The Economics of European Regions: Theory, Empirics, and Policy

Dipartimento di Economia e Management

Co-funded by the Erasmus+ Programme of the European Union

Project funded by

European Commission Erasmus + Programme –Jean Monnet Action

Project number 553280-EPP-1-2015-1-IT-EPPJMO-MODULE

Davide Fiaschi Angela Parenti[1]

November 22, 2018

[1]davide.fiaschi@unipi.it, and angela.parenti@unipi.it.

Solow model with public expenditure

Barro (1990) proposes a model where public expenditure has a positive impact on the productivities of private factors. In particular:

$$Y = K^{\alpha} H^{1-\alpha} G^{1-\alpha}, \tag{1}$$

where G is the total amount of public expenditure.
Assuming that public expenditure is financed in balanced budget with a flat tax rate on income:

$$G = \tau Y, \tag{2}$$

where τ is the tax rate, then:

$$Y = K^{\alpha} H^{1-\alpha} (\tau Y)^{1-\alpha}, \tag{3}$$

i.e.

$$Y = KH^{(1-\alpha)/\alpha} \tau^{(1-\alpha)/\alpha} \tag{4}$$

Net income and optimal level of taxation

The net income of economy is given by:

$$(1-\tau)\,Y = (1-\tau)\,KH^{(1-\alpha)/\alpha}\tau^{(1-\alpha)/\alpha}; \tag{5}$$

the maximum net income is reached for $\tau = 1-\alpha$.
This result is mainly due to the specification of production function.

To complete the model we can add an equation for the accumulation of capital.

$$\dot{K} = sY - \delta K = s\,(1-\tau)\,KH^{(1-\alpha)/\alpha}\tau^{(1-\alpha)/\alpha} - \delta K, \tag{6}$$

$$\frac{\dot{K}}{K} = g_K = s\left(1-\tau\right) H^{(1-\alpha)/\alpha} \tau^{(1-\alpha)/\alpha} - \delta \qquad (7)$$

and therefore:

$$g_k = s\left(1-\tau\right) H^{(1-\alpha)/\alpha} \tau^{(1-\alpha)/\alpha} - \delta - g_L \qquad (8)$$

Here the growth rate of capital per worker can be positive also in the long run without any other source of growth (as technological progress and/or accumulation of human capital).

The growth rate of **output per worker** will be growing at the same rate of the capital per worker.

This a model of **endogenous** growth, where the long-run growth depends also on the level of the flat tax rate.

Structural and cohesion funds could be assimilated to G.

Production Function with Structural and Cohesion Funds

Fiaschi, Lavezzi, Parenti (2017)
Output of region i, Y_i, is defined as:

$$Y_{it} = G(f_i) K_{it}^{\alpha} (A_{it} L_{it})^{1-\alpha}, \tag{9}$$

with $\alpha \in (0, 1)$, where f_i, K_{it}, L_{it}, and A_{it} respectively denote the amount of EU funds per unit of output (such a ratio is assumed to be constant), the capital stock, the employment, and the labour-augmenting technological progress level of region i at time t.

The shape of $G(f_i)$ determines the *unmediated* effect of EU funds on Y_{it}, which can be i) either to **enhance** the returns of private factors (like in Barro, 1990), or ii) to **decrease** the overall efficiency of an economy by affecting the efficient reallocation of resources across sectors.

Limited technological spillovers

In the Solow model we have assumed that technological spillovers are not limited, i.e. each region has access to the same technology. However, this is hardly true in the real world $\Rightarrow$ **Erthur and Koch, 2007**.

Fiaschi, Lavezzi, Parenti (2017)

$$A_{it} = \psi(f_i)\,\Omega_{it} \prod_{j=1, j\neq i}^{N} A_{jt}^{\theta w_{ij}}, \tag{10}$$

where Ω_{it} measures the **technological level** of region i; θ $(0 \leq \theta < 1)$ the **intensity** of the spatial externalities and w_{ij} the relative **connectivity** between region i and its neighbours.

Technological Spillovers (cont.d)

Assuming that region-specific TFP is growing at the exogenous rate μ, i.e. $\Omega_{it} = \Omega_{i0} e^{\mu t}$:

$$A_{it} = \prod_{j=1}^{N} \left[\psi\left(f_j\right)\Omega_{j0}\right]^{\nu_{ij}} e^{\frac{\mu t}{1-\theta}} = A_{i0} e^{\gamma^A t}, \tag{11}$$

where A_{i0} is the initial level of TFP of region i; $\nu_{ij} = \sum_{r=1}^{\infty} \theta^r w_{ij}{}^{(r)}$ is the parameter measuring the **total spatial externalities** that region i receives from region j; $\nu_{ii} = 1 + \sum_{r=1}^{\infty} \theta^r w_{ii}{}^{(r)}$ is the parameter quantifying the total spatial externalities that region i receives from itself.
It is possible to demonstrate that:

$$\gamma^A \equiv \frac{\mu}{1-\theta} \tag{12}$$

is the **growth rate of TFP** of region i.

Equilibrium and Transitional Dynamics

Assume a Solovian rule for the accumulation of physical capital:

$$\dot{k}_{it} = s_i y_{it} - (\delta + n_i) k_{it}, \tag{13}$$

then **GDP per worker in equilibrium**:

$$\tilde{y}_i^{\infty} = \left[\frac{G(f_i) s_i}{\delta + n_i + \gamma^A} \right]^{\frac{\alpha}{1-\alpha}}. \tag{14}$$

From Theoretical Model to Econometric Model

Following Durlauf et al. (2005), the *average* growth rate of GDP per worker of region i in the period τ of length T can be approximated around its long run equilibrium by:

$$\gamma_{it} \approx \gamma^{A} + \beta \left(\log \tilde{y}_{i,t-\tau} - \log \tilde{y}_{it}^{\infty}\right)$$

where $\beta \equiv -\frac{1-e^{-\lambda T}}{T} < 0$.
Then:

$$\begin{aligned} \gamma_{it} \quad \approx & \quad \gamma^{A} + \beta \left[\log y_{i,t-\tau} - \nu_{ii} \log \psi\left(f_{it}\right) \Omega_{i,t-\tau} + \right. \\ - & \left. \sum_{j=1, j \neq i}^{N} \nu_{ij} \log \psi\left(f_{jt}\right) \Omega_{j,t-\tau} \left(\frac{\alpha}{1-\alpha}\right) \log \left(\frac{G\left(f_{it}\right) s_{it}}{\delta + n_{it} + \gamma^{A}}\right)\right]. \end{aligned}$$

The Effect of Funds on Growth

The **total effect** of funds on γ_{it} is given by (under $df_{it} = df_{jt} = df_t \ \forall j$):

$$
\begin{aligned}
\frac{d\gamma_{it}}{df_t} &= -\beta\left(\epsilon_\psi v_{ii} + \frac{\alpha}{1-\alpha}\epsilon_G\right) - \beta\epsilon_\psi \sum_{j\neq i, j=1}^{N} \nu_{ij} = \\
&= \underbrace{-\beta\left[\epsilon_\psi\left(1 + \sum_{r=1}^{\infty}\theta^r {w_{ii}}^{(r)}\right) + \frac{\alpha}{1-\alpha}\epsilon_G\right]}_{\text{direct effect}} + \\
&- \underbrace{\beta\epsilon_\psi \sum_{j\neq i, j=1}^{N}\sum_{r=1}^{\infty}\theta^r {w_{ij}}^{(r)}}_{\text{indirect effect}}.
\end{aligned}
$$

From Theoretical Model to Econometric Model (cont.d)

Two last steps are needed to complete the specification of the econometric model, i.e. **the effect of funds on output and technological progress**:

$$\begin{aligned} \psi\left(f_{i,t}\right) &= e^{\eta_1^{\psi} f_{i,t} + \eta_2^{\psi} f_{i,t}^2}; \\ G\left(f_{i,t}\right) &= e^{\eta_1^{G} f_{i,t} + \eta_2^{G} f_{i,t}^2}, \end{aligned} \tag{15}$$

and **the initial level of technology**:

$$\log \Omega_{i,t-\tau} = \log \overline{\Omega} + d_{t-\tau} + \pi Z_{i,t-\tau}. \tag{16}$$

Adding a random component $e_{i\tau}$, we get our **econometric model**:

$$
\begin{aligned}
\gamma_{it} &= \mu - \beta \log \overline{\Omega} - \beta d_{t-\tau} + \beta \log y_{i,t-\tau} - \beta \left[\eta_1 f_{i,t} + \eta_2 f_{i,t}^2\right] + \\
&- \beta \left(\frac{\alpha}{1-\alpha}\right) \log s_{it} + \beta \left(\frac{\alpha}{1-\alpha}\right) \log \left(\delta + n_{it} + \gamma^A\right) - \\
&- \beta \pi Z_{i,t-\tau} + \\
&+ \theta \beta \left[\sum_{j=1}^{N} w_{ij} \log y_{j,t-\tau}\right] + \theta \beta \left(\frac{\alpha}{1-\alpha}\right) \left[\sum_{j=1}^{N} w_{ij} \log s_{j,t}\right] \\
&+ \theta \beta \left(\frac{\alpha}{1-\alpha}\right) \left[\sum_{j=1}^{N} w_{ij} \left(\eta_1^G f_{j,t} + \eta_2^G f_{j,t}^2\right)\right] + \\
&- \theta \beta \left(\frac{\alpha}{1-\alpha}\right) \left[\sum_{j=1}^{N} w_{ij} \log \left(\delta + n_{j,t} + \gamma^A\right)\right] + \theta \sum_{j=1}^{N} w_{ij} \gamma_{jt} + e_{it},
\end{aligned}
$$

In particular, we estimate:

$$\gamma_t = \phi_0 + \phi_t + \mathbf{X}_t \phi_X + \mathbf{Z}_{t-\tau} \phi_Z + \mathbf{W}\mathbf{X}_t \phi_{WX} + \theta \mathbf{W} \gamma_t + \mathbf{e}_t.$$

Remarks:

- This equation is the basis of the econometric models used in the estimation, being an **unconstrained version of the model**.
- Its specification is not significantly different from Ertur and Koch (2007).
- It belongs to a general class of models denoted as *Spatial Durbin Models* (SDM) (see Anselin, 1988).

Variables Used in the Analysis

- Sample: 175 NUTS 2 regions (12 EU countries less few regions), for 1992-2008 (source: Cambridge Econometrics, 2010)
- Dependent variable: **growth rate of per worker GDP** (annual average)
- **Solovian growth determinants**: initial level of GDP per worker, investment rate, growth rate of employments
- Additional controls: time dummies, **regional fixed effects** (unobservable regional factors are likely correlated with some growth determinants) and human capital

The Composition of Cohesion Policy

Objective	Period I (1989-1993)	Period II (1994-1999)	Period III (2000-2006)
1	67.3	59.7	63.7
2	9.2	6.2	16.7
3	-	8.0	-
4	-	1.3	-
3 & 4	10.4	-	-
5a (Agric)	5.4	3.2	-
5a (Fish)	0.9	0.4	-
5b	3.8	4.2	-
PIM	0.4	-	-
2 Init.	-	3.3	0.5
Other Initiatives	-	1.9	2.4
Cohesion	2.6	11.8	16.8
Total	100	100	100

Tabella: Percentage of commitments of funds according to Objectives. "'PIM": regional program in Period I for regions outside Objective 1; "2 Init.": regional initiatives similar to Objective 2 for period III (*Adapt*, *Employment*, *Rechard*, *Resider*, *Retex*, *Konver*, *SMEs*), "Other Initiatives": other initiatives in Period II (*Leader*, *Regis*, *Urban*, *Pesca*, *Peace*)

Endogeneity of Funds

Funds are potentially endogenous because of:

- their **allocation is non-random**, but conditional on the regional per capita GDP, implying a potential reverse causality of GDP per worker growth on funds (on the assumption that an increase in GDP per worker increases per capita GDP, which affects the allocation of funds)
- the **measurement error** induced by the use of Commitments instead of Payments, and by our reassignment of some funds to NUTS2 regions

As instruments we use:

- the **lag of funds** (for non-random allocation of funds...)
- the **three-group method** described in Kennedy (2008) (for measurement error...)

$\Rightarrow$ **two-stage maximum likelihood** (and test of endogeneity via control function, Wooldridge, 2012)

Spatial Weights Matrix

In the estimate we used different specifications of (row-standardized) spatial weights matrix based on:

- a **geographical distance**, $\mathbf{W}^G$, whose elements are proportional to the inverse of the great circle distance between the centroids of regions or to the minimum travel time between regions' centroids.
- an **technological distance**, $\mathbf{W}^T$, in which distances are measured in terms of the (di)similarity of output composition of regions in the first year of analysis or based on the sectoral distribution of patents.
- a **combination of the two**, $\mathbf{W}^{GT}$, where distance is given by a geometric weighted mean of the geographical and economic distances, with γ measuring the weight of geographical distance

Dependent variable	Average annual growth rate of GDP per worker						
Spatial Matrix	$\mathbf{W^G}$		$\mathbf{W^T}$		$\mathbf{W^{GT}}(\gamma = 0.8)$		
Model	I	II	III	IV	V	VI	VII
Funds	SCF	All Obj.	SCF	All Obj.	SCF	All Obj.	All Obj.
REGIONAL FE	YES	YES	YES	YES	YES	YES	YES
TIME DUMMIES	YES	YES	YES	YES	YES	YES	YES
log.PROD.REL.IN	−0.067 (0.000)	−0.069 (0.000)	−0.073 (0.000)	−0.084 (0.000)	−0.070 (0.000)	−0.070 (0.000)	−0.068 (0000)
log.INV.RATE	−0.007 (0.009)	−0.004 (0.130)	−0.006 (0.112)	0.005 (0.246)	−0.007 (0.009)	0.005 (0.083)	−0.005 (0.111)
log.EMP.GR	−0.011 (0.000)	−0.011 (0.000)	−0.013 (0.000)	−0.013 (0.000)	−0.009 (0.000)	−0.010 (0.000)	−0.010 (0.000)
HC							0.014 (0.056)
W.log.PROD.REL.IN	0.041 (0.000)	0.028 (0.056)	0.039 (0.027)	−0.043 (0.089)	0.054 (0.000)	0.056 (0.000)	0.045 (0.026)
W.log.INV.RATE	−0.035 (0.000)	−0.021 (0.064)	0.002 (0.889)	0.053 (0.002)	−0.035 (0.000)	−0.033 (0.023)	−0.036 (0.012)
W.log.EMP.GR	0.013 (0.046)	0.002 (0.067)	−0.012 (0.182)	0.015 (0.147)	0.007 (0.363)	0.003 (0.721)	0.004 (0.619)
W.HC							−0.026 (0.075)
θ	0.645 (0.067)	0.654 (0.000)	0.315 (0.001)	0.204 (0.040)	0.660 (0.000)	0.680 (0.000)	0.682 (0.000)
N	350	350	350	350	350	350	350
AICc	-2233.444	-2171.465	-2003.763	-1977.948	-2244.197	-2176.26	-2158.93
Generalized $\bar{R}^2$	0.90	0.90	0.81	0.82	0.91	0.90	0.91

Dependent variable	Average annual growth rate of GDP per worker						
Spatial Matrix	$\mathbf{W^G}$		$\mathbf{W^T}$		$\mathbf{W^{GT}}(\gamma = 0.8)$		
SCF	0.305		0.604		0.300		
	(0.002)		(0.002)		(0.002)		
SCF^2	-3.004		-6.135		-2.780		
	(0.001)		(0.001)		(0.002)		
W.SCF	2.848		1.486		2.996		
	(0.000)		(0.010)		(0.000)		
W.SCF^2	-31.686		-19.147		-34.857		
	(0.000)		(0.007)		(0.000)		
CF		-0.972		-3.909		-0.701	-0.792
		(0.112)		(0.001)		(0.237)	(0.179)
OB1		0.156		0.067		0.148	0.146
		(0.200)		(0.001)		(0.229)	(0.237)
$OB1^2$		-0.809		-4.358		-0.957	-0.802
		(0.535)		(0.026)		(0.456)	(0.532)
OB2		0.025		-2.799		0.028	-0.125
		(0.985)		(0.130)		(0.983)	(0.919)
OtherOB		0.015		0.409		-0.041	-0.023
		(0.921)		(0.041)		(0.788)	(0.883)
W.CF		-0.435		-21.542		1.516	1.607
		(0.870)		(0.000)		(0.644)	(0.628)
W.OB1		1.126		4.473		2.002	1.965
		(0.047)		(0.000)		(0.000)	(0.001)
W.$OB1^2$		-18.967		-45.456		-33.909	-33.553
		(0.016)		(0.000)		(0.000)	(0.000)
W.OB2		4.658		-11.627		5.352	6.704
		(0.411)		(0.185)		(0.346)	(0.248)
W.OtherOB		4.349		-0.899		2.811	2.772
		(0.000)		(0.657)		(0.012)	(0.020)
LR test of endogeneity	41.368	17.623	21.496	43.465	45.241	17.706	18.145
	(0.000)	(0.062)	(0.000)	(0.000)	(0.000)	(0.060)	(0.053)
Test of overidentifying restr.	0.977	1.199	0.557	0.510	0.944	1.104	1.083
	(0.404)	(0.303)	(0.643)	(0.827)	(0.419)	(0.360)	(0.37)

Average Effects of Funds

Spatial Matrix	$\mathbf{W^{GT}}(\gamma = 0.8)$		
Average Effects	Direct	Indirect	Total
CF	-0.623 (0.032)	3.170 (0.458)	2.547 (0.571)
OB1	0.307 (0.008)	6.413 (0.012)	6.720 (0.010)
$OB1^2$	-3.561 (0.010)	-105.410 (0.008)	-108.971 (0.007)
OB2	0.433 (0.682)	16.381 (0.133)	16.814 (0.132)
OtherOB	0.168 (0.309)	8.488 (0.018)	8.656 (0.019)

Tabella: Estimation of average *direct*, *indirect* and *total* effects based on the estimation of Model with $\mathbf{W^{GT}}(\gamma = 0.8)$. Dependent variable: annual average growth rate of GDP per worker. P-values in parenthesis.

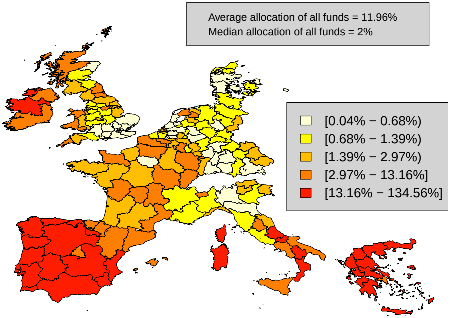

Figura: Map of the cumulated amount of total funds (expressed as ratio of GDP in the first year of each programming period) received by regions in the period 1992-2008.

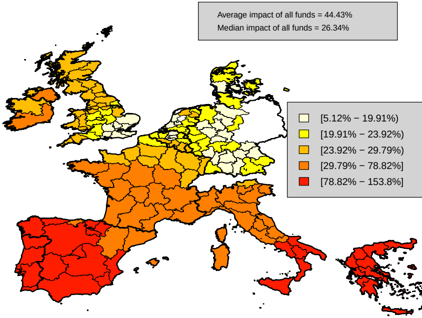

Figura: Map of the estimated cumulative effect on GDP per worker (expressed in percentage change) of total funds given in the period 1992-2008 on the base of the estimate of Model with $\mathbf{W}^{\mathbf{GT}}(\gamma = 0.8)$.

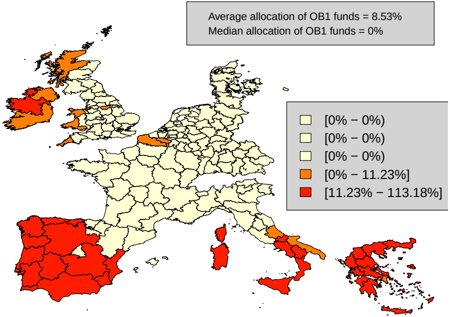

Figura: Map of the cumulated amount of Objective 1 funds (expressed as ratio of GDP in the first year of each programming period) received by regions in the period 1992-2008.

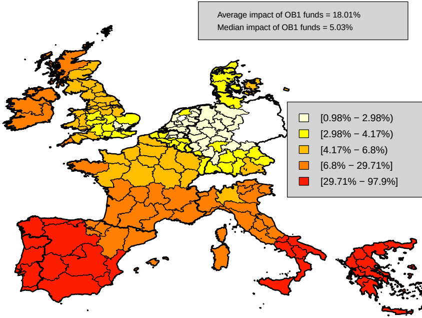

Figura: Map of the estimated cumulative effect on GDP per worker (expressed in percentage change) of Objective 1 funds given in the period 1992-2008 on the base of the estimate of Model with $\mathbf{W}^{\mathbf{GT}}(\gamma = 0.8)$.