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The relationship between economic growth and environmental quality: the contributions of economic structure and agricultural policies

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Abstract

Objectives of this paper is to verify whether the relationship between the level of per capita income and the environment quality, for the Italian regions, follows the prescription of an Environmental Kuznets Curve (EKC), taking into account the contribution of agriculture and rural areas. The Arellano-Bond two-step dynamic panel data GMM estimator has been applied to a data set of the 20 Italian administrative regions referred to the 2000-'06 years. The quality of environment is represented by the level of per capita CO2 emissions from the whole economy and the level of per capita CO2 emissions from agriculture. The regression results show that i) the EKC prescription holds for the Italian regions, ii) the more agricultural regions are found on the rising section of the curve; iii) a greater intensity of expenditure under the RDP regional agro-environmental and forestry measures is positively associated to a more degraded environment.

Keywords: Environmental Kuznets Curve, Agriculture, Agricultural Policy, Regional panel data

JEL classification: Q01, Q15, R11.

1. INTRODUCTION

Objective of this paper is to verify the role played by the Italian rural regions in the mitigation of environment degradation and their contribution in the choice of a sustainable development path for the territory where they are located in.

The definition of rural areas is the one commonly used in literature (Mantino, 2008) that refers to fragile economic systems which need public support, aimed at overcoming their social and economic problems: the depopulation, the productive specialization mainly based on agriculture and the general difficulty of implementing local policy able to ignite a process of autopropulsive economic development. On the other hand, rural areas have to cope with the same problems of industrial and urban areas, such as the scarcity of natural resources and the environmental degradation. However, rural economic systems may potentially contribute to guarantee a path of sustainable economic development more than the urban ones.

Recently many Italian rural areas have experienced strong structural changes towards integrated economic systems which have diversified their productive activities mainly through the tertiarisation of agriculture. This process was facilitated by the network of relations between farms and the local resources and by valorizing the cultural identity of communities, the local tourist attractions and the landscape resources (ECORYS, 2010; OECD, 2009).

The quality of natural resources, therefore, can be the key-variable of the new production mix since rural areas have strong economic incentives to properly manage natural, cultural and human capital resources, which are the inputs of the new services. Environment preservation and economic growth in rural areas can, therefore, be complementary, with a bidirectional causal relationship and it may be crucial to investigate on this relationship specifically for rural areas.

Several empirical researches, by regressing some indicators of environmental quality on the level of per capita income, show that there is a correlation between economic growth and environmental quality. This relation assumes the form of an inverted U, namely increasing levels of per capita income lead initially to a degradation of the environment and then, after a certain level of per capita income, to an improvement in environmental quality. This empirical regularity is called the Environmental Kuznets Curve (EKC).

This relationship stresses that the improvement in the population living standard, associated to the economic development, increases the awareness of the problems due to the environmental degradation and brings to a higher demand for and supply of environmental quality. The resulting changes in the production side are the use of cleaner technologies and the loss of economic importance of traditional and less environmental friendly sectors.

The present paper intends to verify whether and how the Italian rural development and the evolution of Italian agriculture have generated a positive impact on the environmental quality. Particularly, the paper intends to verify whether rural areas have reinforced or not the effect of the economic growth on the environmental quality and what the contribution of rural policies has been in this respect.

The relationship *á la* Kuznets has been studied by using a regional panel data referred to the period 2000-2006. The level of pollution is represented by the level of per capita emissions of CO2 regressed on the level of GDP per capita of the Italian regions and on other variables reflecting the kind of rural development and the intensity of agricultural policies.

The paper is organized as follows. Section 2 reports a brief review of the theoretical debate and of the empirical evidence on the relationship growth-environmental quality. Sections 3 and 4 illustrate the applied methodology by focusing on the econometric approach and on the data used. The results are reported in section 5 while some concluding remarks are reported in section 6.

2. THE SUSTAINABLE GROWTH AND THE EKCS

The broad debate on the relationship between economic growth and environment is deeply rooted in the concept of economic scarcity elaborated by the classics of the economic theory and in the Malthusian and neo-Malthusian theories but particularly in contemporary authors' studies, such as Georgescu-Roegen (1971). This latter stated that, given the physical limits of nature, a model based on continue economic growth will exponentially increase the pressure on natural resources up to their exhaustion. Economic growth is sustainable in the long run only in a model based on negative growth rates.

In the '70s some researchers have introduced the energy, the natural resources and the environmental pollution in the neo-classical theory of growth and have reached the conclusion of an unsustainable growth that gave birth to the pessimistic prescription of the Rome Club (Meadows *et al*, 1972). Afterwards, during the '90s, together with other studies, the Brundtland Commission report (*World Commission on Environment and Development*, 1987) has introduced the idea of environmental sustainability of economic growth. The endogenous growth theory has focused on the question whether and how economic growth can be sustainable in the long run (Aghion e Howitt, 1998).

More precisely the Schumpeterian endogenous models introduce the presence of a research sector which produces vertical innovation and is cleaner than the material good sector. The growth is sustainable if the rate of accumulation of cleaner technologies is higher than the rate of accumulation of physical capital (Cavallaro, 2002).

Within this debate, the Environmental Kuznets Curves have been imposed as a tool willingly understandable for empirical evaluation of the environmental impact of growth and of policies. The idea behind this curve, empirically tested, is that the relationship between economic growth and environmental quality follows an inverted U shape.

The EKC relation shows that different stages of economic development have different impact on environment, indicating that as the per capita income (or per capita wealth) increases, the economy shows first an increase in pressure on the environment (in terms of more pollution and of more intensive use of natural resources), then, after at a certain level of income (called *turning point*), there is a trend reversal, which results in a virtuous cycle of improvement and of reduction of the economic pressure on the environmental resources.

The EKC path has been originally observed for some phenomena of air pollution (particulates, SO_2, NOX, CO_2) and water (river water) since the '90s. Several studies have tested the EKC with a cross-country approach, using data on products from *General Environmental Monitoring System* (GEMS), which contains information on the contamination of air and water from the most common pollutants actually known (Dasgupta *et al*, 2002).

Among those who have first estimated the EKC, Grossman and Krueger (1993) explain the relation by the *scale effect* of growth, that is increasing returns, associated to growth, make the technology more efficient and reduce the cost of pollution abatement; at the same time, the *substitution effect* make it possible to shift to cleaner and non-renewable resource saving techniques; finally, because of the *composition effect* of output, consumption of polluting products is reduced and the weight of the cleaner tertiary sector is increased.

These models seem to suggest a path of *laissez-faire* (Andreoni e Levinson, 2001), that is the increasing income automatically will ensure the improvement of environmental quality.

However, many empirical studies are skeptical in this respect emphasizing the importance of policies to protect the environment (Dasgupta et al, 2002; Panayotou, 1997) and stressing the limits of the family of estimated EKCs' for the following aspects.

First of all, the data concern mainly the developed countries and are scarce for developing countries. In fact, some researchers point that the relationship is first increasing and, after a certain level of income, becomes constant (*Race to the Bottom Scenario*), because pollution is decreasing in the developed countries but increasing in the developing ones. This result is mainly due to the world economic globalization that leads to a "specialized production", in which much polluting technologies are utilized in countries with low incomes and, therefore, with little or no regulation, less social attention to environmental problems, etc.. The relocation of more polluted firms in countries, with weak or absent environmental regulations, and the increasing imports from them because of lower costs (*environmental dumping*) brings to no reduction in world pollution (Cavallaro, 2002).

Furthermore, it is emphasized that the EKC doesn't fit with all the pollutants. In general the data of many types of pollutants are scarce everywhere, there is no information about approximately 100 types of potentially toxic materials, both in terms of degree of toxicity and of the quantities emitted by the countries. Many researchers suggest that the curve has a steady growth path since, against the reduction of some pollutants (conventional), of which there is information, there would be many others that are newly introduced, which are ignored and would actually increase the level of existing pollution *(New Toxics)* (Dasgupta, 2002). They refer to certain persistent organic pollutants, which are recognized as very dangerous for both the major damage causing to human health and because they accumulate in plants and animals so they are difficult to eliminate (eg dioxins).

3. THE METHODOLOGY

The following functional specification of the EKC has been adopted here to examine the impact of GDP per capita on the level of pollution in a panel dataset of the 20 Italian administrative regions for 7 years (1):

$$LogCO2_{i,t} = LogGdp_{i,t} + LogGdp_{i,t}{}^2 + \bar{X}_{i,t} + U_{i,t} \qquad (1)$$

where:

- $LogCO2_{i,t}$ is the logarithm of CO2 emissions per capita at time (t) in region (i);
- $LogGdp_{i,t}$ and $LogGdp_{i,t}{}^2$ are the logarithm of per capita GDP at time (t) in region (i) and its squared;
- $\bar{X}_{i,t}$ is a vector of covariates utilized as proxy to explain the role of economic structure, of agriculture and of agricultural policies.
- $U_{i,t}$ is the error term at time (t) for region (i).

Several econometric problems may arise from estimating equation (1).

Time-invariant region characteristics (fixed effects), such as geography and demographics, may be also correlated with the explanatory variables. The fixed effects are contained in the error term in equation (1), which consists of the unobserved region-specific effects, v_i, and the observation-specific errors, $e_{i,t}$: $U_{i,t} = v_i + e_{i,t}$

In panel data, the lagged dependent variable ($LogCO2_{i,t-1}$ in our case) is correlated with the unobserved region-specific effect residuals (v_i).

In large-T panels a shock to the region's fixed effect, which shows in the error term, will decline with time. Similarly, the correlation of the lagged dependent variable with the error term will be insignificant.

In small-T panels, such as the panel dataset used in this paper which has a short time dimension (T =7) and a larger individual dimension (N =20), the Arellano-Bond two-step dynamic panel data GMM estimator is recommended.

Equation (1) has also been used to also investigate the relation between the level of CO_2 emissions from agriculture and the level of GDP, taking into account the structure of regional agriculture and the agricultural policies.

Specifically, the role of agriculture and of rural development is investigated through the following variables:

- the degree of urbanization (Urban population rate),
- the incidence of areas classified as "rural" in the regional Rural Development Plans (Rural areas *per capita*),
- the payments for agro-environmental and forestry measures provided in the RDP (Agro-environmental outlay on Agric. VA)
- the incidence of agro-tourism (Number of organic farms *per capita*)
- the incidence of organic farms (Number of organic farms *per capita*)
- the agro-environmental outlay on agricultural value added (Agro-environmental outlay on Agric. VA).

1. The proxy for environmental quality

In this paper the environmental quality is represented by the level of the carbon dioxide emissions, estimated for the Italia regions by ENEA (ENEA, 2010). Carbon dioxide emissions represent the pollutant most responsible for the greenhouse effect. In fact, in 2007, greenhouse gases was quite totally due to the CO2 emissions, which amounted on 475,302 Gg and represented around 86% of total emissions of greenhouse gases (ENEA, 2010). For this reason, this gas level is estimated at a regional level, with a privileged analysis respect to others gases.

The methodological path, followed by ENEA in order to estimate the inventory of polluted emissions, is based on the direct ratio between energetic consumes, estimated on the chosen local scale, and the emission factors. To do this at regional level, ENEA estimates the activity sources, derived from data of the Annual Regional Energy that ENEA processes each year, multiplied by the emission factor. This latter is appropriate for specific emission coefficients, expressed in tonnes of substance emitted per tonne of oil equivalent fuel consumed (ENEA, 2010). The sources of activities are represented by the combustion processes of the energy industries (power generation, refineries, etc.), manufacturing industries and construction, transport and other sectors (commercial, residential, agriculture and fisheries). This group, called "Energy" sector, releases polluted gases and it is the most responsible for the greenhouse effect. Regional estimates of CO_2 emissions inventory, utilized in this study, refer to the CO_2 resulting from these energy processes; so the regional levels depend on the energy sources used (production, processing and final uses) and solutions for their reduction, therefore, it is related to regional characteristics. Also, the Italian regions are very different in GDP *per capita,* in economic structure and in agriculture; then there is enough heterogeneity to estimate the contribution of agriculture and rural areas to the growth-environment relationship.

Table 1 reports the descriptive statistics of the data used in the study.

Table 1- The descriptive statistics of variables

Variable	Obs. [1]	Mean	Std. Dev.	Min	Max
CO2 *per capita* emissions	140	8.050	2.657	2.964	14.989
CO2 *per capita* agricultural emissions	140	0.149	0.064	0.016	0.351
Gdp *per capita* (based 2000)	140	20,430.260	4,994.990	13,019.900	27,884.950
Agricultural Value Added weight	140	0.031	0.014	0.011	0.067
Agricultural Value Added *per capita*	140	570.022	179.412	302.441	1,108.385
Urban population rate	140	0.189	0.136	0.000	0.522
Rural areas *per capita*	140	0.004	0.007	0.000	0.027
Number of organic farms *per capita*	140	0.001	0.001	0.000	0.008
Number of agro-tourisms *per capita*	140	0.000	0.001	0.000	0.003
Number of organic farms *per farms*	140	0.024	0.016	0.002	0.086
Number of agro-tourisms *per farms*	140	0.010	0.013	0.001	0.076
Agro-environmental RDP expense *per capita*	140	8.927	9.815	0.602	50.752
Environmental public expense *per capita*	140	361.769	317.332	167.963	1,916.679

[1] Regional values weighted per year
Source: own elaborations on ISTAT, ENEA, INEA-BD VISPA data.

4. THE RESULTS

The dependent variable in the first model is the logarithm of CO_2 emissions *per capita;* the main results of the regressions are reported in the table 2.

Table 2- The results of the Arellano Bond dynamic two-step estimation of Log CO2 emissions *per capita*

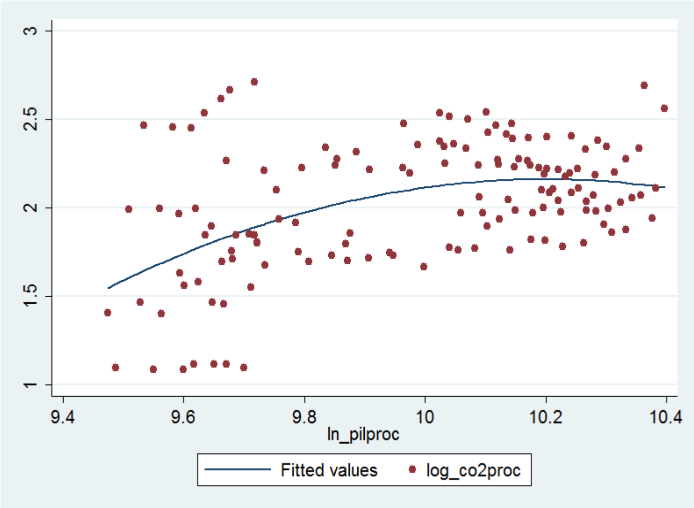
VARIABLES	(1) Model	(2) Model	(3) Model
Lag of logCO2 emissions	0.537***	0.221***	0.276***
	(0.055)	(0.069)	(0.073)
Log Gdp *per capita*	47.636***	48.454***	48.077***
	(11.738)	(11.624)	(13.342)
Log Gdp *per capita* squared	-2.409***	-2.441***	-2.419***
	(0.593)	(0.590)	(0.683)
Urban population rate	7.385***	13.270***	13.075***
	(2.371)	(3.539)	(3.484)
Number of organic farms *per capita*	-19.236***	-16.472***	-18.341***
	(3.200)	(1.422)	(1.130)
Number of agro-tourisms *per capita*	421.917***	203.794	
	(86.872)	(145.914)	
Agro-environmental outlay on Agric. VA	1.905**	2.613***	2.239**
	(0.794)	(0.723)	(0.951)
Rural areas *per capita*		-525.330***	-518.188***
		(145.076)	(100.063)
Observations	100	100	100
Number of regions	20	20	20
Number of years	6	6	6
Number of instruments	21	22	22
Wald Chi2	7986.45	7767.63	27463.67
Chi2(14)-Sargan test[1]	14.66	9.897	10.52

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
[1]Sargan test of over-identifying restrictions, H0: over-identifying restrictions are valid.
Source: own elaborations

First, the prescription of *Kuznet curve* holds for the Italian regions, whose 'turning point' is around 21.000 (2000-based) € level of GDP *per capita*, leaving at the left of the point the regions: Abruzzi, Basilicata, Calabria, Campania, Molise, Puglia, Sardinia, Sicily and Umbria. While, those that are positioned in the descending portion of the predicted curve are: Piedmont, Friuli V. G., Veneto, Lazio, Emilia R., Trentino A.A., Valle d'Aosta, Liguria, Marche, Tuscany and Lombardy.

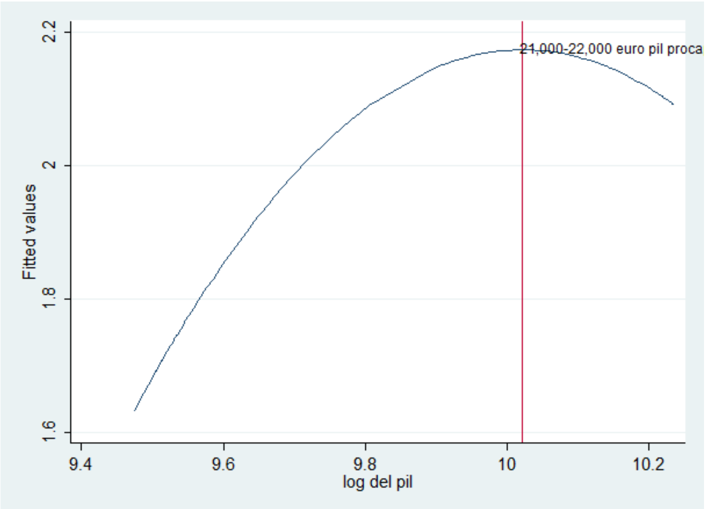
Specifically, in figure 3, which reports the predict curve and plots the actual regional data, we can see that in the increasing section of regional *EKC* there is much heterogeneity between regions, where some regions pollute much more then the predicted value; while in the decreasing path of pollution there are more homogeneity between the ones (Fig.3).

Figure 3- Predicted curve and actual regional values of relationship economic growth-environment



Source: own calculations

Figure 4- Predicted path of relationship growth-environment for a "mean region"



Source: own calculations

The *elasticity* of pollution, calculated with respect to the level of the mean income (average value of the logarithm of GDP *per capita* in the sample, which corresponds to 20,430 €) is equal to -0.90%.

Regards to the other variables, we can see that, regions with a higher proportion of rural land pollute less than the predicted value. Also, the largest presence of organic farms improves the environmental quality, while the agro-tourism displays a negative impact. As regards the agricultural policy the regression show that a greater intensity of expenditure under the RDP regional agro-environmental measures is positively associated to a more degraded (in terms of

CO_2) environment, therefore this specific policy seems to be "therapeutic" rather than preemptive.

The dependent variable in the second model is the logarithm of the level of agricultural CO_2 emissions *per capita,* the main results of the regressions are reported in table 5.

Table 5- The results of the Arellano Bond regression. Dependant variable Log CO2 emissions *per capita* from agriculture

VARIABLES	(1) Model	(2) Model
Lag of logCO2 of agriculture	-0.102***	-0.0906***
	(0.00678)	(0.00468)
Log Gdp *per capita*	120.0***	102.8***
	(20.60)	(15.22)
Log Gdp *per capita* squared	-5.969***	-5.073***
	(1.071)	(0.792)
Number of organic farms *per farm*	-0.344	
	(0.501)	
Number of agro-tourisms *per farm*	-5.051	-6.265*
	(3.434)	(3.482)
Agro-environmental outlay *per farm*	0.000447***	0.000587***
	(0.000127)	(4.74e-05)
Rural areas *per capita*	-1,464***	-1,499***
	(196.9)	(65.23)
Observations	100	100
Number of regions	20	20
Number of years	6	6
Number of instruments	21	20
Wald Chi2	4737.61	1762.21
Chi2(14)-Sargan test[1]	14.28	15.20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
[1]Sargan test of over-identifying restrictions, H0: over-identifying restrictions are valid.
Source: own elaborations

The results of the second set of regressions show that the 'turning point' predicted for the CO_2 emissions from agriculture is around 24.000 (2000 based) € level of GDP per capita, highlighting that after a certain level of per capita income, the agriculture also uses more environmental friendly technologies.

A greater intensity of expenditure under the RDP regional agro-environmental measures doesn't improve the environmental performances of agriculture, thus confirming that agricultural policy is not an environmental policy.

Finally, in contexts where agriculture is new demand-oriented, the primary sector reduces its pollution impact, highlighting how these processes trigger bi-directional causality between the "multifunctional agriculture" and the environmental quality.

5. CONCLUDING REMARKS

Objectives of this paper was to verify whether the relationship between the level of per capita income and the environment quality, for the Italian regions, follows the prescription of an Environmental Kuznets Curve (EKC), taking into account the contribution of agriculture and rural areas.

The Arellano-Bond two-step dynamic panel data GMM estimator bas been applied to a data set of the 20 Italian administrative regions referred to the 2000-'06 years. The quality of environment is represented by the level of per capita CO_2 emissions from the whole economy and the level of per capita CO_2 emissions from agriculture.

The regression results show that the EKC prescription holds for the Italian regions. The turning-point is equal to a level of per capita income of around 21.000 (2000-based) € for the whole economy and to a level of 24.000 (2000-based) € for the primary sector.

This means that agriculture is follower of the other economic sectors in the adoption of environmental friendly techniques. In fact, the more agricultural regions are found on the rising section of the curve with a higher dispersion of regions than in the descending section where the more environmental friendly regions are concentrated.

Finally, the agricultural policy was not an environmental policy since a greater intensity of expenditure under the RDP regional agro-environmental and forestry measures is positively associated to a more degraded (in terms of CO_2) environment.

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