

Macroeconomic effects of the geography of technological change

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Abstract

Integrating space into the framework of mainstream economic theory by the “new economic geography” is a very recent development of economics. Many of the contributions in this area are theoretical and only few of them follow an empirical approach. The unique feature of EcoRET the macroeconometric model with regionally endogenized technological change for Hungary as compared to the tradition in macroeconometric modeling is that it incorporates spatial structure into a traditional macromodel. It can be applied for policy simulations on the macroeconomic effects of changing geographical distribution of regional financial supports. This paper outlines EcoRET and presents simulation results of the macroeconomic effects of different regional distributions of EU Community Support Framework interventions in Hungary.

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Keywords: endogenous growth theory, new economic geography, knowledge spillovers, macroeconomic modeling, total factor productivity, agglomeration economies

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1. Introduction

Mainstream economic thinking is still characterized by a predominantly a-spatial theoretical structure (Fujita and Thisse 2002). Although economists are able to model the impacts of capital, labor or technology on output, employment or prices at both macro and micro levels, our methodological tools are still not sensitive to the influence of geography on the way inputs contribute to production. Nevertheless, in the long run not only the changes in the level and actual combination of inputs but also changes in the geographic distribution of those inputs should matter for macroeconomic performance. At least from the work of Marshall (1890) economists are aware of the role spatial externalities play in production. Positive agglomeration economies such as localized knowledge spillovers, labor pooling or input sharing decrease production costs resulting from the fact that firms and people concentrate in space. As such spatial structure of economic activities is itself a factor of production.

The macroeconomic role of spatial structure is not an issue with a theoretical relevance only. Understanding it has potentially high importance for economic policy making as well. The debate in the European Union on the most efficient geographical distribution of CSF assistance is an excellent case in this respect. Should the EU continue its current regional policy with a dominant focus on cohesion or a change to the promotion of technological progress in the more advanced regions is the most promising option for the Union as a whole (De Groot 2003, Midelfart-Knarvik and Overman 2002)? Understanding how spatial economic structure develops, what role policy can play to influence it and the manner a particular geographical pattern of an

economy impacts macro-level performance and regional convergence would be essential in the design of such regional economic policies.

How much do economists know about the role geographic structure plays in macroeconomic performance? Regional science, urban economics and traditional economic geography have all significantly contributed to our knowledge on important issues such as regional development, urban structure or cross-regional migration. Besides these important contributions, as Krugman (1991) points it out, the “old” spatial economics tradition was unable to integrate space into a coherent model of the economy. This is what could really be identified as the major contribution of the “new” economic geography (NEG).

NEG can indeed be characterized as “a new recipe with old ingredients”. It builds on insights from various sources such as regional science, economic geography, location theory, urban economics, the general equilibrium model with monopolistic competition and the “new” trade theory. The particular mixture of these elements first created by Krugman (1991) is a definitely original contribution to economics: a general spatial equilibrium model of the economy. This model (and several variants of it) explains not only the determination of equilibrium prices, incomes and quantities in each market but also the development of the particular geographical structure of the economy. In other words, NEG derives economic and spatial equilibrium simultaneously (Fujita, Krugman and Venables 1999, Fujita and Thisse 2002). Spatial equilibrium arises as an outcome of the balance between centripetal forces working towards agglomeration (such as increasing returns to scale, industrial demand) and centrifugal forces promoting dispersion (such as transportation costs).

An important step towards understanding how spatial structure interacts with macroeconomic performance is the incorporation of NEG into endogenous growth theory. The most recent models in NEG study macroeconomic growth in a spatial setting. The role of knowledge spillovers in the formation of spatial economic structure and the resulting long-run equilibrium level of economic growth are treated in an integrated analytical framework (Fujita and Thisse 2002, Baldwin, Forslid, Martin, Ottaviano and Robert-Nicoud 2003).

Empirical investigations of the relationship between agglomeration and macroeconomic growth are still relatively rare in the literature. Examples include Ciccone and Hall (1996), Ciccone (2002), Acs and Varga (2004) and Varga and Schalk (2004). Although several traditional regional econometric models exist¹, it is a very recent advancement that geographical structure is modeled simultaneously with other variables in macroeconomic models. The few examples of computable general equilibrium (CGE) models of this type are Oosterhaven et. al (2001), Thissen (2003), Treyz and Treyz (2003).

This paper introduces EcoRET the macroeconometric model with regionally endogenized technological change for Hungary². The unique feature of EcoRET compared to the tradition in macroeconometric modeling (Valadkhani 2004) is that it incorporates spatial structure into a traditional macroeconometric model. The model can be applied for policy simulations on the macroeconomic effects of changing geographical distribution of regional financial supports. In contrast to the above-mentioned recent examples in macromodeling, EcoRET is not a CGE but an econometric model where most of the coefficients are estimated.

¹ For a recent survey see Madsen and Jensen-Butler (2004)

² EcoRET is explained in details in Schalk and Varga (2004)

EcoRET was originally developed for Community Support Framework (CSF) impact analysis for the European Commission for the national development planning period of 2004-2006 (Schalk, Brasse and Kucsera 2003, Varga and Schalk 2003). The model is rooted in five traditions. The Münster Model developed for West Germany represents the core of the model's supply side (Franz and Schalk 1982, Asmacher, Schalk and Thoss 1987, Franz and Schalk 1995, Schalk and Untiedt 2000). This model was extended by the conventional Keynesian demand side mechanisms and closed at the macro level as it has become standard in all macroeconomic modeling works. In this respect we relied heavily on the framework of the OECD-INTERLINK country models³. The regional technology block and its incorporation to the macro model reflect the traditions of the new economic geography, the endogenous economic growth theory and the systems of innovations.

This paper has the following structure. The next section presents the main characteristics of EcoRET while the third section introduces the modeling framework including the supply side block and the major equations of the system. Simulations presented in the fourth section illustrate the power of EcoRET in estimating different macroeconomic effects of changing geographical distribution of financial supports targeting local technology development.

³ See for a description of the database the supplement to the document on the sources and methods of the Economic Outlook under the OECD INTERNET page: <http://www.oecd.org/eco/out/source.htm>. This document provides also the codes and descriptions of the variables and the definitions of and relations between them, from which we have made use in our modeling. Besides this data source we relied on data coming from the Hungarian Statistical Office and IMF. For more details see Schalk, Brasse and Kucsera (2003).

2. The main characteristics of EcoRET

2.1 General features

The specification of our supply-side oriented core model is based on standard theory of the firm. This theory accounts for the simultaneity and mutual interdependence of the firms' decisions with respect to investment, employment and output. There are two key assumptions concerning the form of the underlying production function and the economic behavior of the firms (profit maximization or cost minimization).⁴

It is assumed that firms' production technique can be represented by a "vintage capital" production function in which (vintage) capital or gross investment is viewed as putty-clay. That is ex ante substitutability between capital and labor is assumed but there are fixed ex post proportions after capital installation.⁵ Besides capital and labor employed on this vintage capital the level of technology or Total Factor Productivity (TFP) is introduced explicitly into the production function which reflects the efficiency of all factor inputs included in the production function. By this it is implied that the same labor and capital inputs will produce less output in a less efficient economy than in a more efficient one.

Labor and investment demand is derived under the assumption that the firms minimize their production costs at a given output.⁶ Output depends on domestic and foreign demand as well as production costs such as labor cost and the user cost of capital and the level of technology or TFP. Higher costs of labor and capital increase

⁴ See Schalk, Untiedt 2000 for more details in the following.

⁵ The rationale of our vintage capital approach is given in Faini, Schiantarelli 1985, Artus, Muet 1990 and Schalk, Untiedt 2000.

⁶ See Faini, Schiantarelli 1985, Asmacher, Schalk, Thoss 1986 and Artus, Muet 1990 for theoretical arguments to prefer the cost minimization to a profit maximization model. But there is also a very pragmatic argument in favour of the cost minimization model here: for factor demand functions derived on the basis of profit maximization we never obtained economically reasonable empirical results.

production costs while improvements in TFP lower them. Bargaining between workers and firms determines wages.

Goods markets are assumed to be not competitive resulting in the equilibrium condition that prices of final goods consist of unit capital-labor cost plus a markup on it. Final demand depends on households' real disposable income and the average propensity to consume. Government demand is exogenous in the model.

2.2 Geography and technology development

The major difference between EcoRET and other macroeconometric models is the explicit treatment of technology as an explanatory variable in those relationships on the supply side where it enters because of theoretically founded reasons. Adequate modeling of technological change requires the incorporation of the spatial dimension into the framework. Arguments for this are deeply rooted in recent developments of economics. The conceptual basis of our approach to modeling technology development is derived from the new economic geography literature (e.g., Krugman 1991, Fujita, Krugman and Venables 1999, Fujita and Thisse 2002), the innovation systems literature (e.g., Lundvall 1992, Nelson 1993) and the “new”, endogenous theory of economic growth (e.g., Romer 1991, Aghion and Howitt 1999).

The innovation systems literature emphasizes that technological advance results from collective actions of the actors of a system of innovation. An innovation system includes not only networks of innovative companies with research organizations, suppliers and customers, but also several institutional factors, such as the way publicly financed research is organized in a given country, or the nation's system of schooling, training and financial institutions. The spatial dimension of the systems of innovation has attracted a particular research interest since the mid 1990s.

The main reason of it is that innovation activities exhibit a strong tendency to cluster in space (e.g., as exemplified for the US by Varga 1999 or for the European Union by Caniels 2000). As such, spatial proximity might be instrumental in facilitating knowledge flows among the actors of a system of innovations.

A specific characteristic of knowledge communication explains this observation. Knowledge always involves a degree of tacitness (Polanyi 1967) that is usually very high when the knowledge is in its development stage. However, this is the type of knowledge that is potentially the most essential in innovation (Dosi 1988). The effectiveness of knowledge transmission in space is directly related to the degree of codification. While codified knowledge can easily be transported over large distances in written forms (e.g., in scientific papers, patent documentations) tacit knowledge transmission relies on more complex, non-written types of communication that require personal interactions.

If knowledge is not equally accessible at every point in space, the location of knowledge production and the characteristics of knowledge diffusion become a crucial issue in understanding economic growth. This explains why the extent to which knowledge flows are indeed bounded within geographic limits has received a particular attention in the recent economics literature. Strong evidence is provided both for the US (Jaffe, Trajtenberg and Henderson 1993, Anselin, Varga and Acs, 1997, Varga 1998) and for Europe (Maurseth and Verspagen 1998, Verspagen and Schoenmakers 2000, Fischer and Varga 2003) that knowledge flows are bounded within a relatively narrow geographical range.

The empirical model of technological change in EcoRET is based on the formulation of knowledge production in Romer (1990). According to this the effectiveness of research in creating new technologies is influenced to a large extent

by knowledge spillovers. Romer (1990) assumes that the total stock of knowledge is accessible with no geographical restrictions. However, the recent empirical literature on knowledge spillovers provided sufficient counter-evidence of the Romerian assumption of equal accessibility of knowledge in space. A significant portion of knowledge flows is indeed spatially bounded mainly due to the high level of tacitness in new scientific-technological knowledge.

The two types of knowledge are transferred by different mechanisms. The perfectly accessible part consists of already established knowledge elements in codified forms and as such transmitted via scientific publications or patent documentations. On the other hand the tacit element is accessible most effectively by face-to-face interactions. Additional to the perfectly accessible and the primarily locally available knowledge elements much of knowledge spillovers originate internationally and transmitted by imported products or production processes.

3 The modeling framework

3.1 *Model structure*

EcoRET is divided into four main blocks:

- The *supply side* block including labor market, representing the economic activities of the business sector mainly and determining production, productivity, investment, employment and unemployment, production costs and inflation.
- The *demand side* block, determining the most important behavioral relationship of private households, consumption, and other components of final demand (government consumption, foreign trade etc.) in real and nominal terms and their deflators.

- The *income distribution* block, determining private and government income (labor and property income, profits) and the transfers of income between private households and the government (taxes, social security transfers, other transfers between these sectors).
- The *Total Factor Productivity* block modeling changes in regional level of technology or TFP as a function of certain knowledge-related variables as well as CSF measures such as promotion of physical infrastructure and human capital.

The model is an interdependent system of equations with direct and indirect interrelationships between all endogenous variables. The complete actual version of the model contains 106 variables, 32 of them are explained by behavioral or technical relationships, 16 variables are exogenous while the remainder of the endogenous variables is explained by definitional identities.

Instead of providing a detailed description of the complete model (this is done in Schalk and Varga 2004) our primary focus here is on those elements of EcoRET that enabled us to study the geography impact on macroeconomic variables. These include supply side effects of technology, the regional model of technological change, the main equations carrying the technology effect to macroeconomic variables and the linkage between the regional technology block and the macroeconomic blocks.

3.2 Supply side effects of technological development

Figure 1 shows how technology or TFP affects the supply side. A positive shock on TFP is assumed in the flowchart. TFP reflects technological progress. Recent econometric research on West German and USA regions shows that industrial

structure, age of the capital stock, agglomeration effects, innovation potential and also infrastructure and human resources (qualification of the

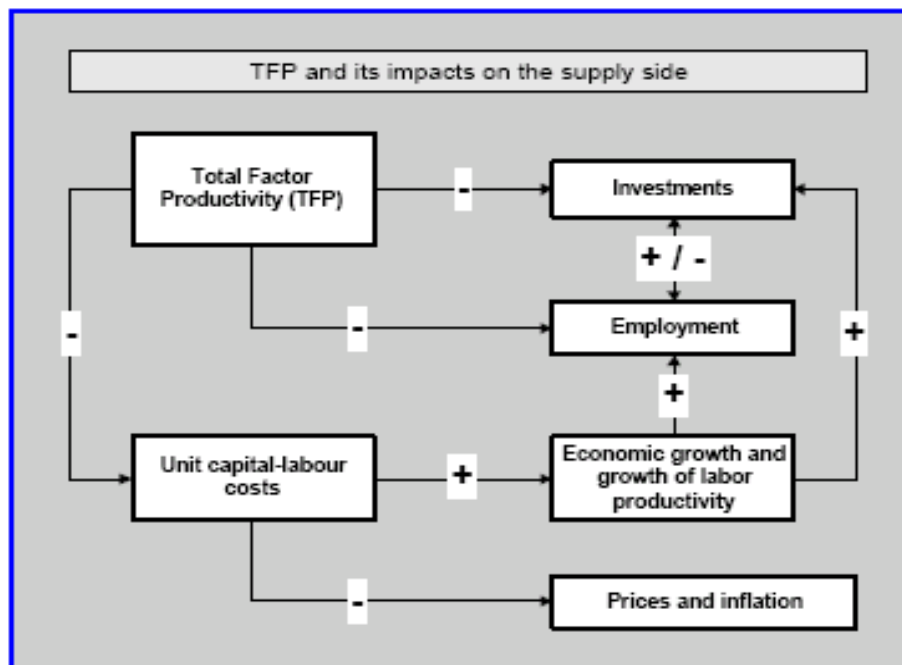


Figure 1. TFP and its impacts on the supply side

labor force) are all related to TFP (Schalk and Untiedt 1996 and Varga 2000). Therefore, public expenditures on basic infrastructure and human resources improve the productivity of capital and the efficiency of labor, respectively, thus increasing TFP. This acts as if firms use more productive capital at no cost or, alternatively, as the actually used factor inputs are available at lower production costs. Combined together, these effects improve competitive advantage, which lead to higher attractiveness of Hungary, more inward investment in production capacity (foreign direct investment) and growth.

The impact on employment is inconclusive. However, the output effect and the income effect (not shown in Figure 1) should be sufficiently large to offset the labor

shedding effects. The effect on growth is unambiguously positive. The advantage of our approach is that it captures in a proper way the channels through which even temporary supply-side oriented programs have the intended permanent effects. A temporary financial support raises TFP and increases productivity and income per capita to a permanently higher level while the (here not considered) Keynesian demand-side effect on output and income tapers off.

3.3 The regional TFP block

Constructing a variable to measure the change in technology was a crucial element in the development and practical implementation of EcoRET. In this respect we followed the solution common in the growth accounting literature (Barro 1998, Barro and Sala-i-Martin 1995). In this literature where the focus is to empirically separate the effects of the changes in capital, labor and technology on economic growth the level of technology is measured as the residual after the contribution of the other two factors of production is accounted for. This residual is called Total Factor Productivity (TFP). Our choice of a regionalized technological change model implies that TFP values are calculated for each of the spatial units. Change in technology is then measured by TFP growth rates.

The technology equation is based on the formulation of technological change in Romer (1990). In the Romerian model the total stock of knowledge is assumed to be accessible with no geographical restrictions. However, the recent empirical literature on knowledge spillovers provided sufficient counter-evidence of this. A significant portion of knowledge flows is indeed spatially bounded mainly due to the high level of tacitness in new scientific-technological knowledge. To account for the geography effect in knowledge production we separated knowledge inputs into three

classes depending on their spatial origin: knowledge sources accessible by way of personal connections (local knowledge); knowledge to be accessed by anyone of the country (codified knowledge); international knowledge sources (mediated e.g., by foreign direct investments).

We also accounted for the effects of other regional factors potentially relevant for TFP growth such as physical infrastructure and human capital. In this respect we draw on an extensive empirical literature that studies the extent to which human capital and basic infrastructure effect economic growth (e.g., Barro 1990, Mulligan and Sala-i-Martin 1995). In our modeling framework this growth effect is channeled via changes in TFP (Schalk and Untiedt 2000).

Estimation of the regional technology equation is based on a time-space data set for the time period of 1998-2000 and for all Hungarian counties. The empirical model has the following estimated form:

$$(1) \quad \text{TFPGR} = -20.90 + 0.001895 * \text{KNAT}(-2) + 1.51\text{E-}06 * \text{RD} + 0.065393 * \text{KIMP} + \\ (-14.02)^{***} \quad (13.99)^{***} \quad (2.23)^{**} \\ 1.93\text{E-}06 * \text{INFRAINV} + 3.79\text{E-}06 * \text{HUMCAPINV} - 0.259222 * \text{DUM98} + \\ (2.29)^{**} \quad (2.93)^{***} \quad (-14.04)^{***} \\ 0.081378 * \text{DUMGY}, \\ (4.71)^{***}$$

$$n=57, \bar{R}^2=0.71$$

where TFPGR is the annual rate of growth of TFP; KNAT is domestically available technological knowledge accessible with no geographical restrictions measured by the stock of (nationally or internationally invented) domestically registered patents the documentation of them is accessible for anyone located in the country with no geographical restrictions; RD stands for private and public local R&D (measured by expenditures); KIMP is imported technologies measured by the share of foreign direct investments in total private investments; INFRAINV is annual change in investment

in physical infrastructure; HUMCAPINV is annual change in investment in human capital, DUM98 is a year dummy for 1998 and DUMGY is a regional dummy (for Győr-Ménfőcsanak-Sopron county). The t-statistics are given in parentheses. We relied on various data sources from the Hungarian Central Statistical Office and the Hungarian Patent Office.

All the parameters enter equation (1) significantly. The estimated parameter of local R&D is consistently significant and its size is stable throughout all the models. This indicates that even after taking into account the impacts of technology import and geographically unconstrained domestic knowledge flows localized knowledge spillovers indeed play a role in technological change. The comparatively small effect of localized spillovers (a 1 million HUF change in regional public and private R&D expenditures implies about a 0.0002 percentage points increase in regional TFP growth rate) is not surprising considering the relatively low share (less than 1 percent) of R&D expenditures in the GDP of Hungary as well as the fact that the country's innovation system is still in transition (Varga and Szerb 2002).

3.4 The major technology-related macroeconomic equations

Table 1 lists the main calibrated equations of EcoRET directly or indirectly related to TFP. These include labor and capital demand as well as the output equation in addition to equations describing the formation of wages and the user cost of capital. This set is complemented by the labor force and private consumption equations and the GDP deflator. Data are collected from various sources from the Hungarian Central Statistical Office, IMF and OECD. Because of the strong structural breaks and changes in the first years of the transformation process, for some variables data prior to 1995 have not been very reliable for econometric estimation. Besides, due to the

Table 1. The main TFP-related equations in EcoRET

EMPLOYMENT OF THE BUSINESS SECTOR:
$ETB = ETB(-1) \cdot \exp(-0.6398 + \log(GDPBV/GDPBV(-1)) - 0.1 \cdot (\log(ETB(-1)/GDPBV(-1)) + (1-XTAU) \cdot \log((WSSE/XTAU)/(UCC/(1-XTAU)))) + \log(TFP) - 0.02866 \cdot DUMMY95)$
PRIVATE TOTAL FIXED CAPITAL FORMATION, VOLUME:
$IPV = IPV(-1) \cdot \exp(-0.4087 - 0.12 \cdot (\log(IPV(-1)/GDPBV(-1)) - (1/0.1) \cdot \log(GDPBV/GDPBV(-1)) - XTAU \cdot \log((WSSE/XTAU)/(UCC/(1-XTAU)))) + \log(TFP))$
GROSS DOMESTIC PRODUCT, BUSINESS SECTOR, VOLUME, FACTOR COST:
$GDPBV = FGDPBV \cdot \exp(2.4755 - 0.4306 \cdot \log(CKL/PGDPB) + 0.7037 \cdot \log(FDDV/FGDPBV))$
COMPENSATION RATE OF THE BUSINESS SECTOR:
$WSSE = \exp(-0.3787 + 0.7601 \cdot \log(PCP) + \log(PROD) - 0.005467 \cdot UNR(-1))$
USER COST OF CAPITAL:
$UCC = PIT \cdot (IRL - DPGDPB + 10.0)$
UNIT CAPITAL-LABOR COSTS:
$CKL = \exp(XTAU \cdot (\log(WSSE/XTAU)) - \log(TFP) + (1-XTAU) \cdot \log(UCC/(1-XTAU)))$
LABOR FORCE:
$LF = POPT \cdot (0.02929 + (LF(-1)/POPT(-1)) + 0.3885 \cdot \log(ETB/ETB(-1)) - 0.003173 \cdot UNR(-1) - 0.001898 \cdot TIME)$
PRIVATE FINAL CONSUMPTION EXPENDITURE, VOLUME:
$CPV = YDRH \cdot \exp(0.05808 + 0.7539 \cdot \log(CPV(-1)/YDRH(-1)) - 0.5335 \cdot \log(YDRH/YDRH(-1)) - 0.004962 \cdot IRL + 0.03006 \cdot DUMMY94)$
GROSS DOMESTIC PRODUCT, BUSINESS SECTOR, DEFLATOR:
$PGDPB = PGDPB(-1) \cdot \exp(-1.8275 + 0.3195 \cdot \log(CKL) - 0.327 \cdot \log(PGDPB(-1)))$

Notes: Variables not explained in the table: DPGDPB is inflation rate of GDPB; FDDV is final domestic expenditure, volume; FGDPBV is World output; PCP is private final consumption expenditure deflator; IRL is long term interest rate on government bonds; PROD is labor productivity of the business sector; UNR is unemployment rate; XTAU is production elasticity of labor; YDRH is household disposable income, volume.

small number of observations available, sophisticated methods and techniques commonly used for econometric estimation and hypothesis testing were either inappropriate or not feasible. Therefore, the parameterization of some behavioral equations has to be performed by way of “indirect” calibration.

It is assumed that firms’ decision about the level and location of production depends upon cost conditions and demand factors. On the supply side, all factors

affecting production costs influence domestic firms' demand for labor and capital and thus the level of production. Production costs depend on labor costs in the business sector, represented by WSSE, the user costs of capital UCC, and the level of technology, which is in our case measured by the variable TFP. Demand factors affecting the capacity output are represented by the final domestic demand variable FDDV and external or "world" demand, represented by foreign gross domestic production in the business sector of Germany, FGDPBV, which is the main foreign trade partner of Hungary. Wages are determined by the price level, the rate of unemployment and productivity, the user cost of capital is related to real interest rate, private consumption expenditures depend on income and the average propensity to consume. Since average propensity to consume is not observed, factors influencing it such as the growth rate of income and the real interest rate are included in the estimated equation instead.

3.5 Linking the TFP block with the rest of EcoRET in policy simulations

The macroeconomic blocks of EcoRET are estimated on the time domain whereas the TFP block is regionalized. As such, linking the changes in TFP growth rates generated by certain policy interventions at the regional level to the rest of EcoRET represented certain challenge. To solve the problem we relied on theoretical and empirical research of agglomeration and technological change (e.g., Feldman 1994, Fujita and Thisse 2002, Varga 2000). This literature indicates a positive relationship between agglomeration and technological development. Various agglomeration effects such as the positive impact of increasing spatial concentration of researchers on tacit knowledge flows or the positive influence of the size of the local economy

(number of related firms, producer services) on localized knowledge spillovers are identified in the literature.

We decided to take the following approach. First, in the TFP block we calculated the changes in TFP growth rates as a result of policy interventions for each county with the estimated TFP equation and to account for the agglomeration effect in technological change we weighted averaged the resulted values with a variable (regional employment) reflecting economic size of regions to get the change in the national TFP growth rate. Note that our regional TFP block gives an extremely good estimation of the national TFP growth rate estimated in the macroeconomic blocks of EcoRET⁷. To further assess the validity of weighting regional TFP growth rate values with regional employment we contrasted national TFP levels calculated directly from national data with national TFP levels estimated with weighted-averaged regional TFP growth rates and national TFP levels estimated with simple-averaged regional TFP growth rates. Weighted-averaged TFP growth rates provided a significantly better approximation of national TFP levels. We took this as an evidence for the size effect in localized knowledge spillovers. For more details see Varga and Schalk 2004.

The change in TFP growth rate calculated in the TFP block feeds into the macroeconomic model as it is included in its technology equation. For example, for 2004 (the first year of CSF support) we calculated the national TFP level in the following manner:

$$(2) \quad TFP = TFP_{-1} e^{\mu e^{DNTFPGR}}$$

⁷ National TFP growth rate as a weighted average of county growth rates with employment values as weights comes very close to what is estimated in the macroeconomic blocks of EcoRET: it is 1.596 percent as a weighted average of regional values whereas its value is 1.585 percent when macro-level

where TFP is the level of national TFP, μ is the estimated growth rate of technology in the macroeconomic blocks, DNTFPGR is the change in the national TFP growth rate (calculated as a weighted average of the changes in regional TFP growth rates). Thus equation (2) is the key equation in linking the TFP block to the rest of our empirical modeling framework. The simulated new national TFP value in equation (2) channels the TFP block results into the macroeconomic blocks as TFP feeds directly or indirectly into several equations of the system (see Table 1).

4. Simulated effects of changing geographical structure of CSF intervention on macroeconomic performance and regional inequality patterns

In this section we present simulation results of the macroeconomic effects of changing geographic patterns of CSF interventions promoting technology development in Hungary for the period of 2004-2007. The analysis relates to the impact of CSF support for infrastructure, human capital development and R&D. These three instruments are supposed to affect the economy by increasing TFP. Details on the amounts planned to spend in each category of interventions, their temporal distribution as well as the share of EU and Hungarian contributions are provided in Table 2. It is clear from the table that the main focus is placed on infrastructure development whereas R&D support is relatively less favored. Note that the vertical

data are used for estimation.. The two values are basically the same. The same value, 1.6 percent was reported for Hungary for the 1990s in Campos and Coricelli (2002).

Table 2. CSF assistance in infrastructure and human resources for Hungary detailed by funding sources, 2004-2007 (million Euro in 1999 prices)

Category	2004		2005		2006		2007		Total	
	EU	Hungary	EU	Hungary	EU	Hungary	EU	Hungary	EU	Hungary
Basic infrastructure	185.96	235.66	549.85	380.11	808.38	328.71	180.16	60.05	1724.34	1004.54
Human resources	41.48	13.83	134.05	44.68	147.33	49.11	256.55	85.52	579.40	193.13
Education and training	34.41	11.47	111.22	37.07	122.23	40.74	212.85	70.95	480.72	160.24
R&D	7.06	2.35	22.83	7.61	25.09	8.36	43.70	14.57	98.69	32.90
Total CSF assistance	283.20	268.49	864.16	486.22	1153.82	445.33	781.68	263.12	3082.86	1463.16

Source: Hungarian Prime Minister's Office

Table 3. National TFP elasticities – changes in the spatial distribution of funds

Instrument	E(TFP,INFRAINV)	E(TFP,EDUEXP)	E(TFP,TRD)	E(TFP,CSF)
Equal distribution	0.0348	0.0881	0.0043	0.0353
Leading regions	0.0558	0.1410	0.0068	0.0565
Lagging regions	0.0252	0.0636	0.0031	0.0255

Note: E(TFP, Instrument) is TFP elasticity with respect to the CSF instrument considered

sum of the annual values should not be equal to the total amount in the last row because expenditures in the third category of CSF instruments (i.e., support for productive investments) are not shown. National contribution is about half of the support provided by the European Commission. The following analysis relates only to the impact of EU assistance.

In the first simulation exercise the point of interest is the assessment of the potential effects of geographical reshuffling of CSF support on national and regional TFP growth rates. Table 3 lists the effects of various geographical distributions of funds on TFP elasticities (elasticity of TFP with respect to instrument). Three possibilities are examined: equal spatial distribution; concentrating all the funds in the counties with the highest regional TFP growth rates (“leading regions”, i.e., Győr-Moson-Sopron, Vas, Veszprém, Fejér, Komárom-Esztergom and Pest counties); concentrating all the funds in the rest of the counties (“lagging regions”) and applying the shares of CSF instruments determined by the Hungarian National Development Plan (NDP 2002).

As shown in Table 3, concentrating assistance in the leading regions increases elasticities by 60 percent while concentrating resources in the lagging regions decreases them by 28 percent (relative to the scenario with equal distribution of support). Geographical concentration of funds in the most developed regions of the country would increase their effectiveness in changing national level technology.

However, this might have an adverse effect on the relative technological development of some of the Hungarian counties.

To measure the impact on the existing spatial pattern of technological development we calculated the ratios of standard deviation of county TFP growth rates resulting from a particular spatial distribution of CSF funds to the standard deviation of county TFP growth rates assuming that funds are equally distributed among regions. We found that geographically concentrating infrastructure and education/training support increase inequalities by 20 and 10 percentages, respectively, whereas R&D support makes no difference in this sense. The total effect is about a 30 percent increase in standard deviations if funds are concentrated in the leading areas versus about a 10 percent decrease in standard deviations relative to the scenario of equal distribution of CSF support if lagging regions are preferred.

It might be of interest as well to assess the outcomes of different spatial distribution strategies in terms of costs and benefits. According to our analysis the cost of about a 25 percent higher growth rate is about a 30 percent increase in regional inequalities whereas the cost of about a 10 percent decline of the relative differences in technological progress among regions is about an 11 percent less increase in the national TFP growth rate than would be the case if the baseline scenario was applied. These numbers are of course only indicative but at least suggest some degrees of freedom for the government to more successfully balance between national growth and regional inequalities.

EcoRET is also capable of simulating the effects of different geographical distributions of public support targeting TFP development on various macroeconomic variables. In what follows we present the impacts on GDP, employment, unemployment, productivity, unit production costs, investments and the inflation rate.

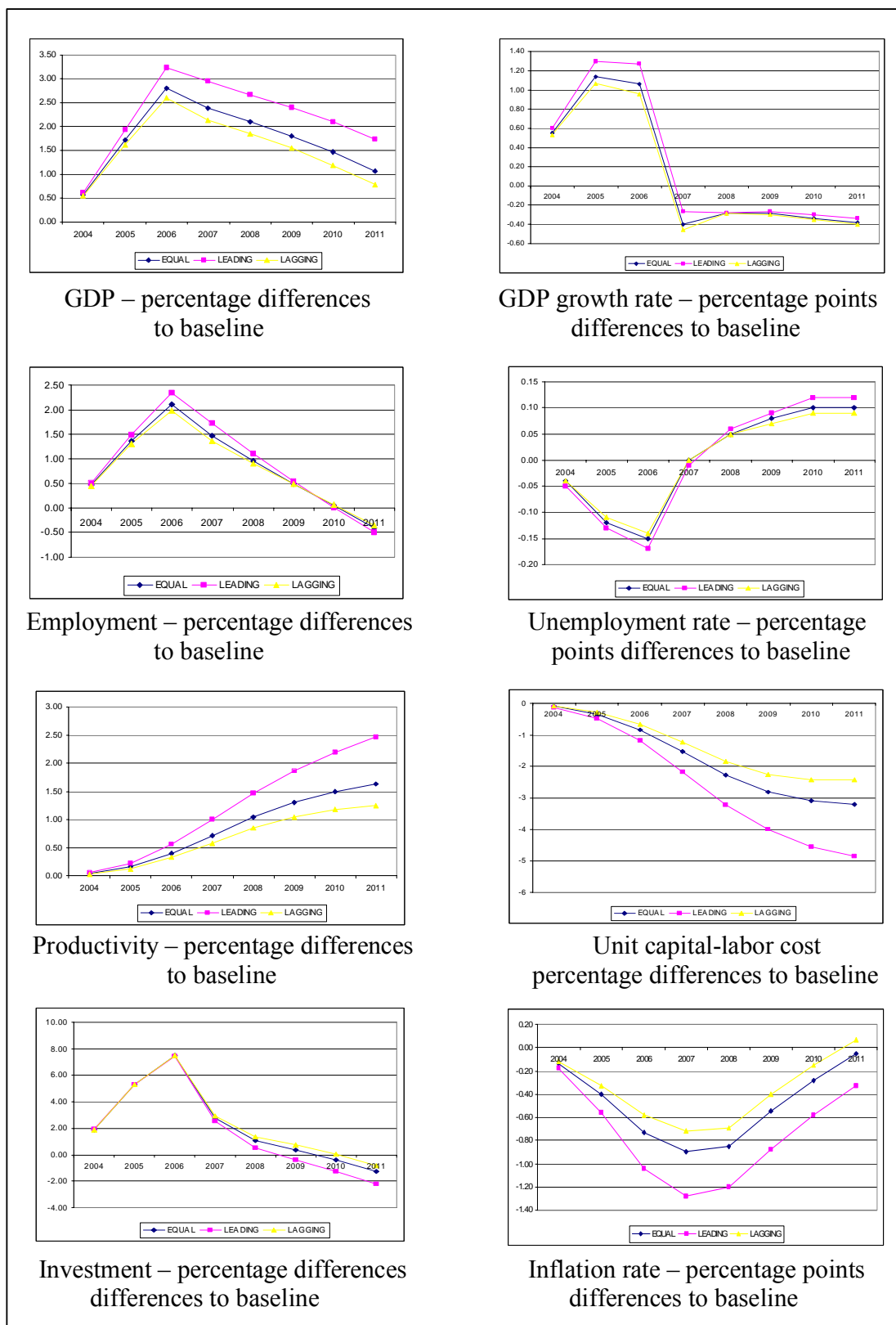


Figure 2. The effects of the geography of CSF support on selected macroeconomic variables

Note: Baseline is the scenario of no CSF support

Simulation results are visualized in Figure 2. For GDP growth rate, unemployment rate and inflation rate the figures show the effects of the three CSF scenarios (i.e., equal distribution, concentration to the most and less advanced regions) in percentage points differences to the case of no CSF intervention at all. For the rest of the variables the differences are measured in percentages relative to the scenario of no CSF support.

The general trend is that after 2006 the effect on any of the variables declines due to the significant decline in the planned assistance in 2007 and the assumption of no CSF support after 2007. Until the year 2007 CSF effects on the supply side (increasing TFP) as well as on the demand side are at work. However, beginning with 2008 only the longer-lasting supply side effect influences the economy. This effect has a declining tendency, but for several variables (such as productivity, unit capital-labor cost) a significant difference remains relative to the baseline scenario during the whole period under study.

Paradoxically, at the second part of the period the respective values become smaller with CSF support than would be the case with no public assistance for some of the variables. For GDP growth rate the reason is that this is calculated at a higher level of GDP. For employment this observation is explained by the fact that the substitution and output effects are almost canceling out each other resulting in a low positive employment effect but this actually tapers off because of higher scrapping from the higher production capacities relative to the baseline. The higher level of unemployment rate results from the higher labor force participation rate and this effect does not disappear so fast as the effect on labor demand.

Focusing on the geography effect on macroeconomic variables it is shown in Figure 2 that this impact is the highest for GDP level, productivity, unit capital labor

cost and the rate of inflation whereas for the rest of the variables it has a relatively minor importance. Indeed the effect on productivity and unit cost is even increasing after 2007. The effect of the spatial structure of CSF support on investment is practically non-existent until 2007 while after this year aggregate investment becomes lower if funds are concentrated in the most developed regions of the country.

5. Summary

The impact of geography on macroeconomic performance belongs to the least researched fields of economics. With the emergence of the new economic geography and the first steps towards the integration of it with the endogenous theory of economic growth the opportunities for empirically studying the “geography effect” on the economy has been significantly increased.

This paper introduced EcoRET the macroeconometric model with regionally endogenized technological change for Hungary as one of the early attempts to integrate the effect of spatial structure into macroeconomic investigations. Simulation results with CSF support to Hungary indicate that the effect of geography exists indeed and it is not uniform for each macroeconomic variable. Further developments of EcoRET will result in finer analyses when a fully regionalized industrially detailed model is developed.

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