

# Stochastic Frontiers Approach: an Empirical Analysis of Italian Environmental Spending

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**Abstract** Using the stochastic frontiers approach (SFA) on a panel of Italian regional data, this paper tries to analyse the optimal design of environmental spending. The main question is, so forth, studying centralization vs decentralization of a public economic function, such as the protection of the environment, in order to improve the welfare of a country. Empirical results on Italy are ambiguous: the changing from a centralized to a decentralized government, giving more autonomy to local units, does not highlight a clear improvement in regional economic performance.

## Centralization or decentralization of the environmental spending

Italy could be defined as a regional system moving towards a federal one. There exist in fact four levels of sub national government: Regions, Provinces, Municipalities and Metropolitan Cities, with these last three entities forming the “local government”. The aim of our paper is to analyse the best design of environmental spending between national or local level. This issue stands on the concept of subsidiarity and on the theory of fiscal federalism. The main question is, so forth, studying when centralisation of public economic functions is welfare improving. The theoretical foundations could be identified in the seminal work of [2] in which he discusses the optimal level of centralisation of several public economic functions and in the works of [5], [4] and [3].

The basic economic theory of fiscal federalism explores the trade-off between the internalisation or not of external effects or economies of scale. The main point for decentralisation is to match the variety of preferences that exist in different

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jurisdictions. In contrast, centralisation may be warranted when the policy of a central government has consequences for another government, that are not taken into account in its decision making process (cross-border externalities). In addition, the presence of fixed costs, may make decentralised policies suboptimal. In that case centralisation benefits from economies of scale.

We model efficiency using the Stochastic Frontiers Approach which allows to distinguish between production inputs and efficiency/inefficiency factors and to disentangle distances from the efficient frontier between those due to systematic components and those due to noise.

Using this approach, we attempt to test if environmental fiscal rules binding on all levels, can help to sustain environmental national commitment and to improve economic efficiency in countries having a design similar to Italy. Coordinating institutions help in the use of moral suasion to encourage a coordinated response. Our preliminary results do not confirm that the more a local government is responsible for its environmental policy the more is efficient in term of economic and social performance. Thus, these results are dampening the hope for gaining efficiency from the changeover to a federalism system.

## The empirical model: the Stochastic Frontiers Approach

The neoclassical paradigm in economics assumes that production is always efficient. However, it is quite unrealistic that two regions can be identical; their eventual difference can be explained through the analysis of efficiency and some unforeseen exogenous shocks.

To test whether local environmental spending affects regional productive efficiency, we have estimated regional production functions using the stochastic frontiers approach. This approach allows to distinguish between production inputs and inefficiency factors. The most recent development of this approach has been the [1] model. Thus, the model specification may be expressed in logs as:

$$(1) \quad Y_{it} = x_{it}\beta + (v_{it} - u_{it}) \quad i=1,\dots,N, t=1,\dots,T$$

where  $Y_{it}$  is the production of the  $i$ -th region in the  $t$ -th time period;  $x_{it}$  is a  $k \times 1$  vector of input quantities of the  $i$ -th region in the  $t$ -th time period;  $\beta$  is a vector of unknown parameters. The unobserved random noise is divided into a first component  $v_{it}$  which is composed by random variables following the assumption of normally distributed error terms [iid  $N(0, \sigma_v^2)$ ], and a second independent component defined as  $u_{it}$  which is composed by non-negative random variables, distributed as a half normal distribution  $N(m_{it}, \sigma_u^2)$ . These variables are assumed to capture the effects of technical inefficiency in production.

The mean of this truncated normal distribution is a function of systematic variables:

$$(2) \quad m_{it} = z_{it}\delta + \varepsilon_{it},$$

where  $z_{it}$  is a  $p \times 1$  vector of variables which may have an effect on the production function of a region; and  $\delta$  is a vector of parameters to be estimated.

The simultaneous maximum likelihood estimation of the two equation system is expressed in terms of the variance parameters  $\sigma^2 = \sigma_v^2 + \sigma_u^2$  and  $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ , to provide asymptotically efficient estimates. The technical efficiency of the  $i$ -th region in the  $t$ -th time period is measured by:

$$(3) \quad TE_i = e^{(-u_i)} = e^{(-z_i\delta - \varepsilon_i)}$$

We perform our estimations using a panel data of 20 Italian regions across 13 years. By assuming that the production function takes the log-linear Cobb-Douglas form, our stochastic frontier production model can be specified as follows:

$$(4) \quad \ln(Y/L)_i = \beta_0 + \beta_1 \ln(K/L)_i + \beta_2 \ln(H/L)_i + \sum_{j=3}^5 (\beta_j \ln(K/L)_i * Macroarea) + \sum_{j=6}^8 (\beta_j \ln(H/L)_i * Macroarea) + v_i - u_i$$

where the dependent variable is the value of the economic performance of the  $i$ -th region at time  $t$ , divided by a scale variable (labour force) in order to remove heteroskedasticity and multicollinearity problems. The independent variables are: i) physical capital per capita ( $K/L$ ) which is the regional capital stock per worker of the  $i$ -th region at time  $t$  and ii) human capital ( $H/L$ ) which is the regional education spending per worker of the  $i$ -th region at time  $t$ . Moreover, to take into account the differences among Italian regions and the impact of local culture and geography on the local economic performance, we have added the interaction of physical and human capital with  $m-1$  dummies (*Macroarea*) accounting for the four different geographical areas in which Italy can be divided.

To analyse the impact of federalism on economic performance, we model the second component of the error as a function of several observable explanatory variables as in the following equation:

$$(5) \quad u_i = \gamma_0 + \gamma_1 DES_{it} + \gamma_2 POP_{it} + \gamma_3 MF_{it} + \gamma_4 PF_{it} + \sum_{k=5}^7 \gamma_k Macroarea + \varepsilon_i$$

where  $DES_{it}$  is the decentralization of environmental spending, measured by the ratio of regional environmental spending on the total public spending. To analyse the autonomy of a jurisdiction, we add:  $POP_{it}$  which represents the size of each region,  $MF_{it}$  which is the fragmentation of the municipalities within a region, computed dividing the number of towns existing in each region by the regional population and  $PF_{it}$  which represent the fragmentation of provinces within a region (ratio between the number of provinces and the regional population).

## Data and Results

The sample used in this paper derives from ISTAT National Economic Accounting, Regional Economic Accounts and Environmental Economic Accounts. Data are collected yearly from 1995 to 2007 for the 20 Italian regions.

In Table 1, we report the results of the stochastic frontier estimations. The results include step by step the different variables of fiscal federalism which are relevant for the analysis of regional environmental decentralization.

**Table 1: Inefficiency models with GDP pro-capite as dependent variable**

<i>Independent variables</i>		(1)	(2)	(3)	(4)	(5)
Const	$\beta_0$	3.52***	3.52***	3.28***	3.28***	3.11***
K/L	$\beta_1$	0.03	0.03	0.35***	0.35***	0.33***
H/L	$\beta_2$	0.02	0.05**	0.06***	0.06***	0.08***
K/L*North West	$\beta_3$	0.23***	0.23***	0.01	0.01	0.07**

K/L*North East $\beta_4$	0.18***	0.18***	-0.05	-0.05	0.20
K/L*South $\beta_5$	0.10***	0.09**	-0.14**	-0.14**	-0.07**
H/L*North West $\beta_6$	-0.08***	-0.11***	0.37***	0.37***	0.30***
H/L*North East $\beta_7$	-0.04	-0.07**	-0.01	-0.01	0.01
H/L*South $\beta_8$	0.63***	0.61***	0.35***	0.35***	0.29***
const $\gamma_0$	0.12*	0.12*	1.45***	1.45***	1.55***
Decentralization $\gamma_1$	-0.22***	0.35***	0.50***	0.50***	0.52***
Population $\gamma_2$		-0.66***	-1.04***	-1.04***	-0.84***
Municipality fragm. $\gamma_3$			-0.07***		-0.09***
Province fragm. $\gamma_4$				-0.07***	0.0001***
North West $\gamma_5$	0.01	0.003	-0.01*	-0.01*	0.01*
North East $\gamma_6$	-0.13***	-0.13***	-0.05	-0.05	0.05
South $\gamma_7$	-0.85**	-0.84**	-0.42**	-0.42**	-0.18***
Observations	280	280	280	280	280

\* significant at 10% level; \*\* significant at 5% level; \*\*\* significant at 1% level

In all columns, results indicate that production functions perform quite well. As usual in these estimations input factors' coefficients show a positive sign. Introducing the technical inefficiency function the coefficients' significance improves. The significant and positive signs of decentralization imply that the federalism of environmental expenditure is not efficient because it increases the specific error component and thus the inefficiency of regions, consequently reducing regional economic performance. Introducing instead municipal and provincial fragmentation separately, the results confirm a negative sign and thus this can have a positive effect on regional efficiency and economic performance. According to these fragmentation variables there are not economies of scales to exploit and hence, at this point, the federalism is good. Moreover, regions belonging to the South area have positive and significant effects on economic efficiency. Instead, results regarding the North-West and the North-East are puzzling. It seems that there is a negative impact on economic performance even if the significance is very low.

In order to deepen this analysis, we list regional technical inefficiency, derived by the column (5) model considering only three different years: 1995, 2000 and 2007. Results confirm the previous amazing findings showing that Valle d'Aosta, Piemonte and Liguria, belonging to the North-West area, are the most inefficient regions with respect to the federalist issue. Puglia, Sardegna and Abruzzo instead, are the more close to the frontier, seeming more efficient in terms of possible improvements deriving from a decentralization. However, the average technical efficiency of the sample is quite high (above 0.8) so Italian regions are rather efficient in terms of federalism.

## References

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