006). At national level, this increase was 22.5%. This way, the labor force of Extremadura lost relevance at national level (from 2.04% in 2000 to 1.92% in 2006). On the other hand, in the case of the programming period 2007-2013, Extremadura had about 395,000 employments in 2007 and 332,400 in 2013 (decreasing –15.85%). Nevertheless, employment in Spain decreased during this period about –16.71%. Thus, employment in Extremadura was 1.91% of the total Spanish employment in 2007, being about 1.93% in 2013. From Table 2, the growth of employment in Extremadura showed a best relative behavior during the programming period 2007-2013.

Table 1. Growth of GDP (Constant € of the year 2000) during the period 2000-2013

Programming period 2000-2006							
	2001	*2002*	*2003*	*2004*	*2005*	*2006*	
Extremadura	2.32%	3.34%	3.17%	3.07%	3.54%	3.74%	
Spain	3.67%	2.71%	3.09%	3.26%	3.58%	4.08%	
Net change	–1.35%	0.63%	0.08%	–0.19%	–0.04%	–0.34%	
Programming period 2007-2013							
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Extremadura	3.86%	1.56%	–3.23%	–0.02%	–0.93%	–2.85%	–1.45%
Spain	3.48%	0.89%	–3.83%	–0.20%	0.05%	–1.64%	–1.22%
Net change	0.38%	0.67%	0.60%	0.18%	–0.98%	–1.21%	–0.23%

Note: Net change is difference between the growth of GDP in Extremadura and the growth of GDP in Spain.
Source: Own elaboration from National Statistics Institute of Spain (2014).

Table 2. Growth of employment during the period 2000-2013

Programming period 2000-2006							
	2001	*2002*	*2003*	*2004*	*2005*	*2006*	
Extremadura	1.37%	2.30%	2.62%	2.80%	3.44%	1.90%	
Spain	3.23%	2.46%	3.21%	3.62%	4.15%	3.98%	
Net change	–1.86%	–0.16%	–0.59%	–0.82%	–0.71%	–2.08%	
Programming period 2007-2013							
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Extremadura	2.23%	0.48%	–5.62%	–1.12%	–2.48%	–4.93%	–3.20%
Spain	3.03%	–0.13%	–6.49%	–2.21%	–1.87%	–4.23%	–2.96%
Net change	–0.80%	0.61%	0.87%	1.09%	–0.61%	–0.70%	–0.24%

Note: Net change denotes the difference between the growth of employment in Extremadura and the growth of employment in Spain.
Source: Own elaboration from National Statistics Institute of Spain (2014).

Finally, Table 3 displays the GDP per capita for both programming periods. In the first programming period, Extremadura had a GDP per capita about the 61.46% of the Spanish average in 2000 (Spanish average =100%), increasing in 2006 (66.01%). In the second programming period, Extremadura increased from 66.76% in 2007 to 68.06% in 2013. As stated before, and for the 2007-2013 period, the European Commission approved a Regional Operational Programme for Extremadura that falls within the framework laid out for the «Convergence Objective» regions.

Tabla 3. GDP per capita during the period 2000-2013

Programming period 2000-2006							
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Spain	21.05	21.50	21.70	21.91	22.37	22.70	23.30
Extremadura	12.94	13.19	13.64	14.06	14.47	14.86	15.38
Percentage	61.46%	61.36%	62.84%	64.16%	64.68%	65.49%	66.01%
Programming period 2007-2013							
Spain	23.85	23.57	22.38	22.20	22.13	21.74	21.53
Extremadura	15.92	16.06	15.47	15.40	15.23	14.81	14.65
Percentage	66.76%	68.14%	69.15%	69.38%	68.81%	68.15%	68.06%

Note: Percentage denotes the ratio between the GDP per capita in Extremadura and the GDP per capita in Spain.
Source: Own elaboration from National Statistics Institute of Spain (2014).

2.2. The EU regional policy for Extremadura 2000-2013

This section is aimed at describing the basic features of the finished Regional Operational Programme for Extremadura for the 2007-2013 programming period, comparing it with the earlier cohesion policy program 2000-2006.

The Structural Funds and Cohesion Funds are the main budgetary items of the European Union to support economic and social cohesion in the member states. Regional and structural policies are the second largest item in the budget after the agricultural funds; they cover more than a third of the budget. They are set-up as multi-annual initiatives, and the period from 2000 to 2013 consists of two programming periods, the first running from 2000 to 2006 and the second from 2007 to 2013.

In Márquez *et al.* (2010) a synthesis of the general lines of the programming period 2000-2006 for Extremadura is presented. On the other hand, the Regional Operational Programme for Extremadura in the period 2007-2013 contemplates seven priorities (see European Commission, 2014). Priority 1 is «Development of the Knowledge Economy». Under this priority, the primary objectives are «*to contribute to increasing economic competitiveness, to increase the effectiveness of the regional system of science and technology, and to increase the level of information and communication technology as a fundamental axis of the knowledge economy*.» Priority 2 is «Entrepreneurial Development and Innovation», that is, «*to safeguard existing competitive enterprises and to create favourable conditions for their expansion as well as for business start-ups and relocations*». Priority 3 is «Environment, Natural Surroundings, Water Resources and Risk Prevention», being the strategic objectives *«to protect and preserve biodiversity, improve water infrastructures and waste management, prevent risks and control pollution»*. Priority 4: *«Transport and Energy»*, where the specific objectives are «*to improve transport infrastructure for better traffic flows through the road network and integrate Extremadura into the* *national communication network; to promote and improve the communication network with neighbouring territories; to promote accessibility within the region; to encourage energy efficiency and the use of renewable sources*». Priority 5: «Local and Urban Sustainable Development», where the main objectives are «*to implement new integrated urban projects for cities in Extremadura and to preserve its historical, artistic, natural and cultural heritage.*» Priority 6: «Social Infrastructures»; where the programme seeks «*to guarantee access to education and health systems and to extend the welfare infrastructure and services to all members of society*». Priority 7: «Technical Assistance», that is, technical assistance in implementing the Programme.

In this context, Table 4 shows a summary of the total funds received by Extremadura during the programming periods 2000-2006 and 2007-2013 in constant euros of 2000. From Table 4, the total amount of funds in the 2007-2013 period decreased 8.21% with respect to the 2000-2006 period (from 3,007,203 thousands of euros to 2,760,078 thousands of euros). Thus, the total funds were obtained from four funds: European Regional Development Fund (ERDF), Cohesion Fund (CF), European Social Fund (ESF), and European Agricultural Fund for Rural Development (EAFRD). The ERDF is the most important fund in both programming periods. It is important to highlight that the EAFRD increased its relevance with respect to the ESF during the programming period 2007-2013.

Table 4. Summary of European Funds received in 2000-2013 by Extremadura (total expenditure, including European and national co-financing; thousands of 2000 constant euros)

	ERDF	*CF*	*ESF*	*EAFRD*	*Total Funds*
Total 2000-2006	1,836,980	0	710,822	459,401	3,007,203
2007	449	0	66,686	0	67,135
2008	4,610	0	66,568	168,357	239,535
2009	232,041	0	67,560	166,947	466,548
2010	396,984	0	68,767	113,875	579,626
2011	278,884	0	70,403	138,627	487,914
2012	222,680	0	72,251	138,454	433,385
2013	183,743	27,190	138,167	136,835	485,935
Total 2007-2013	1,319,391	27,190	550,402	863,095	2,760,078

Note: ERDF = European Regional Development Fund; CF = Cohesion Fund; ESF = European Social Fund; EAFRD = European Agricultural Fund for Rural Development.

Source: Own elaboration using data from the Ministry of Economy and Finance of Spain and the Government of Extremadura.

3. Economic effects of the EU Funds received by Extremadura during the period 2007-2013: a SAM multiplier analysis

For the case of the Spanish regional economy of Extremadura, this section provides the estimation of the economic impact in terms of output and employment induced by the EU Funds received during the programming period 2007-2013.

These effects are computed by using a multisectoral economic model that takes into account the interrelationships between the different agents in the economy. Besides, unlike aggregate macroeconomic models, the multisectoral models provide results with a high disaggregation detail. For this purpose, one of the most used tools in the literature is the input-output analysis. However, a slightly different methodology is employed, in our opinion, more complete and suitable. Specifically, the multiplier effects are obtained from a *social accounting matrix* (SAM) for Extremadura (see, for example, Lima and Cardenete, 2005).

The main difference between the input-output model and the SAM multipliers model is that the latter includes a wider closure model and interdependence effects ignored by the former. In particular, while the traditional input-output demand model only considers the interdependences related to the productive sphere, i.e. the interdependences between production sectors, the SAM multipliers model also includes the primary factors income, its distribution among the institutions (mainly the households) and other income redistribution transactions.

Therefore, the SAM multipliers model can be seen as a generalization of the input-output model, providing a more precise assessment of the effects produced by exogenous changes (as it is considered in this paper). However, the SAM multipliers model also has some limitations that must be considered for the results; mainly, the linear relationships among the economic agents, exogenous prices, and no supply constraints in the economy. Some of these limitations are resolved in the more complex computable general equilibrium models (for some recent applications, see, among others Monrobel *et al.,* 2013, and Cardenete *et al.,* 2014).

3.1. The SAM for Extremadura and the SAM multipliers model

In our application, the SAM of reference comes from the work of De Miguel *et al.* (2009), where a social accounting matrix for Extremadura for the year 2000 (SAMEXT2000) was constructed. Due to statistical limitations, in particular the lack of updated and surveyed input-output tables, this SAM came of updating a previous SAM for Extremadura for the year 1990 by using the cross-entropy method. The original SAMEXT2000 incorporated 37 accounts, including 6 different taxes and a wide sectoral disaggregation, and showing 16 production sectors as well as 9 commodities.

In this paper, the original SAMEXT2000 was aggregated to make easier the assignments of exogenous income injections, resulting a total of 11 accounts. So, the production system was divided into 5 sectors that represent the productive activity of the Extremadurian economy: agriculture, manufacturing, construction, sales oriented services, and non-sales oriented services. Additionally, the social accounting matrix shows two primary factors (labor and capital) and a generic account containing the revenues and expenditures of the households. The aggregate capital account shows all the sources of investment and savings of all the economic agents. The government account includes their relationships with other agents, basically through taxes and transfers. Finally, it was considered an account for the foreign sector, in which relations with external agents (both from the rest of Spain and from the world) are collected. Table 5 shows the 11-accounts SAM that served as basis for the multipliers model described below.

Formally, the development of a SAM multiplier model requires distributing the accounts in the matrix between endogenous and exogenous accounts; that is, it is necessary to establish a closure model assumption. Traditionally, the accounts relative to the government, the capital (saving/investment) accounts, and the foreign sector accounts are considered exogenous. On the other hand, the remaining accounts (usually the primary factors, households and production sectors) are considered endogenous. In our case, given the importance of the public sector in the reception and generation of spending associated with the European Funds, the government account has been considered as endogenous. This way, the only exogenous accounts are those related to savings/investment accounts, and the external sector.[1]

Regarding its mathematical formulation, the SAM multipliers model basically transforms the accounting constraints that have to be verified by the social accounting matrix, expressing them in a different way (to relate exogenous injections with endogenous incomes). Thus, the basic equation of the model can be expressed as follows (Pyatt and Round, 1979):

$$y = (I - A)^{-1}\, x = M \cdot x \tag{1}$$

where y denotes a n-column vector of endogenous incomes, A represents a nxn matrix of average propensities of spending, x is a n-column vector of exogenous investment injections, I is an identity matrix, and M is the multipliers nxn matrix obtained from the original SAM that is usually known as *accounting multipliers matrix* (see Table 6).

These multipliers can be decomposed into several values that reflect the role of the different types of interdependencies. Different methods for multipliers decomposition have been proposed in the literature. In our case, taking as point of departure the work of Cardenete and Sancho (2003), we propose a decomposition technique that allows differentiating between direct effects and non-direct effects. The resulting expression is as follows:

$$M = (I + A) + (M - I - A) = M_{DE} + M_{NDE} \tag{2}$$

[1] Alternative closure model assumptions can be found in the literature, depending on the topic considered. For example, Polo, Roland-Holst and Sancho (1991) and Ferri and Uriel (2000) also include the saving/investment account into the endogenous part of the model.

Table 5. The Social Accounting Matrix for Extremadura (11x11 accounts; thousand euros)

	1. Labor	*2. Capital*	*3. House-holds*	*4. Agricul-ture*	*5. Manufac-turing*	*6. Construc-tion*	*7. Sales Orient*	*8. Non-sales Orient Serv*	*9. Govern-ment*	*10. Saving/inv*	*11. Foreign sec*	*Total*
1. Labor	0	0	0	152,242	513,451	758,846	1,633,713	1,963,176	0	0	0	5,021,428
2. Capital	0	0	0	1,044,882.0	464,264.0	324,881.8	2,517,697.1	177,899.1	0	0	0	4,529,624
3. Households	4,129,264	4,529,624	0	0	0	0	0	0	2,009,696	0	61,948	10,730,532
4. Agriculture	0	0	344,694.4	490,958.6	413,634.7	411.3	71,328.0	8,126.4	119,386.9	139,466.7	631,903.2	2,219,910.0
5. Manufacturing	0	0	871,015.7	88,246.3	242,384.9	250,930.7	184,053.9	85,691.8	0	110,845.2	439,205.6	2,272,374.2
6. Construction	0	0	175,326.4	8,046.7	9,262.4	0	39,765.1	26,856.7	0	1,796,485.7	0	2,055,743
7. Sales Orient	0	0	3,636,264.6	153,229.7	275,806.1	360,457.2	657,945.3	284,196.1	0	47,036.5	40,377.2	5,455,312.6
8. Non-sales Orient Serv	0	0	133,698.8	0	0	0	0	1,235,182,499	2,615,569	0	0	2,750,503
9. Government	892,164	0	1,469,936	0	3,390.3	46,355.7	41,777.8	0	0	2,291,028	0	4,744,651.9
10. Saving/inv	0	0	2,388,158	0	0	0	0	0	0	0	2,236,816	4,624,974
11. Foreign sec	0	0	1,711,438.1	282,304.7	350,180.8	313,860.3	309,032.4	203,321.7	0	240,111.9	0	3,410,250
Total	5,021,428	4,529,624	10,730,532	2,219,910.0	2,272,374.2	2,055,743	5,455,312,636	2,750,503	4,744,651.883	4,624,974	3,410,250	

Source: Own elaboration using data from De Miguel *et al.* (2009).

Table 6. The accounting multipliers matrix, *M*

	1. Labor	*2. Capital*	*3. Households*	*4. Agriculture*	*5. Manufac-turing*	*6. Construction*	*7. Market Servic*	*8. Non Mark Serv*	*9. Government*
1. Labor	1.63	0.56	0.56	0.61	0.79	0.97	0.91	1.33	0.99
2. Capital	0.62	1.60	0.60	1.17	0.92	0.80	1.12	0.70	0.67
3. Households	2.22	2.24	2.24	1.83	1.74	1.79	2.06	2.02	2.11
4. Agriculture	0.19	0.18	0.18	1.45	0.41	0.19	0.20	0.19	0.22
5. Manufacturing	0.27	0.26	0.26	0.28	1.34	0.36	0.29	0.28	0.27
6. Construction	0.05	0.05	0.05	0.04	0.04	1.04	0.05	0.05	0.05
7. Market Servic	0.96	0.95	0.95	0.89	0.92	0.99	2.03	1.00	0.98
8. Non Mark Serv	0.36	0.26	0.26	0.22	0.24	0.27	0.28	1.31	0.84
9. Government	0.60	0.41	0.41	0.37	0.39	0.45	0.46	0.52	1.47

Source: Own elaboration using data from De Miguel *et al.* (2009).

M_{DE} can be called *direct effects matrix* because it captures the direct interdependencies among the different endogenous accounts, including the intermediate inputs. M_{NDE} incorporates the *non-direct effects*, i.e. it is a residual matrix because it includes the rest of interdependencies. Therefore, M_{NDE} captures the indirect effects among the production sectors; the induced effects arising from the feedback among the households and the production sectors through income and consumption; and the non-direct effects linked to the government through taxes, income transfers and public consumption.

3.2. The results

Once exposed the SAM multipliers model, we can use the previous equations to calculate the effects that the EU Funds had in Extremadura during the programming period 2007-2013. In our analysis, we show the following results: first, increases in the domestic production, distinguishing between direct and no direct effects; and second, increases in the volume of employment. In all cases, we adopt the closure model assumption discussed above. Thus, the primary factors labor and capital, the representative group of households, the production sectors and the public sector were considered endogenous accounts.

From the previous equation of the SAM multipliers model, it is possible to express it in incremental terms as follows:

$$\Delta y = M \cdot \Delta x \tag{3}$$

Then, to obtain the economic impact on domestic output (vector Δy) associated with investments derived from the EU Funds, it is necessary to allocate these investments to the different exogenous accounts (vector Δx). The accounting multipliers matrix M acts as a «bridge» matrix to determine the corresponding effects on domestic production.

To compute the employment effects we consider the following equation:

$$\Delta e = E \cdot M \cdot \Delta x \tag{4}$$

where E represents a diagonal matrix whose generic term E_{ii} represents the quantity of employed in each sector for every euro of domestic output in this sector (employment coefficients).

In our application, the temporal distribution of flows that makes up the European Funds was considered, estimating the yearly effects of the investments under the programming period 2007-2013. Therefore, it was necessary to build seven 9-vectors of exogenous injections ($\Delta x(2007)$, $\Delta x(2008)$,..., $\Delta x(2013)$), which has supposed to distribute for each year the investments among the nine endogenous accounts of our model. To do this, the specific objectives of each fund were considered, assigning all the investments projects listed in the programming period to specific production sectors or to the public sector.[2]

[2] See Delgado (2012) and Monrobel (2010) for the assignment rules.

Taking the accounting multipliers matrix for Extremadura *M* (Table 6) and the yearly exogenous sectoral spending $\Delta x(2007)$, $\Delta x(2008)$,..., $\Delta x(2013)$, the effects on the domestic production and the employment were obtained for each of the seven years considered. These multipliers effects are shown in Table 7.

With respect to the output impact, the accumulated estimated effects (7,581 millions of constant euros) should be assessed in relative terms with respect to the entire amount of European Funds received by Extremadura during the period 2007-2013

Table 7. Impact of the European Funds received in the programming period 2007-2013 on the domestic production (constant € of the year 2000) and on the employment of Extremadura

		TOTAL EFFECTS	
		Production	*Employment*
2007	Direct	54,929,615	
	Non direct	116,871,199	
	Total	171,800,814	4,381
2008	Direct	283,617,186	
	Non direct	386,212,664	
	Total	669,829,850	16,402
2009	Direct	515,949,377	
	Non direct	772,261,987	
	Total	1,288,211,364	31,757
2010	Direct	615,432,951	
	Non direct	971,942,810	
	Total	1,587,375,761	39,293
2011	Direct	528,578,190	
	Non direct	812,670,639	
	Total	1,341,248,829	33,136
2012	Direct	472,178,144	
	Non direct	720,100,773	
	Total	1,192,278,917	29,442
2013	Direct	522,348,481	
	Non direct	808,315,485	
	Total	1,330,663,966	32,597
Total 2007-2013	Direct	2,993,033,944	
	Non direct	4,588,375,557	
	Total	7,581,409,501	

Source: Own elaboration.

(over 2,760 million of constant euros). Thus, this implies an output/investment ratio of 2.75, that to say, an efficiency coefficient of output over the period 2007-2013 of 2.75 euros of domestic production for every euro of European Funds entering in the Extremadurian economy. The highest output effects values are for the years 2009 to 2013, those with the most relevant investments executed.

It is relevant to make a comparison with the European Funds received in the previous programming period 2000-2006. It implied a cumulative effect of approximately 6,600 million of euros constant of the year 2000, derived from a total investment of about 3,000 million of constant euros (Márquez *et al.*, 2010). Therefore, the output/investment ratio for the period 2007-2013 (2.75) has been higher than the previous one (2.18 million of euros per million invested for the period 2000-2006).

Regarding the multipliers decomposition, the effects related to the non-direct interdependences are clearly higher than the direct effects for all years considered. In global terms (period 2007-2013), they are more than 50% greater than the direct effects (4,588 millions of euros against 2,993 millions).

As for the effects on employment in each of the years considered (last column of Table 7), it can be seen again that the greatest impact occurs during the period 2009-2013. During these years, they were created (or maintained) a number of employments near or higher than 30,000 employments, with a peak impact about 39,000 employments in year 2010. If we assess the estimates obtained in terms of the volume of investments received each year, the results suggest an efficiency coefficient of employment of 67, that is, for every million of constant euros invested they were generated or maintained around 67 employments in the region during the period 2007-2013.

During the previous period 2000-2006, the greatest impact occurred in the period 2003-2006, where they were generated (or maintained) near or above 24,000 employments, with a peak impact of 32,000 jobs in 2006 (Márquez *et al.*, 2010). Overall, the employment/investment ratio was 49 on average; this implied the generation or maintenance of approximately 49 employments for every million of euros invested.

In summary, and in terms of the benefits obtained from the generation or maintenance of production and employment, the estimates indicate the existence of a greater efficiency coefficients in the programming period 2007-2013 than during the previous programming period 2000-2006.

4. Conclusions

the main purpose of this paper was to compare the returns obtained in terms of output and employment by the European funds received in the Spanish region of Extremadura during the programming periods 2000-2006 and 2007-2013. Extremadura was defined as «Objective 1» regions in the 2000-2006 programming period, while in the 2007-2013 programming period, this region was a «Convergence Objective» region. The main contribution of this paper is that our analysis allows quantifying the effects of the EU regional policy on a regional economy, showing and comparing the efficiency for two different programming periods.

As a first step, the paper has analyzed the impact of the European Funds in the period 2007-2013 on the Convergence Region of Extremadura by means a multipliers analysis based on a Social Accounting Matrix (SAM) of Extremadura for the year 2000. It is important to emphasize the reduction (–8.21%) of the total amount of European Funds in the period 2007-2013 with respect to the 2000-2006 period. Besides, although in both programming periods the ERDF is the most important fund, the EAFRD increased its relevance with respect to the ESF during the programming period 2007-2013.

From the estimations of the impacts of the European investments on the regional economy of Extremadura in 2007-2013, some results can be highlighted. In cumulative terms, the regional production of Extremadura increased above 7,580 millions of constant euros of the year 2000. This amount should be assessed in terms of the total investment, around 2,760 millions of euros constants of the year 2000. This implies an investment/total effect ratio of 2.75. The highest effects appeared in the period 2009-2013, since the main part of both the ERDF and the EAFRD were executed during this period.

Regarding employment effects caused by the European funds on the regional economy of Extremadura in 2007-2013, the greatest impact is, once again, on the period 2009-2013, where they were generated (or maintained) a number of employments of around 30,000. The most important effect was in 2010, with an impact in terms of employments over 39,000. By sectors, the employment effects were generated mainly in the market services sector, followed by non-market services and agriculture.

Considering the amount of investment received each year in Extremadura, the results of the programming period on the Extremadurian employment indicate that, for every million euros (in constant euros of the year 2000) invested in the period 2007-2013, they were generated or maintained on average around 67 employments in the region of Extremadura.

Finally, the main empirical contribution of this paper was to compare the returns obtained in terms of output and employment by the European funds received in the Spanish region of Extremadura during the programming periods 2000-2006 and 2007-2013. In this sense, it is important to remark that, in comparison with the economic impact of European funds received in the previous programming period (2000-2006), our estimations indicate higher efficiency coefficients for the 2007-2013 period. This efficiency is shown in both, in terms of the benefits obtained in generation of new production (an output/investment ratio of 2.18 in 2000-2006 *vs* 2.75 in 2007-2013), and in terms of maintenance or creation of new employments (employment/investment ratio of 49 for the period 2000-2006 *vs* 67 in 2007-2013).

To conclude, two final comments. First, it is necessary to highlight the importance of the economic impact of the European Funds in Extremadura in terms of economic growth and employment in the two programming periods. Second, it needs to be emphasized that the evaluation of the impacts of the two programming periods on the economy of Extremadura shows a more efficient period during the period 2007-2013.

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Section ARTICLES

The Effects of European Structural Funds in the Spanish Regions Using CGE Models: a review

María Teresa Álvarez-Martínez *

ABSTRACT: This paper reviews the few regional studies on the impact of European Structural funds in Spain using Computable General Equilibrium (CGE) Models. While the models in these studies are widely used to evaluate the effects of very different public policies, they rarely have been used to quantify the impact of the Structural funds. In the pioneer papers elaborated for Madrid and Andalusia, the effects of the funds have been simulated through an exogenous change of final demand. I suggest avoiding any accounting of exogenous shocks in final demand of non-affected sectors by more-realistically splitting investment into various capital goods and evaluating the short-run effects of increasing investment in them.

JEL Classification: C68; R53.

Keywords: Structural Funds; Computable General Equilibrium model; Investment goods.

Los efectos de los fondos estructurales europeos en las regiones españolas utilizando modelos CGE: una revisión

RESUMEN: Este documento revisa los escasos estudios regionales sobre el impacto que los fondos estructurales europeos han tenido en España utilizando modelos de Equilibrio General Aplicados (MEGAs). A pesar de que estos modelos se han utilizado ampliamente para evaluar el impacto de diferentes políticas públicas, raramente se han utilizado para cuantificar el impacto de los fondos estructurales. En los estudios originariamente realizados para Madrid y Andalucía, los efectos de los fondos se han simulado mediante una variación exógena en la demanda final. Mi sugerencia para evitar alterar con perturbaciones exógenas la demanda final de sectores productivos no directamente afectados es desagregar la inversión en bienes de inversión y evaluar los efectos de corto plazo de aumentar la inversión en bienes de inversión específicos.

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

European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), and Rutgers University, New Jersey.

Received: 24 march 2014 / Accepted: 2 july 2014.

Clasificación JEL: C68; R53.

Palabras clave: Fondos estructurales; Modelos de Equilibrio General Aplicados; Bienes de inversión.

1. Introduction

European Structural funds are composed in two groups: the European Regional Development Fund (ERDF), established in 1975, and the European Social Fund (ESF) in 1958. The latter program aims to raise labor skills and education among vulnerable populations, while the first fosters economic growth by improving public infrastructure and other productive investments. They constitute the oldest regional policy instruments in the EU, and both programs try to reduce regional disparities and to speed up economic growth. Total resources allocated to these funds have changed over time, absorbing an average of 15% of the EU budget from 1986 through 1993 to almost 33% from 2006 to 2013. In 2007-2013 Spain received around 10% of the total EU funds.

The funds have been always allocated according to priority objectives. From 1993 to 1999, European regions were classified via seven different objectives (Objective 1, Objective 2, Objective 3, Objective 4, Objective 5a, Objective 5b and Objective 6) ranging from those regions whose development lagged behind the EU average (Objective 1) to those regions with very low population densities that needed help in promoting economic development (Objective 6). Since the 2000-2006 period, there have been only three different objectives. **Objective 1** promotes development in regions with a GDP per capita below 75% of the EU-25 average GDP per capita. The areas in Objective 1 receive almost two thirds of the Structural funds budget. **Objective 2** aims to help social and economic conversion in regions struggling with Structural difficulties. Finally, **Objective 3** finances education and training programs in regions not included[1] in Objective 1[2].

Cumulatively, Spain has received a significant share of the funds since it joined the European Union in 1986. It is estimated to have received a total of more than 130.000 Million Euros[3] since it joined the Union (European Commission, 2006). Moreover, it ranks second country[4] in the level of funds obtained since 2007. In 2000-2006, eleven Spanish regions were classified as Objective 1: Galicia, Principado de Asturias, Castilla y León, Castilla-La Mancha, Extremadura, Comunidad Valenciana, Andalusia, Region de Murcia, Ceuta, Melilla and Canarias. Since then, however, just four of the regions —Galicia, Castilla-La Mancha, Extremadura and Andalusia— remained in that category in 2007-2013 and only one —Extremadura— in 2014-2020. These changes are explained by two effects: the EU's phasing out and phasing in regions. The phas-

[1] Regions classified as Objective 2 and Objective 3 are Madrid, Cataluña, Baleares, Navarra, etc.

[2] Recently, these Objectives have been renamed as: Convergence, Regional competitiveness and employment and European territorial cooperation.

[3] Including Cohesion funds. Hübner, 2006.

[4] Poland is the first country. It received 19% of the funds in the time period 2007-2013.

ing out effect is a statistical result of incorporating new countries into the distribution. Enlargement of the EU in 2004 and 2007 reduced the average GDP per capita, which immediately enabled several regions previously classified as Objective 1 to surpass the new GDP requirement, despite little movement in their GDP levels. This was the case for Asturias, Ceuta, Melilla and Murcia. Regions that phased in are those that actually improved their relative position and raised their GDP per capita above the average in the original EU-15. The three Spanish regions that phased in were Canarias, Castilla y León and Comunidad Valenciana. Regions that either phased in or out continued to receive transitory funds from 2007 through 2013. Regions in Spain classified as Objective 2, or Regional competitiveness and employment objective, are: Cantabria, Comunidad de Madrid, Pais Vasco, Navarra, Aragon, La Rioja, Cataluña and Baleares.

There is no doubt that Structural funds have been important in fostering economic growth in Spain, especially in the regions directly receiving the funds. The resources have been used to invest in public infrastructure: highways, roads, high-speed train tracks, sea ports, airports, schools, etc., but also in educational services. The effect of these funds is twofold. On the one hand, the installation and construction of the infrastructure creates a demand effect that raises production. The construction of a new highway raises labour demand for construction and related capital as well as for basic materials —such as concrete, stone, gravel, and tar— and other inputs, such as rental machinery, fuel, and communications services. On the other hand, once the infrastructure is in place, it generally enhances a productivity effect —in the case of roadways faster, more reliable transportation services— that affects all industries in the region as the time passes. Investment in social capital (hospitals, schools, etc.) and education services yield similar effects.

The impacts of final demand and productivity due to the Structural funds have been quantified in the economic literature using various different approaches, econometric (Mohl and Hagen 2010), input-output (Beutel, 2002) and CGE models (Gaspar and Pereira, 1992, Lolos *et al.,* 1995). The latter have been used to evaluate not only the increase of final demand but also the supply effects on productivity and skilled labor supply. In Spain, the focus of this paper, the econometric approach has been intensively used (Sosvilla and Herce, 2003; Sosvilla and Murillo, 2005; Cancelo *et al.,* 2009) and to a lesser extent input-output (I-O) models (Dones and Pérez, 2002) and social accounting matrix models (SAMs) (Lima and Cardenete, 2006; Cámara and Marcos, 2009; Márquez *et al.,* 2010; Lima and Cardenete, 2009; Cardenete and Delgado, 2012).

Input-Output (I-O) models can capture direct, indirect, and induced effects that can result from shocks to final demand. They provide interesting sectoral effects but they are not as complete as those ex tolled by equivalent SAM models[5]. SAMs are balanced square tables that reflect the circular flow of *all* income for a specific period. The incorporation of additional data on income redistribution enables fuller impact analysis of external shocks on endogenous variables. Nevertheless, I-O and SAM

[5] Government income is almost always exogenous and changes in government incomes and non-resident income, for example, cannot recirculate in a single region I-O framework.

models do not allow for substitution among inputs since they are based on a fixed, Leontief technology.

Computable general equilibrium (CGE) models are a combination of linear and nonlinear equations that optimize the behaviour of agents in an economy. Production technology is more generalized, at least allowing substitution among factor inputs. Substitution is enabled through variations in relative prices of the various inputs. To date (and to my knowledge), only four papers use CGE models to evaluate the impact of Structural funds in Spain[6]: Lima and Cardenete (2008), Monrobel *et al.* (2013), Cardenete and Delgado (2013) and Cardenete *et al.* (2014). The objectives of this paper are to describe and critically review the main characteristics of the papers on Structural funds for the Spanish regions and to briefly summarize their main conclusions, their contributions and their main shortcomings. I also present an alternative way to evaluate part of the effects of the funds with a CGE model.

The rest of the paper is divided as follows. In Section 2, I depict the main characteristics of the four CGE regional papers elaborated for Madrid and Andalusia. In Section 3, I propose an alternative way to simulate the increase of public investment financed by Structural funds paying special attention to the final demand effects of infrastructures construction. Finally, some conclusions are presented in Section 4.

2. A critical review

In this section, I depict the main characteristics and conclusions derived from the pioneer papers elaborated for Madrid and Andalusia. These papers represent the first attempt to evaluate the general equilibrium effects of raising final demand due to the Structural funds in two Spanish regions.

2.1. Regional studies for Madrid and Andalusia

The paper elaborated by Monrobel *et al*. (2013) evaluates the impact of the structural funds in Madrid for 2007-13. In the case of Andalusia, Lima and Cardenete (2008) evaluated their effects for the period spanning 2000-2006 using a static CGE model; Cardenete and Delgado (2013) repeated that effort for 2006-2013. More recently, Cardenete *et al.* (2014) enhanced the model by including dynamic relationships for investment, labour and capital.

*Monrobel et al. (2013).*The Madrid region contains the capital of Spain and has a predominantly urban population. It has never been classified as an Objective 1 region, but it does take advantage of structural funds via Objective 2. The funds are

[6] RHOMOLO is a dynamic spatial CGE model developed by the European Commission to evaluate the effects of the Structural funds in 267 NUTS 2-level regions, of which 16 are in Spain. Since RHOMOLO is not aimed to evaluate the effects of the funds in any particular region, it has not been included in the current review.

aimed to transform Madrid into an attractive place to work and to spur both innovation and research activities. The paper elaborated by Monrobel *et al*., calibrates a static CGE model using a 2002 SAM for Madrid that was elaborated by the authors (SAMMD-2002, hereafter). They account for 27 productive industries, one representative household, the corporate sector, one account for government and the foreign sector. There is an account for the Rest of the world and an account for taxes on products. VAT, other taxes on products and taxes on imports are not disentangled; therefore there are no price differences between imports and domestic or Spanish commodities. The production technology consist of a set of nested production functions wherein total supply is an «Armington combination»[7] of domestic production and imports in which there are constant returns to scale (CRS). It is a neoclassical model in which total investment[8] is determined by savings. That is, the model is a savings-driven such that the sum of households' savings, corporate sector savings, government savings and the foreign current balance (FCB) determines the level of total investment.

According to the information in the ERDF Operational programme «Madrid» for 2007-2013, the funds are to foster knowledge, energy resources and transport services, local and urban sustainable development and technical assistance. In the simulations, these funds are distributed among the following industries included in the SAMMD-2002: Energy and mining, Transport material, Transport and communications, etc. The total funds from the ESF are also aggregated and allocated to Corporate services, Education and Public administration. As I mentioned before, these shocks in final demand are included as an additional component that do not seem to affect market clearing conditions, Foreign/ Government savings, households consumption and private investment[9] prevailing investment from fictitious shocks. On the other hand, in this simulation, it is taken for granted there are exogenous final demand increases in Energy and mining products. If we look at the figure included in Spanish I-O Tables for 2002, this industry does not send any production to investment. This means that in the model Structural funds cannot directly increase the amount of production used for investment from Energy and mining goods Instead the funds finance infrastructure that improves the distribution of the industry's services/ commodities. Hence, I suspect the funds to improve Energy efficiency and transport services sector should be allocated to the Construction sector in simulations that analyse the short-run effects of the infrastructure instead of raising final demand on Energy. On the other hand, energy efficiency has to do with prices, an aspect that can be captured with a CGE model, but which is not discussed in the paper. It is likely due to this misallocation of funds in the simulations performed by Monrobel *et al.*

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[7] The cost minimization program displays a Cobb-Douglas instead of the traditional CES function, Armington (1969).

[8] Total investment includes private and public investment.

[9] The neoclassical closure does not seem to be the best for evaluating the impact of final demand shocks (Polo and Valle, 2008, Alvarez-Martinez and Polo, 2010). The reason is that an exogenous shock in variables like exports will affect foreign savings and may produce a fictitious investment shock since investment is affected by total savings.

(2013) that their results reveal the Construction sector is hardly affected and Real estate and leasing increase imperceptibly despite substantial funding. They therefore find in general equilibrium that regional production rises 0.64% in nominal terms and 0.48% in real terms.

Lima and Cardenete (2008). Andalusia is a large region in southern Spain with 8.4 million inhabitants that has been an Objective 1 region since Spain joined the Union. It has long relied on its agrarian economy, although more recently tourism and services have taken the lead. Lima and Cardenete (2008) evaluate the impact of the ERDF in Andalusia using a static CGE model[10] calibrated to three SAMs for 1990, 1995 and 1999. The funds received in each period —1989-1993, 1994-1999 and 2000-2006— are first annualized and then distributed among the «priority axes» and, thereby, the accounts in the SAMs. The main results reveal different effects depending on the database, and show a bigger impact of the funds in the latter period (2000-2006) than in the two others.

This paper for Andalusia presents the same demand perspective later used by Monrobel *et al.* (2013). In this case, however, investment is exogenously fixed and the simulations are performed on this exogenous variable. The effects of the Structural funds are evaluated by reducing total investment. There is no distinction between public and private investment and the affected sectors are not detailed. The effects on GDP after removing the annual investment using the matrices are –0.18% (SAM: 1990), –5.91% (SAM: 1995) and –7.75% (SAM: 1999). They also suggest that employment increases.

Cardenete and Delgado (2013). The model in this paper draws heavily on Lima and Cardenete (2008). Here, however, investment is treated endogenously and consequently, it is more sensitive to changes in savings. In this case, the scenario without funds is implemented by reducing current government consumption[11]. This implies the funds are used to finance public current consumption and no funds are invested in infrastructure[12]. The results are presented for the components of GDP (expenditure and income), Disposable income and Total output. Investment dips steeply (32%), as do private consumption (16%) and net foreign demand (21%), even though the structural funds represent a very small share of total Public expenditures[13], which falls only 1.98%. Additionally, it is displayed what the authors call «efficiency coefficient» that is estimated as the change in GDP for scenarios «with» and «without funds», per unit of all funds received. They conclude the paper by highlighting the relevance of the Structural funds in the context of all regional macroeconomic variables.

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[10] Production technology is a nested constant returns to scale production function with Leontief functional forms.

[11] The SAM for what the model is calibrated is not mentioned in the paper.

[12] There is not any specific mention about the content of the account Government in the SAM, so I am assuming the usual convention that public investment is merged with private investment in the account of Gross Fixed Capital formation.

[13] Part of the effect can be also due to the changes in prices since public expenditure is usually presented in nominal terms.

Cardenete, Delgado and Lima (2014). This is the most recent paper published on the Structural funds effects in Andalusia. Its main objective is to evaluate the likely negative effects of Andalusia losing a substantial amount of Structural funds as it transition from being an Objective 1 region. They use a CGE model with dynamic relationships on investment, capital and labor supply. Also in this model, total investment is endogenously determined in a savings-driven formulation and there is no distinction between public and private investment/capital. The simulations performed engage different sectoral capital/labor ratios, trying to capture the long run effects of the funds, which vary with the allocation of funds to these factors: 50% capital and 50% labor, 60% capital and 40% labor, 70% capital and 30% labor, etc. Two scenarios are employed —an «optimistic» scenario that assumes the funds received in 2014-2020 will be delivered at the same pace as in 2007-2013, and a «realistic» scenario that reduces the allocation of funds delivered in 2007-2013 by a third—.

The results reveal no big differences in the GDP growth rate, which is estimated to be around 6.00% in the realistic scenario and 6.15% in the optimistic one. Moreover, the results are better when the investment is in labour instead of capital. In the paper, these effects are attributed to Andalusia's labour-intensive economy. According to the sectoral findings, only displayed for three sectors (Agriculture, Food and Other Services), Agriculture is the industry most positively affected in the scenarios. It would have been interesting to see also the effects on industries like Construction or Metal manufactures, available in the database used by the authors.

In general, the results are different depending on the region, the time period and the database used. Additionally, none of them performed a sensitivity analysis regarding the closure rule or elasticities of substitution.

3. Further extensions

The availability of new databases published by national and regional statistical offices has improved the quality of the analysis and expands the range of studies. In Spain, national and regional statistical offices are trying to meet requirements of the European Systems of National Accounts (ESA-95) and to provide more details on macroeconomic variables. As a result, Gross Fixed Capital Formation (GFCF) matrices for Spanish national and regional economies from 2000 onwards are now available. A GFCF matrix captures the investment by industry by type of capital goods, P6/CNAE (Agricultural products, Machinery and mechanical products, Transport equipment, Residential investment, Other constructions and Other products). The information in such a matrix differs from data included in the Investment column in Symmetric and Use Tables. The figures in the column do not capture the investment in a commodity; rather it shows the total amount of each commodity supplied for use across all sectors' investments. Thus when simulating an increase of final demand in Energy and mining sector (Monrobel *et al.*, 2013), they cannot be used to properly evaluate the effects of the Structural funds used to improve infrastructure related to the energy sector. According to National Accounts, households' consumption, variations in stocks and net exports compose the totality of final demand.

In my view, the effects of structural funds in investment can be readily evaluated using data from GFCF matrices. The Investment column in Supply Tables can be converted into capital goods using the correspondences between both types of goods (Álvarez-Martínez and Polo, 2014). With this information in hand, the impact of increasing investment in Machinery and mechanical products, for instance, can then be properly simulated by raising the demand for investment in final commodities needed to produce these capital goods. Thus, the effects of increasing the amount of infrastructure related to energy and mining sector could be enabled by increasing the amount of capital goods in «Other constructions», which in turn would raise final demand in Construction and *not* in Energy and mining products.

4. Conclusions

A significant amount of resources are allocated as Structural funds by the EU each year, which makes it an important policy instrument and an evaluation of its impacts a matter of great interest. Despite its relevance in the EU budget and, particularly, its significant role in the economic growth of several Spanish regions, very few evaluations of the funds have been performed using CGE models. These models are the most appropriate to evaluate the impact of Structural funds since they capture the whole circular flow of income, the effects on prices and the possibility of productive factor substitutions. However, few authors have highlighted the relevance of these models to evaluate Structural funds. Here I review four papers that evaluate the impact of the funds in Spain. One focuses on Madrid, and three on Andalusia. No CGE analyses exist for Galicia, Extremadura and Castilla-La Mancha, although they were Objective 1 regions.

All papers highlight simulated increases in GDP and employment associated with the Structural Funds. The magnitude of the changes depends on the region and period of study, which are presented in more or less industry detail, depending on the paper. The literature evaluates the impact of Structural Funds from a final-demand perspective and ignores the important long-run productivity effects, which are the apparent focus of the funds. The shocks on productivity can be understood as the influence the operation of infrastructure that is financed by Structural funds. After all we do not build roads or improve ports for their impacts on construction jobs but rather because they enable the delivery of products and people at lower cost. The same can be said of education and training programs: that is, we do not fund these programs to enhance universities and schools, but rather to improve the capabilities (and hence productivity and wages) of workers. Impacts of infrastructure evaluated as simply rise in final demand is tantamount to estimating the impact only of constructing such infrastructure. In this regard, it seems to me in evaluating infrastructure investment that CGE models should use all information of value that is available from statistical offices, in this case Gross Fixed Capital Formation (GFCF) matrices and I-O tables.

With GFCF information in hand, one need only first identify the kinds of capital goods financed with the Structural funds and then identify some increase in the final commodities/services needed to produce these goods. Otherwise, the changes affecting industries which are not directly involved in the construction of infrastructures can yield erroneous and fictitious results.

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Section Articles

Should cohesion policy focus on fostering R&D? Evidence from Spain

Adolfo Maza *, José Villaverde *, María Hierro *

ABSTRACT: Over the last decades, there has been a vast amount of literature on the subject of Research and Development (R&D) expenditure as a main driver of economic growth, both at national and sub-national levels. This being so, the main purpose of this manuscript is to investigate the role played by R&D as a cohesion instrument. To accomplish this aim, the paper assesses the link between patents (as a proxy for R&D) and economic growth across the Spanish provinces (NUTS3) over the period 1995-2010. In other words, we want to evaluate whether provinces with high patent production grow at a higher rate than those with low innovative performance. In addition, we want to test for the presence of spatial spillovers, and to assess if the effect of patents on economic growth depends on the development degree of provinces. The results show, firstly, that patents act as a growth driver. Secondly, that there is no evidence of spatial spillovers. And, thirdly, that the effect of patents on growth seems to be higher for developed than for less developed provinces. In view of these findings, major efforts should be devoted to promote a cohesion policy focused on R&D investment in the less developed territories.

JEL Classification: O30; O40; O11; R11.

Keywords: patents; economic growth; Spanish provinces.

¿Debería la política de cohesión centrarse en el fomento de la I+D?: Evidencia para España

RESUMEN: Durante las últimas décadas la literatura sobre los gastos en investigación y desarrollo (I+D) como motor de desarrollo, tanto a nivel nacional como regional, ha crecido de forma notable. En este contexto, el objetivo de este trabajo es examinar el papel jugado por los gastos en I+D como instrumento de cohesión. Para ello, el trabajo evalúa la conexión entre patentes (como *proxy* de gastos en I+D) y el crecimiento económico entre las provincias españolas (NUTS3) durante

We would like to thank two anonymous referees for their helpful comments and suggestions. The usual disclaimer applies.

* Department of Economics. University of Cantabria. Av. Los Castros, s/n. 39005 Santander (SPAIN). E-mail: *mazaaj@unican.es*; *villavej@unican.es*; *hierroma@unican.es.*

Received: 14 march 2014 / Accepted: 30 june 2014.

el periodo 1995-2010. En otras palabras, queremos averiguar si las provincias con mayor número de patentes crecen a un ritmo más alto que aquéllas con poco impulso innovador. Además, el trabajo analiza la presencia de efectos desbordamiento, así como si el efecto de las patentes sobre el crecimiento depende del grado de desarrollo de cada provincia. Los resultados ponen de relieve, primero, que las patentes impulsan el crecimiento. Segundo, que no hay evidencia que apoye la existencia de efectos desbordamiento. Tercero, que el efecto de las patentes sobre el crecimiento parece ser mayor en las regiones más desarrolladas que en la menos desarrolladas. De acuerdo con estos resultados, una política de cohesión enfocada en la inversión en I+D en las regiones menos desarrolladas parece ser necesaria.

Clasificación JEL: O30; O40; O11; R11.

Palabras clave: patentes; crecimiento económico; provincias españolas.

1. Introduction

The existence of large and persistent regional disparities constitutes one of the main traits of the European Union (EU). As these disparities might pose some problems to the process of European integration, their analysis and, correspondingly, the issue of how to deal with them has caught the attention of both academics and policy makers since at least the 1970's, spawning a large theoretical and empirical research. In truth, this analysis revolves around a simple but critical question: why some territories are rich and others are not? Put it other way, it discusses on the main sources of economic growth.

Among these sources, Research and Development (R&D) investment clearly stands out. There is a general consensus on the fact that disparities are mainly explained by differences in productivity, and that these differences are, to a great extent, due to the development of new technologies as well as the capacity of regions to profit from technology and, eventually, to harvest the benefits of investments on R&D. That is to say, there is a well-defined strand of research confirming the relevance of technological progress as a growth engine and, consequently, of R&D as a key element in not only regional but also national and European-wide growth policies [1]. Therefore, remarkable efforts have been displayed by different governments to increase the expenditure on R&D as a percentage of GDP, especially in the last decades.

Bearing these considerations in mind, the aim of this paper is to assess the pertinence of the use of R&D investments not only as a growth driver but also as an instrument of the cohesion policy, let's say a potential cohesion enhancer. But, how can we accomplish these two goals together? To do that, and although we are conscious of their limitations, we employ (both standard and spatially) conditioning beta-convergence approaches. By using these approaches we can establish whether, or not, regions that allocate a larger share of output to R&D grow at a higher rate than those with a

[1] One of the criteria of the Lisbon Strategy is, for example, that 3% of GDP is invested in R&D.

poor innovative performance and, by doing that, we also intend to estimate the potential contribution of R&D investments to convergence or cohesion. Additionally, the paper addresses two closely related issues. Firstly, and taking into account a relatively new and important branch of the literature —the New Economic Geography (NEG) models inspired on the ground-breaking paper by Krugman (1991)—, it studies the interaction of R&D activities in one place with those in another[2]. This is an extremely important topic (see e.g. Funke and Niebuhr, 2005), because this kind of intangible assets are specially pruned to the presence of spatial spillovers[3]. Then, it also examines, by employing a spatially conditioning beta-convergence approach, whether the increase in R&D in a province positively affects the rate of economic growth of its neighbors. Secondly, and due to the fact that previous papers have shown that the effect of R&D expenditures on economic growth could depend on the development level of the areas where they are conducted, the paper also tests this hypothesis by using a set of interaction variables (combining R&D investments and the level of per capita GDP).

Regarding data, this paper takes the Spanish case as a sort of laboratory. To be precise, we use a sample of 50 Spanish provinces (excluding Ceuta and Melilla) over the period 1995-2010 and, due to R&D data unavailability at provincial level[4], we employ patent data (Patent Co-operation Treaty (PCT) patent applications per million inhabitants) as a proxy for R&D expenditure. Data about patents come from the *Main Science and Technology Indicators* databank provided by the OECD. Other data sources, such as Eurostat and IVIE, are also employed for the inclusion of some control variables in the study.

Bearing these considerations in mind, the rest of the paper is organized as follows. Section 2 presents a succinct review of the theoretical framework regarding the link between R&D and economic growth/convergence. Section 3 reviews the empirical literature devoted to the relationship between R&D and economic growth. Section 4 describes, in a concise way, the provincial distribution of patents in Spain. After that, Section 5 assesses the role played by patents as an engine for economic growth and convergence, the existence of spatial spillovers, and of differences according to the development level of provinces. Finally, Section 6 concludes and provides some lessons and challenges for cohesion policy.

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[2] An extensive analysis of the inner connectivity of the Spanish Regional Innovation Systems has been recently published by Alberdi Pons *et al.* (2014).

[3] This is one of the reasons why the Lisbon Strategy focuses on R&D: EU countries/regions collect well-being gains from each other's investments on R&D.

[4] It is worth noting that the analysis could be carried out at regional (NUTS2) level using R&D investment data. However, we decided to run it at provincial (NUTS3) level because not only patents are commonly used as a proxy for R&D but mainly because we consider that an analysis at regional level suffers from serious problems of aggregation (the Spanish regions are of widely different sizes and encompass different number of provinces). Furthermore, the use of data at provincial level allows us to deal with to the potential existence of spatial dependence problems in the estimation of our model (as it is well-known that models including a spatial structure need a big sample), which could crucially affect the reliability of the results. Although at the same time we are aware that there are some papers indicating that the use of patents is not suitable because they are not a good proxy for R&D (e.g. Griliches, 1990; Sánchez *et al.,* s.d.), we perceive the pros outweigh the cons.

2. Theoretical literature review

Although the interest on R&D investments dates back to classical economists, in the modern era it was spurred by Solow's (1956, 1957) work, that established the roots of the neoclassical growth theory. According to it, economic growth is explained by factor accumulation and productivity growth, this last one being considered as an exogenous variable. The problem with this approach is that empirical literature has found, as mentioned in the Introduction, that the bulk of income differences among regions cannot be explained by differences in factor endowments, but by differences in productivity growth (Caselli, 2005). In other words, empirical evidence does not support the predictions made by Solow's model.

Even though since Solow's seminal papers several advances have been made, the next big step on the theory of economic growth did not take place until around mid-eighties with the endogenous growth theory (Romer, 1986, and Lucas, 1988). This theory tries to incorporate technological change, namely innovations, into economic growth models. Accordingly, productivity growth starts to be treated as an endogenous driver of growth. One of the reasons leading to this conclusion is that technological knowledge accumulated through the allocation of resources to R&D promotes productivity growth. As explained by Wei *et al.* (2001: 155), «the more resources allocated to R&D, the higher the incentive for firms to innovate, the greater the firms' abilities to create new technological ideas, and the higher the rate of growth a country will enjoy». Accordingly, differences in capabilities, resources and incentives to undertake innovative processes are expected to provoke large regional differences.

Following this line of research, during the last two decades there has been a surge in the literature devoted to assess the importance of investment in R&D as a source of economic growth. Among the most relevant papers, those by Romer (1990), with his product-variety model, Grossman and Helpman (1991), including spillover effects in the research sector, and Aghion and Howitt (1992), with their quality-ladder model involving creative destruction, stand out. As summarized by Barro and Sala-i-Martin (1995: 12), «in these models, technological advance results from purposive R&D activity, and this activity is rewarded by some form of ex-post monopoly power». These models conclude the existence of «scale effects» on innovation: the size of population affects long-run economic growth as any increase in population, ceteris paribus, raises the number of researchers.

Nevertheless, the prediction of «scale effects» in innovation based on the first generation of endogenous growth models was afterwards challenged, on empirical grounds, by Jones (1995), which developed a model that maintains the main features of the R&D-based models but eliminates this «scale effect» prediction[5]. In the

[5] In this model economic growth is not endogenously determined but the result of population growth or, more specifically, the result of «the growth in the effective number of researchers» (Jones, 1995: 778).

same vein, many other models eliminating the «scale effect» have been proposed, among which those of Young (1998), Peretto (1998) and Howitt (1999) are probably the most prominent. These models, in short, include «horizontal» innovation as well as «vertical» innovation, so that the aggregate effect of any-one sector R&D investments diminishes and, in consequence, the effect of population on resources devoted to R&D and economic growth vanishes (Garner, 2010).

In sum, from a theoretical perspective there are different approaches to assess the relationship between economic growth and R&D investments. Regarding neoclassical models, and apart from the accumulation of factors, productivity gains induced by technological advances are a main source of economic growth. Therefore, the use of R&D investments as a way to boost productivity and, therefore, promote economic growth might even be considered an implicit finding from the neoclassical approach. From the endogenous growth theory perspective, R&D is explicitly taken as a growth driver. Therefore, there seems to be a unanimous conclusion: there is a link between R&D expenditures and economic growth. With respect to this issue, Aghion and Howitt (2007: 93) indicate «that the contributions of capital accumulation and innovation to growth cannot be estimated without such a hybrid *(neoclassical and endogenous)* theory».

3. Empirical literature review

Accordingly with the theory, the empirical evidence on the impact of R&D investment on economic growth has generally found that this is positive and quite significant (see Nadiri, 1993, for a review). This notwithstanding, and as reported by Griliches (1992) in his analysis of R&D externalities, the range of elasticity estimates is very large, from a minimum of 20% to a maximum of 80%, depending on the firms, industries and countries under consideration[6]. Drawing on this conclusion, Jones and Williams (1998) developed an endogenous-growth model to estimate the social rate of return of R&D[7] and, after calibrating it and showing that previous results represented a lower bound, found that most decentralized economies undertake too little investment in R&D. In particular, they found that optimal R&D investment is about four times greater than actual spending[8].

With a more critical approach, other authors consider that the contribution of R&D to growth is somewhat uncertain as R&D investments cause not only positive externalities but also some negative spillovers. In this vein, Pessoa (2010) stresses the fact that relying on a «linear model» to capture the impact of R&D on economic growth is somewhat restrictive because of the many factors omitted in conventional

[6] For a thorough review of the empirical literature on measuring the returns to R&D, see Hall *et al.* (2009).

[7] In this model the link between R&D and growth depends only on the production possibilities of the economy.

[8] By using a different approach —calibrating and endogenous growth model— Jones and Williams (2000) confirm the conclusion that decentralized economies typically underinvest in R&D.

regressions[9]. More specifically, Pessoa (2010: 152-153) states that «if such factors have a clear effect on TFP and, at the same time, induce firms to invest in R&D, R&D intensity seems rather a proxy of the level of development than a cause of it». As a (partial) consequence of this, he shows, for a sample of 28 OECD countries, that the average rate of GDP growth between 1995 and 2005 was not positively correlated to R&D intensity in the business sector, therefore casting some doubts about the conventional link between both variables. Similarly, papers by Dosi *et al.* (2006) and Braunerhjelm *et al.* (2010), for EU and OECD countries respectively, conclude that R&D efforts do not lead to sufficient economic growth. Ejermo *et al.* (2011), analyzing the R&D-growth paradox (R&D growth being higher than economic growth) for the Swedish case, observed that this is related to different sector growth patterns, with the fast-growing industries, not the traditional ones, being those that contribute the most to the paradox.

Another strand of empirical research, pioneered by Ulku (2004) in his work for 20 OECD and 10 non-OECD countries, challenges the assumption, employed when using OLS regressions, that the elasticity of output with respect to R&D is constant. According to some of these papers (see references in Wang *et al.,* 2013) the rate of return of R&D crucially depends on the industries in which R&D takes place, with that corresponding to high-tech industries generating the highest returns, a result that is at odds with that of Ejermo *et al.* (2011). In accordance with this conclusion, Wang *et al.* (2013) move a bit further and, by studying a sample of 23 OECD countries plus Taiwan, show that the impact of R&D investments in high-tech sectors is heterogeneous across economies with different levels of per capita income. Similarly, a very recent research for the OECD countries (Westmore, 2013) casts some doubts about the robustness of the positive link between R&D and growth; more specifically, it states that the strength of the link depends on «well designed framework policies that allow spillovers to proliferate» (Westmore, 2013: 2), meaning that the impact may be heterogeneous across countries[10].

Apart from the type of industry or country that is undertaking the R&D investment, its effect on the rate of economic growth might depend on the private or public character of the investment. Here the evidence is also mixed, and although the results are generally positive for both types of investment and as a total, there are some papers (Kealey, 1996) suggesting that public investment in R&D might deter growth. Sylwester (2001), in an analysis of the relationship between both public and private R&D investments and growth for a sample of 20 OECD countries, finds that albeit both coefficients are positive none of them are significant at conventional levels. When the relationship is estimated, however, just for the G-7 countries, the evidence of a positive effect is stronger, particularly regarding non-government R&D expenditures.

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[9] A recent paper by Strobel (2012) also stresses the different impact of R&D on growth by industry type, that is, the non-linearity of the relationship between both variables.

[10] Goel and Ram (1994) also concluded that, after controlling for several variables, there is a positive correlation (they do not talk about causality) between R&D investment and growth, but only for rich countries.

Within the bulk of papers adopting a country approach, it is important to mention a very recent and interesting one, by López-Rodríguez and Martínez (2014), which compares R&D and non-R&D innovation expenditures for a sample of 26 EU countries. As these authors demonstrate, the effect of the former (R&D) is almost twice as larger as that of the latter (non-R&D). In addition, they show that the distance to the technological leader has a positive impact on growth.

From a regional perspective there are also many studies analyzing the effects of R&D on growth, particularly for the EU regions (see Sterlacchini, 2008, for some references). Among them, one of the most interesting from the point of view of this paper, as its econometric approach is roughly the same, is that by Sterlacchini (2008) for a sample of 197 NUTS2 regions over the period 1995-2002. By estimating a rather conventional beta-convergence equation in which, among others, patents are included as a control variable, two main conclusions arise. First, that R&D exerts a significant impact on GDP growth. And, second, that this effect is less significant for regions with relatively low levels of per capita income, which implicitly means that R&D works against convergence.

There are, however, much less studies about the R&D-growth link at regional level within a single country, and most of them are mainly interested in quantifying spatial spillovers. Among them, Funke and Niebuhr (2005) examine the (West) German case between 1976 and 1996 and, estimating a conventional beta-convergence model with spatial dependence, they achieve two relevant conclusions. First, that R&D has a positive impact on the rate of economic growth and, second, that investment in R&D in a region positively affects income growth in other regions; this effect is, however, much stronger for geographically close regions than for the rest.

Finally, another interesting study, in between those of Sterlacchini (2008) and Funke and Niebuhr (2005) but with a somewhat different aim, is that by Bottazzi and Peri (2003). In this paper, and by means of using an innovation generating function for 86 EU regions for the period 1977-1995, the authors estimate the elasticity of innovation to R&D and find that it declines heavily with distance. From this conclusion, the implication is obvious: as in Funke and Niebuhr (2005), spatial spillovers of R&D on growth only affect to the closest regions to those in which the R&D investment takes place.

4. The geographic distribution of patents across the Spanish provinces

In their attempt to measure the innovative performance of economic areas, researchers have commonly followed one of these two strategies: First, the use of statistics on R&D expenditures over GDP, considered as input indicators; second, the use of data on patent applications per million inhabitants as output indicators. As mentioned in the introduction, in this paper we have opted for using the number of patents per million of inhabitants for reasons of data availability. In any case, due to relatively high correlation usually found between both variables (see, for instance, Bottazzi and Peri, 2003, and Bilbao-Osorio and Rodríguez-Pose, 2004) there is no reason to think that results are quite sensitive to the strategy adopted.

Table 1 displays some descriptive statistics based on the original data on patents for the Spanish provinces over the sample period. A first glance to this table reveals that important differences exist and, furthermore, that innovative performance increased significantly over the sample period, the largest growth rates being recorded in Orense (28.5%) and Alava (23.9%). In fact, only four provinces registered a negative evolution: Cáceres, Las Palmas, Segovia and Teruel. But maybe the most important fact that emerges from this table is that the year-by-year data on patents are extremely volatile, with a coefficient of variation close to 0.5 for the whole country and even close to 1 for some Spanish provinces. As this fact makes difficult to model the evolution of patents, we decided to treat raw data by moving average techniques over the two neighboring points. As a result, from now on the new sample period ranges from 1996 to 2009 and these smoothed data are used in order to explore more deeply the main characteristics of the geographic distribution of patents across of Spanish provinces. Specifically, we focus our attention on three aspects of the distribution: inequality, external shape and spatial dependence[11].

Table 1. Patent applications per million inhabitants in the Spanish provinces (1995-2010)

Prov.	*Min.*	*Max.*	*Mean*	*CV*	*GR*
Álava	3.6	89.9	38.1	0.64	23.9
Albacete	2.8	20.8	9.8	0.58	8.3
Alicante	9.1	32.9	19.5	0.38	8.5
Almería	2	30.5	10.1	0.84	3.8
Ávila	5.9	18.3	8.3	0.54	0.1
Badajoz	1.5	10.4	4.5	0.62	7.3
Baleares	1.4	18	9.6	0.46	13.9
Barcelona	18.8	80	53.1	0.45	9.9
Burgos	4.3	34.5	18.1	0.53	5.3
Cáceres	0.3	7.4	2.9	0.57	–16.8
Cádiz	2	28.6	8.0	0.88	8.6
Castellón	5.1	33.5	17.1	0.44	13.3
Ciudad Real	0.5	20.3	5.4	1	9
Córdoba	1.3	18.3	6.3	0.82	15.4
Coruña	1.8	37.6	12.0	0.8	15.1
Cuenca	0.4	19.9	6.3	0.88	22.5

[11] We have also analyzed the polarization degree of the distribution. Although this information is not included for reasons of space, it is available upon request.

Table 1. *(Continue)*

Prov.	*Min.*	*Max.*	*Mean*	*CV*	*GR*
Girona	4.9	49.8	28.8	0.51	11
Granada	2.4	33.9	13.4	0.79	17.2
Guadalajara	1.5	23.7	11.6	0.59	2.9
Guipúzcoa	4.5	80.1	37.5	0.64	19.5
Huelva	1.1	23.2	7.5	0.71	12.5
Huesca	4.8	25.8	15.1	0.46	10.8
Jaén	0.3	13.5	4.1	1.13	15.5
León	3.3	16.3	8.8	0.4	7
Lleida	2.8	25	12.5	0.5	14.7
Rioja, La	0.9	34.8	15.3	0.69	10.4
Lugo	0.5	12.3	4.3	0.87	15.6
Madrid	13.2	67.3	36.3	0.5	11.1
Málaga	5.9	20.4	12.8	0.37	7.8
Murcia	0.3	23	11.9	0.59	12.4
Navarra	7.9	110.3	56.2	0.61	19.2
Orense	0.3	13.8	5.1	0.69	28.5
Asturias	2.5	23.3	10.1	0.66	12.5
Palencia	0.9	17.5	5.3	0.96	9.8
Palmas, Las	3.6	12.8	6.6	0.4	–1.4
Pontevedra	1.1	24.4	12.2	0.61	10.9
Salamanca	2.8	23.6	12.5	0.61	10.3
Tenerife	1.4	16.2	6.6	0.57	11.8
Cantabria	1.9	20.1	9.2	0.7	15.9
Segovia	1.6	19.4	7.6	0.58	–9.3
Sevilla	2	46.8	17.0	0.74	22.5
Soria	4	20.2	9.1	0.41	11.4
Tarragona	10.8	59.1	30.2	0.5	6.4
Teruel	1.4	23.7	10.1	0.58	–10.4
Toledo	0.8	27	12.9	0.62	9
Valencia	7.4	44.1	27.8	0.43	12.2
Valladolid	4	34	15.0	0.65	10.1
Vizcaya	5.6	54.7	23.3	0.66	14.2
Zamora	0.6	15.5	5.0	0.93	15.9
Zaragoza	7.1	77.7	33.2	0.73	16.1
SPAIN	**7.1**	**38.4**	**22.8**	**0.48**	**11.9**

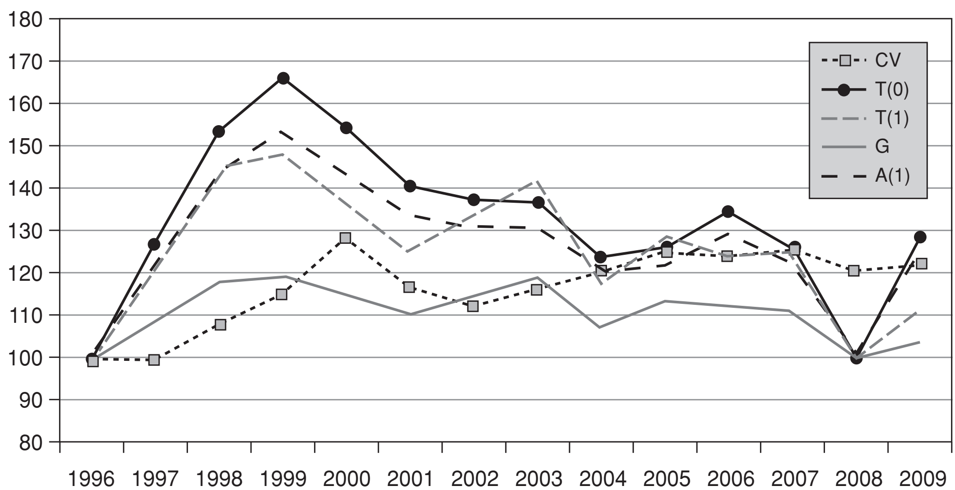
Notes: GR = growth rate; CV = Coefficient of variation.
Source: OECD and own elaboration.

4.1. Inequality

First we study the evolution of provincial disparities in patent applications. Since there is no accepted best measure of inequality, we consider here the most commonly used inequality indicators: the coefficient of variation (*CV*), the Gini index (*G*), two versions of the Theil index (*T(0)* and *T(1)*) and a version of the Atkinson index (*A(1)*). All indices are independent of both scale and population size, and each one fulfills the Pigou-Dalton transfer principle (Cowell, 1995).

Results from applying the above mentioned inequality measures are shown in Figure 1. The main conclusion is that there was a high increase of inequality during the late 1990s, followed by a downward trend that has not been intense enough to reach in 2009 lower inequality levels than in 1996. Additionally, it can be observed that, even using moving averages, the time pattern of patents is rather volatile.

Figure 1. Inequality measures (1996 = 100)



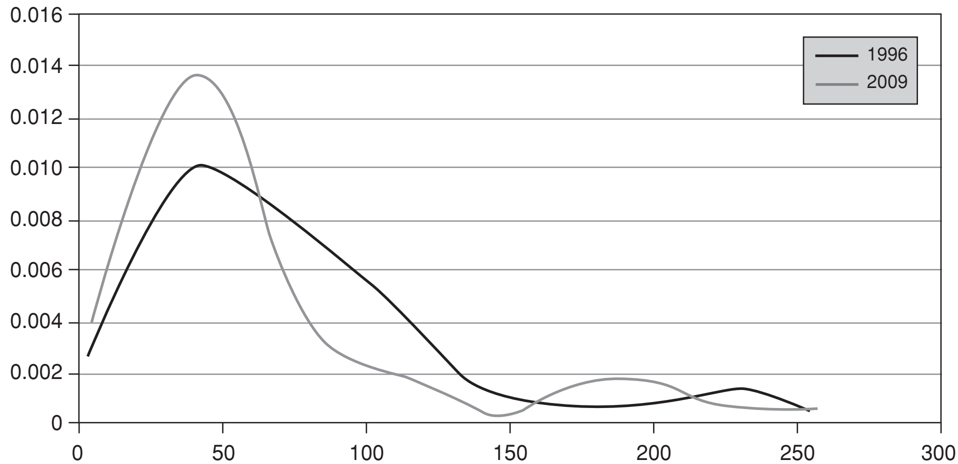
Source: OECD and own elaboration.

4.2. External Shape of the Distribution

Supplementary information of the distribution can be inferred from the construction of density functions. This representation, understood as a smoothed version of a histogram, provides a very simple yet highly intuitive graphical tool to visualize some general characteristics of any distribution, as well as to study the manner its external shape evolves over time. In order to estimate a density function we use a Gaussian kernel with optimal bandwidth according to the well-known Silverman's rule-of-thumb (Silverman, 1986).

Figure 2 plots Spain's patents distribution for the initial and final years of the sample period: 1996 and 2009. In this case, data are normalized by the Spanish average (Spain = 100). The figure shows that in 1996 the distribution is bimodal; by using Salgado-Ugarte *et al.* (1997) technique to identify the modes, it can be said that the main mode is located at 47.2% while the second is at 229.2% of the Spanish average. As for 2009, the distribution continues to be bimodal; now the differences are that the two modes have somewhat changed to the left (40.4 and 195.5% respectively) and that the mass of probability is more concentrated around the main one.

Figure 2. Density plots for relative patent applications



Source: OECD and own elaboration.

4.3. Spatial dependence

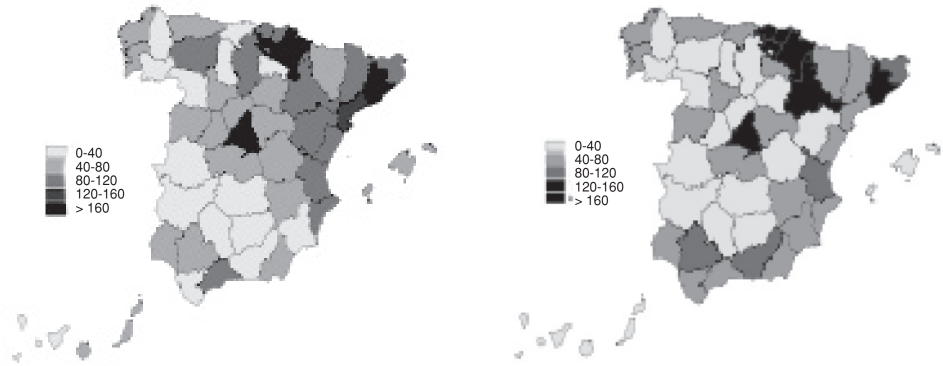
A first look at Spain's map in both 1996 and 2009 (Figures 3a, 3b) reveals that, as expected, innovative performance has tended to cluster in rich areas characterized by high economic dynamism, such as those in the North-East of the country. In addition, when Figures 3a and 3b are compared, it seems that spatial concentration has decayed at the end of the period; this conclusion stems from the fact that areas with similar values (high or low) of patent applications seem to be more spatially clustered in 1996 than in 2009.

As these conclusions are tentative at best, because they lack any sound statistical basis, to examine their real strength next we estimate the most widespread statistic in spatial analysis (ESDA): the Moran's *I* statistic [12]. Using the inverse of the standard-

[12] This is expressed as follows (Anselin, 1988):

$$I(t) = \frac{n}{\sum_i \sum_j w_{ij}^*} \frac{\sum_i \sum_j w_{ij}^* \left[y_i(t) - \mu(t) \right] \left[y_j(t) - \mu(t) \right]}{\sum_i \left[y_i(t) - \mu(t) \right]^2}$$

Figure 3. Relative patent applications across the Spanish provinces (Spanish average = 100)



(a) Year 1996 (b) Year 2009

Source: OECD and own elaboration.

Table 2. Moran's *I* statistic

Year	*Value*	*z-value*	*Prob.*
1996	0.086	4.832	0.000
1997	0.137	7.158	0.000
1998	0.092	5.083	0.000
1999	0.150	7.736	0.000
2000	0.094	5.198	0.000
2001	0.127	6.700	0.000
2002	0.124	6.546	0.000
2003	0.082	4.657	0.000
2004	0.080	4.566	0.000
2005	0.114	6.089	0.000
2006	0.098	5.391	0.000
2007	0.078	4.453	0.000
2008	0.055	3.434	0.000
2009	0.076	4.386	0.000

Source: OECD and own elaboration.

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where y_i and y_j are patent applications per million inhabitants of provinces i and j, respectively; μ is the Spanish average; $w^*_{ij} = w_{ij} \Big/ \sum_j w_{ij}$ are the standardized spatial weights describing the distance between provinces i and j; and n is the number of provinces. In order to facilitate the interpretation of the statistic, the standardized value (z-value) is obtained. Accordingly, a significant positive (negative) value for the Moran's I statistic will imply positive (negative) spatial association, herein interpreted to imply similar (dissimilar) values of patent applications per million inhabitants being clustered together in space.

ized distance between the corresponding provincial centroids as a distance measure, the results for the Moran's *I* statistic reveal a positive statistically significant spatial dependence between provinces (see Table 2). It can also be noted that the degree of spatial dependence declined slightly over the sample period, which shows the existence of a global downward tendency towards a geographical clustering of similar provinces.

5. Econometric analysis

As previously mentioned, the objective of this section is threefold. Firstly, to examine the role of patents as a factor promoting economic growth and, possibly, convergence (economic cohesion); secondly, to test the presence of spatial spillovers; and finally, to check the interaction between patens and level of development when it comes to evaluate the effect of the former on economic growth and cohesion.

5.1. Patents and economic growth

As mentioned in the introduction and summarized in the second section of the paper, there is a well-known belief that innovative activities contribute to economic growth and, depending on their territorial distribution, to economic cohesion. However, the empirical literature on this topic is not conclusive. This being so, the main aim of this section is to assess if, effectively, technological progress has fostered economic growth for the case of Spanish provinces. To accomplish this aim we make use, as in some other papers cited above, of the standard convergence approach popularized by Barro and Sala-i-Martin (1992). In this regard, we can assess not only whether innovation has promoted growth but also whether or not it has contributed to convergence, and in consequence to foster territorial cohesion. We know this approach has some limitations, as it fails to capture potentially interesting characteristics of the underlying income distribution and its evolution over time (see, e.g., Quah, 1993), but we think it is the best one to accomplish the main goals of this paper[13].

Bearing these points in mind, and taking per capita income (Eurostat) as a proxy for economic development, this section proceeds in various steps. Firstly, it estimates an absolute β-convergence equation. Secondly, an analysis of conditional β-convergence is carried out, in which patents (expressed in both levels and growth rates) are included as our basic conditioning variable. If, as expected, patents foster income growth their coefficients will be positive and statistically significant. Thirdly, and for the sake of robustness, additional control variables to explain the role of structural differences among the Spanish provinces are considered. To be precise, we include human capital (*HC*), investment (*Inv*), market access (*MA*) and the share of industry

[13] An alternative to the standard convergence approach is the so-called distribution dynamics approach (e.g. Maza *et al.,* 2010, 2012), but this methodology is not especially suitable in this case.

(*Ind*) and service (*Ser*) sectors[14]. It is convenient to note that we choose a log-specification for all the equations, except for those variables expressed in percentages, so that the estimates are less sensible to outliers.

To begin with, we estimate an absolute β-convergence equation, which is used as a benchmark. This equation is given by the expression:

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \varepsilon_i \tag{1}$$

in which $\Delta y_{i,96\text{-}09}$ represents the growth rate of per capita income in province i, and $y_{i,96}$ refers to per capita income (in logs) at the initial year[15].

The results of this estimation are offered in column (1) of Table 3, which shows that the coefficient β is negative and statistically significant; this implies that a convergence process did in fact take place among the Spanish provinces over the sample period. In addition, the table reports the speed of convergence[16] and the half-life[17], the latter representing the number of years necessary to cover half the distance separating the Spanish provinces from their steady state, assuming that the current convergence speed is maintained. The speed is apparently very low, 1.54% per year, implying a half-life of 49.2 years.

Taking this estimation as a point of reference, we proceed by assessing the effect of patents on growth. In order to do that we again estimate equation (1), but now including two additional independent variables: $Pat_{i,96}$ and $\Delta Pat_{i,96\text{-}09}$, each one denoting patents in the initial year and the patents rate of growth for the whole period, respectively. Following Bilbao-Osorio and Rodríguez-Pose (2004), we include these two variables as it seems obvious that they could affect provincial economic growth. More specifically, we estimate the following equation:

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \varepsilon_i \tag{2}$$

Column (2) of Table 3 reports the results. A first glance to this table reveals that both coefficients γ_1 and γ_2 are positive and statistically different from zero, this indi-

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[14] The human capital variable, taken from IVIE, is defined as the proportion of the population of working age over total population with first and second stage of tertiary education. Investment, from Eurostat, is defined as the ratio between total investment and GDP. Market access for any province *i* (MA_i) is defined, according to López-Rodríguez *et al.* (2007), as: $MA_i = \sum_{j=1}^{n} M_j / D_{ij}$, where M_j is a measure of the volume of economic activity (in this case population taken from Eurostat) and D_{ij} is a measure of the distance between provinces i and j (defined as the geographic distance between the corresponding provincial centroids); the internal distance for each province has been calculated as $0.66\sqrt{Area_i/\pi}$. Finally, the share of industry and service sectors has been computed as the percentage of employment in these sectors over the total employment (data come from Eurostat). We wished to use the percentage of population working in high-technology manufacturing and service sectors, but these data are not available at provincial level.

[15] As can be seen, we opted for developing a cross-section analysis because patents data are quite volatile, even after taking moving averages, between years.

[16] The convergence speed (b) is calculated as $b = -\ln(1 + T\beta)/T$, where T is the number of years in the sample.

[17] The half-life (τ) is calculated as $\tau = -\ln(2)/\ln(1 + \beta)$.

cating the importance of patents (both their initial level and growth rate) and, in sum, the role of innovation as a mechanism to foster economic growth. A closer look to these results also indicates that the coefficient linked to initial per capita income increases in absolute value (from 0.014 to 0.024) when these variables are considered; the same occurs, obviously, with the annual speed of convergence (it goes from 1.54 to 2.80%).

Table 3. Patents and economic growth relationship

$\Delta y_{i,96–09}$ *Independent*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
constant	0.174*** (0.039)	0.252*** (0.047)	0.368*** (0.064)	0.142*** (3.21)	0.217*** (0.046)	0.319*** (0.061)
$y_{i,96}$	–0.014*** (0.004)	–0.024*** (0.005)	–0.029*** (0.005)	–0.013*** (0.004)	–0.023*** (0.005)	–0.028*** (0.004)
$Pat_{i,96}$		0.005*** (0.002)	0.005** (0.002)		0.005*** (0.002)	0.005*** (0.002)
$\Delta Pat_{i,96–09}$		0.057*** (0.015)	0.035** (0.016)		0.057*** (0.014)	0.035** (0.014)
$HC_{i,96}$			0.001*** (0.000)			0.001*** (0.000)
$Inv_{i,96}$			–0.000 (0.000)			–0.000 (0.000)
$MA_{i,96}$			–0.004 (0.004)			–0.000 (0.000)
$Ind_{i,96}$			0.000 (0.000)			0.000 (0.000)
$Ser_{i,96}$			0.001*** (0.000)			0.001*** (0.000)
$W\Delta y_{i,96–09}$				0.523* (0.30)	0.683*** (0.210)	0.558** (0.028)
LM-ERR	3.57** [0.06]	9.02*** [0.01]	0.42 [0.51]			
LM-EL	8.14*** [0.01]	12.88*** [0.00]	1.92 [0.17]			
LM-LAG	1.15 [0.28]	3.21* [0.07]	1.64 [0.20]			
LM-LE	5.72** [0.02]	7.07*** [0.00]	3.13* [0.07]			
R^2	0.19	0.42	0.61			
LIK	183.98	192.24	202.39	184.59	193.73	204.00
AIC	–363.96	–376.48	–386.78	–364.18	–377.46	–387.40

Table 3. *(Continue)*

$\Delta y_{i,96-09}$ *Independent*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
SC	–360.13	–368.82	–369.57	–367.64	–369.89	–369.67
Speed of convergence (%)	1.54	2.80	3.63	1.41	2.72	3.49
Half-life (years)	49.2	29.1	23.6	53.3	29.8	24.4

Notes: LM-ERR = Lagrange multiplier for spatial errors; LM-EL = LM-ERR associated robust; LM-LAG = Lagrange multiplier for spatial lags; LM-LE = LM-LAG associated robust; LIK = Logarithm of maximum likelihood; AIC = Akaike's Information Criterion; SC = Schwartz's Criterion. (***) significant at 1%; (**) significant at 5%; (*) significant at 10%. Standard errors for coefficient estimates are in parenthesis. *p*-Values for the statistics are in brackets.
Source: OECD and own elaboration.

In order to check for the robustness of the results just discussed, we consider additional control variables to include other factors potentially explaining per capita income growth. Thus, the next equation we estimate is:

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \phi Z_{i,96} + \varepsilon_i \qquad (3)$$

where $Z_{i,96}$ denotes the set of control variables previously mentioned[18].

As column (3) of Table 3 shows, the results obtained reinforce the idea that patents have contributed to economic growth in the Spanish provinces. Regarding the speed of convergence, the results reveal that this is a bit higher when we control for structural differences. As for the new control variables, our findings unveil the role played by human capital as an important factor fostering economic growth. For the case of investment and market access, however, the link with per capita income growth is not statistically significant. Additionally, the coefficient associated to the service sector share is positive and different from zero, this suggesting that, ceteris paribus, those provinces specialized in services have experienced higher per capita income growth than the others. On the contrary, the coefficient linked to the industry share does not result significant at conventional levels.

After this analysis, and for the sake of robustness, we test for the presence of spatial dependence in the equations (1)-(3) because, as it is well known, this could give rise to biased and inefficient OLS estimates (Anselin, 1988). To do that we performed a series of tests, with the Lagrange multipliers standing out, based on the principle of maximum likelihood[19]. Table 3 displays the results for these diagnostic tests. On observing the robust contrasts, it can be seen that both the null hypothesis of absence

[18] We tried with other control variables, such as population density, the share of the agricultural sector, alternative measures of economic activity for the computation of the market access variable, etc., being the results quite similar to those shown here.

[19] The LM-ERR test, in particular, along with the associated robust LM-EL, tests for the absence of residual spatial autocorrelation, which would occur by not including a structure of spatial dependence in the error term. The LM-LAG test is also used; this test, along with the associated robust LM-LE, tests for the absence of substantive spatial autocorrelation, which would be caused by the presence of spatial dependence in the endogenous variable.

of residual and substantive spatial dependence can be rejected at the conventional levels in equations (1) and (2), while in equation (3) this is true only for substantive spatial dependence at 10%. This being so, and taking into account the recommendations made by Fingleton and López-Bazo (2006)[20], we decided to estimate a spatial autorregresive model (SAR). For it, we included an spatial lag of the dependent variable, $\rho W \Delta y_{i,96\text{-}09}$, where ρ is the spatial coefficient and W the distance matrix defined, as mentioned in the previous section, as the inverse of the standardized geographical distance or, more precisely, the inverse of the great-circle distance between provincial capitals. Thus, we now estimate the following three equations:

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \rho W \Delta y_{i,96-09} + \varepsilon_i \tag{4}$$

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \rho W \Delta y_{i,96-09} + \varepsilon_i \tag{5}$$

$$\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \phi Z_{i,96} + \rho W \Delta y_{i,96-09} + \varepsilon_i \tag{6}$$

The last three columns of Table 3 display the results of the estimation of equations (4)-(6) by maximum likelihood[21]. Explicitly, it is worthy to highlight three points. First, that all of the measures of relative statistical quality that are comparable between the two models, such as the logarithm of maximum likelihood (LIK), Akaike's Information Criterion (AIC), and Schwartz's Criterion (SC), demonstrate that these new equations achieve a better fit. Second, that the coefficient linked to the spatial lag of the dependent variable is positive and statistically significant in all cases, confirming the results of the earlier spatial dependence tests, i.e., that the behavior of each province is closely related to the behavior of its neighboring provinces. Third, that for the rest of variables the results are roughly the same, which reveals the robustness of previous estimations; in particular, we want to stress the pivotal role of patents as a growth engine. Furthermore, if we consider provincial cohesion as a desirable goal or even as a core priority, the previous results obviously imply that cohesion policy focused on R&D promotion should play a more active role in the Spanish landscape.

5.2. Patents and spatial spillovers

As stated in the third section of the paper, there is positive spatial dependence in the provincial distribution of patents in Spain; in other words, provinces with high (low) number of patents do tend to be geographically concentrated. This being so, in this subsection we take a complementary view with the purpose of discerning whether there are also spatial spillovers; that is, whether an increase in the number

[20] These authors indicate that spatial dependence in empirical growth models and convergence regressions is mostly a substantive phenomenon caused by technology diffusion and/or other externalities with a spatial dimension.

[21] Spatial dependence invalidates the traditional OLS estimation method. Likewise, according to our tests, there are no problems of heteroskedasticity in this model.

of patents in a given province may bring forth an increase of per capita income in neighboring provinces.

To start with, it is crucial to point out herein that one of the main conclusions of the (theoretical and empirical) literature on this issue is that the aforementioned relationship depends critically on the way R&D investment is measured. When we measure it as the ratio of R&D expenditures over GDP, it is generally considered that technological knowledge is partially a public good so that the existence of spillovers seems to be granted. On the contrary, when the effort on R&D is proxied, as in this paper, by patent data, then the improvement in technological knowledge is not considered as a public good but, for the very nature of patents, as a private good (Sedgley, 1998); therefore, the new knowledge is both excludable and rival, this making spillover effects much less relevant. This being said, it is also important to note that, contrary to what conventional R&D growth models generally assume, the duration of patents is not infinite. In fact, patents have a limited life (Noda, 2012), this meaning that spillover effects that initially are very low, if any, tend to grow over time.

In order to address this issue, here we estimate an enlarged version of equations (5) and (6). Specifically, in order to test for the presence of spatial spillovers the spatial lags of patents ($WPat_{i,96}$) and patents growth ($W\Delta Pat_{i,96\text{-}09}$) have been included as independent variables (Rey and Montouri, 1999). The new regression equations are as follows:

$$\begin{aligned}\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \rho W \Delta y_{i,96-09} + \\ + \lambda_1 WPat_{i,96} + \lambda_2 W\Delta Pat_{i,96-09} + \varepsilon_i\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta y_{i,96-09} = \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} + \gamma_2 \Delta Pat_{i,96-09} + \phi Z_{i,96} + \\ + \rho W \Delta y_{i,96-09} + \lambda_1 WPat_{i,96} + \lambda_2 W\Delta Pat_{i,96-09} + \varepsilon_i\end{aligned} \tag{8}$$

Table 4. Patents and the existence of spatial spillovers

$\Delta y_{i,96-09}$ / *Independent*	(7)	(8)
constant	0.237*** (0.053)	0.315*** (0.077)
$y_{i,96}$	–0.028*** (0.006)	–0.030*** (0.006)
$Pat_{i,96}$	0.006*** (0.002)	0.005*** (0.002)
$\Delta Pat_{i,96-09}$	0.055*** (0.014)	0.034** (0.014)
$HC_{i,96}$		0.001*** (0.000)

Table 4. *(Continue)*

$\Delta y_{i,96\text{–}09}$ *Independent*	(7)	(8)
$Inv_{i,96}$		–0.000 (0.000)
$MA_{i,96}$		–0.003 (0.004)
$Ind_{i,96}$		0.000 (0.000)
$Ser_{i,96}$		0.001*** (0.000)
$W\Delta y_{i,96\text{–}09}$	0.732*** (0.182)	0.600** (0.265)
$WPat_{i,96}$	0.009 (0.007)	0.004 (0.007)
$W\Delta Pat_{i,96\text{–}09}$	0.098 (0.142)	0.058 (0.142)
LIK	194.55	203.36
AIC	–375.10	–382.72
SC	–361.72	–359.78
Speed of convergence (%)	3.47	3.74
Half-life (years)	24.5	23.1

Notes: LIK = Logarithm of maximum likelihood; AIC= Akaike's Information Criterion; SC = Schwartz's Criterion. (***) significant at 1%; (**) significant at 5%; (*) significant at 10%. Standard errors for coefficient estimates are in parenthesis. p-Values for the statistics are in brackets.
Source: OECD and own elaboration.

Table 4 reports the estimates. Two main conclusions can be drawn. First, regarding the influence of the original determining factors on income growth, it is important to note that the results are not substantially different to the previous ones. The only noteworthy difference is that the value of the β coefficient rises slightly in the two convergence equations. Second, and more important, the coefficients linked to the spatial lag are not statistically significant. This reflects that there is no evidence supporting the existence of spatial spillovers, so an increase in the number of patents in a province does not promote economic growth in its neighbors. This is in line with that predicted by theory, namely that a patent can be considered more a private than a public good (Sedgley, 1998), and, therefore, that it is necessary quite a long time to reverse this situation.

5.3. Patents and the level of development

Finally, in this section we test the stability of the parameters linked to patents and patents growth for groups of provinces with different levels of development. As indicated in the second section of the paper, there is ample evidence supporting the idea that the impact of R&D on growth depends on the income level, and here we want to check if this is true for the Spanish case. To do this, we somehow following Sterlacchini (2008)[22] and split the whole set of provinces into two groups: (1) provinces with a per capita income above the national average in the initial year [let us call them developed provinces (Dev)], (2) provinces below the mean [less developed provinces (LDev)]. Then, we construct two dummies (one for each group) and multiply them by the original patents and patents growth rate variables. If, by doing this, the parameters associated to these new variables were statistically different, the hypothesis about a different impact of patents on economic growth for these groups would be proven. Therefore, our new equations are as follows:

$$\begin{aligned}\Delta y_{i,96-09} &= \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} \bullet d_{Dev} + \gamma_2 \Delta Pat_{i,96-09} \bullet d_{Dev} + \\ &+ \gamma_1^{'} Pat_{i,96} \bullet d_{LDev} + \gamma_2^{'} \Delta Pat_{i,96-09} \bullet d_{LDev} + \rho W \Delta y_{i,96-09} + \varepsilon_i\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta y_{i,96-09} &= \alpha + \beta y_{i,96} + \gamma_1 Pat_{i,96} \bullet d_{Dev} + \gamma_2 \Delta Pat_{i,96-09} \bullet d_{Dev} + \\ &+ \gamma_1^{'} Pat_{i,96} \bullet d_{LDev} + \gamma_2^{'} \Delta Pat_{i,96-09} \bullet d_{LDev} + \phi Z_{i,96} + \rho W \Delta y_{i,96-09} + \varepsilon_i\end{aligned} \tag{10}$$

As can be seen a spatial lag of the dependent variable is included in the equations because the aspatial estimation of these equations (without the spatial lag and by OLS) reported problems of substantive spatial dependence. The results obtained are reported in Table 5. Focusing our comments on the interaction variables, it is observed that all parameters linked to them are positive and statistically significant; this suggests that all Spanish provinces, even the less developed, have reached the minimum threshold needed for innovation to promote economic growth (Rodríguez-Pose, 2001). Regarding their differences, however, we can see that the parameters connected to the patents growth variable are very different, rejecting the Wald test the hypothesis of equality in equation (9). There seems to be certain evidence, therefore, that the increase of innovation spending acts as a higher driver for income growth in developed than in less developed provinces. This result could also be indicating that patents have hindered convergence during the period under study. Another remarkable feature is that the rate of convergence rises when these interaction variables are included, what could be interpreted as a sign of the existence of convergence clubs in Spain, one for rich provinces and other for poor provinces.

[22] A quantile regression would be another option to examine the heterogeneous effect of patents on income growth.

Table 5. Patents and differences according to the level of development

$\Delta y_{i,96\text{–}09}$ *Independent*	*(9)*	*(10)*
constant	0.307*** (0.067)	0.366*** (0.067)
$y_{i,96}$	–0.032*** (0.007)	–0.035*** (0.006)
$Pat_{i,96} \bullet d_{Dev}$	0.006*** (0.002)	0.006*** (0.002)
$\Delta Pat_{i,96\text{–}09} \bullet d_{Dev}$	0.084*** (0.021)	0.042* (0.023)
$Pat_{i,96} \bullet d_{LDev}$	0.004*** (0.002)	0.004*** (0.002)
$\Delta Pat_{i,96\text{–}09} \bullet d_{LDev}$	0.042*** (0.015)	0.031** (0.015)
$HC_{i,96}$		0.001*** (0.000)
$Inv_{i,96}$		–0.000 (0.000)
$MA_{i,96}$		–0.001 (0.003)
$Ind_{i,96}$		0.000 (0.000)
$Ser_{i,96}$		0.001** (0.000)
$W\Delta y_{i,96\text{–}09}$	0.681*** (0.212)	0.597** (0.262)
LIK	195.63	204.37
AIC	–377.27	–384.74
SC	–363.88	–364.79
Speed of convergence (%)	4.21	4.61
Half-life (years)	21.0	19.6

Notes: LIK = Logarithm of maximum likelihood; AIC= Akaike's Information Criterion; SC = Schwartz's Criterion. (***) significant at 1%; (**) significant at 5%; (*) significant at 10%. Standard errors for coefficient estimates are in parenthesis. p-Values for the statistics are in brackets.
Source: OECD and own elaboration.

6. Conclusions

This paper examines the relationship between R&D and economic growth and convergence across the Spanish provinces over the period 1995-2010. As its starting point, it reviews the literature devoted to the issue, both from a theoretical and empirical perspective, pointing out that most papers support the idea that R&D is a driver for economic growth.

Subsequently, the analysis of the provincial distribution of R&D (proxied by the number of patents applications per million of inhabitants) offers some interesting results. First, patents are characterized by a high volatility. Second, there are important differences between provinces, although they have decreased from 2000 onwards. Third, there are also clear signs of spatial dependence in the patents distribution, this meaning that provinces with high (low) values tend to be clustered; specifically, R&D is quite concentrated in the richest areas of the country.

After that, the main section of the paper evaluates the role played by patents on economic growth. To begin with, an absolute β-convergence equation is estimated as a benchmark, unveiling that a convergence process in per capita income has indeed taken place. Next, an analysis of conditional β-convergence is carried out including patents (in both levels and growth rates) as additional independent variables. The results prove that innovation promotes economic growth. Then, and for the sake of robustness, a group of control variables, such as human capital, the level of investment over GDP, market access and both industry and service sector shares, are included in order to better explain the performance of per capita income growth. The results regarding the positive effect of patents on economic growth do not change, this confirming the robustness of the previous findings. With regard to the rest of variables, the coefficients linked to human capital and service sector share are positive and statistically significant, which implies that educational attainment and the service sector foster economic growth.

Then, the paper checks for the presence of spatial spillovers and finds that they do not exist, a result that is probably related to the way R&D spending is measured. Finally, it also tests the possibility of the results being sensitive to the level of development of each province, finding that the impact of patents on economic growth seems to be higher in the most developed ones.

Overall, there seem to be sound reasons to keep that R&D distribution in itself increases provincial disparities. First, because innovative processes tend to cluster geographically where services and resources necessary to develop these processes are concentrated (Audretsch and Feldman, 1996); in other words, R&D tends to be concentrated in rich provinces. Second, because R&D effectively acts as a growth engine, especially in the richest provinces; this result is in line with those obtained for the European Cohesion Policy by Rodríguez-Pose and Novak (2013), whom indicate that Structural Fund investment bears higher outcomes in wealthier regions. And, third, because R&D (at least when it is proxied by patents) does not generate spatial spillovers that could benefit less developed provinces.

As stated in the introduction, some lessons related to the use of R&D as an instrument of cohesion policy at national level could be drawn from the previous conclusions. Should the Spanish case be considered as an example of what typically happens at the EU level, these lessons could also be extrapolated to the European cohesion policy. Considering the trade-off that exists between efficiency and equity, the main point here refers to the specific role we want R&D policy to play in this respect. If, without forgetting the efficiency goal, we were mainly concerned with equity issues related to the increasing gap between rich and poor regions, it should be evident that the findings obtained in this paper support a cohesion policy more directly focused on fostering R&D efforts in the poorest regions, at both private and public levels. This could be done, for example, by creating more favorable conditions for investments in poor regions through funding R&D cooperative projects and/or improving their infrastructure endowments (Basile *et al.,* 2008). Although the location of intensive R&D activities can distort regional specialization, it is also true that, as indicated by Mairate (2006: 171), «it can create a "snowfall effect" of new economic activities and [...] strengthen their capacity for adapting to economic change and to innovate». In addition, and also in view of the results obtained, we can state that cohesion policy should try to diffuse spillover effects more quickly and largely than up to now. By doing this, cohesion policy would achieve that R&D investments located in developed regions, more attractive than less developed ones, lead to a higher income growth not only in the richest regions but also in the others. Accordingly, helping to create joint research centers and research networks between rich and poor regions could prove very fruitful not only for boosting the role played by R&D as a cohesion enhancer but also for not hindering economic growth at the global level. In other words, it would be a good try to reconcile the trade-off between equity and efficiency.

Finally we want to stress that, while appealing, our results should be considered as furnishing only a broad picture of a much more complex phenomenon which requires further investigation. In particular, a clear avenue for future research would be to evaluate the robustness of these results by taking alternative estimation methodologies and variables, and looking more deeply into the potential existence of endogeneity problems in the estimations. Another possible extension of this work is, data allowing, to focus on all the European rather than only Spanish regions/provinces, as cohesion policies are usually established in Europe at the regional level. These and other questions provide new directions for future research.

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Section ARTICLES

Territorial Capital and the Effectiveness of Cohesion Policies: an Assessment for CEE Regions

Ugo Fratesi*, Giovanni Perucca**

ABSTRACT: On May 1st 2004, 10 Central and Eastern European (CEE) countries joined the EU and became fully eligible for communitarian financial support. While the conditions for eligibility are the same, at regional level CEE territories are characterized by very different socioeconomic settings. In particular, different regions are differently endowed with what has been labelled "territorial capital', so that the endowment of public and private, material and immaterial assets significantly varies across regions, including infrastructure, private capital, human and social capital. This set of territorial conditions, enabling economic development to take place, is here assumed to impact the outcome of cohesion policies as well. This paper is hence aimed at assessing the role of specific territorial conditions on the efficient implementation of cohesion policies in CEE NUTS3 regions. The analysis points out the mechanisms through which the endowment of specific territorial assets affects the outcome of Cohesion policies. It appears that for a large number of territorial capital assets, increasing returns are present and regions more endowed with specific types of territorial capital are more able to gain from policy investment in related fields.

JEL Classification: R10; R11; R58.

Keywords: Territorial Capital; Cohesion Policy; Central and Eastern European Countries.

Capital Territorial y efectividad de la Política de Cohesión Europea

RESUMEN: El 1 de mayo de 2004, diez países del centro y este de Europa se unieron a la UE y se convirtieron en elegibles para recibir financiación comunitaria. Aunque los criterios de elegibilidad son los mismos, a nivel regional los territorios de los países del centro y este de Europa se caracterizan por tener condiciones socioeconómicas muy distintas. En particular, las distintas regiones tienen unas dotaciones muy diferentes de lo que se ha denominado «capital territorial», de manera

* Politecnico di Milano, Department of Architecture, Built Environment and Construction Engineering, Piazza Leonardo da Vinci 32, 20133 Milano. *ugo.fratesi@polimi.it.*
** Politecnico di Milano, Department of Architecture, Built Environment and Construction Engineering, Piazza Leonardo da Vinci 32, 20133 Milano. *giovanni.perucca@polimi.it.*

Received: 1 february 2014 / Accepted: 5 august 2014.

que la dotación de activos públicos y privados, materiales e inmateriales varía de forma significativa entre los distintos territorios. Este conjunto de condiciones territoriales, que facilita que el desarrollo económico tenga lugar, se asume en el contexto de este trabajo que afecta también a los resultados de la política de cohesión. Este trabajo tiene por tanto como objetivo evaluar el papel y las condiciones territoriales específicas que tienen sobre la implementación eficiente de las políticas de cohesión a nivel de regiones NUTS3 en los países del CEE. El análisis señala los mecanismos a través de los cuales la dotación de activos territoriales específicos afectan a los resultados de las políticas de cohesión. Parece que una mayor dotación de activos territoriales específicos conlleva la presencia de rendimientos crecientes, y que las regiones mejor dotadas con tipos específicos de capital territorial son más capaces de obtener ganancias a partir de las inversiones realizadas en los diferentes campos.

Clasificación JEL: R10; R11; R58.

Palabras clave: Capital territorial; Política de Cohesión; Países del centro y este de Europa.

1. Introduction[1]

On May 1st 2004, Central and Eastern European (CEE) countries (with the exception of Romania and Bulgaria) joined the EU and became fully eligible for the Communitarian financial support. The vast majority of CEE regions shared the same macroeconomic conditions for funding eligibility, being most of them included in the Objective 1 category[2]. Between 2004 and 2006 more than 21 billion euro were invested in projects and policies aimed at fostering the development and structural adjustment of CEE regions.

Despite the abovementioned homogeneity in the conditions for eligibility, however, these regions were characterized by very different systems of territorial assets of economic, cultural, social and environmental nature. As pointed out by Camagni (2008) these elements, included under the comprehensive concept of territorial capital, represent the development potential of places. In the words of the EU Commission itself, the regional endowments of territorial capital raise relevant policy implications, as «each region has a specific "territorial capital" that is distinct from that of other areas and generates a higher return for specific kinds of investments than for others, since these are better suited to the area and use its assets and potential more effectively» (European Commission, 2005, p. 1).

The aim of the present paper is to provide evidence on the relationship between the structural characteristics of the recipient regions of funds and the impact of the EU financial support on economic growth in CEE NUTS3 areas. The assumption

1 The research leading to these results has received partial funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement «Growth-Innovation-Competitiveness: Fostering Cohesion in Central and Eastern Europe» (GRINCOH).

2 All NUTS3 regions are included in the Objective 1 category apart from Prague and Bratislava.

to be tested is that the outcome of public policies is mediated and reinforced by the presence of territorial capital. The focus on CEE regions is motivated by two reasons. First of all since, contrary to Western countries, all these regions became eligible for EU funding simultaneously; therefore there is not any asymmetry to be taken into account, such as learning effects on the capability of efficiently managing the resources. Secondly, as stated above, almost all regions are eligible for the same EU actions, i.e. those of the Objective 1 program.

This work places itself in the long stream of research focused on the outcomes of EU regional policies. To the best of our knowledge, however, almost none of these works systematically considered the role of the characteristics of receptive territories on the impact of the Cohesion policies.

The article is organized as follows. The next section is devoted to the definition of what is meant by territorial capital and to a brief review of the typologies of structural funds and of the literature on their impact on economic development. The third section is aimed at pointing out the link between territorial capital and EU funds and the mechanisms through which these two elements are expected to generate economic growth. Following some descriptive evidence on the data used in the present study, the fourth section presents the estimation methodology and the fifth one focuses on the interpretative analysis of the role of territorial capital in fostering the impact of EU funds. Finally, the last section summarizes the main conclusions and discusses which policy prescriptions stem from the analysis.

2. Territorial capital and the outcome of regional EU policies: evidence from the literature

2.1. Territorial capital

The literature on endogenous regional growth identified several factors impacting the macroeconomic performance of territories. Examples are provided by the intense research on social capital (Putnam, 1993), on private (Barro, 1991) and public capital (De Haan and Romp, 2007) and on human capital (Lucas, 1988).

An exhaustive classification of endogenous local assets was recently settled through the concept of territorial capital, firstly introduced by OECD (2001). Territorial capital is defined by the system of a variety of territorial assets having economic, cultural, social and environmental nature (Camagni, 2008). In order to succeed, regions and territories have to exploit the potential of this complex set of locally-based factors. Camagni (2008) provided a taxonomy for these elements, based on their degree of materiality and rivalry. Rather than a simple list of local assets, this approach explicitly defines their properties, allowing to identify potential interactions and policy implication.

The graphical representation of territorial capital proposed by Camagni (2008) is reported in Figure 1.

Figure 1. Territorial capital: a taxonomy

(high)	*Private goods*	**c** Private fixed capital stock Pecuniary externalities Toll goods	**i** Relational private services operating on: — External linkages for firms — Transfer of R&D results	**f** Human capital Pecuniary externalities
Rivalry ↑	*Club goods, impure public goods*	**b** Proprietary networks Collective goods: — Landscape — Cultural heritage	**h** Cooperation networks Governance on land and cultural resources	**e** Relational capital
(low)	*Public goods*	**a** Resources: — Natural — Cultural (punctual) Social overhead capital: Infrastructure	**g** Agglomeration and district economies Agencies for R&D transcoding Receptivity enhancing tools Connectivity	**d** Social capital: — Institutions — Behavioural modes, values trust, reputation
		Tangible goods (hard)	*Mixed goods (hard + soft)*	*Intangible goods*
		(high)	**Materiality** →	**(low)**

Source: Camagni (2008).

Recalling what suggested by the European Commission (2005), different kinds of investments are likely to have different returns based on the peculiar territorial capital endowments of each region. EU Cohesion policies, a program of regional public investments in a set of diversified fields (from R&D to transport infrastructure, from SME to social inclusion) is perfectly suited for testing this assumption.

2.2. Cohesion policies (2000-2006): instruments and actions

In the period 2000-2006 the EU budget for the communitarian regional policies was about 213 billion euro. These funds were managed by three main instruments, the two Structural Funds and the Cohesion Fund. As far as the former are concerned, the European Regional Development Fund (ERDF) mainly contributed to assisting those regions whose development is lagging behind and those undergoing economic conversion or experiencing structural difficulties. The European Social Fund (ESF), on the other hand, mainly provided assistance under the EU employment strategy[3].

[3] Apart from these two instruments, two other funds under the CAP involved regional development issues, even if to a more limited extent, namely the EuropeanAgriculturalGuidance and Guarantee Fund (EAGF) and the Financial Instrument for Fisheries Guidance (FIFG).

The Cohesion Fund (CF) co-financed actions in the fields of the environment and transport infrastructure of common interest with a view to promoting economic and social cohesion and solidarity between member states. Eligibility was restricted to member states whose per capita gross national product (GNP) is less than 90% of the Community average.

The budget devoted to these funds (approximately one third of the overall EU budget) finances different types of actions and initiatives. Between 2000 and 2006 these programmes of intervention were classified into objectives and initiatives. The largest share of the resources (182.5 billion Euro) were aimed at pursuing the three communitarian objectives. Objective 1, devoted to regions with a per capita gross domestic product (GDP) lower than 75% of the community average, covered about the 69.1% of the total allocations and was financed by the ERDF and by the ESF. These funds financed also the Objective 2, covering about 11.5% of the total allocations. Finally, Objective 3 was financed by the ESF and covered about 12.5% of the funds.

A lower budget (10 billion euro) was available for supporting four initiatives[4].

The data set employed in the present paper covers ERDF and CF commitments in NUTS3 EU regions. Table 1 shows the amount of commitments in CEE countries between 2004 and 2006. It is worth noting that, beyond the classification of actions into objectives and initiatives, EU funds are allocated to a variety of policies and interventions, from the support to private firms to actions for enlarging women participation in the labour market, to the building of transport infrastructure. All these axes of expenditure are classified, in Table 1, into four categories, according to the disaggregation reported in Appendix A.

The largest share of funds (85%) was allocated to the realization of basic infrastructure, followed by programmes aimed at supporting the productive environment (15%). Being almost all CEE regions eligible for the Objective 1 actions, the vast majority of commitments fell in this category (43 per cent) and under the CF (53 per cent).

[4] The Interreg III initiative (financed through the ERDF) was aimed at stimulating cross-border, transnational and inter-regional cooperation. Leader+ initiative (EAGGF) promoted rural development. Equal and Urban II initiatives were respectively focused on the reduction of any form of discrimination and inequality in access to the labour market (ESF) and to the promotion of the socio-economic regeneration of declining towns and cities (ERDF).A last family of interventions concerns the innovative measures aimed at promoting new strategies for development. About the 0.65% of the Cohesion policy budget was devoted to the promotion of such activities.

Table 1. ERDF and CF expenditure commitments in CEE regions, 2004-2006.

	Productive Environment	*Human Resources*	*Basic Infrastructure*	*Other*	*Total*	*%*
ERDF Objective1	2,849	182	5,749	284	9,065	43%
ERDF Objective2	49	7	74	4	134	1%
CF	0	0	11,028	132	11,160	52%
Urban II	0	0	0	0	0	0%
Interreg III	287	56	353	50	747	4%
TOTAL	3,186	246	17,204	471	21,106	100%
%	15%	1%	82%	2%	100%	

Millions of Euro.
Source: SWECO (2008).

2.3. Cohesion policies and economic development: evidence from the literature

A long stream of research focused on the impact of Cohesion policies on economic growth, from both a national and regional perspective. As far as the latter is concerned[5], empirical evidence provides contrasting results.

Analysing the case of Eastern Germany between 1995 and 2004, Eggert *et al.* (2007) found a positive impact of Cohesion policies on regional convergence, but a negative effect on aggregate growth. Dall'erba and Le Gallo (2008) dealt with the case of 145 EU regions between 1989 and 1999. Even if processes of regional convergence took place in that period, the authors found no causal relationships between funds and economic growth. For the same years Esposti and Bussoletti (2008) evaluated the effect of Cohesion policies in Objective1 regions, finding a positive overall impact of regional funds, whose magnitude is however negligible and may become, in some cases, even negative, due to country effects.

The majority of studies, however, suggested a positive impact of Cohesion policies on economic growth (Ramajo *et al.*, 2008; Dall'Erba, 2005).While the above-mentioned studies dealt with the time period pre-2000, some works assessed the wave of funding programmes 2000-2006, the first also including CEE regions. Becker *et al.* (2010) were able to estimate the impact of Objective 1 actions on regional GDP growth in monetary terms. According to their findings, each Euro of transfers leads to 1.20 Euro of additional GDP. Similar evidence occurred, as far as Objective 1 regions

[5] Also country studies on the same issue provided mixed evidence. A negative impact of the Structural Funds Programme on GDP growth was found by Boldrin and Canova (2001), while the opposite holds for the evaluation by Midelfart-Knarvik and Overman (2002). Other scholars (Leonardi, 2006) claimed that the impact of Cohesion policies significantly varied across countries.

are concerned, in the analysis by Mohl and Hagen (2010). More recently Becker *et al.* (2012) suggested that in more than one third of the recipient regions the intensity of funding was above the most efficient level, and they estimated that in 18% of the regions a reduction of transfers would not lead to a slowdown in economic growth.

This divergence in the results of the literature on Cohesion policies reflects the variety of approaches and techniques employed in the studies summarized above[6].In particular, a problematic issue is represented by the classification of the funds. When investigating the relationship between investments and economic growth, almost all works did not distinguish among the axes of expenditure of Cohesion policies. As pointed out by Dall'erba *et al.* (2009) the expected impact of an investment in public infrastructure is likely to be very different to the outcome of policies aimed at the reduction of long-term unemployment. Based on a similar reasoning Rodríguez-Pose and Fratesi (2004) classified EU funds according to the different axes of intervention. Their results showed that only funds directed to education and human capital hada positive and significant impact on economic growth in the period 1989-1999.

The approach adopted in the present paper is similar. Our assumption is that Cohesion policy investments can be classified into two main categories. The first one includes those interventions not principally aimed at fostering economic growth but rather at reaching social and political outcomes. Measures for the reduction of inequalities and for the support of cohesion and sustainability pertain to this group. The second category of investments comprehends all the policies and programmes whose main objective is to promote economic growth and competitiveness. The provision of new infrastructures, R&D incentives, support to large companies and SMEs are examples for such interventions. This classification is needed since the role of territorial capital on the outcome of Cohesion policies is assumed to differ between the two typologies of investments, as discussed in the next section.

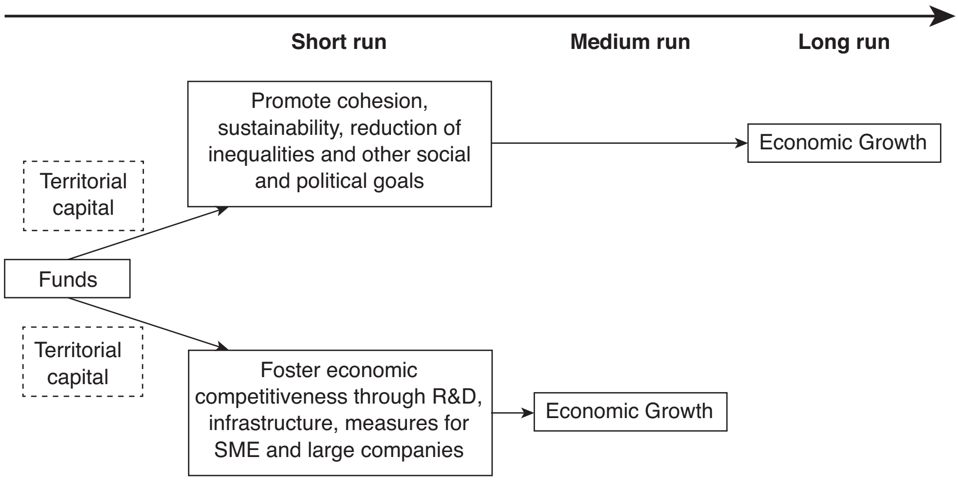
3. Territorial capital, Cohesion policies and economic growth

3.1. The role of territorial capital on the effectiveness of Cohesion policies: ex-ante assumptions

Based on the literature and evidence summarized in the previous section, the research question which will be addressed by the present paper is what is the relationship between territorial capital, Cohesion policies and economic growth. The theoretical assumption to be tested is that cohesion policies and territorial capital concur in fostering economic growth through two different mechanisms, as depicted in Figure 2.

[6] Among other things, the lack of counterfactual evidence represents a concern in such studies (Becker *et al.*, 2010). Reverse causality between eligibility for funds and economic growth was discussed by Bouvet (2005) and Dall'erba and Le Gallo (2008). The issue on the territorialisation of Cohesion policies and their implementation at different institutional levels was examined by Bachtler *et al.* (2013) and Ferry and McMaster (2013).

Figure 2. Territorial capital, Cohesion policies and economic growth



In the short run territorial capital is assumed to mediate the impact of the funds (lower side of Figure 2). Following a place-based approach to development strategies (Barca, 2009; OECD, 2009), any policy is implemented in a specific place, defined by peculiar cultural, social, economic characteristics or, in a nutshell, by a distinctive endowment of territorial capital. These territorial conditions are not neutral with respect to the policy outcomes (Pike *et al.*, 2006). Moreover, these local factors are expected to mediate the impact of both categories of policies identified in the previous section.

In the medium and long run, however, Cohesion policies are also aimed at the generation and accumulation of territorial capital, which will be the prerequisite for economic growth in the longer run (upper side of Figure 2). The building of a new highway, for instance, will lead to an increase in the infrastructural endowment of the region (box *a*, Figure 1). Policies supporting women participation in the labour market are likely to produce positive spillovers on the social capital of a given place (box *d*, Figure 1). The enriched endowment of territorial capital, in turn, is expected to promote economic growth (Capello and Perucca, 2014).

These accumulation processes require different amounts of time. Investments in infrastructure, R&D, entrepreneurship are likely to impact economic growth in the short run, while the financing of social inclusion or sustainable development policies are assumed to manifest their results in the long run.

The focus of this paper is on the medium term mechanisms highlighted by the arrows in the lower part of Figure 2. The outcome of the first years of Cohesion policy expenditure (2004-2006) on economic growth in CEE regions is measured on the regional GDP growth between 2006 and 2010. Therefore, among the 20 available axes of expenditure (reported in the Appendix A) we just considered those belonging to the category of investments directly aimed at fostering economic development.

The purpose of this paper is to investigate the relationship between new territorial capital (i.e. the EU funds invested in each region), the regional endowment at the beginning of the period of implementation of the Cohesion policies (2004) and the economic growth observed in the subsequent years (2006-2010).This research question was not inspected by previous literature, at least as far as Cohesion policies are concerned. Nevertheless, some works addressed this issue in other contexts. Resmini and Casi (2013) focused on the role of territorial capital in enhancing FDI. Their findings show that the impact of FDI is constrained by the regional socio-economic characteristics, in particular by the endowment of intangible elements (boxes d, e, f in Figure 1). In a recent study Dall'erba and Llamosas-Rosas (2013) analysed the relationship between territorial factors and the outcome of federal spending in the USA, pointing out the interaction between public expenditure and local elements such as human capital and entrepreneurship. These findings reinforce the interest towards a similar analysis on Cohesion policies.

To reach this goal the first step consists in the definition of an empirical measurement of territorial capital, based on the theoretical framework discussed in section 2.

3.2. Territorial capital: an empirical measurement

The objective to provide an empirical measurement of territorial capital for CEE NUTS3 is constrained by the availability of data at a small spatial level, especially when considering the indicators of the «innovative cross», characterized by intermediate levels of both rivalry and materiality. Nevertheless, the NUTS3 classification is the most relevant when dealing with territorial capital (Camagni, 2008). NUTS2 regions, in fact, are too large for capturing the variety of socio-economic characteristics of places and may include heterogeneous territories within. Moreover, the choice of this smaller territorial scale allows increasing the sample of regions. Starting from the tangible assets, those owing low levels of materiality are proxied by an index of the multimodal accessibility of a given place (Figure 3), whose role in fostering economic growth refers to the size of the regional market potential (Redding and Sturm, 2008). Based on this literature, physical accessibility is expected to reinforce the impact of policies aimed at assisting firms (axes 15 and 16, Appendix A). Keeping other things constant, companies able to reach a broader market are more likely to get a higher return on the investment. On the other hand, assuming a diminishing productivity of transport investments (Banister and Berechman, 2001), we expect the degree of accessibility to be negatively related to the return of the funds spent on basic infrastructures (axes 31-34).

The availability of statistics on impure public goods, such as cultural heritage and monuments, included in box *b* is extremely limited and not fully comparable across countries. For this reason we chose as an empirical measurement for this dimension the per capita number of bed places in tourists accommodation facilities, based on

Figure 3. Territorial capital: an empirical measurement for CEE NUTS3 regions

Rivalry				
(high)	*Private goods*	**c** IP addresses	**i** Workforce by ISCO function	**f** Resident population by ISCED educational attainment
↑ (high)	*Club goods, impure public goods*	**b** Bed places in tourists accomodation facilities	**h**	**e**
(low)	*Public goods*	**a** Multimodal accessibility Natural capital	**g** Urban/rural typology	**d** Female unemployment rate
		Tangible goods (hard)	*Mixed goods (hard + soft)*	*Intangible goods*
		(high)	**Materiality** →	**(low)**

the assumption that the supply of bed places is positively correlated with the attractiveness of each place. This territorial capital element is expected to boost economic growth in regions implementing projects related to tourism (axis 17).

The stock of private capital (box *c*) is captured by the per capita number of computers with active Internet Protocol (IP) addresses. Even if the diffusion of ICT may not be constant across sectors (Becchetti and Adriani, 2005) the number of internet connections is associated to the endowment of private capital in the region. This territorial capital variable has been tested in interaction with the structural fund investments in productive environment (axes 15 and 16) and labor market policies (21-24). However, the potential link between the number of IP addresses and the regional sectoral specialization prevents us from getting significant results.

The proxy for social capital (box *d*) is represented by the gender inequalities measured by the labor market participation of women. The relationship between traditional indicators of social capital, as for instance trust (Fukuyama, 2001), and gender unbalances was discussed in the literature (Rothstein and Stolle, 2003). This component of territorial capital is expected to reinforce the impact of policies focused on the training and inclusion of the labor force (axes 21-25).

Human capital (box *f*) is measured in terms resident population by educational attainment. As pointed out by the long stream of research on this form of capital (Lucas, 1988; Barro, 1991), its impact on economic growth operates through a raise in labor productivity and the adoption of new technologies (Nelson and Phelps, 1966). Following this theoretical background the regions with a higher endowment of human capital are expected to generate higher returns than the others from investments in the productive environment (axes 15-16), labour market (axis 21) and telecommunication infrastructure (axis 32).

Table 2. Territorial capital, data and sources

Quadrant of Territorial Capital	*Name of proxy*	*Description*	*Source of data*
a	Accessibility	Population potential within 50 km airline distance.	ESPON
b	Bed places	Per capita bed places in registered tourist accommodation.	EUROSTAT
c	IP addresses	Number of registered IP addresses.	ESPON
d	Female unemployment rate	Ratio between female and male unemployment (age over 15).	EUROSTAT
f	Resident population by ISCED attainment	Share of high educated residents (ISCED 5 and 6) over the total.	EUROSTAT
g	Urban/rural typology	Urban/ rural settlements.	ESPON
i	Workforce by ISCO function	Share of professionals and managers over the total.	EUROSTAT

In the context of this paper agglomeration economies (box g) are considered in terms of the positive externalities induced by the urban environment (Parr, 2002). Based on the literature devote to the role of urbanization economies in fostering economic growth (Rosenthal and Strange, 2004), this component of territorial capital is assumed to be linked to higher GDP growth rate. At the same time, however, their marginal return is expected to decrease as the size of the city increases (Graham, 2007). In other words, investments in basic infrastructures (axes 31-34) are expected to be less effective as the intensity of urbanization economies raises. In the data set employed in the paper the proxy for this territorial asset is represented by a categorical variable identifying environments characterized by different degrees of urbanization (urban/intermediate/rural).

The territorial capital elements characterized by a high degree of rivalry and an intermediate level of materiality (box *i*) are empirically measured by the classification of the regional workforce according to the ISCO functions. With respect to the educational attainment, job functions cannot be considered as pure intangible goods, since they represent skills and competences integrated in a production process. They are assumed to improve the effectiveness of labor market policies (axes 21-25): regional labor markets marked by low-level functions are expected to be less capable than the others to implement inclusive labor policies.

Finally, data at NUTS3 level are unfortunately not available for the components of territorial capital included in boxes *e* and *h*.

4. Methodology and general results of structural fund on growth

In order to estimate the impact of territorial capital on structural funds effectiveness a cross section regression model is used. Panel data, in fact, only exist for expenditure at an aggregate level (total amount), which is not relevant in this context. Since on the contrary expenditure at category level is only available for the full programming period 2000-2006, a cross section model is the only available option.

At the basis of the analysis, used as benchmark for the insertion of the other regressors, there is a traditional Barro-like regional growth model, taking the form:

$$ln(GDP_{i,2010}) - ln(GDP_{i,2006}) = lnGDP_i + specialization_i + reg.\_typology_i + \varepsilon_i \qquad (1)$$

where regions i are the 108 CEE regions of the sample, and the explained growth rate is the one between 2006 and 2010, i.e. the growth rate in the four years after the policy expenditure has taken place.

Moreover, the regression includes a number of controls, quite standard in the literature, which are inserted in order to avoid an omitted variables bias in the regressions:

— regional specialization (measured by the share of workers employed in the agricultural sector);
— the regional typology (measured by a dummy for those regions in industrial transition industrialization, deindustrialization and structural change, according to ESPON 2010)[7];
— regional per capita GDP at the beginning of the period, included in order to account for the degree of development of the region and all other factors correlated with it;
— finally, country dummies are inserted in order to consider the national factors of regional growth, which are highly relevant since, especially in periods of macroeconomic trouble, the national conditions are determinants of paramount importance, due to aspect such as public finance, de-valuation/re-valuation, the economic regulation setting, the legal system and the likes.

[7] Regions are classified according to the on-going process of industrial restructuring in four categories: regions with manufacturing branches losing importance, regions with manufacturing branches gaining importance, regions with internal (within the same sectors of specialization) industrial structural change, regions with a stable composition of their productive sector (*source:* ESPON, 2010).

This cross section model can be estimated by standard OLS but, since the observations of this model are regions (at Nuts3 level), it is possible that its residuals are spatially autocorrelated and estimates would hence be biased. For this reason, the residuals of the model have been tested for spatial autocorrelations with different typologies of distance matrixes in order to see whether there is the need for a spatial regression model.

The results, presented in Table 3, show that there would be a significant spatial autocorrelation without the national fixed effects. However, once the national fixed effects are inserted in the model, there is no residual spatial autocorrelation, nor if the matrix is a binary neighbour matrix, nor if the matrix is an inverse distance matrix.

Spatial autocorrelation only appears when the distance is the 3rd quantile distance, but this distance is so big that the effect is no longer a spatial effect but actually a global effect.

The conclusion which stems from Table 3 is that the spatial effects are indeed due to the fact that, as supposed, the regional growth rate depends significantly on national growth, and regions are normally closer to regions belonging to the same country.

Finally, it is a possibility that negative spatial autocorrelation emerges once national effects are inserted, due to the fact that some regions are by definition above or below the average of their respective country, but in this case the problem is not present, most likely because Nuts3 regions are small enough that there are many of them inside the same country, so that one of them having a higher growth rate exerts a negligible effect on differential of the others with respect to the country.

Table 3. Spatial autocorrelation tests

Binary neighbours matrix	*OLS without country FE*	*OLS with country FE*				
	Largest minimum distance	*Largest minimum distance*	*1st quartile distance*	*Median distance*	*3rd quartile distance*	*Smallest maximum distance*
Spatial error						
Moran's I	10.492***	0.221	0.265	–0.857	–0.556	–0.413
Lagrange multiplier	86.689***	0.999	1.538	3.294*	2.646	2.42
Robust Lagrange multiplier	0.148	1.332	2.482	2.231	2.904*	3.199*
Spatial lag						
Lagrange multiplier	100.682***	0.134	0.013	1.121	0.543	0.425
Robust Lagrange multiplier	14.142***	0.467	0.957	0.059	0.8	1.204

Inverse distance matrix	*OLS without country FE*	*OLS with country FE*				
	Largest minimum distance	*Largest minimum distance*	*1st quartile distance*	*Median distance*	*3rd quartile distance*	*Smallest maximum distance*
Spatial error						
Moran's I	11.023***	1.009	1.094	–2.221	–2.825	–0.621
Lagrange multiplier	92.561***	0.172	0.517	2.563	1.253	0.72
Robust Lagrange multiplier	0.518	0.464	1.007	0.531	0.607	1.385
Spatial lag						
Lagrange multiplier	106.992***	0.003	0.033	3.097	4.092**	3.106*
Robust Lagrange multiplier	14.949***	0.295	0.524	1.064	3.446*	3.770*

*** significant at 1%, ** significant at 5%, * significant at 10%.

The basic regression model (1st column of Table 4) has a high R^2, despite of the fact that not all regressors are significant. Significant regressors include the dummy for structural change regions, which is negative and the country dummies, since national aspects are as expected highly relevant to regional growth. Moreover, the dummy for deindustrialization is borderline significant, with a p-value very close to 0.1.

Although some regressors are unsignificant, the model is robust to the subtraction of some of them, therefore we chose to keep the full specification as the basis for the analysis which will follow.

Finally, also the normality of residuals have to be tested. According to the Shapiro-Wilk W test for normality it is not possible to reject the hypothesis that the residuals are normally distributed.

With this standard model as benchmark, the significance of structural funds expenditure has been tested. The standard model of regression has been added up with the commitment of structural funds as in the following equation (2), which extends equation (1):

$$ln(GDP_{i,2010}) - ln(GDP_{i,2006}) = lnGDP_i + specialization_i + reg.\_typology_i + share\_funds_{i,j} + \varepsilon_i \quad (2)$$

where *j* (= 1,..,19) represents the two-digit expenditure classification, and the shares of funds include all the actions and programs covered in the database. All other variables have the same notation of equation 1.

Table 4. Results of the standard regression model

Variables	*(1)*	*(2)*	*(3)*	*(4)*
Per capita GDP	0.010	0.009		0.018
Specialization (agric.)	0.002		–0.002	0.013
Industrial transition:				
Deindustrialization	–0.028	–0.030*	–0.031*	
Industrialization	–0.017	–0.018	–0.020	
Structural change	–0.028*	–0.029*	–0.030*	
Country fixed effects	Yes	Yes	Yes	Yes
Constant	0.215*	0.214*	0.167***	0.223*
R-squared	0.789	0.789	0.788	0.784
Observations	108	108	108	108

Robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In the regressions, the share of expenditure in each axis is included rather than the total amount (or the amount per capita). This is a methodological choice due to the following reasons:

— First of all, the amount of funds in each axis in the database is highly correlated with total funds, since normally those regions having more funds tended to spend more in all axes. Therefore, the commitment in each axis is correlated with GDP, which means that the commitments per capita are not uncorrelated with the variable which defines the eligibility for the policy.
— Second, the amount of funds in various axes are positively correlated among themselves (also because regions receiving more funds are likely to spend more in all axes);
— Finally, all regions but a few ones were Convergence Regions, hence they all are treated regions, which means that all of them were eligible for the same expenditure axes and there are no regions uneligible to some of them.

The results, shown in Table 5 show that apparently the impact of the single commitments on regional growth are not as positive and significant as one would hope.

Table 5 shows the synthesis results of 19 regressions where each time one of the structural funds axes is included along the regressors of the standard model. Only the coefficients for the structural funds axes are shown in the table, and many of them are insignificant, and some are even negative and significant.

These results are not surprising, since they reflect the lack of evidence in the literature about a stable relationship between EU funds and regional growth. As discussed in the previous sections, this is probably due to two reasons. First of all some of the axes of intervention, as for instance planning and rehabilitation policies or the

Table 5. Estimation results for the individual axes of commitments

Commitment categories	*Coefficient*
1. PRODUCTIVE ENVIRONMENT	
11 Agriculture	–0.031
12 Forestry	–0.106***
13 Promoting the adaptation and the development of rural areas	–0.006**
14 Fisheries	–3.491
15 Assisting large business organisations	–0.002
16 Assisting SMEs and the craft sector	0.000
17 Tourism	–0.003**
18 Research, technological development and innovation (RTDI)	0.000
2. HUMAN RESOURCES	
21 Labour market policy	–0.027***
22 Social inclusion	–0.022***
23 Educational and vocational training not linked to a specific sector	–0.001
24 Workforce flexibility, entrepreneurship, innovation, info. and comm.	–0.005
25 Positive labour market actions for women	–0.186
3. BASIC INFRASTRUCTURE	
31 Transport infrastructure	0.000
32 Telecommunications infrastructure and information society	–0.005***
33 Energy infrastructures (production, delivery)	–0.001
34 Environmental infrastructure (including water)	0.000
35 Planning and rehabilitation	–0.006***
36 Social and public health infrastructure	0.001

Note: only shown are the coefficients of the single axes, obtained by estimating 19 regressions where the basic model regressors are included and each time only one of the axes is included.
Robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

interventions focused on forest, are not primarily devoted to the pursue of economic goals. Second, confirming our hypothesis, investments per se are not a guarantee for speeding up economic growth, but they gain effectiveness only in conjunction with some territorial enabling conditions.

To test the hypothesis that the impact of structural funds is mediated by the endowment of territorial capital of the regions, and expenditure per se is not effective if it is not activated by the prerequisite of the region having the relevant territorial capital assets, territorial capital is added to the previous specification of the model as in the following equation:

$$ln(GDP_{i,2010}) - ln(GDP_{i,2006}) = lnGDP_i + specialization_i + \\ + reg.\_typology_i + share\_funds_{i,j} + X_i + \varepsilon_i \tag{3}$$

where X_i represents the set of territorial capital assets and all other variables retain the same meaning they had before.

Then, the interactions between territorial capital and EU structural funds commitments are added to the model:

$$ln(GDP_{i,2010}) - ln(GDP_{i,2006}) = lnGDP_i + specialization_i + reg.\_typology_i + \\ + share\_funds_{i,j} + X_i + (share\_funds_{i,j}) + X_i + \varepsilon_i \tag{4}$$

An analysis including steps 3 and 4 cannot be performed on all 19 axes but only on those expenditure axes for which it theoretically relevant and empirically feasible.

The empirical analysis, presented in the next sub-section will hence focus on a subset of axes, those where:

- There exist a sufficiently appropriate variable of territorial capital which is related to the expenditure item. As it was shown in Section 3, empirical proxies of territorial capital are not always easily available. Moreover, the variable of territorial capital has to be clearly related to the policy axis, at least theoretically, and there are policy axes for which none of the proxies outlined in Section 3 are relevant.
- Expenditure is intended or expected to impact on economic growth and not only socio-territorial assets. As known, and shown in Figure 2, not all structural fund expenditure is due to impact on regional growth, while some axes are more devoted to improvements in the quality of life and wellbeing of people living in the region rather than direct economic output (e.g. sewage systems, assistance to disadvantaged categories, etc.)

5. The effect of territorial capital on the impact on structural fund expenditure

This section will show how the impact of some structural fund expenditure axes is bound to have a different impact depending on the regional endowment of territorial capital, with the methodological steps illustrated in Section 4.

A first example is shown in Table 6a, where analysed is the case of axis 21, «labour market policy», which normally involves measures of training of employed and unemployed workers. The regressions for the different axes reported in the table include the standard regressions variables included in model (1), whose level of significance is not affected by the inclusion of the territorial capital and regional policy variables.

Table 6. Estimation results for the expenditure axes

a] Cat. 21: Labour market policy				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 21	–0.023***		–0.022***	–0.027***
High-value functions		0.084	0.028	0.026
Funds * high-value funct.				0.390*
Country fixed effects	Included	Included	Included	Included
Constant	0.199*	0.161	0.181	0.181
R-squared	0.796	0.790	0.796	0.798
Observations	108	108	108	108
b] Cat. 24: Workforce flexibility, entrepreneurship, innovation, info. and communication				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 24	–0.000		–0.000	–0.021*
Human capital		–0.002	–0.001	–0.053
Funds * human capital				0.283***
Country fixed effects	Included	Included	Included	Included
Constant	0.215*	0.216	0.216	0.202
R-squared corr.	0.789	0.789	0.789	0.795
Observations	108	108	108	108
c] Cat. 25: Positive labour market actions for women				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 25 (dummy)	–0.013		–0.013	–0.011
Human capital		–0.002	0.010	–0.031
Funds * human capital				0.631*
Country fixed effects	Included	Included	Included	Included
Constant	0.217*	0.216	0.213	0.216
R-squared	0.791	0.789	0.791	0.796
Observations	108	108	108	108

d] Cat. 17: Tourism				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 17	–0.003***		–0.002**	–0.004***
Bed places in accom. facil.		–0.012*	–0.009*	–0.018**
Funds * bed places				0.002***
Country fixed effects	In1cluded	Included	Included	Included
Constant	0.207*	0.221**	0.213*	0.212*
R-squared	0.800	0.795	0.803	0.811
Observations	108	108	108	108
e] Cat. 33: Energy infrastructures (production, delivery)				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 33	–0.002		–0.000	–0.008
Intermediate urban region		–0.050**	–0.050**	–0.062**
Rural region		–0.069**	–0.069**	–0.074**
Funds * intermediate region				0.018*
Funds * rural region				0.008
Country fixed effects	Included	Included	Included	Included
Constant	0.215*	0.081	0.081	0.083
R-squared	0.789	0.808	0.808	0.812
Observations	108	108	108	108
f] Cat. 34: Environmental infrastructure (including water)				
Variables	*(1)*	*(2)*	*(3)*	*(4)*
Standard regr. controls	Included	Included	Included	Included
Funds cat. 34	–0.000		–0.000	–0.000
Intermediate urban region		–0.050**	–0.050**	–0.058**
Rural region		–0.069**	–0.069**	–0.069**
Funds * intermediate region				0.013*
Funds * rural region				0.001
Country fixed effects	Included	Included	Included	Included
Constant	0.215*	0.081	0.081	0.081
R-squared corr.	0.789	0.808	0.808	0.811
Observations	108	108	108	108

Robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

By just looking at the direct correlation between commitment in this axis and their impact on growth, it appears that having a high share of funds devoted to it is associated with a negative growth rate (column 1 in the table). This is probably due to the fact that regions tend to spend more on this axis if they are plagued by problems in the labour market, and hence tend to be weaker regions. However, the impact on growth of these funds is not independent on the territorial capital of the region. In this case, one plausible relevant asset of territorial capital are the high value functions (which are private and mixed material-immaterial goods in Figure 3).

Despite of the fact that high value functions per se are unable to induce growth (in column 2 the coefficient is positive but not enough to be significant), they represent a pre-requisite for regional policy related to the labour market to function. In column 4 of the table, one can see that a high share of funds for labour market policies is negative per se but positive if related to high value functions. It is hence possible to conclude that labour market policies are more effective in those regions which are specialized in high value functions, i.e. are regions whose production system is performing higher value tasks which therefore need a more specialized labour force.

Table 6b presents are the results for commitment axis 24, «workforce flexibility, entrepreneurship, innovation, information and communication». In this case, there is no significant impact of the share of funds devoted to this axis on regional growth (column 1). Measures related to this axis are expected to impact on the innovativeness of firms, and on the likelihood to help entrepreneurs successfully building new firms in the region. The territorial capital pre-requisite for these measures to function is human capital, since the possibility to hire workers with better skills should improve the success rate of new entrepreneurial initiatives and also help improve the possibility for existing firms to introduce new innovations. Human capital is an intangible and private element of territorial capital.

In this case, also the territorial capital variable per se does not have a significant impact on regional growth in this case (column 2 of Table 6b) but, as shown by the full model in column 4, it strongly affects the possibility of measures in axis 24 to successfully increase the regional growth rate. The negative coefficient for the pure commitment variable remains negative as in Table 5.

It hence appears that investing in Workforce flexibility, entrepreneurship, innovation, information and communication is a good way to increase the growth rate in those regions which are well endowed with human capital, whereas for those regions where human capital is not present, this development strategy is ineffective if not detrimental.

A result similar to the previous one is obtained for the commitment axis 25 «positive labour market actions for women» (Table 6c). This axis involves measures able to increase the involvement of women in the labour market, which appears not to be having a significant impact on regional growth. However, also in this case, the presence of human capital appears to be a territorial capital pre-requisite for the impact of the policy of regional growth, and this type of policy brings positive effects when crossed with the endowment of human capital. Regions more endowed with human capital, in fact, are normally more able to take advantage of the inclusion of women, while regions with lower human capital are unable to benefit from what women can bring to the labour force.

The analysis can move out of labour market related issues towards more traditional support to specific sectors. In Table 6d the impact of tourism commitments is analysed and one can see that, as already seen in Table 5, the coefficient of the impact of tourism expenditure is negative. This can take place, more than from the ineffectiveness of the policy itself, from the fact that tourism suffered the economic crisis more than other sectors (the estimation sample is 2006-2010) and therefore regions that have invested more in this sector are those specialized in a difficult sector.

Also in this case, however, the endowment of territorial capital manages to mediate the impact of the policy. In this case, the relevant territorial capital variable is a hard good, whose rivalry is partial (since it can be used by many and crowding out only takes place after a certain threshold), i.e. the endowment of bedplaces.

From Table 6d it is evident that the endowment of bedplaces, signalling a specialization in tourism, is by itself negatively correlated to growth. However, those regions which hold a larger number of bedplaces per inhabitant are more able to take advantage from structural funds investments in the touristic sector. One can in fact expect that any policy improving the touristic attractiveness of regions is more effective when these regions already hold the facilities to accommodate increasing touristic flows.

The last two axes which are analysed in this paper are hard ones which involve the building of basic infrastructure for the regions.

As far as energy infrastructures are concerned, the regressions (Table 6e) show that this commitment axis does not have an impact per se on the regional performance of CEE regions. However, the regional settlement typology of regions is very important in this case: first, it is evident that intermediate urban regions and rural regions have a disadvantage with respect to the mostly urban regions. It is a known fact that urban regions led the development of these countries before and after they joined the EU (Capello and Perucca, 2014).

The settlement structure is a measure of agglomeration and economies and congestion diseconomies, it is hence a mixed (hard+soft) public good in the territorial capital classification.

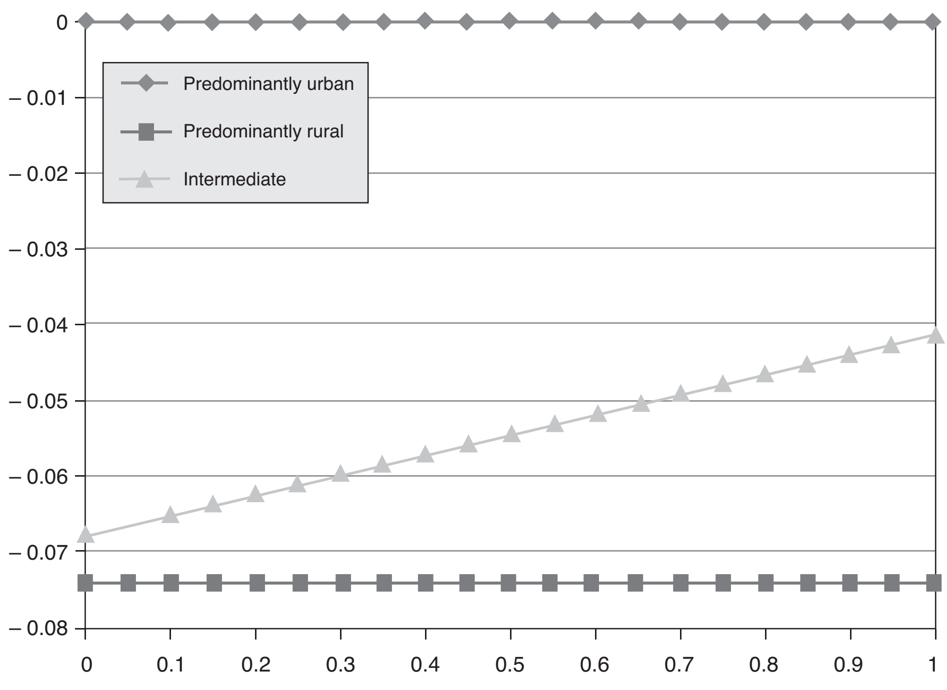
Table 6e shows that, although agglomeration economies are still important in CEE countries and no significant decreasing returns appear, as signalled by the higher growth rate of the urban areas, intermediate regions, those where agglomeration economies are present but farer from reaching the congestion threshold, are those more able to take advantage of investments in energy infrastructure. Urban areas, in fact, already have a relatively good delivery infrastructure, while firms in rural areas do not have enough agglomeration economies to benefit from improvements in energy delivery.

The final commitment axis presented in the paper is axis 34, Environmental infrastructure, whose impact also depends on the degree of agglomeration economies (Table 6f).

As in the previous case, the axis per se is insignificant, but its impact becomes significant when a region is an intermediate urban one. These regions, in fact, benefit from the improved presence of water, sewage and other environmental infrastructure which allow them to grow and expand their agglomeration economies without paying costs in terms of pollution and lower quality of life. Rural areas, on the contrary, most likely hold enough environmental capital that investment in that axis is not able to change the situation.

By drawing the impact of the coefficients of model (4) of Table 6f, one can see that predominantly rural regions are ceteris paribus growing less than their predominantly urban counterparts. At the same time, also intermediate urban regions are growing less, even if less markedly, and, more important, the impact of the policy in these regions is clearly felt. The more the policy invests in environmental infrastructure, the lower becomes the gap between their growth rate and the one of the predominantly urban regions, which however remain more dynamic.

Figure 4. Impact of environmental infrastructure policy on the growth rate of the three typologies of regions



6. Conclusions

This paper, with an empirical analysis on CEE Nuts3 regions, has shown that regional policy is not so much effective per se but its impact depends on the type and amount of territorial capital possessed by the region. Regions more endowed with territorial capital appear to be more able to take advantage from the policy support of structural funds.

Moreover, territorial capital is differentiated in terms of materiality and rivalry, and the analysis has shown that different policy axes are facilitated by different endowments of territorial capital.

Structural Funds, therefore, work well as economic growth activators when they complement with the regional endowment of territorial capital. Each expenditure axis is hence more fruitful in a different type of region.

In CEE regions[8], the economic impact of EU policy investments in immaterial assets appear to be characterized by increasing returns: they tend to be more effective where regions are more endowed, for example:

— labour market policies are only effective when there is in the region a presence of high value functions;
— workforce flexibility, entrepreneurship, innovation, information and telecommunication policies are only effective when the region is endowed with human capital, while their impact in regions not endowed is not positive;
— also positive labour market actions for women policies work only when the regions hold a good level of human capital.

Increasing returns also exist in some cases of harder policy investments. For example, tourism policies are more effective when regions have the possibility to host the increased flows of people in their structures.

Finally, it also appears that agglomeration economies play a role in some infrastructural policies. As in the CEE countries development has been concentric for a long time, urban regions have an advantage, but the intermediate regions, having the possibility of exploiting an increased degree of agglomeration without incurring in congestion costs, are those that can take advantage of Structural Fund policies in both energy and environmental infrastructure.

It hence looks like there are some decreasing returns emerging, since it is not the largest urban areas that take advantage from these investments but the intermediate ones.

Rural areas, however, also don't take advantage of these hard investments, which questions the whole role of Structural Funds since these regions tend to be the poorest and less developed ones.

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[8] These results have been obtained in the specific case of transition countries, but we are confident that the relationship between territorial capital and the effectiveness of regional policy will hold also for the EU15 regions, although it is possible that, in a different socio-economic context, this relationship might be stronger for some axes and weaker for some others.

If structural funds are more effective when there is territorial capital, it means that investing policy funds in regions already more developed pays more than investing them in weaker regions. It looks like a trade-off is emerging between the effectiveness of policies and the degree of spatial equity they can achieve, which is something very likely when agglomeration economies are strong (Fratesi, 2008), which is probably the case in CEE countries where there is still the possibility of further agglomeration before congestion diseconomies become too large.

One way to sort out of this potential policy dilemma lies in the fact that, as shown in Figure 2, Structural Funds can be devoted to enhancing the competitiveness of regions and hence create growth in the short-medium term, but can also be used as enhancers of territorial capital in the medium-long run. This enriched endowment of territorial capital will eventually enhance the long run growth of the poorest regions.

Where territorial capital is not present, therefore, structural funds could and should be used to enhance territorial capital in the region. This is a long run strategy, which does not produce growth in the short run but should put the bases for growth in the longer run.

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Appendix A. Regional EU policy in CEE regions: classification of expenditure categories

Expenditure categories	*Expenditure axes*	*Per capita funds in axis*				*Share of funds in axis*	
1. PRODUCTIVE ENVIRONMENT	**11.** Agriculture	*Mean*	*Std. Dev.*	*Min*	*Max*	*Mean*	*Std. Dev.*
	12. Forestry	0.04	0.11	0	0.43	0.02	0.06
	13. Promoting the adaptation and the development of rural areas	0,15	0.37	0	3.38	0.07	0.15
	14. Fisheries	219	5.84	0	51.9	0.74	1.72
	15. Assisting large business organisations	0	0.01	0	0.02	0	0
	16. Assisting SMEs and the craft sector	3.85	7.47	0	62.38	1.37	1.92
	17. Tourism	21.58	16.7	0.89	122.61	8.75	6.59
	18. Research, technological development and innovation (RTDI)	13.75	16.94	0	90.3	4.99	6.88
2. HUMAN RESOURCES	**21.** Labour market policy	6.81	9.24	0	47.77	2.73	5.04
	22. Social inclusion	0.8	1.96	0	11.03	0.33	0.9
	23. Educational and vocational training not linked to a specific sector	0.79	1.9	0	11.15	0.32	0.85
	24. Workforce flexibility, entrepreneurship, innovation, information and communication	1.87	3.25	0	20.39	0.74	1.66
	25. Positive labour market actions for women	0.35	1	0	5.99	0.15	0.5
3. BASIC INFRASTRUCTURE	**31.** Transport infrastructure	0.03	0.05	0	0.15	0.01	0.03
	32. Telecommunications infrastructure and information society	132.26	171.8	0.4	1448.94	36.32	21.46
	33. Energy infrastructures (production, delivery)	6.47	7.09	0	54.01	2.95	3.82
	34. Environmental infrastructure (including water)	3.26	5.59	0	29.82	0.97	1.51
	35. Planning and rehabilitation	93.2	71.02	1.49	342.83	29.86	17.2
	36. Social and public health infrastructure	7.43	6.63	0	35.99	3.24	3.1
4. OTHER	**41.** Technical assistance and innovative actions	12.27	16.93	0	90.57	3.94	4.36
	TOTAL	**313.99**	**206.85**	**75.6**	**1685.26**	**100**	

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Section ARTICLES

The Geography of Multinational Corporations in CEE Countries: Perspectives for Second-Tier City Regions and European Cohesion Policy

Teodora Dogaru*, Martijn Burger**, Frank van Oort*** and Bas Karreman**

ABSTRACT: The largest regional disparities in CEE countries are between capital and non-capital city regions. MNCs invest in these regions for various reasons, contributing to regional development exogenously. In this paper we analyse location decisions of FDI investments in the period 2003-2010. We find that the most important location factors for FDI are market accessibility, strategic assets, institutional quality and agglomeration, in the post-crisis era even more than before. Presently, second-tier city regions are not capable of offering all these factors simultaneously. For improving their opportunities and contribution to European cohesion and convergence, more substantial and direct investments are needed. Without these, the recently suggested competitiveness opportunities of second-tier city regions are difficult to obtain.

JEL Classification: R38; R58; R12.

Keywords: Greenfield FDI; CEE regions; location factors; competitive advantage.

La geografía de las corporaciones multinacionales en los países del centro y este de Europa. Perspectivas para regiones con ciudades de segundo nivel y la política de cohesión europea

RESUMEN: Las mayores disparidades regionales en los países del centro y este de Europa se observan entre las regiones con las capitales y el resto. Las empresas multinacionales invierten en estas regiones por distintas razones, contribuyendo de manera exógena al desarrollo regional. En este artículo, analizamos las decisiones de localización de las inversiones directas extranjeras entre 2003 y 2010. Encontramos que los factores más importantes de las inversiones extranjeras son la accesibilidad del mercado, las ventajas estratégicas, la calidad institucional y aglomeración, más aún en la época después de la crisis. En la actualidad, las regiones con ciudades secundarias no son capaces de ofrecer todos estos factores al mismo tiempo. Para me-

* Universidad de A Coruña, Spain. *dora.dogaru@gmail.com.*
** Erasmus University Rotterdam.
*** Utrecht University.

Received: 14 february 2014 / Accepted: 5 august 2014.

jorar sus oportunidades y contribuciones a la cohesión y convergencia europea se requieren mayores inversiones. Sin *éstas*, las oportunidades de competir mencionadas anteriormente para las regiones con ciudades secundarias serían difíciles de obtener.

Clasificación JEL: R38; R58; R12.

Palabras clave: Inversión «Greenfield»; regiones del centro y este de Europa; factores de localización; ventaja competitiva.

1. Introduction

When identifying growth opportunities for Europe, one cannot overlook the regional patterns of its composite member states. The difference in growth opportunities between Western and Central Eastern (CEE) countries and regions is obvious but complex (Dogaru *et al.,* 2011; Maroccu *et al.,* 2012, and Capello *et al.,* 2008). Western European regions identify themselves through internationally competitive cities like London, München, Paris, Barcelona or Amsterdam. Such places became landmarks for their surrounding regions and function in larger-scale city-regions. They distinguish themselves through competitive advantages in innovation capacity, labour market efficiency and productive economic specializations (Annoni and Dijkstra, 2013). Policy makers in these places strive for better quality of life —the ultimate goal of competitiveness (Gardiner *et al.,* 2004). In this view, they develop strategic innovative regional and urban development plans which target continuous employment, sustainable environment and accessible housing schemes, public amenities, qualitative and affordable education and healthcare or cultural enhancement and harmonization. But all these objectives are generally supported by a healthy business environment, embedded in a regional knowledge economy with knowledge-intensive specializations and sound institutions as well as good functioning multilevel governance structures (Barca *et al.,* 2012). Strong financial sectors support entrepreneurship. Qualitative transport infrastructure increases accessibility and supports a good position in international trade networks. Highly qualified human resources drive the development of top sectors and in combination with other factors lead towards a service economy.

Central Eastern European regions are part of more recent member states characterized by former communist regimes —such as regions in Poland, Czech Republic, Slovakia, Hungary, Romania or Bulgaria—. These countries used to be centralized economies where the capital city was the most important location of decision and development (Gorzelak *et al.,* 2012, and Müller *et al.,* 2005). Besides some secondary city regions that focus on industrial specialization, university capacity or touristic centers, the rest of the regions in these countries largely remained agricultural-based economies. Building on their basic industrial composition heritage, these countries and their regions developed only little beyond their former profile. However, due to their entry in the EU and its trade benefits, as well as their strategic geographic location, low levels of wages and taxes or even natural resources, they increasingly become an attraction for international corporations mostly for production and medium-low service functions. Frequently, the major landmarks are at national level and in capital city regions.

Dogaru *et al.* (2014) note that there is regional convergence among Central and Eastern European countries and between CEE and Western European countries. However, regional disparities within the CEE countries have yet prevailed over the past years (Ezcurra *et al.,* 2007; Niebuhr and Schlitte, 2009; Rodríguez-Pose and Ezcurra 2010; Kallioras and Petrakos 2010, and Chapman *et al.,* 2012). In the wake of EU enlargement, capital city regions started taking different development paths and grew with a faster rhythm than the other regions in CEE countries. Nevertheless, recent evidence by Dijkstra (2013), Dijkstra *et al.* (2013) and ESPON (2012) suggests that non-capital city regions or regions containing so-called secondary cities show better growth figures over the last years. Arguably, both agglomeration diseconomies in the largest cities and untapped potential and knowledge intensive specializations in cities other than the capitals (like in München in Germany, Milano in Italy, Eindhoven in The Netherlands, and Barcelona in Spain) may contribute to this finding (Camagni *et al.,* 2014, Angoletti *et al.,* 2014, Camagni and Capello, 2014). It is argued by Thissen *et al.* (2013) that besides endogenous agglomeration forces, linking up with specialized international knowledge networks and the embedding of international knowledge, trade and FDI networks in local knowledge intensive environments (of firms, universities and governmental agencies) may foster growth opportunities in second tier city regions relatively more than in capital regions. Still, the applicability of these findings in CEE countries remains uncertain. Endogenous growth opportunities may be limited in CEE countries because of less knowledge-intensive specializations, less learning experiences, culturally different evolved social capital and institutional constraints (Rodríguez-Pose *et al.,* 2013, 2014). Besides this, several studies have pointed to differences with respect to embeddedness in international networks and industrial restructuring as the reason for regional disparities in the CEE countries (Heidenreich and Wunder, 2008, and Chapman and Valentina, 2011).

The degree in which regions in CEE countries are able to attract and embed foreign investments, and particularly what role capital and secondary city regions may play in this, has not received much attention. This is mainly due to data limitations. Concerning regional development, Malecki (2002), Frenken and Hoekman (2006) as well as Tracey and Clark (2003) have drawn attention to the potential importance of global networks as sources of goods and knowledge in shaping firm competitiveness in a particular area. This issue becomes more prominent as regional positions in knowledge, trade and FDI networks are regarded as important attributes of smart specialization strategies of European regions, aiming at future cohesion (Thissen *et al.,* 2013). Barca *et al.* (2012) argue why place-based development strategies in European Union in relation to international network positions may be determining for future cohesive development. In spatially blind approaches it is argued that agglomeration in combination with encouraging people's mobility not only allows individuals to live where they expect to be better off but also increases individual incomes, productivity, knowledge and aggregate growth. From this perspective, spatially blind policies are also seen as «people-based», representing the best approach to improving inhabitants' lives. Consequently, development intervention should be space-neutral, and factors should be encouraged to move where they are most productive. In reality, this is primarily in large cities. In contrast, the place-based approach assumes that the interactions between institutions and geography are critical for development, and many of the clues for development policy lie in these interactions. To understand the likely impacts of a policy, the interactions between institutions and geography, therefore, requires explicit consideration over specifics of the local and wider regional context. In Europe, all urban regions may inhabit such unique development features (Barca *et al.,* 2012, p. 140).

This article aims at testing whether the position of CEE regions in international networks of multinational corporations (MNCs) attributes to regional development potentials and future competitiveness and cohesion. We are especially interested in the position of capital city regions versus second tier city regions in networks of foreign direct investments. Despite the suggested advantages of second tier city regions and the fact that most CEE regions experienced productivity growth in manufacturing industries, the CEE capital city regions are converging at a faster rate due to their networked, service oriented economies (Dogaru *et al.,* 2011). Reasons for this matter may be related to international (FDI) network positions. The present analysis focuses on the location decisions of MNCs investment in the NUTS-2 regions of CEE countries. Overall, the number of alternative locations is larger for MNCs than for domestic firms when making an investment decision. In addition, MNCs are expected to select the foreign investment locations that best fit the characteristics of the investment project and yield the largest benefits for the firm. This applies to greenfield FDI that does not face constraints from existing capital instalments or prior investments (unlike mergers and acquisitions). Hence, the location decisions of MNCs clearly reflect the particular competitive advantage of certain regions and provide a meaningful way to compare the attractiveness of different regions for particular sectors and functions. We hypothesize that competitive advantages of regions may be in market accessibility, labour cost advantages, strategic assets, natural resources, institutional quality and agglomeration, in the post-crisis era even more than before. Section 2 discusses more detailed the motivations for location of MNCs in regions. Section 3 then introduces both the data used for empirical testing and a classification of capital and second tier city regions in CEE countries. Section 4 provides an overview of the empirical results and discusses the findings. Section 5 presents conclusions and discusses what our results suggest for competitiveness, cohesion policy and place-based development strategies.

2. Motivations for MNCs to invest in CEE regions

As Brienen *et al.* (2010) and Burger *et al.* (2013) summarize, the literature on FDI generally acknowledges that an increase in FDI is beneficial for home activities through the acquisition of skills and technology from abroad, when foreign employment does not replace national employment. However, for host countries and regions, the location decision of MNCs is also important, as FDI can boost a host country's prospects for (regional) economic development through effects such as the creation of employment, growth of the capital stock, and the promotion of exports. As the FDI literature on economic geography, international business, and international economics suggests, investments by MNCs are attracted by favorable economic location factors. Moreover, as MNCs expanding internationally into new geographical markets encounter uncertainty, the imitation of past behavior by other MNCs can stimulate investments.

Foreign direct investments (FDI) are long-range investments in a country other than the country in which the foreign direct investor is based. Firms internationalize if the competitive advantages gained from operating abroad are high enough to cover the additional costs and risks that are associated with this action. Following Dunning's OLI paradigm, Brienen *et al.* (2010) argue that firms decide to invest abroad when they have market power, given by the ownership (O) of products or production processes, a location advantage (L) in placing their plant in a foreign country rather than their homeland, and an advantage gained from internationalizing (I) their foreign activities in fully owned subsidiaries rather than carrying them out through market transactions (trade) or networked relationships with other firms (licensing and franchising).

From the perspective of the internal organization of the MNC, FDI can be horizontal and vertical (Barba Navaretti and Venables, 2004, Iammarino and McCann, 2013). Horizontal FDI are investments in which a firm duplicates a number of its own activities abroad that are carried out in the home country. The main trade-off faced by firms for this type of investment is between the increased sales (market access), strategic advantage and lower transportation costs that are gained by operating abroad versus the foregone internal economies of scale and disintegration costs. Vertical FDI are investments in which a firm decides to geographically disperse its activities by function, whereby some of these functions are now carried out abroad. In this case, the main trade-off is between the lower factor costs associated with investing abroad versus the increased trade and disintegration costs. In relation to the distinction between horizontal and vertical FDI, Brienen *et al.* (2010) and Burger *et al.* (2013) distinguish between four reasons of firms to internationalize the production process, which stress the location aspects of FDI.

1. *Foreign-market-seeking FDI.* Firms will supply their goods or services to foreign markets and possibly enhance third markets from this location. In most cases these markets are previously served through exports from the domestic market. This type of FDI is usually a form of horizontal investment, whereby (emerging) markets are served by a local affiliate. Except for market size, accessibility and infrastructure also play a key role.
2. *Efficiency-seeking FDI.* Firms are trying to reduce their costs of production related to labor, machinery and materials. Differences in the costs of production factors across regions can make a firm decide to geographically separate its tasks. These lower production costs abroad are often associated with labor market and trade circumstances —lower wages, taxes and trade costs as well

as the availability of grants and subsidies in a host country—. This type of investment is most often vertical FDI.

3. *Resource-seeking FDI.* The firm invests abroad to procure certain resources at lower costs than those in their original market. In this case, the availability of natural resources, the presence of a good infrastructure (to secure physical supply), and local partners to obtain knowledge and exploit these resources are relevant reasons to place investments abroad.
4. *Strategic asset-seeking FDI.* The firm aims at purchasing assets of foreign firms to foster their long-term strategic objectives, sustaining and advancing the firm's international competitiveness. This FDI category is determined by the requisite of firms to obtain assets and knowledge ranging from specific technological capabilities to management or marketing expertise. This type of investment features both horizontal and vertical FDI.

In short, it can be expected that horizontal FDI will be drawn to locations with good market access, while vertical FDI will be drawn to places with lower factor costs. A distinction in functions of investments (R&D, production, sales, etc.) will be informative as well, as this is closely related to the motivations for their location choice.

Two more important explanations for regional attractiveness (for FDI) should be mentioned for CEE regions. First, good institutions, legal frameworks and trust among citizens and government may be of key importance (Rodríguez-Pose 2013). For practically all regions in CEE countries, the recently developed key indicator of «quality of government» scores particularly low (Charron *et al.,* 2014). Still, variation across regions in CEE countries may pose important attractions to firms (re) locating activities abroad. Second, agglomeration patterns are more polarized in CEE countries compared to West-European countries. CEE country regions also exhibit marked different sectoral structures compared to West-European regions (Van Oort *et al.,* 2014) and FDI seems to foster productivity and vertical spillovers more than in Western European countries (Lipsey, 2006). It is therefore important to test for agglomeration (productivity) magnitudes and composition explicitly.

3. Data and variables

In this article, we concentrate on Greenfield FDI in 49 NUTS-2 regions in 6 CEE countries. Information on Greenfield FDI is provided by the Financial Times fDi Markets database. This project-level data was gathered primarily from publicly available resources such as formal media sources, financial information databases, industry organisations, and publications of companies. Overall, our database comprises 7,284 investments belonging to 3,465 different MNCs in 6 CEE countries (Poland, Czech Republic, Slovakia, Hungary, Romania and Bulgaria) between January 2003 and December 2010[1]. Most Greenfield investments in the CEE countries originated

[1] For 52 investments (0.7%), we were unable to obtain the region in which the investment was made. Hence, these investments were omitted from the database. See Burger *et al.* (2013) for a more elaborate description of the European database on Greenfield investments.

from within the European Union, EFTA (71%) and North America (16%), aiming at low-tech manufacturing (21%), medium-tech manufacturing (19%), and commercial services (17%).

By using Eurostat's taxonomy of metropolitan regions, the NUTS-2 regions were grouped into one of the following three categories (Dijkstra, 2009, Chapman and Valentina, 2012; see Appendix A):

- Capital city regions: NUTS-2 regions around the capital city. In the analysed CEE countries, these capital city regions are also the ones which are best embedded into international markets (Fratesi, 2012).
- Regions with a second-tier city: NUTS-2 regions with at least one second-tier city. Second-tier cities are the largest cities in the country, excluding the capital. In the CEE countries, there is a maximum of 5 second-tier cities per country.
- Other regions: regions with a smaller city and non-metropolitan regions. Smaller city-regions are NUTS-2 regions with at least one urban area of 250,000 inhabitants. These larger urban zones include major cities and are adjoining travel-to-work areas. Non-metropolitan regions are NUTS-2 regions without at least a 250,000 inhabitant urban zone.

Table 1 shows the number of investments in the period 2003-2010 by CEE countries and these three region types. Capital city regions attract by far most investments in all CEE countries. Second tier city regions appear as particularly attractive destinations for foreign investors in Poland.

Table 1. Number of investments (2003-2010) by destination country and region type

	Capital City Region	*Region with Second-Tier City*	*Other Region*
Bulgaria	436 (52.1)	197 (23.6)	203 (24.2)
Czech Republic	429 (41.6)	234 (22.7)	368 (35.7)
Hungary	534 (44.3)	176 (14.6)	495 (41.1)
Poland	528 (27.4)	1075 (55.9)	320 (16.6)
Romania	742 (47.6)	354 (22.7)	462 (29.7)
Slovakia	198 (32.9)	101 (16.8)	303 (50.3)
Total Investments	**2867 (40.1)**	**2137 (29.9)**	**2151 (30.0)**
Number of Regions	7	17	25

Row percentages in parentheses. Other regions are NUTS-2 regions with smaller city or non-metropolitan regions. A taxonomy of regions can be found in Appendix A.

In terms of functions, most investments were made in production plants (43%), business, sales and marketing offices (23%) as well as building and construction (11%). This study focuses on which functions attract FDI, using information about the economic activities pursued by MNCs. These functions can be linked to the quality of the investment made and to the various motivations why MNCs have to invest abroad. Building on earlier research by Defever (2006) and Spies (2010), we group the economic functions into four different categories (see Appendix B): upstream activities (i.e., management, headquarters and R&D), construction and utilities, production plants, and downstream activities (i.e., business services, sales and marketing, support functions, and logistics). Table 2 displays the distribution of the investments across region type. Both upstream activities and services and downstream functions tend to be concentrated in the capital city regions. Production facilities and resource-seeking investments (extraction & energy) are relatively more oriented towards second tier and smaller city regions. Logistics and distribution activities are more evenly spread across the three types of regions.

Table 2. Number of investments (2003-2010) by broad function and region type

	Capital City Region	*Region with Second-Tier City*	*Other Region*
Headquarters	64 (77.1)	10 (12.1)	9 (10.8)
R&D	177 (53.2)	97 (29.1)	59 (17.7)
Construction	487 (58.3)	183 (21.9)	165 (19.8)
Extraction & Energy	67 (28.3)	86 (36.7)	83 (35.0)
Production Plants	486 (16.0)	1146 (37.7)	1410 (46.3)
Business, Sales & Marketing	1157 (70.4)	293 (17.8)	194 (11.8)
Support & Servicing	184 (51.0)	118 (32.7)	59 (16.3)
Logistics & Distribution	245 (39.5)	203 (32.8)	172 (27.7)
Total Investments	**2867 (40.1)**	**2137 (29.9)**	**2151 (30.0)**
Number of Regions	7	17	25

Row percentages in parentheses. Other regions are NUTS-2 regions with smaller city or non-metropolitan regions A taxonomy of regions can be found in Appendix A. A taxonomy of broad functions can be found in Appendix B.

The explanatory variables used in the analysis represent or proxy the motives of foreign firms for investment. Appendix C provides descriptive statistics of the variables used. In the baseline model, only the distinction in capital city regions (reference), second tier city regions and other regions will be used by introducing dummy variables. Multimodal accessibility (by road, air and rail) of regions captures the market accessibility motive of investments. This indicator is highly correlated with other indicators, like market potential and traffic indicators (compare Dogaru *et al.,* 2011). The labour market argument is captured by the wage costs and unemployment rate variables. (Long-term) unemployment may be an (additional) source of cheap labor, but may also reflect an inefficient labour market system where demand does not meet supply (Elhorst, 2003). The strategic assets argument is captured by the number of patents issued in the regions and the share of the working population with a university degree. The resource seeking argument is captured by the share of mining employment in total employment. Finally, the institutional quality index for European regions is a composite measure concerning corruption, impartial public services, and rule of law. This indicator is highly correlated to sub-national levels of socio-economic development and levels of social trust. It is noted in Charron *et al.* (2014) that the indicator is not correlated with the degree of political decentralization (devolution). The degree of agglomeration in regions is captured by the density of capital stock. All investments in a certain year (2003-2010) are linked to time corresponding indicators. Appendix D provides a correlation matrix of all explanatory variables used, showing that multicollinearity is a limited problem in our analyses.

4. The model

Location choices of multinational corporations are often modeled using discrete choice models (see Crozet *et al.,* 2004; Head and Mayer, 2004; Defever, 2006; Basile *et al.,* 2008 and Schmidheiny and Brülhart, 2011). Probably the most often discrete choice model used is the conditional logit (McFadden, 1974). In our context, this model assumes that each multinational investing in CEE countries is faced with a set of alternative investment regions for the location of its establishment abroad, with each multinational comparing relevant location attributes. Accordingly, each location decision is considered to be the outcome of a discrete choice among a set of alternatives, where it is assumed that a utility-maximizing firm will choose to locate its subsidiary in a region if this decision maximizes the expected future profits from its investment (Long, 1997).

The conditional logit model is subject to restrictive assumptions regarding the substitution patterns across alternative investment locations. This is better known as the independence of irrelevant alternatives (IIA) and violation of this assumption is common to datasets with a large number of alternatives. Not accounting for the violation of the IIA assumption can result in inconsistent and biased estimates. Accordingly, we use a mixed logit estimation, allowing for random taste variation and unrestricted substitution patterns in the discrete choice model (see Defever, 2006 and Basile *et al.,* 2008 for similar empirical strategies in the context of location decision of multinational corporations).

Table 3 presents the outcomes of our models. Among the random terms of the coefficients, a number of variables show significant variation, indicating that the multinational firms tend to value the different location characteristics not uniformly in their location decision. As indicatively suggested by the typology of functions (Table 2 and Appendix B) and the typology of motivations for investment, this is related to the functional division of labor in capital city regions versus that in other types of regions. In column (1), outcomes of a baseline model are presented, where the only explanatory variables are the division of regions containing capital cities, second-tier cities and other regions. The capital city region category is taken as reference.

Table 3. Mixed Logit Estimates for Location Choices of Multinationals in CEE Regions (2003-2010)

	(1) Baseline	*(2) + Market Accessibility*	*(3) +Labor Costs*	*(4) +Strategic Assets*	*(5) + Presence Resources*	*(6) + Institutional Quality and Agglomeration*	*(7) Full Specification*
Region type							
— Capital city region	•	•	•	•	•	•	•
— Region with second-tier city	–1.417 (0.057)***	–0.404 (0.088)***	–1.388 (0.067)***	–0.265 (0.091)***	–1.682 (0.057)***	–0.836 (0.070)***	0.204 (0.091)**
— Other region	–1.946 (0.064)***	–0.670 (0.082)***	–1.837 (0.073)***	–0.345 (0.091)***	–2.100 (0.062)***	–1.327 (0.083)***	0.009 (0.115)
Ln multimodal accessibility		1.593 (0.083)***					1.056 (0.098)***
Ln unit wage costs			–0.903 (0.230)***				–0.098 (0.245)
Long-term unemployment rate			–0.023 (0.012)**				–0.027 (0.012)**
Ln number of patents				0.454 (0.030)***			0.378 (0.033)***
University degree rate				0.044 (0.005)***			0.022 (0.008)***
Share mining					0.155 (0.013)***		0.101 (0.014)***
Institutional quality						–0.075 (0.067)	0.130 (0.069)*
Ln capital stock density						0.238 (0.024)***	0.075 (0.034)**
Random Parts Coefficients							
— Capital city region	•	•	•	•	•	•	•
— Region with second-tier city	1.223 (0.109)***	1.209 (0.137)***	1.101 (0.146)***	0.849 (0.148)***	1.258 (0.103)***	0.980 (0.158)***	0.543 (0.136)***
— Other region	1.615 (0.108)***	1.532 (0.160)***	1.696 (0.135)***	0.988 (0.225)***	1.638 (0.117)***	1.673 (0.210)***	1.082 (0.187)***
Ln multimodal accessibility		0.475 (0.135)***					0.669 (0.135)***
Ln unit wage costs			1.750 (0.494)***				2.352 (0.305)***

Long-term unemployment rate			0.109 (0.025)***				0.101 (0.023)***
Ln number of patents				0.179 (0.068)***			0.224 (0.048)***
University degree rate				0.073 (0.008)***			0.073 (0.009)***
Institutional quality						0.489 (0.093)***	0.780 (0.066)***
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Number of Observations	350,595	350,595	350,595	350,595	350,595	350,595	350,595
Number of Investment Decisions	7,155	7,155	7,155	7,155	7,155	7,155	7,155
Number of Alternatives	49	49	49	49	49	49	49
Wald Chi-Square	1,181	1,440	992	1,005	1,616	814	955

Robust standard errors in parentheses. Error terms are clustered by parent firm *** $p < 0.01$; ** $p < 0.05$, * $p < 0.10$. • = Reference category. Only significant random components of the coefficients are reported.

Both regions with second-tier cities and other cities receive significant and substantially less foreign investments than capital city regions, confirming earlier research by Dogaru *et al.* (2014). The second model presented in column (2) introduces multimodal accessibility of regions as an indicator of the market access reason of foreign investments. Better accessibility is associated with more foreign investments, as the coefficient is highly significant.

Market access (foreign market seeking motivation) is a major reason for investments. Controlled for market access, which is high in the capital city regions, second-tier and other types of regions still receive significantly less investments than capital city regions. The third model in Table 3 introduces labour costs (efficiency seeking) as a motive for investments, proxied by wages and unemployment levels. High wages are negatively related to foreign investments in regions in CEE-countries. Second-tier and smaller urban regions, in particular, have such cost advantages (Dogaru *et al.,* 2014). Controlling for cost advantages, non-capital city regions receive significant less investments than capital city regions. Other advantages of capital regions therefore have to be explored as well. Higher (long-term) unemployment rates attracts less foreign investments. The inefficient labour market argument hampering the attraction of FDI appears more important than the potential (and additional) cheap labour argument. In column (4) in Table 3, the strategic asset motivation for investments is tested. Measured by a larger share of higher educated workforce and the number of patents, it turns out that this argument is a very important explanation for investments in the capital regions compared to regions with second-tier cities and other regions. The variable is highly significant and positive: high scores on these indicators are associated with higher investment levels. Still, after controlling for this motive, second-tier city-regions and other regions receive fewer investments. Model (5) tests for the resource seeking argument —measured as location factor by the share of mining in the regional labour force—. A high share of mining is significantly correlated with more foreign investments, confirming the resource motivation hypothesis. Again, controlled for this, the regions with second-tier cities and the smaller urban regions receive less investment than capital regions.

Having confirmed all four hypothesized motivations for foreign investments in our CEE-setting, we also tested for institutional quality and agglomeration (model 6 in Table 3). Institutional quality did not come out as an individual significant (positive or negative) driving force. Agglomeration (measured by capital stock), does. Economic mass is thus important and probably instrumental for other motives for investments, like market access and strategic asset seeking. In column (7) of Table 3 we present a model in which all explanatory variables are introduced simultaneously. Now, the wage variable is not significantly attached to (less) investments anymore, indicating the little importance of the efficiency seeking argument of investments compared to other motives. All other motivation-based indicators remain significant and of the hypothesized sign. Remarkably, the good-institutions variable becomes significant now in explaining investment attraction: better institutions are associated with more investments.

Controlled for all these factors, model (7) shows that regions with second-tier cities receive relatively *more* investments than capital city regions. Once controlled for all hypothesized motivations, we can remark that smaller urban regions do not receive more investments. In line with ESPON (2012), Breuss *et al.* (2010) and Scherpenzeel (2010), we are inclined to hypothesize that subsidies and region-specific economic and cohesion programmes may be responsible for this favourable outcome for second-tier city regions. It may well be that for future investment potentials, such subsidies and programmes in second-tier city regions should be connected more to several of the motivation factors distinguished in our analyses simultaneously. This may be a severe task, as our models clearly indicate that capital cities and capital city-regions score high on those indicators that attract most investments (market seeking) and the potentially most productive and innovative ones (strategic asset seeking). A simultaneous improvement of critical mass, accessibility (market potential), and strategic asset concentration (universities, R&D) may be too much to demand from second-tier urban regions.

Because FDI is argued to be one of the variables very sensitive to economic shocks (The Economist 2012), the full model 7 in Table 3 is re-estimated for two periods in time: a pre-crisis period (2003-2007) and a (post) crisis period (2008-2010). Table 4 reports the results of this analysis. The general structure of factors influencing locational decisions of multinational investments is similar in both periods. Important for our analysis is to notice that controlled for all factors, the position of regions with second-tier cities does not significantly contribute to the attraction of investments. The labour market arguments (wages and unemployment) are insig-

Table 4. Mixed Logit Estimates for Location Choices of Multinationals in CEE Regions by Period

	2003-2007	*2008-2010*
Region type		
— Capital city region	•	•
— Region with second-tier city	0.040 (0.129)	–0.186 (0.149)
— Other region	–0.044 (0.141)	–0.437 (0.166)***
Ln multimodal accessibility	0.989 (0.134)***	0.726 (0.162)***
Ln unit wage costs	–0.641 (0.350)*	–0.266 (0.360)
Long-term unemployment rate	–0.025 (0.012)**	–0.012 (0.034)
Ln number of patents	0.304 (0.033)***	0.416 (0.049)***
University degree rate	0.025 (0.010)***	–0.006 (0.012)
Share mining	0.098 (0.015)***	0.084 (0.024)***
Institutional quality	0.046 (0.078)	0.142 (0.099)
Ln capital stock density	0.068 (0.041)	0.156 (0.055)***

	2003-2007	*2008-2010*
Random Parts Coefficients		
— Capital city region	•	•
— Region with second-tier city	1.091 (0.162)***	
— Other region	1.256 (0.215)***	0.981 (0.166)***
Ln multimodal accessibility		0.490 (0.192)**
Ln unit wage costs		3.074 (0.369)***
Long-term unemployment rate	0.132 (0.017)***	0.145 (0.046)***
University degree rate	0.065 (0.010)***	0.074 (0.012)***
Share mining	0.096 (0.025)***	
Institutional quality	0.713 (0.071)***	
Ln capital stock density		0.124 (0.063)**
Country Fixed Effects	YES	YES
Number of Observations	226,821	123,774
Number of Investment Decisions	4,629	2,526
Number of Alternatives	49	49
Wald Chi-Square	1,218	663

Robust standard errors in parentheses. Error terms are clustered by parent firm *** $p < 0.01$; ** $p < 0.05$, * $p < 0.10$.
• = Reference category Only significant random components of the coefficients are reported.

nificant in the (post) crisis model compared to the pre-crisis period. Agglomeration (measured by capital stock density) is significantly attached to investments in the (post) crisis period, and not in the per-crisis period. Combined, this suggests that economic agglomeration in larger city-regions provides larger opportunities of attracting investments in post-crisis circumstances, arguably due to the concentration of talent and a diversified economy that may mitigate the worse effects of recession (see for this argumentation Clark, 2009, and Cohen, 2012, p. 349).

5. Conclusions and discussion

In this paper we were looking for explanations of foreign direct investments in various types of regions in Central and Eastern European countries. Capital city regions attract by far most investments during 2003-2010, especially investments with motivations for market-seeking and strategic asset seeking. Agglomeration economies are also important, indicating that a critical mass is needed to attract (more) investments. This critical mass may well be instrumental for market-seeking and strategic-asset seeking investments as well. Despite recently suggested advantages of second-tier city regions (less congestion, growth opportunities in niche markets, strategic network connections in value chains, lower costs of living), our findings foresee difficulties in achieving better positions in FDI networks for such cities and regions. As exogenous growth facilitator in regions, FDI «loves agglomeration».

Although agglomeration economies in the capital cities are already developed and their costs (negative externalities) are already high, these cities benefit from the critical size requirement that obviously plays a dominant role in investment decisions. It should be remarked that the capital city regions are a heterogeneous and expanding group themselves. Between 1914 and 2014 there were drastic changes in the number of independent countries in Central and Eastern Europe, implying also a large variation in capital cities. Before 1914 there were five recognized capitals [2], after 1920 this grew to eleven [3], after 1945 it declined to eight again [4], and after 1992 it grew to twenty-one [5]. All differ in size and structure —and not all of them are in the European Union—. In the same vein, second-tier cities differ in structure and sizes. Rotterdam (The Netherlands), Milano (Italy), München (Germany) and Barcelona (Spain) are somewhat at odds in size, agglomeration and functional structure with Timisoara (Romania), Krakow (Poland), Brno (Czech Republic) or Szeged (Hungary). Still, all these cities are marked as second-tier cities (ESPON, 2012). The often suggested functioning of such cities in polycentric urban networks that collective may form a critical mass, is often met with institutional and cognitive barriers between the cities (Davoudi, 2003). For such a strategy to be successful, efforts of local and national governments in working on economic complementarities, infrastructure connections, translocal service provision and a supra-regional strategy is necessary. It requires an adjusted strategy on place-based development, taking into account positions in networks of trade, knowledge and FDI as growth factors both (inter) regionally and (inter) nationally.

In order to create conditions for the economic performance of secondary city regions, strong public interventions are advocated by ESPON (2012), aiming at the creation of integrated, multi-level and participatory governance. These interventions should come, on the one hand, from the cities themselves, and, one the other hand, from the national and European level. Second-tier city regions are supposed to open up their internal structures towards cooperation with other stakeholders, mainly the economic and educational partners (triple Helix). They are also stimulated to open up in territorial sense, towards their surrounding areas, aiming at uniting the functional urban area —economic development needs well organized functional cooperation area to allow agglomeration economies—. The tasks of national governments then is to establish overarching governance reforms to initiate cooperation between local governments within the same urban area and stimulate more regional decentralization: regions with more regional independence in planning would give more power to secondary cities as centres of the regions. However, in CEE countries this decentralization

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[2] Vienna, Belgrade, Bucharest, Sofia, Cetinie (Montenegro).

[3] Vienna, Belgrade, Bucharest, Sofia, Budapest, Warsaw, Prague, Tirana, Tallinn, Riga, Vilnius.

[4] Vienna, Belgrade, Bucharest, Sofia, Budapest, Warsaw, Prague, Tirana.

[5] Vienna, Belgrade, Bucharest, Sofia, Budapest, Warsaw, Prague, Tirana, Tallinn, Riga, Vilnius, Bratislava, Ljubljana, Zagreb, Sarajevo, Podgorica, Pristine, Skopje, Minsk, Kiev, Chisinau.

process has not yet been experienced before at such levels. There is little experience and, more important, institutional and human resources are lacking. In consequence, future decentralization policies should come in well-planned and safe steps in order to avoid unstable public institutional capacity regarding public safety or local healthcare systems especially affecting smaller cities or rural areas within a region.

In the case of the Central East European secondary city regions there is little progress regarding their own efforts and more open and flexible government policies (Parkinson *et al.,* 2014).There is a clear need for more European involvement in redirecting financing to secondary city regions. In this view, cohesion policy should partly shift its emphasis from compensating for deficient regional growth to encouraging secondary growth centres. Additionally, EU guidelines should emphasize the importance of more decentralized regional development.

Our research outcomes confirm that a positive development of second-tier city regions in Europe is not as straightforward as recently suggested. Second-tier city regions do not have an overall central position in networks of foreign direct investment —an important (exogenous) development factor of regions and cities—. Given the simultaneously needed critical mass, knowledge endowments and physical accessibility, especially in post-crisis investment trajectories of multinationals, a networked FDI based development will be difficult. Presently, second-tier city regions, and even some of the smaller CEE capital city regions, are not capable of offering all these factors simultaneously in sufficient quantities. For improving their opportunities and contribution to European cohesion and convergence, more substantial and directed investments are needed. Without these, the suggested competitiveness opportunities of second-tier city regions are difficult to obtain.

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Appendix A. Taxonomy of regions

NUTS-code	*Region Type*	*NUTS-code*	*Region Type*
BG31	Other Region	PL31	Other Region
BG32	Other Region	PL32	Other Region
BG33	Region with Second-Tier City	PL33	Other Region
BG34	Other Region	PL34	Other Region
BG41	Capital City Region	PL41	Region with Second-Tier City
BG42	Region with Second-Tier City	PL42	Other Region
CZ01	Capital City Region	PL43	Other Region
CZ02*	Capital City Region	PL51	Region with Second-Tier City
CZ03	Other Region	PL52	Other Region
CZ04	Other Region	PL61	Other Region
CZ05	Other Region	PL62	Other Region
CZ06	Region with Second-Tier City	PL63	Region with Second-Tier City
CZ07	Other Region	RO11	Region with Second-Tier City
CZ08	Region with Second-Tier City	RO12	Other Region
HU10	Capital City Region	RO21	Region with Second-Tier City
HU21	Other Region	RO22	Region with Second-Tier City
HU22	Other Region	RO31	Other Region
HU23	Other Region	RO32	Capital City Region
HU31	Region with Second-Tier City	RO41	Region with Second-Tier City
HU32	Region with Second-Tier City	RO42	Other Region
HU33	Other Region	SK01	Capital City Region
PL11	Region with Second-Tier City	SK02	Other Region
PL12	Capital City Region	SK03	Other Region
PL21	Region with Second-Tier City	SK04	Region with Second-Tier City
PL22	Region with Second-Tier City		

* Constitutes travel-to-work area of Prague (CZ01)

Appendix B. Taxonomy of investments by broad functions

Category	*Functions*
Headquarters	Headquarters
R&D	Design, Development, and Testing Education and Training Research and Development
Construction	Construction ICT and Internet Infrastructure
Extraction & Energy	Extraction Energy
Production Plants	Manufacturing
Business, Sales & Marketing	Business Services Sales, Marketing, and Support
Support & Servicing	Customer Contact Centres Maintenance & Servicing Shared Service Centres Technical Support Centres
Logistics & Distribution	Logistics, Distribution and Transportation Retail

Appendix C. Descriptive statistics of variables included in the regressions

Name	*Description*	*Mean*	*SD*
Region with second-tier city dummy	Takes value 1 if region with second-tier city. Classification based on Dijkstra (2009).	0.35	0.48
Other region dummy	Takes value 1 if region is not capital city region or region with second-tier city. Classification based on Dijkstra (2009).	0.51	0.50
Ln multimodal accessibility	Natural logarithm of number of people that can potentially be accessed by air, rail, and road. Obtained from Spiekermann and Wegener (2006).	16.60	0.40
Ln unit wage costs	Natural logarithm of regional wage costs divided by regional gross value added. Obtained from Cambridge Econometrics.	0.54	0.22
Long-term unemployment rate	Long-term unemployment rate in a region. Obtained from Eurostat.	5.14	3.33
Ln number of patents	Natural logarithm of number of patent applications. Obtained from Eurostat.	1.62	0.98
University degree rate	Percentage of the workforce between 25 and 64 with tertiary (ISCED 5-6) education. Obtained from Eurostat.	19.10	6.53
Share mining	Employment in mining and utilities as percentage of total employment. Obtained from Cambridge Econometrics.	2.62	1.38
Institutional quality	Institutional quality index for European regions by Charron *et al.* (2014).	–1.01	0.62
Ln capital stock density	Natural logarithm of (capital stock / total area in km^2). Obtained from Cambridge Econometrics.	0.51	1.32

Number of observations = 350595. Please note that for all logarithmic transformation we applied an inverse hyperbolic sine transformation (Burbidge *et al.,* 1988) when we had to deal with variables that included observations with zero value.

Appendix D. Correlation table of main variables included in the analyses (N=350595)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
(1) Region with second-tier city	1.00									
(2) Other region dummy	–0.74	1.00								
(3) Ln multimodal accessibility	–0.14	–0.35	1.00							
(4) Ln unit wage costs	0.04	0.07	–0.25	1.00						
(5) Long-term unemployment rate	0.13	0.09	–0.19	0.45	1.00					
(6) Ln number of patents	–0.02	–0.32	0.72	–0.29	–0.16	1.00				
(7) University degree rate	–0.13	–0.27	0.43	0.20	–0.10	0.47	1.00			
(8) Share mining	0.23	–0.04	–0.15	0.07	0.16	–0.33	–0.35	1.00		
(9) Institutional quality	0.04	0.06	0.23	–0.23	0.01	0.43	0.02	–0.41	1.00	
(10) Ln capital density	–0.11	–0.29	0.81	–0.34	–0.18	0.75	0.49	–0.26	0.35	1.00

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Section ARTICLES

The European Cohesion policy and the promotion of entrepreneurship. The case of Andalusia

Isidoro Romero*, José Fernández-Serrano**

ABSTRACT: This paper discusses the significance, trends and achievements of the entrepreneurship and small and medium-sized enterprise policy in Andalusia developed with the support of the European Regional Development Fund (ERDF). The lack of entrepreneurial culture and business environment conditions unfavourable to entrepreneurship have traditionally acted as structural obstacles to regional development in Andalusia. In order to face this problem, the role of the entrepreneurship policy within the strategy for regional development has increased over the programming periods of the European Cohesion policy. This article proposes some recommendations for a more effective and efficient design of the Cohesion policy in this field drawing on the analysis of the experience of Andalusia.

JEL Classification: R11; R58; L26.

Keywords: Cohesion policy; ERDF; entrepreneurship; regional development; Andalusia.

La política europea de Cohesión y la promoción del emprendimiento. El caso de Andalucía

RESUMEN: Este trabajo tiene como objetivo discutir el sentido, las tendencias y los logros de las iniciativas de fomento de la actividad emprendedora y de la PYME en Andalucía desarrolladas con el apoyo del Fondo Europeo de Desarrollo Regional (FEDER). La falta de cultura emprendedora, junto a las condiciones desfavorables del entorno empresarial, han representado tradicionalmente obstáculos estructurales para el desarrollo regional. Para afrontar ese problema, el papel de la política de fomento empresarial en el marco de la estrategia andaluza para el desarrollo regional se ha incrementado a lo largo de los sucesivos periodos de programación de la política europea de Cohesión. El artículo presenta algunas re-

* Departamento de Economía Aplicada I. Universidad de Sevilla. Facultad de CC. Económicas y Empresariales. Av. Ramón y Cajal, 1, 41018, Sevilla, *isidoro@us.es.*
** Departamento de Economía Aplicada I. Universidad de Sevilla.

Received: 29 january 2014 / Accepted: 28 july 2014.

comendaciones para un diseño más eficaz y eficiente de la política de Cohesión en este ámbito basadas en la experiencia de Andalucía.

Clasificación JEL: R11; R58; L26.

Palabras clave: Política de Cohesión; FEDER; emprendimiento; desarrollo regional; Andalucía.

1. Introduction

The Cohesion policy is one of the most important European Union (EU) policies and also one of the most controversial. Thus, a debate exists about its effectiveness to foster regional development and achieve the convergence of regional economies (see, for instance, Rodríguez-Pose and Fratesi, 2004; Ramajo *et al.*, 2008; Sosvilla-Rivero and Herce, 2008; Villaverde and Maza, 2010; Rodríguez-Pose and Novak, 2013). The discussion on the role and significance of regional development policies, along with the changes experienced by the European regions in the last two decades, have led to re-thinking regional policies in the EU. As a result, the design, implementation and evaluation of the EU Cohesion policy have undergone fundamental changes in recent times (Bachtler and Wrenb, 2006; McCann and Ortega-Argilés, 2013).

One of the principles that inspire the EU Cohesion policy post-2013 is the requirement for all regions to develop a «smart specialisation» strategy. This notion is based on the idea that economic growth relies on innovation, entrepreneurship and risk-taking. Therefore, policy action should build these conditions and favour them as a way of stimulating the adoption, embodiment, and adaptation of new technologies (McCann and Ortega-Argilés, 2013).

In the last decades the European institutions have been implementing an Enterprise policy to tackle the significant deficiencies in entrepreneurship observed in EU countries and regions, especially in comparison to other economies, such as the USA (European Commission, 2003 and 2013; Leibovitz, 2003; Romero and Fernández-Serrano, 2005). In this context, Cohesion policy instruments have also been employed with an increasing commitment to promote entrepreneurial activity in the EU member states.

This paper explores the relationship between these two lines of European policy intervention, considering the role of entrepreneurship promotion as a strategic dimension within the Cohesion policy that might contribute to increasing its effectiveness. From this perspective, the paper analyses the experience of the European Regional Development Fund (ERDF) in Andalusia (Spain) in the period 1989-2013. The article is based on the study case for Andalusia (Faíña *et al.*, 2013), within the project «Evaluation of the main achievements of Cohesion policy programmes and projects over the long term in 15 selected regions (from the 1989-1993 programming period to the present)»[1].

[1] This project was commanded by the European Commission and coordinated by the London School of Economics and the European Policies Research Centre of the University of Strathclyde. See Bachtler *et al.* (2013) for the overall conclusions.

The particular aim of this paper is to assess the role that entrepreneurship promotion has played within the ERDF strategy in Andalusia and get closer to the possible results obtained. Andalusia represents an interesting case study in this respect, since it is a comparatively low-income region in the European and Spanish contexts that traditionally suffers from a lack of entrepreneurial culture and a fragile business structure.

For the purposes of this paper, entrepreneurship policy is defined from a broad perspective including the actions aiming at:

a) Stimulating the emergence of entrepreneurs and firm creation.
b) Supporting an entrepreneurial orientation in small and medium-sized enterprises (SMEs) materialised in risk-taking, innovation, access to external markets or firm growth and, therefore, improving the «entrepreneurial quality» of the SME sector (Fernández-Serrano and Romero, 2013).

Though over the last four decades multiple initiatives in this policy field have been developed in Andalusia and implemented as part of national, regional and local programmes (Marchese and Potter, 2011), this paper will only consider the interventions within the ERDF framework.

The following section presents the rationale of the regional development strategy in Andalusia supported by the ERDF facilities. This section shows the importance given to the different priorities based on the diagnosis of the regional development problems. Section 3 describes the main interventions in the field of entrepreneurship policy undertaken within the ERDF framework over the successive programming periods. Section 4 assesses the results which might have been derived from these actions based on the evolution of different entrepreneurship indicators. Section 3 and 4 are based on the analysis of the ERDF programmes, planning documents and evaluations, on complementary information from the Directorate General for Planning and European Funds of the regional administration of Andalusia, on the views of experts interviewed and other statistical sources (see Faíña *et al.*, 2013: 136-139). Next, Section 5 draws some lessons from the Andalusian experience regarding the entrepreneurship promotion within the ERDF framework and the possible implications for the design of the Cohesion policy.

2. The role of entrepreneurship policy within the ERDF regional strategy in Andalusia

From the 1989-93 programming period to the 2007-13 period the total expenditure of ERDF and Cohesion funds in Andalusia was 26,869.4 million Euros (at a constant 2000 value) (Faíña *et al*., 2013)[2]. This substantial financial support received by Andalusia from European institutions —as an Objective 1 region, later Convergence region— has contributed significantly to regional growth and development over the last 25 years (Marchante and Sánchez-Maldonado, 2005; Lima and Cardenete, 2008; Sosvilla, 2009). Cohesion policy has favoured the process of convergence of the An-

[2] The initial allocations are computed for the 2007-13 programing period.

dalusian economy with the European Union standards. Thus, in 2011 the Gross Domestic Product (GDP) per capita (in PPS) of Andalusia reached 62.67 per cent of the EU-15 average while it was only 47.28 per cent in 1989.

In the late 1980s, Andalusia, a peripheral region in the Southern extreme of Europe, suffered from severe deficiencies in transport infrastructure. Communication networks with the rest of Spain were poor and the region was deeply disjointed internally. Furthermore, important deficits existed regarding environmental infrastructure, especially associated with water supply, distribution and purification (Zaragoza, 1991; Junta de Andalucía, 2007).

The region also had important weaknesses regarding human capital resources (Requena and Cantón, 2007). In addition, the lack of an entrepreneurial culture and business environment conditions unfavourable to entrepreneurship historically acted as major obstacles to regional development. As a result of this, the small average business size and the underinvestment in research, technological development and innovation (RTDI) have always been important deficiencies of this regional economy (Junta de Andalucía, 2000; Marchese and Potter, 2011). These factors have also conditioned the regional specialisation in light industries, distribution and commercial services, agriculture and tourism, that is, in general terms, activities of relatively low value-added (Guzmán *et al.*, 2000; Antúnez and Sanjuan, 2008; Marchese and Potter, 2011).

Today, a large part of these needs have been met. Andalusia has transport infrastructures comparable to those in many regions of the most developed European countries and the achievements in the field of environmental infrastructures have also been very significant (Faíña *et al*., 2013). However, in the field of entrepreneurship, innovation and competitiveness, though some improvement has been observed, the results are more debatable.

The analysis of the programmes and the ERDF expenditure (see Table 1) reveals that, among all the important needs of Andalusia at the end of the 1980s, the regional development strategy focused on increasing the connectivity of the territory and facilitating access to other markets. This strategy aimed at mitigating the peripheral situation of the region and achieving economic growth through large investments in transport infrastructure projects[3].

From this perspective, the deficiencies in the transport infrastructure were the main obstacle to regional development in Andalusia. Once the infrastructure bottlenecks were resolved, other important needs related to improving human capital, fostering entrepreneurship and stimulating RTDI or internationalisation could be addressed more effectively. In this way, the achievements in accessibility and internal connectivity led to a lesser emphasis on investment in transport infrastructure, though this remained a high priority over successive periods. In this way, the ERDF strategy evolved towards competitiveness, entrepreneurship and innovation in later programming periods. This has been a common pattern in other less developed regions in the

[3] Projects such as the A92 motorway connecting Sevilla-Granada-Almería or the first high-speed train line —AVE— connecting Sevilla-Córdoba-Madrid are representative examples of this aim in the initial programming periods.

framework of the European Cohesion policy (European Commission, 2014). Environmental infrastructure and reforestation was the second most important priority in Andalusia, also remaining constant over the programming periods (Junta de Andalucía, 2007 and 2012; Faíña *et al.*, 2013).

Consequently, the strategy became more complex over successive programming periods and was enriched with other objectives and interventions in the field of social infrastructure (education and healthcare), as well as tourism infrastructure. This strategic evolution was reinforced especially from 2000-06 onwards. In the 2000-06 period, competitiveness, the knowledge economy and innovation became priorities and the 2007-13 programme consolidated these new priorities in accordance with the new Strategy for the Competitiveness of Andalusia (Junta de Andalucía, 2007) and the objectives of the Lisbon Strategy and the National Reform Plan of Spain.

This evolution in the strategy brought a change in the distribution of expenditure according to the eight thematic axes shown in Table 1. As pointed out in the introduction, the broad field of entrepreneurship and enterprise policy includes a wide range of interventions directly oriented to fostering business creation and business development (firm survival and growth, internationalisation and innovation). These interventions can naturally be associated with the following three thematic axes in Table 1: Enterprise (1), Structural Adjustment (2) and Innovation (3). The expenditure in these axes represents a reasonable approximation regarding the magnitude of entrepreneurship policy actions implemented with ERDF support, based on the information available[4]. The last two columns in Table 1 show the aggregate expenditure in these areas as percentages of the overall funds.

As can be observed, the main priorities remain infrastructure and environmental sustainability, even in the last programming periods. The regional strategy also paid especial attention to the needs regarding social and spatial cohesion, through investment in education, health and other social services.

The allocations and expenditure in the entrepreneurship and enterprise field of intervention grew over the programming periods[5]. The share of the ERDF programmes in the Community Support Framework (CSF) allotted to the enterprise and structural adjustment axes in the 2007-13 period (allocations) almost doubled the share in the programming 1989-93 period (expenditure). Moreover, when this comparison is made considering the previous two axes together with that of innovation, the share more than tripled.

[4] Some interventions within these three categories were not oriented to promoting entrepreneurship and supporting SMEs' development. The Structural Adjustment axis includes some incentives for the location of large companies in the region, particularly, in specific problematic areas. Furthermore, the Innovation axis includes interventions in the public innovation system (public universities and research centres), which cannot be considered as part of the entrepreneurship policy either. However, some ERDF interventions in other axes could have also contributed to improving the entrepreneurial capabilities, for instance, the investments in educational infrastructures (secondary education, professional training and universities).

[5] Data on «expenditure» for the 2007-13 programme is provisional. Consequently, it does not allow for an accurate comparison with previous periods.

Table 1. ERDF funds by thematic axes in Andalusia in percentages

Axes	*1989-1993*	*1994-1999*			*2000-2006*			*2007-2013*			
	CSF Total Exp	ROP Alloc	ROP Exp	CSF Total Exp	ROP Alloc	ROP Exp	CSF Total Exp	ROP Alloc	ROP Exp	CSF Total Alloc	CSF Total Exp (*)
1	0.8%	1.4%	2.1%	1.8%	4.8%	4.7%	4.1%	1.7%	0.9%	1.2%	0.9%
2	9.0%	4.9%	10.7%	11.4%	5.6%	8.1%	11.5%	20.9%	17.1%	14.8%	15.9%
3	1.8%	3.9%	2.2%	1.7%	3.2%	3.1%	6.8%	4.4%	2.6%	18.5%	2.4%
4	12.6%	26.5%	32.7%	37.0%	28.9%	24.3%	24.2%	29.4%	19.5%	21.2%	18.5%
5	1.4%	3.6%	4.5%	3.6%	3.2%	2.6%	2.1%	3.2%	2.7%	2.3%	2.5%
6	1.1%	2.9%	2.5%	2.0%	2.8%	2.5%	3.0%	8.7%	6.2%	6.1%	5.8%
7	73.1%	56.4%	44.9%	42.3%	51.3%	54.4%	48.1%	31.0%	50.5%	35.5%	53.6%
8	0.2%	0.3%	0.4%	0.3%	0.3%	0.3%	0.2%	0.6%	0.5%	0.4%	0.5%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1+2	***9.8%***	*6.3%*	*12.8%*	*13.2%*	*10.4%*	*12.8%*	*15.6%*	*22.6%*	*18.0%*	***16.0%***	*16.8%*
1+2+3	***11.6%***	*10.2%*	*15.0%*	*14.9%*	*13.6%*	*15.9%*	*22.4%*	*27.0%*	*20.6%*	***34.5%***	*19.2%*

Source: Re-elaborated from Faíña *et al*. (2013) based on the ERDF expenditure table and complementary information from DG for the Planning and European Funds of Andalucía.

1. Enterprise, 2. Structural Adjustment, 3. Innovation, 4. Environmental Sustainability, 5. Labour Market, 6. Social Cohesion, 7. Infrastructure and Spatial Distribution of Economic Activity, 8. Unspecified. CSF: ERDF programmes in the Community Support Framework. ROP: Regional Operational Programmes. Alloc: allocations. Exp: expenditure. (*) Provisional data.

The table shows the expenditure and allocation in the initiatives within Regional Operational Programmes (ROP) and the overall expenditure and allocation in all the ERDF programmes in the CSF. In this respect, it is convenient to point out that the increase in the expenditure and allocation in the three entrepreneurship-related axes is more intense when all the ERDF programmes in the CSF are taken into account. This is due to some national programmes (i.e., regional incentives, the knowledge economy and the technological fund), in which Andalusia has had a high participation, but which were not part of the ROP. In this respect, the evolution in the regional strategy cannot be seen exclusively as the result of a change in the regional policy of Andalusia. It was also driven by the changes in the national and European Cohesion strategy.

3. Entrepreneurship policy interventions in Andalusia within the ERDF framework

The Andalusian strategy in the field of the entrepreneurship and enterprise policy has been oriented to four objectives: *a)* Providing financial support for firm creation and development; *b)* Improving entrepreneurial capabilities and providing consultancy services; *c)* Fostering entrepreneurial culture and d) Improving the business environment.

The ERDF interventions have mainly been concentrated on the first category. However, investments in educational infrastructures (secondary education, professional training and universities) with ERDF support could have also contributed to improving the managerial capabilities of potential entrepreneurs. Furthermore, as will be commented upon later, some incentives were implemented with the intervention of ERDF to facilitate the access of SMEs to professional consultancy services. Regarding the promotion of entrepreneurial culture, there was an important role played by the European Social Fund (ESF). This supported many actions undertaken by the public foundation «Andalucía Emprende». Finally, the strategy to improve the business environment in Andalusia has been mainly oriented towards the creation of business and technology parks, as special microenvironments particularly favourable for the creation and development of SMEs. The impact of business and technology parks in Europe is controversial. Nevertheless, this instrument seems to have better results in less developed countries than in highly-developed ones and the experience with them in Spain has been assessed in positive terms (Romera, 2003; Barge-Gil *et al.*, 2011).

The actions implemented gained in complexity throughout the different programme periods, broadening the range of project types and using a wider range of intervention tools. In spite of classical regional incentives being used since the initial 1989-93 programming period as a mechanism to support structural adjustment, different types of actions backing the creation, expansion and modernisation of enterprises increased in importance over the periods. The implementation of this strategic change towards enterprise and innovation benefited from the application of new financial instruments in the last programming periods. JEREMIE and JESSICA funds were introduced in the 2007-13 period, providing a more efficient design of the incentive system. Moreover, RDTI were reinforced in the last programming periods through the support of research projects and infrastructure in universities, enabling the transfer of technology, knowledge and applied research.

Next, the main ERDF interventions in this field will be presented following the three main axes differentiated in the previous section: Enterprise Development, Structural Adjustment and Innovation.

3.1. Enterprise Development

Business development initiatives[6] have been implemented by the regional government and the intermediary body in charge of managing the Andalusian Global

[6] The regional and multiregional ERDF programmes in Andalusia invested €730.9 million (at a constant 2000 value) in the Enterprise Development axis in the 1989-2011 period, equivalent to circa 3 per cent of the overall expenditure across the study period.

Grant Operational Programme: the Institute for the Economic Promotion of Andalusia (IFA), later renamed Agency for the Innovation and Development of Andalusia (IDEA). In time, this regional development agency has acquired a central role in the management of business incentives[7].

The interventions in this axis can be classified into four categories:

- Measures to facilitate the access of SMEs to funding. A selection of financial instruments has been used, adapted in each period to the changing financial and economic conditions.
- Provision of business infrastructure, particularly in industrial areas and business parks.
- Actions to facilitate and stimulate the access of SMEs to consulting services and technical expertise. These investments, although of relatively modest amounts, aimed at promoting entrepreneurial culture and increasing the managerial capabilities of SMEs.
- Actions to stimulate and support the internationalisation of Andalusian companies.

Table 2 points out some of the main interventions in Enterprise Development initiatives with ERDF support.

Table 2. Main interventions in the axis of Enterprise Development in Andalusia with ERDF[8 9]

Objectives	*Instruments/interventions*
Facilitating the access of SMEs to funding	1989-93 period: contribution to mutual guarantee societies (€17.85 million) and subsidies for interest rates. 1994-99 period: contribution to mutual guarantee societies (€18.4 million); interest rate bonuses for SME loans (€82.6 million); reimbursable grants (loans) to young entrepreneurs for starting new companies[8]. 2000-06 period: 1,347 warranties, 212 reimbursable grants and 5,266 interest subsidies (€3,340 million, 2.1 per cent of private fixed capital formation in the period)[9]. 2007-13 period: grants to support firm creation, expansion and modernisation; new grants for supporting RTDI and innovative start-ups; JEREMIE fund (€235.7 million).

[7] The incentives for financial instruments were grouped into a single scheme from 2005 onwards. In the 2007-13 programme, the system of business incentives underwent major modifications with the aim of promoting business development and focussing on innovation, as a strategy to achieve a new growth model based on the knowledge economy.

[8] Reported achievements include 151 companies created, with an induced investment of €45.1 million and 920 new jobs (0.14 per cent of private fixed capital formation in the period).

[9] According to the results reported, 17,296 gross jobs were created (0.6 per cent of the employed population) and 133,746 jobs were maintained (4.8 per cent of the employed population).

Table 2. *(Continue)*

Objectives	*Instruments/interventions*
Providing business infrastructure	1989-93 and 1994-99 periods: infrastructure to provide SMEs with training and advisory services; infr. for basic services (telecommunications, electricity, etc.) in industrial areas and business parks. 2000-06 period: business and industrial parks in particular sectors (i.e., metal-mechanical, automotive components, chemicals, furniture)[10].
Facilitating the access of SMEs to consulting services and technical expertise	2000-06 period: promotion of consultancy services in quality management and product design. 2007-13 period: «Cheque Innovación» (subsidy to facilitate and encourage the use of innovation consulting services for SMEs).
Stimulating internationalisation	Support for promotion campaigns, participation in fairs and technical and financial assistance for the internationalisation plans of SMEs by the Trade Promotion Agency of Andalusia (EXTENDA). Programmes by the Spanish Institute for Foreign Trade (ICEX) and the Chambers of Commerce.

Source: Elaborated from Faíña *et al.* (2013).

3.2. Structural Adjustment

Various courses of action have been deployed in the field of Structural Adjustment[11] from classic incentives for private investments in backward areas, to incentives for industrial diversification, tourism development or the technological modernisation of businesses, as presented in Table 3.

Table 3. Main interventions in the axis of Structural Adjustment in Andalusia with ERDF

Objectives	*Instruments/interventions*
Developing backward areas	Incentives for attracting new investments to problematic areas (i.e., «Zonas de Acción Espacial» —ZAE— of Cádiz, Campo de Gibraltar, Jaén, etc.). Projects for industrial development focussed on priority sectors (food industry, electronics industry, ICT, etc.).
Strengthening competitiveness	Incentives for the technological modernisation of firms. Reinforcing supply chains, upgrading production technologies and generating high-value-added products.

[10] An occupancy rate of 81 per cent was achieved for industrial sites. 5,995 jobs created (0.2 per cent of employed population in 2000-2006) with an induced investment of €18.5 million.

[11] The ERDF programmes — regional and multiregional — invested €3,310.5 million in the theme of Structural Adjustment up to the end of 2011, equivalent to approximately 11 per cent of overall expenditure in the 1989-2011 period.

Table 3. *(Continue)*

Objectives	*Instruments/interventions*
Fostering productive diversification	Incentives for industrial diversification. Incentives for tourism development. Creation of a brand image for Andalusia. Tourism diversification developing new forms of tourism different from «sun and sand» type, especially in inland and rural areas.

Source: Elaborated from Faíña *et al.* (2013).

3.3. Innovation

The actions in the Innovation axis have grown in financial importance over the programme periods and innovation has been established as a key strategic priority for the improvement and enhancement of business competitiveness in Andalusia [12].

The innovation strategy was oriented to promote and coordinate the regional innovation system. Three lines of action were developed with the aid of ERDF funding:

— Support of research projects and equipment endowment programmes, mostly in the public sector.
— Fostering knowledge and technology transfer and supporting applied research in sectors with a strong presence in Andalusia and other emerging sectors.
— Promotion of information and communication technologies (ICT).

Despite the ERDF emphasis given to RTDI in the later programming periods, the achievements stemmed mostly from the public sector, reflecting the lack of private sector capabilities. Nevertheless, different actions can be pointed out that directly targeted business innovation, as shown in Table 4.

Table 4. Main interventions in the axis of Innovation in Andalusia with ERDF

Objectives	*Instruments/interventions*
Supporting applied research and technology transfer	Technology Parks (i.e., Technology Park of Andalusia —PTA—, Scientific and Technological Park Cartuja 93 and Andalusian Aerospace Technology Park —Aerópolis [13]).

[12] The amount of €1,151.3 million was allocated to the priority of Innovation through ERDF programmes up to the end of 2011, approximately equivalent to 4 per cent of total investments across the study period.

[13] In the 1994-99 programme, the introduction of high-tech equipment facilitated manufacturing programmes in aeronautical factories, paving the way for the creation of the Andalusian Aerospace Technology Park (Aerópolis) in Seville in the following period and the consolidation of the aeronautical cluster in Andalusia. Aerópolis started its operations in 2003 and was conceived to support the Andalusian industry for large Airbus projects, e.g., the military transport plane A400M and the manufacture of high-technology components for the Airbus 350.

Table 4. *(Continue)*

Objectives	*Instruments/interventions*
Supporting applied research and technology transfer	Technology centres oriented to traditional and emerging sectors (i.e., Centre for Advanced Aerospace Technologies —CATEC— the Andalusian Centre of Innovation, Information and Communication Technologies (CITIC), and the Andalusian Stone Technology Centre —CTAP). Projects promoted by the Centre for Industrial Technological Development (CDTI), the Offices of Research Results Transfer (OTRIs) of the universities and the Innovation and Technology Transfer Centre of Andalusia (Andalucía CIT).
Promoting information and communication technologies (ICT)	Public contracts with private companies to implement ICT applications and systems for public services in education, health, environmental protection, etc.

Source: Elaborated from Faíña *et al.* (2013).

4. About the overall impact of the ERDF initiatives on entrepreneurial activity in Andalusia

The ERDF interventions described in the previous section had direct effects in terms of start-ups, employment creation, investment, patents or other indicators that are reported as achievements in the ex-post evaluations of the programmes. However, a different issue is to what extent these efforts might have induced a change in the entrepreneurial activity from a macroeconomic perspective, strengthening the entrepreneurship culture and the competitiveness of the SME sector in Andalusia. This section will try to approach this key issue by observing a set of indicators on entrepreneurship and business development in the region[14]. Table 8 presents some summarised results at the end of this section. Due to limitations regarding data availability, most of the analysis will be focused on the 1995-2013 period.

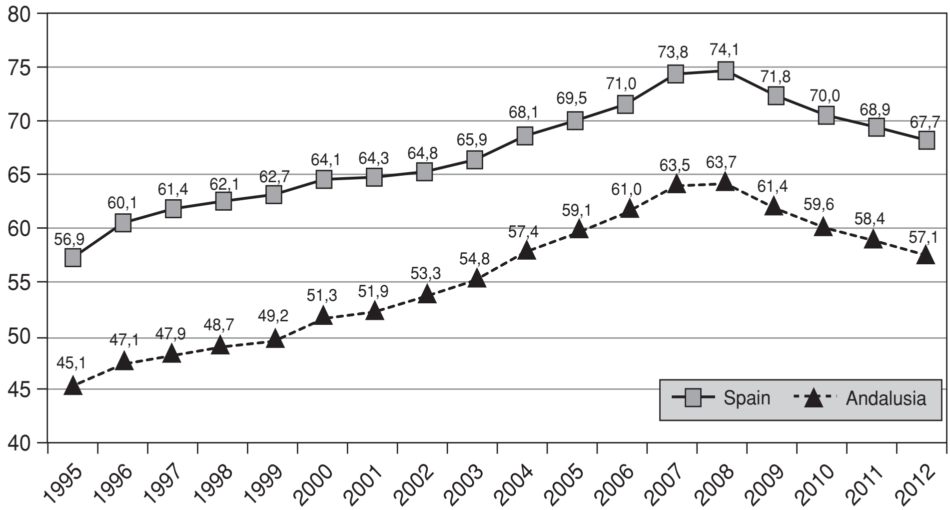
The level of business density in Andalusia has been traditionally among the lowest of the Spanish regions. Nevertheless, as a result of the trends in business demography (birth and mortality), business density —measured as the number of businesses per 1,000 inhabitants— has increased both in Andalusia and the whole of Spain in the last two decades (see Figure 1). The evolution of this indicator has followed the same pattern in both areas according to the business cycle: a steady increase throughout the expansion period (1995-2008) followed by a fall in the current crisis (2009-12).

The overall performance of this indicator in the last decade in the case of Andalusia has brought about a slight catching-up process with respect to the Spanish

[14] It is not possible to establish a direct causal link between the ERDF interventions and the overall changes experienced in these entrepreneurship indicators, since many other factors intervened. Nonetheless, this analysis aims to check whether some changes can be appreciated in the entrepreneurial culture and entrepreneurial orientation of Andalusian SMEs —versus the traditional deficiencies in this area— that could be reasonably and partially attributed to the ERDF programmes.

standards. The business density in Andalusia was 79.2% of the Spanish average in 1995 and reached 86.0% in 2008. In this period, Andalusia reduced its gap with the national average by almost seven percentage points due to an especially intense process of business creation throughout the expansion. This catching-up process has been partially reversed in the 2009-12 period due to the economic crisis. Thus, Andalusian business density fell to 84.3 per cent of the national average in 2012. However, the gap between the Andalusian and national averages decreased by more than five percentage points over the whole period 1995-2012.

Figure 1. Business density (number of business per 1,000 inhabitants)



Source: Elaborated from DIRCE, National Statistics Institute (INE).

Regarding entrepreneurship rates, Andalusia has presented in the last decade figures comparable to the national average. The average rate of Total Entrepreneurial Activity (TEA)[15] in the 2003-12 period has been 6.0 in Andalusia and 6.1 in the whole Spain (data from the Global Entrepreneurship Monitor —GEM— project). Andalusia shows lower rates than Cataluña (6.9) for the period, but higher than the Basque Country (4.8), a region which has traditionally been associated with a sound entrepreneurial culture. Within the current crisis period, Andalusia is indicating a slightly higher entrepreneurial activity than the national average: 5.8 in Andalusia and 5.6 in Spain in the period 2008-12. Moreover, in 2012 Andalusia presents the second highest TEA among all the Spanish regions, only lower than Cataluña. The entrepreneurship rate in Andalusia is higher than

[15] The total early-stage Entrepreneurial Activity (TEA) is defined, within the Global Entrepreneurship Monitor (GEM) project, as the percentage of the 18-64 years-old population who are either a nascent entrepreneur or an owner-manager of a new business.

in the large EU economies (France, Germany or Italy), with the unique exception of the United Kingdom (see Table 5).

Table 5. TEA in the largest Spanish regions and EU economies

	2003	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Andalusia	6.2	6.0	5.7	6.1	7.2	6.7	6.3	4.0	5.8	6.1
Catalonia	7.7	5.6	6.8	8.6	8.4	7.3	6.4	4.0	6.8	7.5
Madrid	—	4.4	6.9	9.3	7.9	8.5	5.1	4.5	5.6	4.4
The Basque country	—	5.3	5.4	5.4	6.4	7.0	3.0	2.5	3.9	4.4
Spain	6.8	5.2	5.7	7.3	7.6	7.0	5.1	4.3	5.8	5.7
Germany	5.2	4.4	5.1	4.2	—	3.8	4.1	4.2	5.6	5.3
France	1.6	6	5.4	4.4	3.2	5.6	4.3	5.8	5.7	5.2
Italy	3.1	4.3	4.9	3.5	5	4.6	3.7	2.4	—	4.3
UK	6.4	6.2	6.2	5.8	5.5	5.9	5.7	6.4	7.3	9

Source: Elaborated from *http://www.gemconsortium.org/key-indicators,* Ruiz *et al.* (2013) and Xavier *et al.* (2013).

This could be partially explained by the current crisis and the extraordinary high unemployment rates —especially severe in Andalusia[16]— as factors causing an increase in the number of new entrepreneurs driven by necessity motives. According to the GEM data, necessity entrepreneurs represent 21.5% of the total number of entrepreneurs in Spain and 25.9% in Andalusia as an average in the 2008-12 period. However, the rate of opportunity entrepreneurship (with respect to the working-age population) in Spain and Andalusia are similar: 4.2 and 4.0 as an average in the 2008-12 period.

In the expansion period of 1999-07, the total number of businesses increased in Andalusia faster than in the whole of Spain (see Table 6). Though a significant number of businesses were oriented to construction in this period, the comparative positive performance of Andalusia within the national framework also applies when the construction sector is excluded.

The current crisis is causing a reduction in the number of registered companies in Andalusia and Spain, which is more intense in the former. However, overall, in the 1999-2013 period the total number of businesses in Andalusia increased by 31.2 per cent versus a rise of 24.9 per cent in the whole of Spain. These data reveal a good performance of Andalusia in terms of business demography. This conclusion is also valid when businesses without employees (self-employment) are excluded (see Table 6).

[16] The unemployment rate in Andalusia was 36.3% versus 26.4% in Spain in 2013 according to the Economically Active Population Survey elaborated by the National Statistics Institute.

Table 6. Evolution of the number of businesses (average annual growth rate)

	Andalusia			*Spain*		
	1999-07	*2008-13*	*1999-13*	*1999-07*	*2008-13*	*1999-13*
Total number of businesses	4.25	–2.04	1.96	3.46	–1.67	1.60
Number of businesses (construction excluded)	3.78	–0.90	1.64	2.96	–0.57	1.37
Number of businesses with at least one employee	5.97	–2.93	2.70	4.41	–2.56	1.87
Number of businesses with at least one employee (construction excluded)	5.60	–1.06	2.78	4.15	–0.96	1.95

Source: Elaborated from DIRCE, INE (2013: data at 01/01/13).

The regional economy has experienced a certain positive structural change in the last two decades, with a slight process of diversification [17] and some emerging sectors (aeronautics, business services and renewable energy). However, the industrial sector (with the exception of energy and construction) remained relatively modest in Andalusia, with its weight reducing from 11 per cent of regional employment and Gross Value Added (GVA) in 1999 to merely 8.8 per cent in 2011 (calculated from the Spanish Regional Accounts elaborated by the National Statistics Institute). Structural adjustment has failed in its attempt to build a sustainable manufacturing sector strong enough to significantly diversify the economic base of Andalusia and reinforce its potential to develop into a growth model focused on innovation and productivity. Diversification has mainly occurred through advances in tourism.

A major structural drawback of the Andalusian economy is the small average business size, leading to a problem of business fragmentation. The Andalusian productive system is characterised by a marked predominance of self-employees and microenterprises and a comparatively low participation of SMEs and large enterprises (see Table 7). In this respect, a positive trend was observed in the last expansion period with a relative decrease in the proportion of firms without employees in favour of micro-enterprises (1 to 9 employees) and a slight increase in the proportion of SMEs.

The crisis has stopped this positive evolution and the proportion of self-employees and microenterprises has increased together with the reduction in the share of SMEs. This is explained by the higher mortality rates observed for SMEs.

Andalusia has been traditionally characterised by its backwardness — in the national and European context — regarding RTDI. In this field, some progress has been

[17] The index of relative specialisation — given by the ratio of the Herfindahl index in the region to the average value of this index across all the Spanish regions — shows a decline in the level of specialisation from 1.26 in the 1985-89 period to 1.11 in 2005-10 (Faíña *et al.*, 2013).

Table 7. Composition of the production system in Andalusia based on firm size (%)

	Andalusia			*Spain*		
	1999	*2009*	*2013*	*1999*	*2009*	*2013*
Without employees	56.97	51.58	52.35	55.11	52.67	53.44
Microenterprises (from 1 to 9 employees)	38.26	43.48	44.02	39.13	41.81	42.22
Small companies (from 10 to 49 employees)	4.21	4.31	3.14	4.97	4.68	3.61
Medium-sized companies (from 50 a 199 employees)	0.48	0.55	0.40	0.64	0.68	0.57
Large companies (200 employees and more)	0.08	0.08	0.09	0.15	0.16	0.16
Total	100	100	100	100	100	100

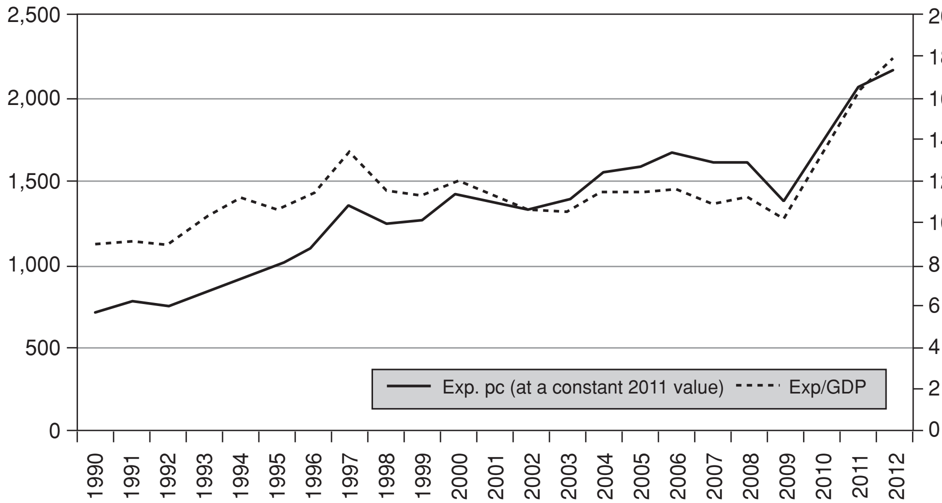
Source: Elaborated from DIRCE, INE.

observed in the last two decades in line with the performance at a national level. However, a clear imbalance can be observed when comparing the innovation activities of the public and private agents. Substantial improvements have been achieved regarding the capacity of the public innovation system, but the actual impact of these actions in the private sector — fostering innovation in businesses — has not been so significant.

Nonetheless, the total internal expenditure on Research and Development (R&D) in businesses increased in Andalusia and Spain from 0.16 and 0.39 per cent of GDP in 1996 to 0.43 and 0.61 per cent in 2010 (calculated based on Eurostat data). The indicator for Andalusia more than doubled in the period considered, which illustrates a great effort by Andalusian companies. This performance allowed for a slight catching-up process with the whole of Spain regarding the business R&D effort (the distance to the Spanish figures has been cut down by 0.05 percentage points). Furthermore, the number of patents applications increased by 373 per cent in Andalusia from an annual average of 12.83 in the 1990-92 period to an average of 60.68 in the 2007-09 period. This increase was slightly greater than the one experienced at a national level, where these averages increased by 364 per cent (Eurostat data).

Furthermore, the strengthening of SMEs in Andalusia is leading to achievements in internationalisation. An increase in the export rate has been observed, moving from 8.8 per cent in 1990 to 17.6 per cent of GDP in 2012. The evolution of the export rate has been affected by the business cycle. Thus, throughout the expansion period in the late 90s and first part of the 2000s the export rate declined due to a growth model orientated towards the domestic demand. However, the Andalusian export ratio has risen very fast since the beginning of the crisis. Moreover, the improvement in the export capacity of the Andalusian companies over time can be more clearly appreciated in the steady increase in the exports per capita which were in 2012 3.1 times larger than in 1990 (see Figure 2).

Figure 2. Andalusian exports of goods
(as percentage of GDP and per capita in thousand constant 2011 euros)



Source: Elaborated from data of the Institute of Statistics and Cartography of Andalusia.

Table 8. Some evidence about the changes in the entrepreneurial activity in Andalusia

Area	*Traditional deficiencies*	*Recent trends and current situation. Evidence/results*
Rate of entrepreneurial activity	Low entrepreneurial activity	TEA around the Spanish averages and higher than in the large economies in the EU (with the exception of the UK).
Type of entrepreneurship. Motivations	Preponderance of necessity entrepreneurship	Overall, similar composition of the total entrepreneurial activity to the whole of Spain. Slightly higher proportion of necessity entrepreneurs.
Business creation	Low business creation	Rates of increase in the number of business significantly higher than in the whole of Spain.
Business density	Low business density	Overall increase in business density (with a procyclical behaviour). Slight reduction in the gap with the values for the whole of Spain.

Table 8. *(Continue)*

Area	*Traditional deficiencies*	*Recent trends and current situation. Evidence/results*
Firm size composition	Excessive preponderance of microenterprises and self-employees (fragmentation). Scarce presence of large companies	Reduction in the proportion of self-employees (without workers). Increase in the proportion of microenterprises. Decrease in the share of SMEs.
Innovation	Low firm innovation	Increase in R&D in the private sector. Slight reduction in the gap with the effort at a national level. Increase in patent applications.
Internationalisation	Low export activity (especially for SMEs)	Overall increase in the export/PIB (with a procyclical behaviour). Steady and persistent increase in exports per capita.

Source: Own elaboration.

5. Analysis and lessons from the case study of Andalusia

The analysis of the Andalusian experience allows for some conclusions to be drawn about the role that entrepreneurship promotion can play in the Cohesion policy framework (see Table 9 for a summary). In this respect, different considerations can be made regarding the strategy definition, the programme design and implementation and the evaluation of the initiatives.

The development strategy in Andalusia focused on increasing the connectivity of the region and facilitating access to other markets through large investments in transport infrastructure. Once the most important infrastructures were constructed, the expected returns of new infrastructural projects declined and some over-capacity may have appeared in particular cases. The strategy evolved in this way over the successive periods, changing the focus of attention towards the field of enterprise and innovation.

This strategic option could have been justified based on recent theoretical developments. In addition to other socio-economic disadvantages, the peripheral position of Andalusia restricted returns from human capital, discouraging investment in education (Redding and Schott, 2003; López-Rodríguez *et al.*, 2007). The deficiencies in internal connectivity also limited the consolidation of an internal regional market with similar effects on the returns of human capital. Therefore, a distortion in the comparative wages of skilled and unskilled workers was induced (decreasing the relative wage of skilled workers), leading to a negative effect on highly-qualified workers. These deficiencies of skilled human capital were a major constraint

Table 9. Some lessons regarding entrepreneurship promotion within the Cohesion policy framework based on the Andalusian experience

Level of intervention	*Considerations*
Strategy	First, improving accessibility. Later, stimulating entrepreneurship and innovation.
	Evolution in the strategy over time: Looking for an optimal timing in the reorientation in priorities.
	Long run policies with a slow maturation process: It is not possible to develop an entrepreneurial culture in the short and medium run.
Programme design/ implementation	Adaptation to the regional socio-cultural environment.
	Convenience of a bottom-up approach and demand analysis.
	Benefits from a more integrated and coordinated approach.
	Preference for reimbursable financial instruments to avoid a subsidy culture.
Evaluation	Necessity of a culture of evaluation of the initiatives.

Source: Own elaboration.

on the development of economic activities oriented towards technology and innovation. In this context, the improvements in accessibility and internal connectivity could help to increase market potential and, therefore, the returns of human capital, stimulating the investment in education and the efforts to foster competitiveness (Faíña *et al*., 2013).

Consequently, the Andalusian strategy could have certainly represented the best possible approach considering the situation of this region at the end of the 1980s. More debatable is whether the change towards priorities in the fields of enterprise and innovation should have been more intense. Nowadays, though some progress has been made in this field as has been shown in Section 4, the main problems of the Andalusian economy are still related to business development, innovation and competitiveness.

In this respect, it is necessary to take into account that for an efficient use of the European Structural and Cohesion instruments it is also necessary for the productive system in a region to have enough absorption capacity. The Andalusian economy is characterised by significant weaknesses in its enterprise culture and business capabilities. Hence, regional companies may have not been prepared to assume a more ambitious enterprise and innovation policy.

One illustrative example of this is the case of the technological centres that have been created across the region to attend to the necessities of local industrial clusters. This initiative aimed at improving the transfer of research results to the business sector and improving the technological capacity of SMEs that had not the financial and human capabilities to assume R&D efforts on their own.

However, a number of centres are experiencing difficulties in consolidating their activities and assuring their viability. Many of the centres are oriented towards sectors and local businesses with a low demand for their technological services. Business owners in Andalusia often assume an unimaginative and unadventurous approach to the management of their companies and are reluctant concerning cooperation initiatives. This entrepreneurial culture poses an important obstacle for innovation along with the excessive presence of micro-enterprises and small firms. As Batterbury (2002) pointed out, a mismatch between the socio-cultural environment and policy design can reduce the effectiveness of public policies that are not adapted to the local conditions.

As a result, these efforts to stimulate innovation in the private sector are facing serious difficulties in their implementation in order to be effective. The key issue is developing a policy design, tailored to the characteristics and demands of the Andalusian business owners and companies, which effectively stimulates business innovation in the short run and contributes to the formation of a real culture of innovation in the long term. Furthermore, the productive specialisation of the Andalusia economy towards tourism and other, generally non-RTDI intensive, sectors constrains the achievements of the region in this area.

Deficiencies in entrepreneurial culture and entrepreneurial dynamism (birth, survival and expansion) have been a major structural drawback in Andalusia. The different actions developed within the ERDF programmes in the field of enterprise, innovation and structural adjustment have contributed to certain observed improvements, mainly in the last two decades. This effect of the Cohesion policy increasing entrepreneurship activity in economically backward regions has also been observed in other studies (see Sternberg, 2012, for Spain and Germany).

However, the entrepreneurial spirit has been historically poor in Andalusia, and significant socio-cultural obstacles make it difficult to obtain rapid and substantial results in this field. The role of education in instilling entrepreneurial attitudes and culture is crucial, but it needs to operate slowly. In this respect, there is another lesson that can be learnt from the Andalusian case: it is not possible to substantially change the entrepreneurial culture in a region with structural deficiencies in the short or medium run. Only in the long run could the actions reverse the situation and stimulate a vibrant entrepreneurial system. This has to be considered when evaluating the results of the programmes implemented.

In addition, in the design of the entrepreneurship policy, it is crucial to take demand considerations into account and to apply a bottom-up approach granting an important role to the private and intermediate agents. The supply side and top-down strategy could be an efficient approach for the development of large infrastructure projects. However, when the goal is stimulating firm creation and development, the primary role of public planning institutions might not lead to desirable results and it is recommendable to establish a more direct and intense dialogue with the intermediate public institutions and private agents on a decentralised basis. The questionable experience of Andalusia with the technology centres, previously presented, can be seen as an illustration of these considerations.

Entrepreneurship policy initiatives would also benefit from a more integrated and coordinated approach to policy design and implementation. This would facilitate the consideration of the complementarities/synergies and trade-offs between the projects supported by funding institutions at different levels (European, national, regional and local) and oriented to different fields of intervention (infrastructure, skills training, innovation and R&D, etc.).

Another lesson from the case of Andalusia is that, when trying to promote a real entrepreneurial culture in a region, the use of grants and subsidies implies the risk of creating a 'subsidy' culture and rent-seeking behaviours. In this respect, the use of reimbursable funds, credit guaranties or loans could have healthier effects for the stimulation of a real entrepreneurial culture.

Finally, it is convenient to develop a sound culture of evaluation of the interventions. Only in this way is it possible to detect best practices and learn from the errors in the design and implementation of the initiatives. Policy evaluation should be a tool for the introduction of corrective actions assuring the efficacy and efficiency of the programmes and interventions. The experience of Andalusia with the European Structural and Cohesion funds reveals that there is important room for improvement in this respect.

6. Conclusion

The relevance of entrepreneurship promotion has increased in the new Cohesion policy framework, which is inspired by the notion of smart specialisation. Regional policies seeking to stimulate a smart specialisation should foster entrepreneurship and technological diversification on the basis of the region's existing skills, technologies, and institutions (McCann and Ortega-Argilés, 2013).

This new approach calls for a better integration of the European Enterprise and Cohesion policies in order to develop an efficient framework to foster economic growth and social and spatial cohesion. In order to achieve this, a more profound theoretical understanding of the significance of entrepreneurship for regional development is needed together with further insights about the practical aspects of policy implementation in this field. In addition, the effectiveness of entrepreneurship promotion within the Cohesion policy framework requires these interventions to be tailored to the specific needs, capabilities and institutions of each region.

In this paper some conclusions have been drawn from the analysis of the experience of Andalusia with the ERDF and its implications from the perspective of the entrepreneurship policy. Though a great heterogeneity exists regarding the entrepreneurial cultures and SME sectors within the EU (Romero and Fernández-Serrano, 2007), some of these lessons could be relevant for other European regions, especially for other Mediterranean economies with similar problems to Andalusia.

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