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Section ARTICLES

Investigaciones Regionales

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

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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

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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).

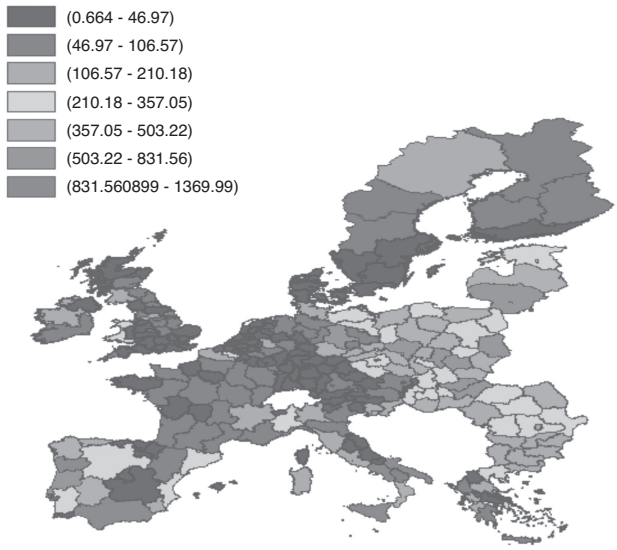
In Europe about 40-60% of the industrial value-added and 50% of all industry employees are engaged in the non-R&D-intensive sector (Rammer *et al.,* 2011, Hirsch-Kreinsen, 2008, Som, 2012). Additionally, more than 50% of all innovating firms in the EU are non-R&D performers (Rammer *et al.,* 2011, Som *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.

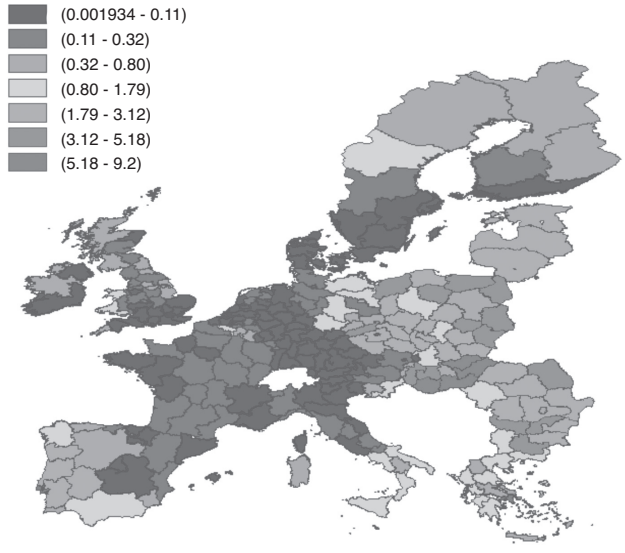
[1] The shares are computed based on 2009 GDP figures.

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.

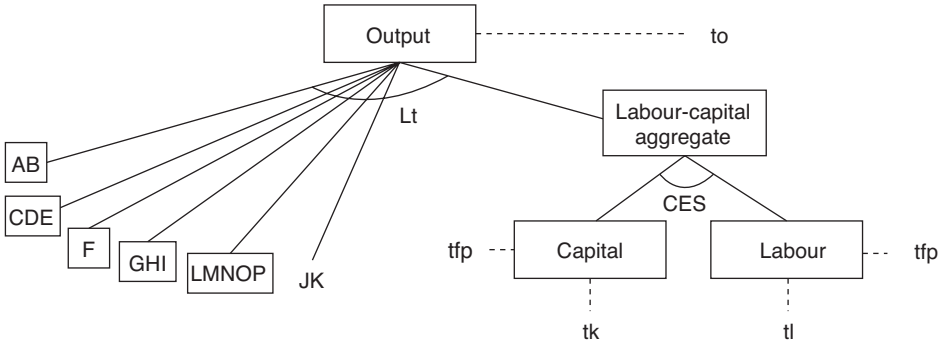
The results were compared with the scenario when regions receive funding within the framework of the EU Cohesion Policy to support non-R&D activities. Taking into account the productivity enhancing nature of non-R&D investments (Arundel *et al.,* 2008, Khan *et al.,* 2010, Hervas-Oliver and Albors-Garrigos, 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.

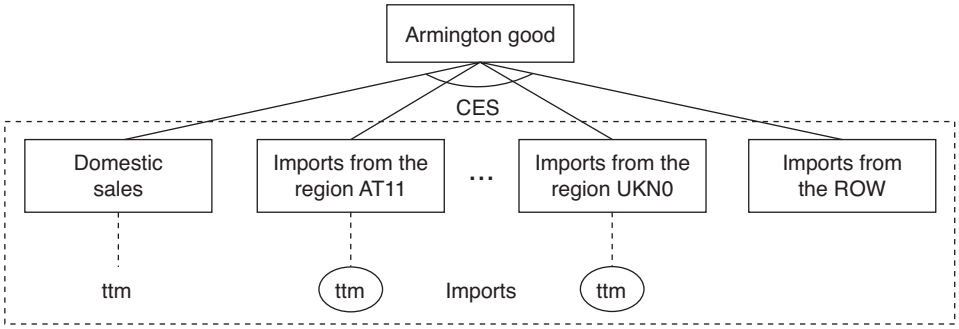
Taking into account that sectors' export supply to the NUTS2 regions is determined by import demand of these regions (see Figure 4), we can dismiss the constant elasticity of transformation (CET) function of output transformation to the regional markets. However, the non-EU aggregate cannot be treated 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

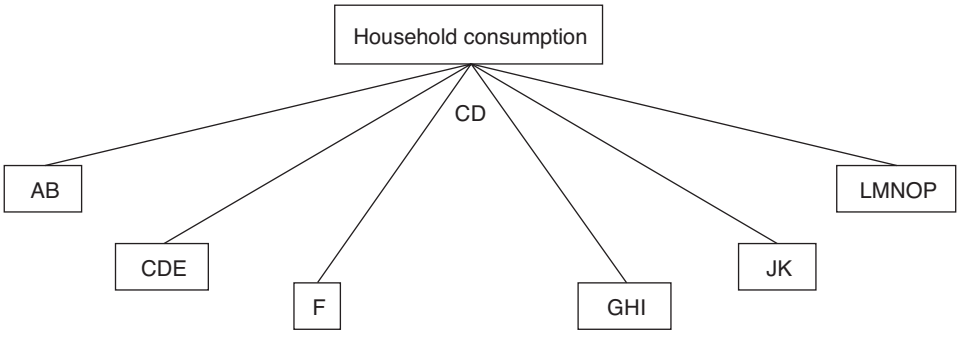


Following the information provided in the regional SAMs, a composite of domestically produced and imported goods is consumed by sectors, as intermediate goods, households, the government, and investment sector.

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



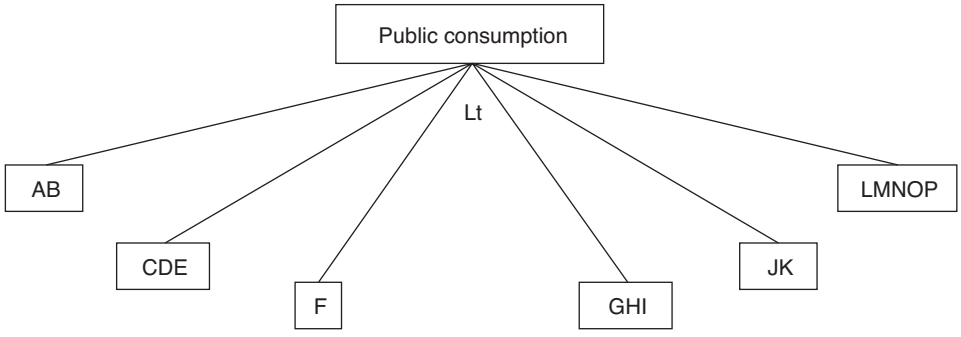
where AB-Agriculture, CDE-Manufacturing and energy, F-Construction, GHI-Transport, JK- Financial services and LMNOP-Non-market services.

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 $\gamma_3 + \gamma_1 \bar{IRD}$, where $\bar{Ird}$ 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 $\gamma_3 + \gamma_1 \bar{IRD}$ 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.

[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 $\gamma_3 + \gamma_1 \overline{IRD}$). 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;
$\gamma_3 + \gamma_1 \overline{IRD}$	= 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

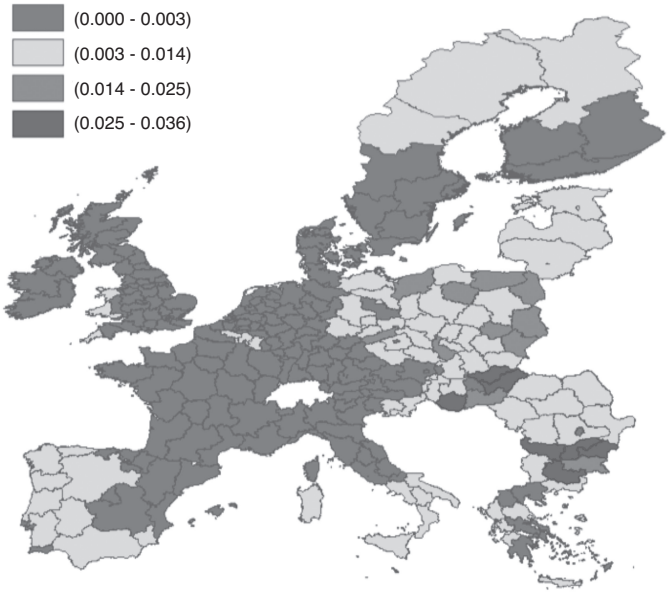
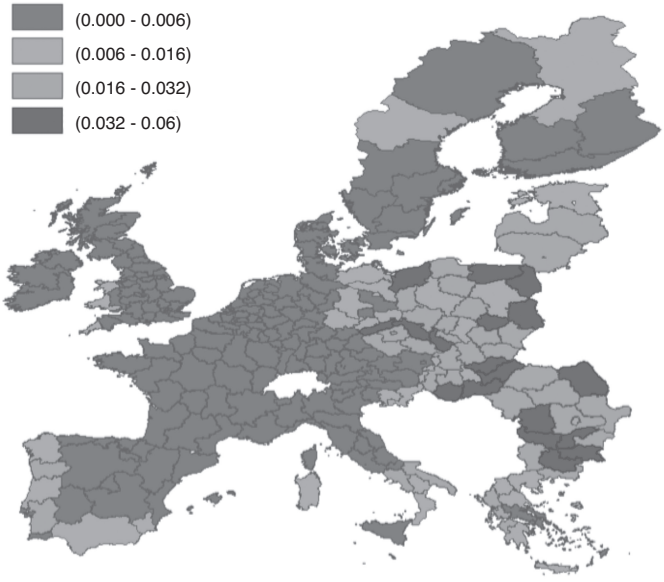


Figure 8. Changes in regional cumulative household consumption due to non-R&D innovation expenditures in 2003, % relative to the baseline projections



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

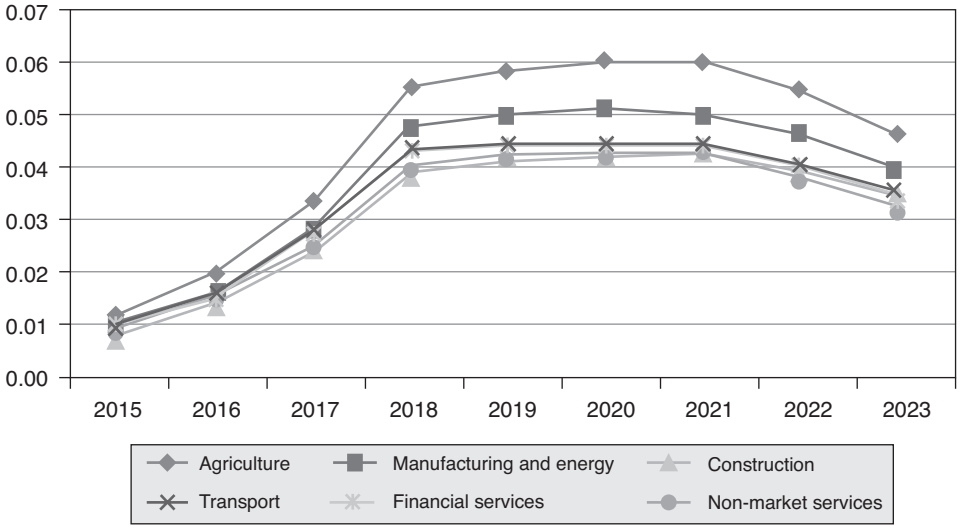
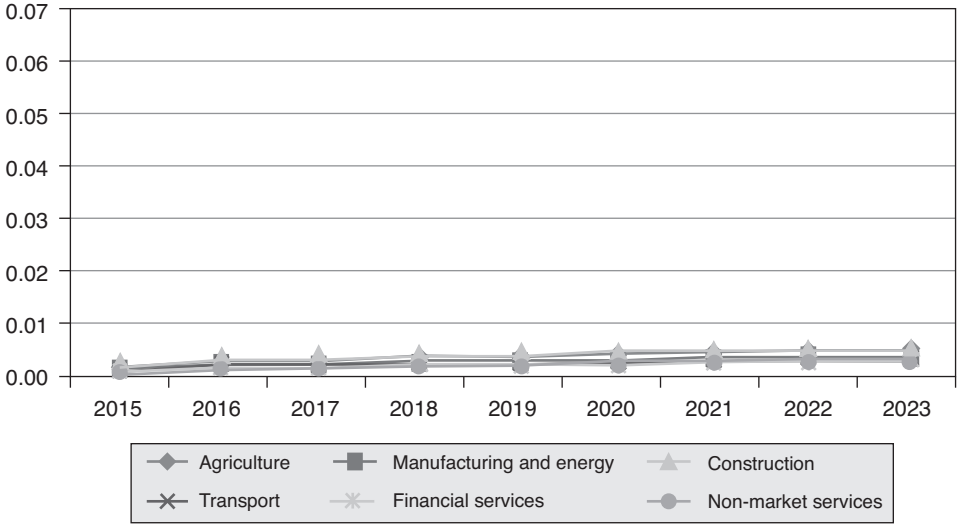


Figure 10. Sectors' production in the EU-15, % relative to the baseline projections



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.

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