Agglomeration externalities and technical efficiency in Italian regions

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Abstract: The aim of the present work is to estimate an aggregate production function for the 20 Italian regions for the period 1970-1993 by emphasizing the role that agglomeration externalities (localization externalities and urbanization externalities) and spatial spillovers have in influencing the technical efficiency of the production process. To this purpose, we use the stochastic frontier approach, which seems suitable to explain whether the persistent regional disparity in terms of productivity is due to differences in technology levels, factors endowments or efficiency

The results highlight the relevance and the positive impact that localization and urbanization externalities have in improving the efficiency level of the production process of Northern and Central Italy regions. Furthermore, spatial spillovers represent a source of development and growth both for Northern, Central and Southern regions.

Keywords*: Agglomeration externalities, Spatial spillovers, Stochastic frontier, Technical efficiency, Italian regions.*

JEL classification: *R10, O1, D24*

1. Introduction

In recent years territory has been seen as an independent production factor able to enter the production function and to affect the efficiency of classic production factors, i.e. labor and capital. With regard to this issue, De Groot et al. (2007) state that “The productivity of the open urban economy depends also on spatial factors, internally through density and infrastructure and externally through spatial interaction with other cities and regions. Resources, production factors and geography then combine with an industrial structure characterised by specialisation, competition and diversity, to yield innovation and productivity growth that encourages employment expansion. … In the presence of economic diversity and increasing returns, capital and labour are not flowing in opposite directions, as in static neoclassical theory. Instead, the city attracts capital too. Many aspects of this self-reinforcing and virtuous process yield benefits that are external to individual market transactions and such externalities are therefore central to agglomeration processes”.

The principle of agglomeration is mainly associated with the concept of externalities. If these externalities are designed in their positive sense, i.e. in terms of benefits, they can be identified in the so-called agglomeration economies. It is well known that the traditional classification (Hoover 1937; Richardson 1969) divides these agglomeration economies in internal economies, i.e. economies of scale, and external economies, i.e. localization economies and urbanization economies. Economies of scale are defined as internal benefits because they are related to the internal organization of the productive activity of firms and they are not caused by factors external to them, such as proximity of other firms or presence of particular services. In contrast, localization and urbanization economies are defined as external benefits or economies. In particular, the former type of economies are derived from benefits external to the individual firm but internal to the sector they belong to, while the latter are derived from benefits external both to the individual firm and to their sector. In short, economies related to the internal production of the firm, that arise from its resources, its internal organizational capacity and its management efficiency, can be controlled directly by the firm, while external economies depend on production relations that are generated outside of the firm and are not controllable by it. Hence, traditional literature identifies three types of agglomeration externalities: localization externalities, also known as Marshall externalities or MAR (Marshall 1890; Arrow 1962; Romer 1986), “represented by all those advantages the territory can bring to the firm production if it is organized into an agglomeration characterized by localization” (Camatti 2009) and urbanization externalities, also called Jacobs externalities (Jacobs, 1969), “represented by all those advantages the territory can bring to the firm production if it is organized into an agglomeration characterized by urbanization” (Camatti 2009). The existence of these two typologies of territorial externalities is one of the key factors of agglomeration, through the action of increasing returns that are generated by interactions and spillovers between firms. Finally, the literature considers Porter externalities (Porter 1990), that are based on the assumption that “the competition among firms at local level represents a source of positive externalities as it encourages the production and the adoption of innovations.” (Cingano and Schivardi 2005).

Several empirical studies have tried to determine which is the most important characteristic of the production structure in generating externalities, focusing on the role of sector specialization (localization externalities) and production variety (urbanization externalities) (Cingano and Schivardi 2005). In particular, Glaeser et al. (1992) demonstrate, in their seminal work conducted on a sample of American cities, that localization externalities have a negative effect on growth, while urbanization externalities have a positive effect on it. Subsequent studies extended to other countries (as, for instance, Combes 2000 for the case of France; Bradley and Gans 1998 in Australia; Cainelli and Leoncini 1999, Cingano and Schivardi 2005, Paci and Usai 2001 and Pagnini 2005 in Italy) confirm the negative relationship between productive specialization and growth, while the relationship between urbanization externalities and growth seems ambiguous.

In this regard, the present study aims at estimating an aggregate production function for the 20 Italian regions by emphasizing the role that territorial externalities have in influencing the technical efficiency of the production process. In addition we also consider spatial spillovers among the possible factors that may influence the production process, starting from the reasonable hypothesis that they do not exhaust their effects only within the local economy in which they are generated but they also spread to neighboring regions. To this end, the stochastic frontier approach seems suitable to explain whether the persistent regional disparity in terms of productivity is due to differences in technology levels, factors endowments or efficiency (Mastromarco and Woitek 2006).

The paper is organized as follows. In Section 2 we define some measures used for agglomeration externalities, in Section 3 we present the methodology and the data used, in Section 4 we describe the results obtained and in Section 5 we conclude.

2. Agglomeration externalities

Since early empirical studies (Glaeser et al. 1992; Henderson et al. 1995) the focus on the identification of the agglomeration externalities intensity has been developed in terms of some indicators. The empirical literature usually refers to three types of territorial externalities, MAR (Marshall, Arrow, Romer) externalities, Jacobs externalities and Porter externalities.

MAR externalities are generated through knowledge spillovers between firms within the same industry. In this case the spatial agglomeration of the industry, and hence its regional specialization, tends to stimulate knowledge spillovers between firms and, therefore, the growth of that local industry (Cainelli and Leoncini 1998). This theory suggests the presence of a monopolistic market: in fact it allows people to protect their innovations and to make better use of them. These externalities are given by the following indicator:

$$MAR_i = \max_j \left(s_{ij} / s_j \right)$$

where s_{ij} denotes the ratio between employed people in sector *j* in region *i* and total employed in region *i*, while s_j denotes the ratio between employed people in sector *j* at country level and total employed at country level (Duranton and Puga 2000).

Jacobs externalities (Jacobs 1969) are based on the assumption that the industry variety is able to promote the long-term development through cross-fertilization of ideas between different productive activities. Competition is the market form most appropriate to this type of externalities, because only competition allows firms to increase their knowledge levels and thus to survive (Cainelli and Leoncini 1998). Such externalities are commonly expressed by the inverse of the Hirshman-Herfindal index (Duranton and Puga 2000)[1]:

$$J_i = 1 \Big/ \sum_j \left| s_{ij} - s_j \right|$$

Finally, Porter externalities (Porter 1990), which are a cross between the MAR and the Jacobs thesis, are expressed by the following indicator:

$$P_{i,j} = \left(impresa_{i,j} \big/ s_{i,j} \right) \Big/ \left(\sum_i \sum_j impresa_{i,j} \Big/ \sum_i \sum_j s_{i,j} \right)$$

where $impresa_{i,j}$ indicates the number of firms in sector *j* in region *i*. Due to the unavailability of the number of firms by sector, we are not able to get this indicator and therefore it will be omitted from the analysis.

Furthermore, since it is likely that the externalities produced in a specific local economy do not exert their effects only within it but they can affect the performance of other locations (Pagnini 2003), we include an additional variable whose purpose is to quantify the externalities associated with industrial agglomeration processes; therefore we take into account a variable expressing spillover effects generated by the concentration of employment in the regions close to a given region and whose effect is an improvement of local growth, productivity and efficiency (Guiso and Schivardi 2007; Battese and Tveteras 2006). We denote this variable with the following expression:

$$WE_{i,t} = \sum_{k \neq j} E_{k,t} d_{j,k}^{-1}$$

where $E_{k,t}$ represents the employed people of location *k* (usually also the disposable income or GDP) at time *t*, $d_{j,k}$ is the distance between two generic locations and *j* and *k* represent the subscripts that identify the element of the distance matrix **W**. This index is simply a lagged variable in space. In particular, we use as a measure of the distance from one region and others the inverse of the distance expressed in km. This distance matrix has an interesting economic meaning: the increase of distance reduces the strength of ties between a given region and neighboring regions.

3. Methodology

Building on the work of Mastromarco and Woitek (2006), we consider a standard growth model with externalities. In particular, we assume a Cobb-Douglas production function where, besides considering production, labor and the stock of capital (respectively, $Y_{i,t}, L_{i,t}$ and $K_{i,t}$), we also include territorial externalities

[1] The more the production structure of the corresponding region reflects the diversity of the national economy, the more the Hefindal index increases (Cirilli e Veneri, 2009).

($MAR_{i,t}$, $J_{i,t}$ e $P_{i,t}$) that, together with technological progress denoted by $A_{i,t}$, represent the total factor productivity level (TFP[2]) (Cingano and Schivardi 2005). This relation is given by $Y_{i,t} = F\left(A_{i,t}, L_{i,t}, K_{i,t}, MAR_{i,t}, J_{i,t}\right)$.
Assuming that agglomeration externalities and technological progress are external to firms, we model them in the following way:

$$
\begin{aligned}
Y_{i,t} &= A_{i,t} * MAR_{i,t}^{\beta_3} * J_{i,t}^{\beta_4} * f\left(L_{i,t}, K_{i,t}\right) \\
PTF_{i,t} &= A_{i,t} * MAR_{i,t}^{\beta_3} * J_{i,t}^{\beta_4}
\end{aligned}
\qquad (1)
$$

Consequently, the function we estimate under spatial spillovers hypothesis is the following one:

$$
\begin{aligned}
Y_{i,t} &= A_{i,t} * MAR_{i,t}^{\beta_3} * J_{i,t}^{\beta_4} * WE_{i,t}^{\beta_5} * f\left(L_{i,t}, K_{i,t}\right) \\
PTF_{i,t} &= A_{i,t} * MAR_{i,t}^{\beta_3} * J_{i,t}^{\beta_4} * WE_{i,t}^{\beta_5}
\end{aligned}
\qquad (2)
$$

Our analysis will proceed in two steps. First, we consider a model where inefficiency is a function of agglomeration externalities only (eq. 1), then we implement a model that also includes spatial spillovers among the factors leading to inefficiency (eq. 2). Finally, we compare how the spillover effects affect the determination of efficiency.
We model agglomeration externalities as a spillover effect that increases the productivity of all inputs by increasing efficiency (Hulten and Schwab 1993). Our Cobb-Douglas production function will have the following form:

$$Y_{i,t} = \Lambda_{i,t} * L_{i,t}^{\beta_1} * K_{i,t}^{\beta_2}, \qquad i = 1,\ldots,20;\ t = 1970,\ldots,1993 \qquad (3)$$

where $\Lambda_{i,t} = A\tau_{i,t}\omega_{i,t}$, where A denotes the level of technology, $\tau_{i,t}$ is an efficiency measure, with $0 \le \tau_{i,t} \le 1$, and $\omega_{i,t}$ is a measurement error.
Writing equation (3) in logarithms we obtain:

$$y_{i,t} = \alpha + \beta_1 l_{i,t} + \beta_2 k_{i,t} + \varepsilon_{i,t}, \qquad i = 1,\ldots,20;\ t = 1970,\ldots,1993 \qquad (4)$$

with $\varepsilon_{i,t} = v_{i,t} - u_{i,t}$

where $u_{i,t} = -\ln\left(\tau_{i,t}\right)$ is a non-negative random variable and $v_{i,t} = \ln\left(\omega_{i,t}\right)$. Expected inefficieny is given by:

$$E\left[u_{i,t}\right] = z_{i,t}\lambda \qquad (5)$$

[2] TFP measures the output growth attributable to technical progress and to efficiency in the combination of production factors.

where $u_{i,t}$ are assumed to be independently but not identically distributed, $\mathbf{z}_{i,t}$ is the vector of variables which influence efficiency and $\boldsymbol{\lambda}$ is the vector of coefficients (Mastromarco and Woitek 2006). A single-stage Maximum Likelihood allows us to estimate both the parameters of the production function and those in equation (5) (Kumbhakar et al. 1991; Battese and Coelli 1995).
We consider four different specifications for $u_{i,t}$. In the first model, inefficiency is a function of MAR externalities and of Jacobs externalities:

$$E[u_{i,t}] = \lambda_0 + \lambda_1 MAR_{i,t} + \lambda_2 J_{i,t} \tag{6}$$

The second model also takes into account spatial spillovers:

$$E[u_{i,t}] = \lambda_0 + \lambda_1 MAR_{i,t} + \lambda_2 J_{i,t} + \lambda_3 WE_{i,t} \tag{7}$$

The third model takes into account the differences in the reaction of inefficiency dependent on the region (Mastromarco and Woitek 2006). We consider a slope dummy variable $D_{i,t}$, which is equal to one for Northern and Central Italy regions and is equal to zero for Southern regions[3] (Mastromarco and Woitek 2006). This specification allow us to verify whether the impact of externalities is stronger in Northern and Central regions rather than in Southern ones.

$$E[u_{i,t}] = \lambda_0 + (\lambda_{11} + \lambda_{12} D_{i,t}) MAR_{i,t} + (\lambda_{21} + \lambda_{22} D_{i,t}) J_{i,t} \tag{8}$$

$$D_{i,t} = \begin{cases} 1 \ if \ \ i = CN \\ 0 \ if \ \ i = S \end{cases}$$

Finally, the fourth model adds spatial spillovers to the third model (8):

$$E[u_{i,t}] = \lambda_0 + (\lambda_{11} + \lambda_{12} D_{i,t}) MAR_{i,t} + (\lambda_{21} + \lambda_{22} D_{i,t}) J_{i,t} + (\lambda_{31} + \lambda_{32}) WE_{i,t} \tag{9}$$

Externalities modeled in this way are interpreted as determinants of inefficiency because they directly explain the inefficiency results of regions.

4. Data and results

The analysis will be conducted on the data of the 20 Italian regions for the period 1970-1993[4]. Data has been obtained from CRENOS (Centre for North South

[3] Northern and Central Italy (NC): Piemonte (PIE), Valle d'Aosta (VDA), Lombardia (LOM), Liguria (LIG),Trentino Alto Adige (TAA), Veneto (VEN), Friuli Venezia Giulia (FVG), Emilia Romagna (EMR), Toscana (TOS), Umbria (UMB), Marche (MAR), Lazio (LAZ). Southern Italy (S): Abruzzo (ABR), Molise (MOL), Puglia (PUG), Campania (CAM), Basilicata (BAS), Calabria (CAL), Sicilia (SIC), Sardegna (SAR).
[4] The observation period is restricted to the years 1970-1993 because at the moment more recent data are not available.

Economic Research)[5]. The output measure is regional GDP at constant 1985 prices, the capital stock is also expressed at constant 1985 prices, the measure for labor input is the number of employed people. Moreover, since the number of employees in different production sectors is useful for computing the indexes that express territorial externalities, we also consider the employees in five manufacturing sectors[6], the employees in four service sectors[7], the employees in the construction sector, the employees in the fuel and power products sector and the employees in mining and chemical sectors. All variables are expressed in logarithms.

In Table 1 we report the estimates results of the models considered. The Likelihood ratio test, rejecting the null hypothesis in all four cases, confirms the presence of technical inefficiency (for critical values of the test see Kodde and Palm (1996)). In addition, the significance of the parameter γ, i.e. the ratio between the variance of the inefficiency term $\sigma^2{}_u$ and the sum of the total variance $\sigma_v^2 + \sigma_u^2 = \sigma^2$, shows that 85% (column 1), 86% (column 2), 87% (column 3) and 89% (column 4) of the output change among Italian regions is due to differences in their technical inefficiencies. Log Likelihood values, being higher, always lead to prefer the model with spatial spillovers to the one without them.

With regard to the first model, all parameters of the production function are significant and have the correct sign. In particular, the elasticity of capital is equal to 0.53 while labor elasticity is equal to 0.55 (column 1). The effects of MAR and Jacobs externalities have a negative effect on efficiency, leading to a reduction. With regard to MAR externalities, the negative effect of specialization on efficiency could be explained by the fact that a high specialization generates low flexibility and poor adaptability of products, technologies and infrastructure when the sector is in decline; on the contrary, more flexible sectors would be more able to convert their operations (Combes 2000). The negative effect of specialization on the efficiency refers to industrial and services sectors (see footnotes 6 and 7) (Combes 2000). Jacobs externalities, with their positive sign, show that a higher level of production diversification makes regions less efficient. Combes (2000) observes a positive relationship with urbanization economies only for the high-tech industrial sector, while he verifies a negative relationship for traditional industrial sectors. The negative impact of Jacobs externalities on the efficiency of the production process is supported both by the work of Henderson (1997) and Combes (2000), who found the presence of urbanization economies only for new industries, not for the nature ones.

By examining column (2) we can note that MAR and Jacobs externalities as well as being significant, still retain their negative impact on efficiency. On the contrary, the coefficient associated with spatial spillovers, as well as being significant, has a negative sign thus showing its positive effect on efficiency. It is evident that the externalities associated with industrial agglomeration through spillover effects generated by the concentration of employed people in the regions close to a given region have a positive effect on the production process of that region. In our case, given the positive impact of spatial spillovers on efficiency,

[5] Regio-IT1970-2004 and Regio(cap)-IT_70-94 (www.crenos.it).

[6] Minerals and non-metallic mineral products; Metal products and machinery and transport equipment; Food, beverages, tobacco; Textiles and clothing, leather and footwear; Paper and printing products; Wood, rubber and other industrial products.

[7] Trade, hotels and public establishment; Transport and communication services; Credit and insurance institutions; Other market services.

we look at what is called "concentrated development", that is expected when regions get a positive benefit from external growth opportunities (Capello 2009).

Insert Table 1

With the introduction of regional effects in the other two specifications of the model (columns 3 and 4), the reading of the results becomes more complicated. For this reason we introduce a different way of interpreting this results, as suggested by Mastromarco and Woitek (2006):

$$d\tau = -\tau\lambda_i \frac{dz_i}{z_i} \tag{10}$$

Hence, we can express the results as change in efficiency due to a percentage change in externalities. For example, by calculating (10) in terms of mean efficiency (equal to 0.8553, column 1 in Table 1), we obtain that a 10% increase in MAR and Jacobs externalities leads to an efficiency change equal to -4% (MAR) e -0.4% (Jacobs). This highlights the negative impact of both externalities and the higher impact of MAR externalities compared with Jacobs externalities.
In Table 2 we report the results of (10) for the different estimates proposed. By observing column 2, in addition to verifying the continuing negative impact of MAR and Jacobs externalities on efficiency, we may note that spatial spillovers have a positive effect, equal to 4%, on efficiency.
By focusing on regional analysis, we observe that in the case without spatial spillovers the differences between the two areas of the country are substantial (column 3). In particular, we verify that the productive efficiency of Central and Northern Italy is positively influenced by both specialization and urbanization externalities (Paci and Usai 2000; Henderson et al. 1995). We find an opposite situation for Southern Italy, where the effect of both externalities results to be negative. The only thing that unites the two Italian areas is given by the minor weight of Jacobs externalities compared to MAR externalities.
Finally, in the fourth model (column 4), we observe that MAR externalities have no effect on Southern regions, whereas Jacobs externalities register a positive impact on efficiency. It is worth stressing that spatial spillovers produce a positive impact on both areas of the country, more pronounced in Central and Northern Italy than in Southern Italy (2.8% versus 2.5%).

Insert Table 2

4.1 Importance of spatial spillovers on regions' efficiency

We conclude the analysis by answering the following question: how important are spatial spillovers in determining the efficiency of individual regions? In this regard we report in Table 3 the efficiency ranking for each region, by considering the results arising from the assumptions on the $u_{i,t}$ term (presence and absence of spatial spillovers) in equations (6) and (7).
The efficiency ranking analysis for the last year (1993), shows the presence of three groups of regions. The first group consists of the regions that retain the same position in the rankings: Veneto, Friuli Venezia Giulia, Liguria, Umbria, Abruzzo,

Puglia and Calabria (indicated by (*)). The second group consists of the regions which benefit from the positive effects of spatial spillovers, by improving their ranking and therefore their efficiency score: Valle d'Aosta, Trentino Alto Adige, Molise and Basilicata (indicated by (+)). The third group includes regions located at the bottom of the ranking as they suffer a loss of efficiency due to the presence of spatial spillovers: Piemonte, Lombardia, Emilia Romagna, Toscana, Marche, Lazio, Campania and Sicilia (indicated by (-)). This result is justified by the fact that "... there are cases where the growth potential developed by a region adversely affects the growth of neighboring regions which become donors of tangible and intangible resources, and thus become subject to gradual impoverishment and economic decline" (Capello 2009).
These results are very important because they reveal substantial differences among Italian regions due to the presence of spatial spillovers. In particular, their effects is not obvious: in fact, some regions benefit from their presence, while others are indifferent or suffer from a negative effect in terms of efficiency.

Insert Table 3

By observing Figures 1 and 2, we can note that spatial spillovers affect the results in terms of efficiency. In particular, we observe, after considering spatial spillovers, a clear spread of shades of grey: this indicates a reduction of the concentration of efficiency among Italian regions. For Northern and Central regions, we can observe a kind of osmosis between "donor" regions, which lose efficiency, and "receiving" regions, which gain in efficiency (Capello 2009).

Insert Figure 1

Fig. 1: Efficiency scores without spatial spillovers, year 1993

Insert Figure 2

Fig. 2: Efficiency scores with spatial spillovers, year 1993

5. Conclusion

In this paper, we have examined the influence of agglomeration externalities and spatial spillovers on the production process of Italian regions. To this purpose, we have estimated a stochastic frontier production function on 20 Italian regions data for the period 1970-1993.
The results point out substantial differences in the Italian macroareas. More specifically, we have verified that localization externalities and urbanization externalities positively affect the productive efficiency of Central and Northern Italy regions. Hence, these results show that production is positively affected by those sectors where the region appears to be specialized and that a higher level of regions diversification favors the production process: "… it is important to make clear that these two externalities are not necessarily opposed, since specialization is a particular feature of a certain sector within a [regions] whilst diversity is a characteristic of the whole area" (Paci and Usai 2000). On the contrary, the efficiency of Southern Italy regions suffers the positive influence only by diversification economies (after taking into account spatial spillovers).

Moreover, the spatial autoregressive term among the regressors reveals that spatial spillovers has a strong impact in determining a growth of efficiency of the production process. This highlights that the externalities produced in a specific local economy do not exert their effects only within this location but that they cross the boundaries to influence the performance of other locations (Pagnini 2003). In fact it is rather restrictive to assume that spillover effects run out only within the local economy in which they are generated, and it seems logical to assume that the interdependence degree between these economies is inversely related to distance.
In particular, "This spillover effect indicates that the spatial association patterns are not neutral for the economic performances of [Italian] regions. The more a region is surrounded by dynamic regions with high [employment], the higher will be its [productivity]. In other words, the geographical environment has an influence on growth processes. This corroborates the theoretical results highlighted by the New Economic Geography." (Baumont et al. 2001).
Substantial differences among Italian regions arise when we take into account spatial spillovers effects on individual regions. In particular, spatial spillovers show a negative effect on the efficiency level of some regions, called the donor ones.
Another interesting issue is related to the delay with which agglomeration externalities affect production (Combes 2000). In this respect, Henderson (1997) shows that the most significant impacts of localization externalities occur after three or four years, while those related to urbanization externalities show increased persistence that extends up to eight years. In future work we could refer to a dynamic stochastic frontier model estimated by using the generalized method of moments (GMM) (Ahn et al. 1994; Ahn and Schmidt 1995; Ayed-Mouelhi and Goaied 2003; Schmidt and Sickles 1984).

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Table 1: Results

Variables	**Basic Model**		**Regional Model**	
	Without spatial spillovers (1)	With spatial spillovers (2)	Without spatial spillovers (3)	With spatial spillovers (4)
costant	0,1675* (1,7499)	0,4540*** (4,3512)	0,0253 (0,3315)	0,4497*** (6,1125)
capital	0,5329*** (35,2112)	0,4585*** (25,4018)	0,5539*** (46,9051)	0,4595*** (35,6903)
labor	0,5534*** (39,0471)	0,6454*** (34,1017)	0,5341*** (49,1599)	0,6387*** (47,2472)
costant	-0,1061** (-2,4448)	3,1456*** (11,7304)	0,2720*** (6,4980)	2,3795*** (10,3614)
MAR	0,4660*** (13,0338)	0,3675*** (8,5651)	0,0784** (2,2987)	-0,0086 (-0,2122)
J	0,0470** (2,9873)	0,0597*** (3,6942)	-0,0379** (-2,1069)	-0,1016*** (-4,7308)
WE		-0,4606*** (-11,5209)		-0,2867*** (-8,3364)
D*MAR			-0,4426*** (-6,8938)	-0,2713*** (-4,1569)
D*J			-0,0429*** (-4,9071)	0,0706*** (2,7527)
D*WE				-0,0261*** (-2,7709)
σ^2	0,0082*** (10,0389)	0,0057*** (10,1064)	0,0045*** (10,5232)	0,0031*** (17,5473)
$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$	0,8662*** (20,3906)	0,7202*** (9,1487)	0,7421*** (10,4378)	0,1252*** (8,6684)
LR test of $\sigma_u^2 = 0$	371,2250***	503,1071***	642,0008***	711,4107***
Log-likelihood	541,7245	607,6656	677,1125	711,8174
Mean efficiency	0,8553	0,8562	0,8706	0,8874

***, **, *: 1%, 5%, 10%; (): t statistics.

Table 2: Efficiency change compared to percentage change in externalities

Externalities	**Italy (basic model)**		**NC (regional model)**		**S (regional model)**	
	(1)	**(2)**	**(3)**	**(4)**	**(3)**	**(4)**
MAR	-4%	-3%	3%	2.4%	-0.7%	Not significant
J	-0.4%	-0.5%	0.7%	0.3%	-0.3%	0.9%
WE		4%		2.8%		2.5%

Table 3: Efficiency scores and efficiency ranking, 1993

Regions	Efficiency score without spatial spillovers	Efficiency ranking without spatial spillovers	Efficiency score with spatial spillovers	Efficiency ranking with spatial spillovers
PIE (-)	0.9356	7	0.9382	9
VDA (+)	0.8803	12	0.9714	3
LOM (-)	0.9240	9	0.9078	12
TAA (+)	0.8956	11	0.9418	8
VEN (*)	0.9191	10	0.9148	10
FVG (*)	0.9737	2	0.9791	2
LIG (*)	0.9868	1	0.9891	1
EMR (-)	0.9627	3	0.9626	4
TOS (-)	0.9509	5	0.9467	7
UMB (*)	0.9455	6	0.9581	6
MAR (-)	0.9583	4	0.9587	5
LAZ (-)	0.9306	8	0.9145	11
ABR (*)	0.8778	13	0.8912	13
MOL (+)	0.7597	18	0.8054	16
CAM (-)	0.7664	17	0.7581	19
PUG (*)	0.8279	15	0.8173	15
BAS (+)	0.7181	19	0.7616	18
CAL (*)	0.6929	20	0.7111	20
SIC (-)	0.7709	16	0.7788	17
SAR (*)	0.829	14	0.8621	14

(-), (+), (*): first, second and third group, respectively.

Fig. 1: Efficiency scores without spatial spillovers, year 1993

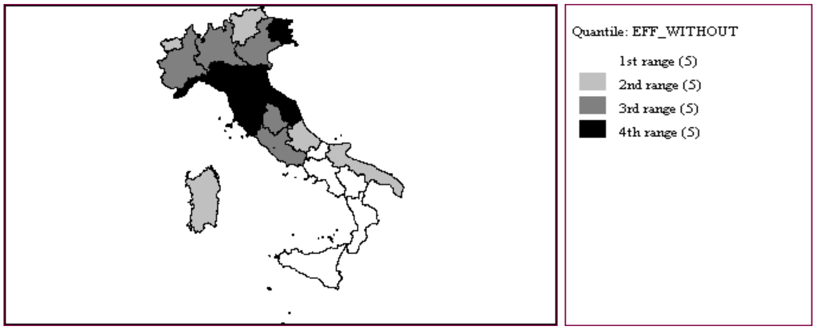

Fig. 2: Efficiency scores with spatial spillovers, year 1993