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Environmental Policy Options

in the Multi-Regimes Framework

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Abstract – In this paper we extend the multi-regime framework to variables involved in the debate on economic growth and environmental quality, starting from a reexamination of the so-called Environmental Kuznets Curve. The aim is to discuss the *double convergence hypothesis* that implicitly stems from a recent line of research. According to it, some stylized facts would support the almost paradoxical hypothesis that economic growth produce not only cross-countries or regions convergence in per capita output, but also in (the demand of) environmental quality.

Factual analysis seems to reject the hypothesis of convergence in output or income levels. Available evidence, rather, seems to point out that there is no such a thing as a unique avenue to sustainable development while the convergence predicted in more conventional analyses, in particular within the framework of the so called Environmental Kutznets Curve, is far away from being demonstrated. Actual growth processes do differ from each other in a deep qualitative sense, to the effect of profoundly influencing final outcomes as well as the unfolding of the processes themselves. This reflects differences in initial conditions, of course, but also the different sectoral or integrated policies that have been implemented along the way.

Therefore, in contrast to the *double convergence hypothesis*, in our contribution we argue that *growth is a necessary but not sufficient condition* for the required change in the individuals' preferences needed to shift social preferences away from private to public goods and that, moreover, the relationship between growth and environmental quality depends crucially upon the country's growth model. Therefore, more than the quantitative it is the qualitative aspects that matters.

The theoretical context that seems to lend itself to the analysis of such issues falls within the boundaries of the theories of endogenous growth. We argue that sustainable development, if it emerges at all, is the result of investment in immaterial capital (research, education and the like) more than the reflection of the exogenous forces (technological progress and demographic growth) of the neoclassical theory. In the analysis of such issues, the environment offered by the multiregime approach proves useful as it highlights the qualitative properties of the dynamic processes, instead of focusing upon quantitative estimation of some special asymptotic states whose existence is often all but to be demonstrated.

***Jel Classification**:* C60, C61, O10, O13, O15, Q01

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1. Introduction

This paper extends the multi-regime framework (see e.g. Boehm and Punzo, 1994, 2001) to variables involved in the debate on the relation between environmental quality and economic growth. In this light, it reexamines the interpretation of the so-called Environmental Kutznets Curve (from now on EKC). The adapted framework can account for one fundamental finding, which does not find a place in the relevant literature: namely, the diversity across countries and regions of the development experience in terms of both growth performance *and* evolution of environmental quality. On the other hand, the paper reviews the proposition of the associated potential conflict between these two targets, and the presence of a trade-off between them. The issues captured by this simpler notion of tradeoff are essentially of a qualitative nature. We propose hereafter a formal way to think about these issues. The bonus is a framework that seems more appropriate for designing integrated policy plans apt to guide an economy along the difficult *traverse* between two different growth mixes.

Our argument can be introduced in the following way. The key issue traditionally associated with the notion of *sustainable development* has, for a long time, been how to reconcile growth with environmental preservation. Sustainable development involves much more complex aspects revolving around problems of social, economic and cultural relevance.

Often, objectives and aims of social and environmental nature are predicated as constraints to the growth of GDP, e.g. as objectives whose realization can be attained only at the detriment of growth. In recent years, however, we have witnessed the unfolding of a new line of research whereby some stylized facts have been identified supporting the almost paradoxical hypothesis that environmental quality represent the joint product of economic growth (a reference is to e.g. Beckerman, 1992).[1] Economic growth is, therefore, seen to produce not only cross-country convergence in per capita output, but also in the levels of environmental quality: a *double convergence hypothesis*.

According to this set of studies, generated by the interpretation of the EKC,[2] there is a quadratic relation (a U-shaped curve) linking environmental quality, generally proxied by some index of emission, and *per capita* GDP. The current interpretation maintains that, in the initial phase of a growth process, environmental quality exhibits a tendency to deteriorate, while, once passed some threshold value of income, its further growth will generate improvement in the environmental

[1] These aspects are critically discussed in Torras and Boyce (1998) and Grossman and Krueger (1995).

[2] The seminal work of Simon Kuznets (1955) evidenced a quadratic relationship between equality and economic growth, i.e. an U-shaped curve.

quality. The hypothesis is that higher income level automatically boosts the demand for environmental protection and quality (income elasticity hypothesis).

In contrast to such strong hypothesis, our contribution argues that:

- *growth is a necessary but not sufficient condition* to produce the required change in the individuals' preferences needed to shift social preferences away from private to public goods;
- the relationship between growth and environmental quality depends crucially upon the country's growth model. In other words, more than the quantitative it is the qualitative aspect of growth that matter here, an aspect captured by the complex notion of *model of growth*.

Abundant factual evidence is known, which casts doubts on the *classical* hypothesis of convergence in output or income levels. It also seems to indicate that there is no such thing as a unique avenue to sustainable development. At the same time, double convergence implicitly predicted in conventional analyses, in particular within the framework of the so-called EKC, is far away from being demonstrated. Looked at in a multivariable framework, actual growth processes seem often to differ from each other also in some deeper qualitative sense, to the effect of profoundly influencing final outcomes, as well as the time unfolding of the processes themselves. This would reflect differences in initial conditions, so called idiosyncratic shocks, of course, but also the different sectoral or integrated policy actions that have been implemented along the way. The dependence upon initial conditions and implemented policies will be the focus for our analysis, hereafter.

The theoretical context that seems to lend itself to the analysis of such issues falls within the boundaries of the theories of endogenous growth. We argue that, if it emerges at all, sustainable development is bound to be the result of investment in immaterial capital (research, education and the like), more than the exogenous forces (technological progress and demographic growth) of the neoclassical theory. Accordingly, for its very nature, sustainability demands an approach based upon the design and implementation of integrated (non sectoral) policies. Only with these can a traverse path be initialized that may take low income/low environmental quality economies directly across to high income levels without having to pay for this with a phase of environmental degradation. The length of the latter is one of the uncertain elements in this cost calculation: perhaps long or infinitely long, there being the risk for one such economy to get stuck in it.

In the analysis of such issues, the environment offered by the multiregime approach proves useful as it highlights the qualitative properties of the dynamic processes, instead of focussing upon quantitative estimation of some special asymptotic states whose existence is often all but to be demonstrated. This is a natural consequence of the fact that, in the standard studies, growth is generally described as a sequence of practically predetermined phases, each being characterized by peculiar structural features. That such phases can be changing over time, hence inducing changes not only on the levels of certain variables, but also and more importantly in the ways they dynamically interact, makes it natural to think in terms of an ever expanding portfolio of dynamic regimes and of a dynamics across them. This allows, among other things, a useful comparison of structurally different economies on a qualitative basis.

Although there is an ample choice in the multiregime literature, the approach introduced by Boehm and Punzo (2001) will be adopted and adapted to the treatment of environment as one of the variables defining regimes.

2. The Environmental Kuznets Curve: a short review

Studies on the relation between economic growth and environmental quality are synthesized by the debate around the EKC and in fact are based upon a dynamic re-interpretation of such curve. They all seem to accept a suggestion from conventional growth theory, whose scope is extended to include some environmental variable and whose predictions are articulated into phases chained together in the transition to the long run path the theory is really concerned with.

The EKC relation, taken as a dynamical law, indicates that environmental quality would deteriorate in the initial phases of the growth process, therefore affecting the level of total welfare to an extent that may be difficult to anticipate, while, once surpassed some given threshold value of income level, further growth will go along with its improvement.[3] However, it is worth noting that empirical results depend crucially on the index of environmental quality used (World Bank, 1992), as we will see in the following sections, as well as the type of analysis, whether cross country or of the time series type, and that they also vary greatly across equipes of researchers (Ekins, 1997).

Why the relation takes up this shape, there is no consensus. The majority of studies has explained it uniquely in terms of income elasticity demand. Behind this set of studies lies the fundamental assumption (that should be tested rather than be taken for granted) according to which environment is an income-elastic commodity (*luxury good*). According to the income elasticity hypothesis, in the advanced phases of the development process, environmental quality improves

[3] Pezzey (1989) argued that, at least in the long run, the inverted-U relationship may not hold. More likely is a so-called N-shaped curve.

because people become more environmentally conscious, and can afford to build up political pressure for the enforcement of environmental regulations and protection. In other words, studies on the EKC implicitly assume that economic growth, because of the income elasticity of demand for amenities, and the greater information accessibility it produces, directly spurs an increase of demand for policies devoted to environmental protection and related environmental expenditures (Selden and Song, 1994).

More recently, the focus has shifted onto the role played by policies in shaping up the upward branch of the curve (Grossman and Krueger, 1995; Panayotou, 1995; Torras and Boyce, 1998). Other researchers took the road of trying to estimate empirically the relevance that some structural factors may have, together with income, in explaining the curve taken to be a stylized fact. Grossman and Krueger (1995, 1996) have identified three channels through which economic growth can exert an influence upon environmental quality: a scale effect, which would tend to prevail in the early phase of development; a composition effect modifying the productive structure of an economy; and finally, a technological effect, linked to the introduction of new and more efficient production techniques.

However, it is worth to point out that with a few notable exceptions, no *direct* measure of expenditure and/or of environmental policies has ever been tested for econometric relevance.[4] Actually, as a proxy for environmental quality of a country normally some index of emission is deployed, whose change, we will see, not necessarily must be imputed directly or solely to the impact of adopted environmental policies.[5] Moreover, this sort of indices neglect the stock effect typically associated with pollution emissions. In fact, long run sustainability does not only depend upon the annual rate of emissions; it crucially depends on the past levels of pollution, due to the cumulative effects of emissions and to the delayed effect of past accumulations of pollutants, and the capacity of the environment of absorbing it (Kaufmann and Cleveland, 1995).

3. The EKC and the theory of growth . Reconsidering the convergence issue.

The literature on the EKC has gone along to a generalization of the convergence result associated with the traditional exogenous growth theory. According to the latter, whatever their initial conditions, countries will be converging to a long run path, tagged by a level of output per capita and the corresponding rate of growth. Under the known strict assumptions as to the production of innovation and new technologies, like their accessibility and the properties of production

[4] Mangani (2000) constructs a test for the existence of the EKC using R&D expenditure for environmental protection.
[5] List and Gallet (1999), for instance, carried on an analysis of emissions of SO_2 and NO_x for the States of the US between 1929 and 1994.

technologies being implemented, such long run is unique, implying the same level of output per capita or production, and the same rate of steady state growth, the latter being zero. Hence, the long run is a stationary state. The original model, of course, does not take into account the presence of resources and or the pollution of environment. The current interpretation of the EKC can be seen as an extension so as to fit in the latter problem.

In this enlarged framework, prediction is a little more sophisticated: one has to explain the two branches of the curve, which have opposite properties. The standard interpretation assumes there is a dynamical process behind the curve, so that points scattered around it do represent basically states on a trajectory. Accordingly, the downward sloping branch has been interpreted as the set of trade off equilibria where higher (lower) levels of one variable are consistent with lower (higher) levels of the other. In other words, it is a trade off relation, in conception similar to the one implied in the Phillips curve. At one point entered the interpretation of the Phillips curve that points along the curve could only be seen as short run equilibria, in other words, in a full dynamics as transients towards a long run equilibrium pair acting as the global attractor.[6] Similarly, for EKC, points on the left will eventually fly away towards the right or upward sloping branch of the curve. There, the trade off relation between the two variables disappears, and both "move" together, tending towards some long run equilibrium values, which evidence cannot show but its apparent monotonicity suggests. It also seems to suggest the existence of some attractor, somewhere, to be imputed to external or internal constraints on the generating model. In the current interpretation, the Solow's value of the growth rate of productivity will be married together with a corresponding value of the environmental index.

4. Modeling income growth and environmental protection

The multi-faceted nature of the environmental issue in relation to growth does not make it easy to construct synthetic indices. For want of such indices, as stated above, results tend to be dependent upon the kind of indicator our choice falls for, much more than one would like (World Bank, 1992). Although we are aware of this inherent limit, in this section we review the relationship using a typical index of emission, i.e. the index of CO_2 emission.

The analysis deals with a sample of countries that is more or less homogenous from the point of view of economic performance (in growth terms), as they have all concluded the first phase of development and, all but Albania, display a composition of VA typical of advanced countries (where the service sector has the greatest share, representing no less than 45% of total VA, while

[6] In that case the natural rate of unemployment, associated with any level of the inflation rate. Notice the similarity with our treatment of the consequeunces of the three dimensional EKC .

agriculture is the least relevant).[7] Figures 1 and 2 show that with the CO_2 index one cannot find any U-shaped inverse relationship. Being countries just exited from the initial phases of their development, the first branch of such a curve is missing. It's no surprise that Albania finds itself in an anomalous situation, its V.A. composition being totally different from that of other countries. The upward sloping branch disappears also as a result of having considered only countries with a V.A. composition typical of the advanced world. This in turn has the effect of reducing the re-allocative effect of production. The more advanced countries show a tendency to relocate their dirty or technologically backward production lines into the lesser developed countries, and this automatically positions the latter along the upward sloping branch of the curve (Suri and Chapman, 1998; Musu, 2000). The same re-allocative process can account for the explanation offered by Vincent (1997), according to which the EKC would really be the result of the superposition of two distinct relations, a negative one for the less developed and a positive for the more developed countries.

Besides this aspect, it is to be noticed that the result graphed in Fig.1 is not necessarily to be attributed to more restrictive environmental policies, partially in contradiction with what is said in the example of the previous section. Energy efficiency may be un-related or independent of the degree of environmental awareness of a country, as said above. A large contribution to it comes from the level of energy price and the countries' energy self-sufficiency. The explanation of the inverted-U form of the curve would lie in the price sensitivity of the curve, because of its energy foundations.[8] By implication the transition from the polluting phases to the one where environmental quality marries growth can be brought about by an external shock, as it has been the case of the petrol crisis at the beginning of the seventies, rather than of intentional policies. Unruh e Moomaw (1998) question the income determinism of the EKC. They maintain that it has been the petrol shock instead of the reaching of a high level of income, to have brought about the qualitative change in the growth-environment relationship.[9] Put differently, the transition would have been the outcome of a Hicksian induced innovation (an endogenously triggered innovation), more than by a change in the social preference ordering over private and public goods.

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[7] de Bruyn *et al*. (1997) are a good reference for an analysis of the relation between growth and de-materialization of production processes.

[8] The majority of the studies on the EKC use as a proxy for the environmental quality pollutant emissions that originate almost entirely from fossil fuel burning. This depends on the energetic paradigm. Contrary to what usually believed, not only energy matters for environment. Matter matters too (just think of fertile soil).

[9] They find that the transition is not best correlated to a specific income level but to historic events common to the 16-country set they analysed, that is the oil price shocks of the 1970s. Price shocks rather than income level appears to provide a sufficient incentive for new policy initiatives to overcome the political and economic inertia that maintained the previous trajectory or attractor (Unruh and Moomaw, 1998, p. 227).

Fig. 1 - Relationship between pc income and CO2 per $ of GDP

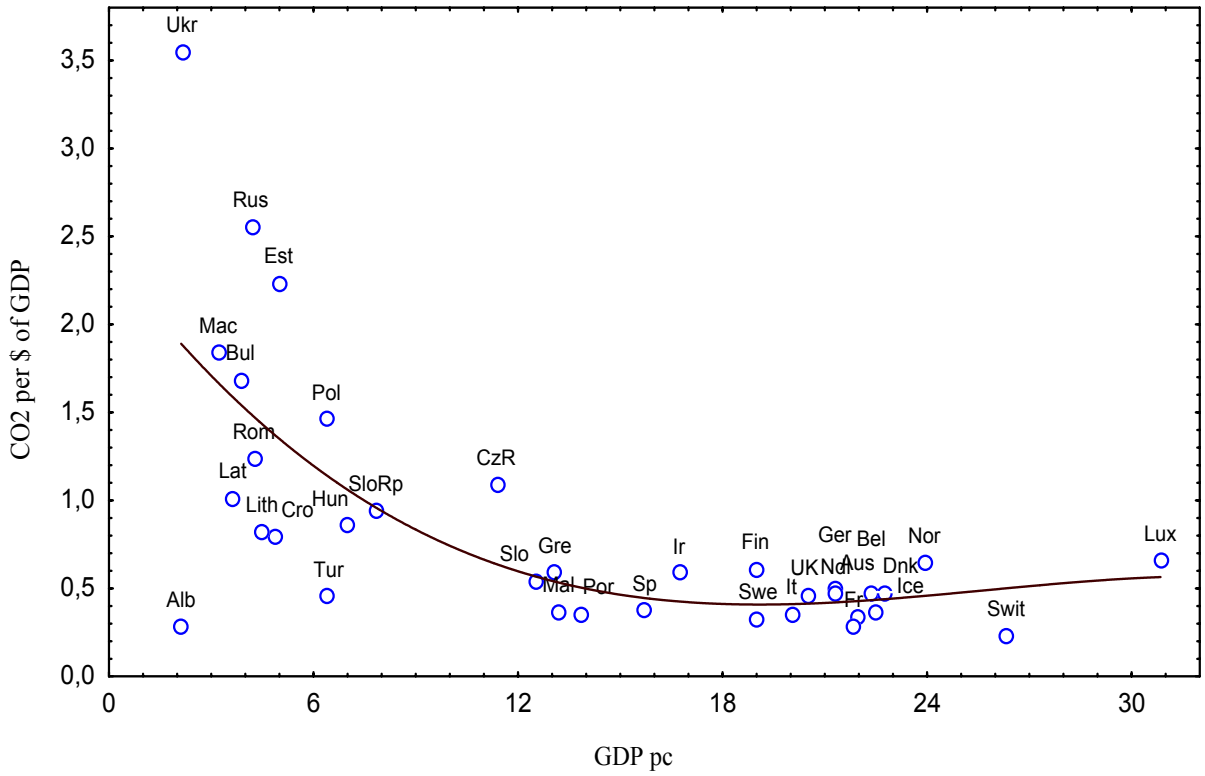
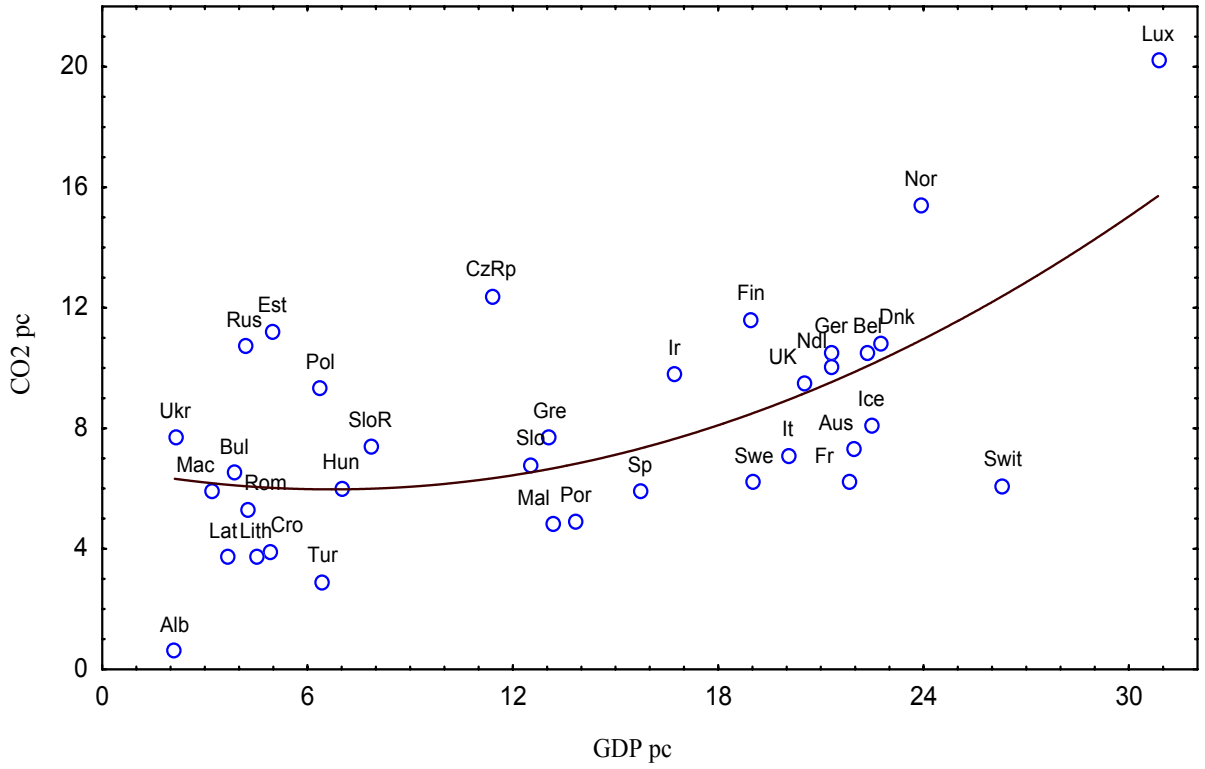


Fig. 2 - Relationship between pc income and pc CO2 emission



However, the essentially economic nature of the relation finds strong support in the analysis of figure 2. There, per capita emission replaces the index of energy efficiency in the role of proxy for environmental quality. Despite a high variability, the observed relation indicates the prevalence of the scale effect, embedded into the level of *per capita* GDP, over efficiency enhancing effects of technological and substitution nature.

5. The Environmental Kutznets relationship: a curve or a surface?

In order to avoid some of the above highlighted ambiguities, in this section we test the EKC hypothesis introducing a different environmental indicator: namely, the percentage of national territory that has been set aside and protected, i.e. destined to Parks and wild life reserves. Such variables, in fact, can be taken as a *direct* measure of environmental policy of a country, as it is not influenced by factors of any other nature (e.g. prices of fuels). According to the IUCN *World Commission on Protected Areas* (1994), *a protected area is defined to be a terrestrial or maritime area specifically destined to protection and to the preservation of biological diversities, natural and cultural resources, and is to be managed through the usage of appropriate tools dictated by laws or of any other nature*". Representing the effect of an active policy, the chosen index can be considered to be a good proxy of the preferences of a country as regards to such goods as natural resources and biodiversity. To a large extent, the decision of protecting a given piece of national territory is unrelated with the level of national wealth, though evidence shows that the richer countries are those protecting more of their land. Vice versa, all indices of pollution emission fundamentally depend upon the kind of technology being adopted and implemented. The possibility of accessing certain technologies is often precluded to poor countries lacking financial and human capital.

Figure 3 shows that, using the percentage of protected territory, the relationship reveals a quadratic form, although the upward branch appears to be prevailing as our data refers only to advanced countries. The relation in the EKC may induce to hastened conclusions, such as that growth automatically generates greater environment protection. As we said, by increasing income and therefore opportunities, in principle growth is a necessary element of this nice story. That logical conclusion is not granted in reality, though.

To revise this set of issues without the temptation of falling into simplistic deductions, we have to take up and evaluate the whole analysis, and for this we better go back to the beginnings, to the way it was born in the mind of Kuznets in 1955. At a closer look, it is possible to notice that many of the studies on the EKC depart from the original curve by Kuznets himself, for it deletes a

crucial variable in this latter, income distribution. This implicitly conveys the idea that in the KC, as well as in the EKC, per capita income is *the* explanatory variable and no room is left for mutual influences between variables. At any rate, beyond the history of ideas, it is this assumption that forces us to consider also income distribution. This also depends on the usual Income Elasticity Assumption (IEA) underlying the EKC hypothesis. In fact, growth in average income does not imply growth of income for the median individual. According to the IEA, if income growth goes along with increasing inequality (concentrated growth) growth can bring about a reduction or depression in environmental demand rather than increasing it, even though this demand is elastic to income (Magnani, 2000). Simply, a strongly concentrated income distribution discriminates opportunities across the citizens. Actually, as stressed by Kuznets, increasing inequality accompanying the initial growth phases determines the fall in environmental quality. Taking this extra variable into account, it is more appropriate to talk of a *Kuznets environmental surface* in three-dimensional space instead of a simpler curve.

Fig. 3 - Relationship between environmental quality and income level

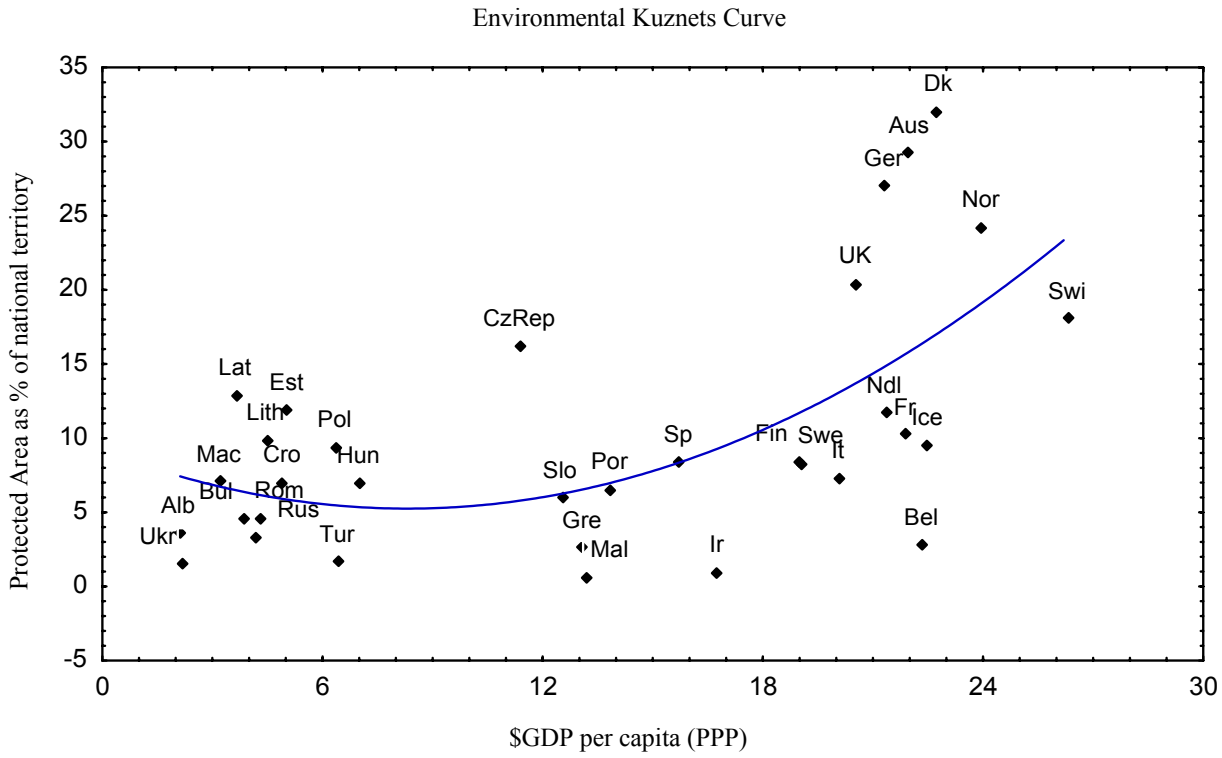
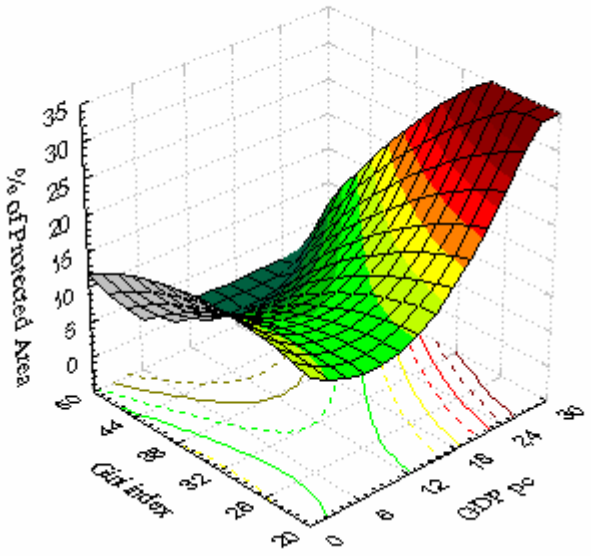


Figure 4 seems to show the net worth of this working hypothesis. As easily checked by inspecting sections of the surface, there is a *whole family of EKC,* parameterized by the Gini index. In other words, the *position* of the representative EKC varies at the varying of the value of the Gini index, this showing the demand for environmental protection together with the increase in income

equality just as the effect of the broader capacity of effectively choosing (and/or increase in opportunities) afforded by greater income equality. The worst famines were determined by entitlements issues, more than by overall food shortage, as pointed out by Sen (1981).

Fig. 4 - Relationship between income level, equality and environmental quality
Environmental Kuznets Surface



Therefore, the standard version of the EKC isolating the relation between per capita income and pollution emission level, disregards an important aspect inbuilt into Kuznets' own treatment. Evidence points out a key fact, that at the same income level (hence, level of development) environmental quality does improve parallel to the reduction in income concentration. A more equal distribution of income has the effect of speeding up the passage to growth paths that are more environmentally conscious, and thus have the effect of shifting upwards the conventional EKC. This confirms that environmental demand is indeed influenced by the relative levels of income and social position, as well as by their absolute levels.[10]

Then, a participated and diffused growth does represent one of the necessary conditions to generate the sought traverse process. A greater income equality increases individual readiness to pay for the environmental good, thus shifting upwards the minimal level of environmental quality a community or country is prepared to accept during the growth process (Bimonte, 2002). Such property proves to be crucial whenever there are threshold values to environmental damage beyond which it becomes irreversible.

[10] This hypothesis seems to be also verified by the Easterlin paradox (Easterlin, 1974), according to which in spite of an overall wealth increase, people perceive a reduction in their own well-being.

Evidence, therefore, points out the relevance of thinking in terms of and designing integrated policies. The class of theories of endogenous growth offers the theoretical context that seems to best accommodate the task of dealing with these aspects. Sustainable development seems to result more from investment in immaterial capital (R&D, education, etc.) than from the exogenous forces of technological progress and demographic growth. Therefore, it is easy to introduce the multiregime framework where growth is basically seen as an endogenous phenomenon and therefore it does not follow standardized patterns or shapes.

This approach focuses upon certain qualitative properties of growth processes rather than the quantitative estimation of some steady state values for the involved variables. In economic analyses like the one we are dealing with here, growth is described as a sequence of predetermined phases, each being characterized in its turn by more or less specific structural features. That such component phases may change over time and across space, thus bringing about changes in the levels of relevant variables as much as in the way the economy dynamically operates, makes it natural to invoke such notions as regimes and regime switch. Moreover, in comparing performance across economies in terms of a set of variables instead of single indicators (e.g., the growth rate of productivity), the qualitative aspects naturally come to the fore and, often, only qualitative analysis can be carried on.

6. The EKC as a dynamic metaphor and convergence

From a theoretical point of view, we can reconstruct the reasoning as follows. Confronted with a scatter plot in a plane of two variables, the ordinary attitude reacts by estimating a best fitting curve, via one of the ordinary methods econometrics teaches us. We get a curve, and the EKC is like any other curve fitting data for *a population of countries*. Now, what is crucial is the interpretation of the population. If its *internal structure* and *relative dynamics* are deemed not to be important, the curve is taken to tell us something about "average dynamics of the population". A country is taken to be representative of a state on a path; it does not count as an individual country. It is following this common interpretation, that we derive *dynamical* laws of tendency from distribution data at one point of time. We can break down a single curve, with separate interpretation of the two branches, the downward sloping with a trade-off relation between the two variables and the upwards piece with consistent behavior of variables, inferring basically a short run dynamics in two phases that will eventually land onto a monotonic approach to the *implied long run*. (A similar argument rationalizes the implied dynamics in other popular trade-off curves in the macroeconomic literature.)

Thus, in the conventional interpretation, the EKC is understood as a law giving a tendency: all countries will eventually converge in the long run to a given common path, characterized by a double feature, i.e. the same level of GDP per capita (predicted by the exogenous growth theory) and a corresponding level of environmental quality. The latter is unique only if the curve holds true, otherwise it would be a whole (possibly dense) set. Adding the distribution variable has the effect of generating an interval of values of the index of quality corresponding to different values of the Gini coefficient.

It would be hard to falsify the proposition of the existence of such a thing as an *implied long run*, to which all countries would approach had it not been for shocks and the like systematically shifting the target along the way. Still, in this paper we try out a new working hypothesis,[11] according to which the distribution of countries in the plane of growth paths intended in this extended way, may embody a distribution across different qualitative features, summarized into the notion of the set of regimes. Therefore, the countries' distribution is in a space of behaviors and not just paths and, if reducible to a finite set of internally homogenous models, these behaviors likely reflect mechanisms endogenous to the various economies. Thus, the distribution should really be understood and treated as the allocation of members of a population across a theoretical territory, rather than as a set of sampled individuals on transient paths, running towards some well defined final goal, an attractor or a distribution around its equivalent.

The logical consequence of this view is in that the points/countries, in the scatter diagram along the EKC curve, need not move together, actually they would be expected to move about where they are, if the cell of state space to which they belong is the *support of some regime* with some stability property. This is the idea we are going to formalize in the next section.

7. Growth as an option set of regimes

Theory behind the EKC assumes implicitly that different economies converge towards one another and therefore to a unique common path, and that the end state of such a process is independent of the initial conditions. What has been seen so far seems to suggest, to the contrary, the existence of a variety of regimes in the dynamics of sustainable development as shown by the sample of countries under our scrutiny, at the same time highlighting the key influence exerted by initial conditions.

It is now time to convert the previous analysis into the framework of the multiregime dynamics, and to construct the heuristic device called the Framework Space (*FS*). The former can be defined, in short, as a formal environment in which distinct countries (or generically *systems*)

[11] Consistent with the endogenous growth inspiration of the multiregime dynamics framework.

can follow different models of growth, depending upon where in their state space they happen to be. The definition implies therefore a way to capture dependence of growth performance and other dynamical properties upon initial conditions. This may play a relevant role in explaining why countries do not seem to comply to a common pattern, this in its turn raising a whole set of issues that span from the interpretation of the EKC to the discussion of why growth rates differ.

As explained elsewhere, behind a multiregime approach lies the hypothesis that quantitative differences among economies or sectors may sometimes be better explained by the existence of different models of behaviours, so that an economy's history can be seen as a *choice* of which model to adhere to. This choice might generally be unconscious or even forced by external or domestic shocks, but more often than not these factors interact with the conscious implementation via active policies[12]. Two sorts of *ideal* histories may thus be encountered: at one extreme those exhibiting uncertain pattern with very frequent changes of the adopted models; at the other extreme, there are economies with a very high degree of "stability" with respect to the chosen model, up to the point that they never seem to depart from it. Of course, reality is generally somewhere in the middle. It is therefore *prudent* policy to work with a framework capable of accommodating the phenomena associated with this sort of qualitative variability (on top of the obvious quantitative variability, with which standard techniques are concerned).[13] This is what the multiregime approach tries to do.[14]

As constructed in Boehm and Punzo (2001), the multiregime approach was born to account for some generally accepted stylized facts of growth empirics, and to introduce structural change as discontinuous change embedded into observed dynamics. In order to deal with this twofold issue, we need an articulated dynamical framework, where multi-regime dynamics generates a chart of dynamical behaviours, the *FS*. *The latter becomes a space of growth paths where trajectories are generally traverses from one path to another, some of them implying also crossing the border into a different growth model*. A *regime*, in such a space, is defined to be a pair: a growth model (in the sense of a *class* of models generating the same prediction) and the *slice* of state space to which that class applies, its *supporting slice* or *domain*. There is a finite number of regimes, and therefore the partition is finite.[15] In a sense, behind dynamics observed in the *FS* there is a *dual* space of *generating models* with the explicatory variables, these being stochastic and deterministic factors, mechanisms of behaviour and growth, finally policy choices.

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[12] This is our point hereafter.

[13] An argument made clear and formal in the notion of entropy, see Brida and Punzo (2003)

[14] And of course not everything can be formalised, which justifies the prevalence of formal techniques *devised to tame* variability.

[15] The finesse of the partition, hence the number of recognised regimes, depends upon the criterion adopted to induce equivalence classes.

Due to the way they are defined, regimes deserve the qualification of dynamic. Nothing prevents to use the notion of multi-regime framework with other different variables and to produce the corresponding version of the *FS*. This is what we are going to do hereafter. In fact, a *FS* is nothing but any n-dimensional space with a regime partition superimposed on it. Of course, traverses and episodes of structural change (i.e. *regime switches*) can only be fully represented if we have dynamical data at hands. We do not have this kind of data for the present application. Still, the idea of defining *qualitative* behaviours in terms of the variables chosen holds good, and via a reinterpretation we will be able to keep thinking of it as a dynamical framework, though a little special.

To represent and to classify homogeneously such different behaviors we need an adequate space representing all the variables believed to be crucial. Of course, there will be different constructions depending upon the choice of the variables and these latter will also determine *dimension*. The *FS* appropriate for the exercise here can be obtained in the following way.

The foregoing discussion of the dynamics implicit along the EKC suggests that there are at least three variables involved in addition to *per capita* GDP, namely our two alternative indices of environmental impact (the first standing for pollution and the second for protection) and an index of income distribution. So far, the two environmental indices have been plotted (figs 1, 3 and 4) against *per capita* GDP as the measure of relative welfare in order to derive variants of the EKC. But we have already argued that we should consider the curve as really a *section* of the *true* relationship (as put forward by Kuznets): a surface in a four-dimensional space where distribution of income (together with its level) plays a key role as explanatory variable and indices are also plotted. The standard EKC, therefore, should be regarded as a section taken for some given distribution of income (*and* against one environmental index only). We can pick and choose among other sections, though.

If we let income distribution inequality vary at the same time as a chosen environmental index (or else at the same time as *per capita* GDP), we get that different combinations of the values of the two *explanatory* variables would be consistent with the same level of *per capita* GDP (the same level of environmental quality, respectively). What can be seen from this sort of section? A given high level of protection could turn up to be consistent with high per capita GDP and high inequality, or else low *per capita* GDP with a high equality**.** There would appear, in other words, a trade-off also between welfare and distribution. This relation would not be different from the classical EKC, though, still it would demonstrate that the world of choices over curves is greater than expected.

If on the other hand, we take, sectioning for given *per capita* GDP and given value of the Gini index, our two environmental indices and plot them one against the other we obtain a full plane where a regime classification can be introduced. Every point in this plane is a chosen pair of values for the two pollution indices, and therefore they may be taken to reflect the result of a chosen *integrated* policy plan. The plane so obtained is the plane of (the effects of) implementable integrated policies.

With a slight modification to our standard procedure[16], we can introduce the notion of regime by means of equivalence classes over a space of policy plans. Thus, a regime is (associated with) a whole *set of integrated policy actions* (implying choice of the corresponding mixes of the two environmental variables) driving a given model of growth[17], and four regimes are identified in the graphs below.[18]

To each such policy option or choice corresponds at least a level of welfare and a value of income concentration: in other words, if we consider the values of the latter as equilibrium values, there is a *correspondence* between this version of the *FS* and a space of dynamical paths. The environmental policy *FS* is the space of values indexing (sets of) dynamical paths of an economy, which can therefore follow different behaviours depending upon the policy implemented. The original *FS*, as discussed in e.g. Boehm and Punzo (2001), is constructed in the state space of growth paths. The environmental *FS* is constructed in the *dual space of the generating models and the explanatory variables*, by introducing the hypothesis that environmental policies (perhaps together with other variables) can drive an economy's dynamic path. Given their strong relation, we can still talk of *traverses* from one path to another in the economy's own state space as the result of a policy choice represented in the present framework.

In figure 5 the two indices of environmental quality are used: tons of CO_2 per million dollars of GDP produced and percentage of protected territory. Moreover, countries with income levels above the sample average have been identified. By plotting data for the different countries, after normalizing them on the basis of average values of the two indicators, we obtain the landscape of the models of growth followed by the various countries. These can be interpreted on the basis of the standard categories of substitutability of the models of sustainable growth proposed by Solow after Dasgupta[19]. With the latter classifying criterion, the picture shows four identifiable regimes: i.e. the

[16] Where regimes are introduced in the framework space: the space of dynamical paths. Here, instead, they are defined in a space of policy plans: vectors of paths for policy targets inducing certain dynamic behaviours.

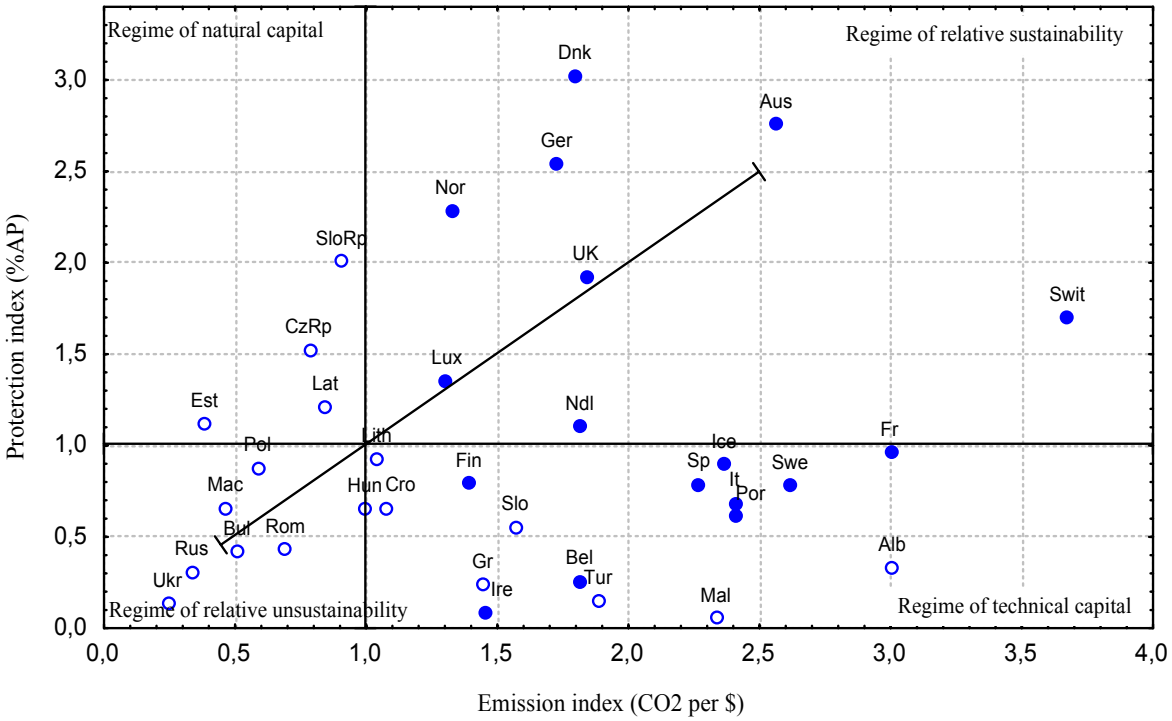
[17] Recall that a model of growth is a qualitative prediction of a set of growth paths.

[18] It is clear that our definition of sustainability is different from the one more commonly used in the literature, hence the qualification of *relative*.

[19] Just for ease of exposition, here the index of polluting emissions have been rendered as the inverse of the ratio of the emission rate of a given country to average rate. This has the effect that shifts rightwards along the horizontal axis correspond to abatements in the levels of polluting emission , or else to increased energetic efficiency.

regime of the relative sustainability, of relative un-sustainability, of technical and natural capital, respectively.

Fig. 5 - Models of integrated policies



Notwithstanding the simplicity of the tool and without pretending to make universal statements, it is still possible to put forward a key to read the evidence so assembled. Countries tend to follow their own ways to environmental protection. The latter reflects to a large extent the relative availability of resources as well as the levels of social participation in the allocative process. Thus, apart from the countries in regime 1, of relative sustainability, which seem to implement adequate *integrated* measures to cope with the problem, all other countries still rely upon a purely sectoral approach. In particular, the few countries with a relatively lower density of inhabitants and a higher geographical concentration tend to implement a policy of conservation and to concentrate in regime 2 (the one defined of the natural capital). On the other hand, countries with a greater energetic dependence seem to concentrate on the objective of increasing energetic efficiency, thus locating themselves in the regime 4 of technical capital.

The issue at this point becomes the following: is it possible to activate a process such that economies with low income and environmental quality levels can traverse directly to higher levels of income without having to go through the phases of environmental degradation that seems to be implied (or predicted) by the EKC? The question can be rephrased to advantage in terms of our chosen regime framework: from the regime 3 of relative un-sustainability can we jump directly into the regime of relative sustainability.

The assumption lying behind the conventional understanding and treatment of the EKC (i.e. the income elasticity hypothesis) has as a consequence an actually testable hypothesis, which however has never really been tested. This hypothesis says that, by generating an increase of income levels and therefore enlarging individuals' choice sets, growth will automatically bring about an increase in the their demand for environmental protection. But, to make this possible, we need both an enlargement of individuals' choice sets *and* a real possibility to choose. According to Berlin (1969) and Sen's (1999) influential works, freedom is the opportunity to act, not action itself. The problem arises when to a formal opportunity to act, which means no violation of negative liberty (freedom "from"), corresponds a substantial lack of opportunity for action, that is, a violation of the positive liberty (freedom "to do"). If we accept this hypothesis, the answer to the previous question becomes obviously to integrate social, economic, environmental policies into a single coordinated, multi-valued action plan.

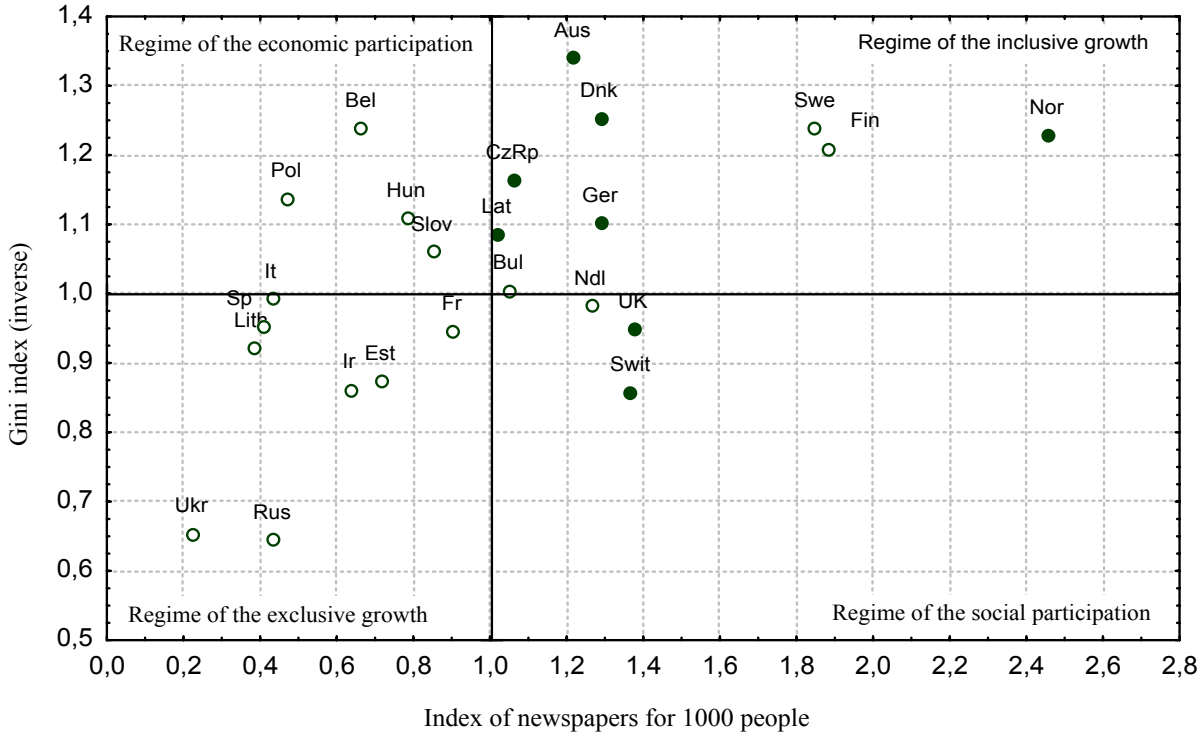
Figure 6 shows data on indices of equality, accessibility to information and education in a set of countries. Data have being normalized on the bases of average values;[20] countries with a protection level higher than the average have been marked for easier identification. Use of the three variables as coordinates makes it possible to identify four regimes, differing on the basis of the relative degree of participation (i.e. the level of literacy, information access, and equality) in the growth processes, degrees that can be interpreted by recalling categories typical of the theoretical models of sustainability associated with works of Sen and Schumpeter.

Sen (1999) focuses upon the "capability to function", i.e. what a person can really do or be, and defines development as improvement in such function This in its turn is seen as the primary goal for and a means to enhance development policies. In a Schumpeterian view, on the other hand, the focus is on intangible resources, that is on institutional features (social facts) that determine how effective an event is in generating growth. In our words, social participation increases "environmental returns", by modifying dynamical behavior.

Although our data set seems to indicate that it is hard to see any cross country convergence process, and that again this can be attributed to the relevance of initial conditions,[21] on the whole the likelihood that environment be effectively protected increases with income equality and with the accessibility to information. This on its turn stresses once again the relevance of social policies and the necessity of abandoning a purely sectoral approach in favor of an integrated approach to the issues.

[20] It can be noticed that we are dealing with a smaller sample than before, this being due to the fact that for many countries data on the Gini index and annual sales of newspapers (this being our proxy for education) are unavailable.
[21] They only appear in the debate on β-convergence.

Fig. 6 - Environmental quality and levels of participation



8. Some conclusions

Functional relations, whether in terms of trade off or not, figure prominently in the macroeconomic literature, providing the hopeful reader with a menu *a la carte* for policy design and intervention. In practice, here it has been shown that around the scattered points of these curves there is a much richer dynamics than expected. The image of the flow of points transiting together towards some well defined state, or ergodic distribution, appears, at a closer look, marred by local cyclicity, irregular behaviors, roles interchanges, and the like. That much desirable long run predictable state has often emerged more to be a logical and statistical construction, or as the tendency implied by certain a priori assumptions. Here we tried to exit this situation treating each point state as a path of its own, along its own trajectory, at least in principle, till it can be "proved" that the hopes of theories turn up well founded.

On the basis of the argument above, we maintained that there is no unique formula to sustainable development and that the convergence implied and expected by all the traditional studies of the EKC as extensions of growth theory is far from being demonstrated. Growth processes, on the contrary, exhibit characteristics that are patently, dramatically different in some and many qualitative senses, and these do produce the outcomes that we can observe. Contrary to

some well-established theorems, these outcomes carry the deep marks imprinted by their initial conditions, as well as those left by economic policies implemented on the way.

Initial conditions do appear in the growth literature, in that they determine the transitional dynamics towards the long run steady state. Initial conditions determine in the sample the sign and generally the value of the speed of convergence. They do not intervene in shaping up the growth process. On the other hand, initial conditions are expected to have no role in determining what the long run will look like. This is the twofold point here: just like in the models in the endogenous growth, we maintain that they do influence the values of the long run equilibrium. Our idea of the multiplicity of regimes as qualitatively different behaviors, implies something more: that there may be clusters of behaviors that on top of quantitative differences reveal different qualitative features.

Our analysis is consistent with the vistas offered by certain endogenous growth models in the Schumpeterian family, where two factors of growth are taken to be crucial: accumulation of physical capital and innovation as it generates accumulation of immaterial capital. This paper stressed the relevance of the latter. We have seen that for a development path to become sustainable a balanced mix of technological progress, carefully designed environmental policies and social participation are necessary ingredients, and the latter has to be understood in the twofold aspect of participation in the choice process as well as in the division of the wealth so created.

As it brings about improvements in capabilities to function and/or modification in institutional features (as society's culture and attitudes), participation allows us to give an endogenous explanation of the shape of the EKC and the underlying dynamic behavior. This permits also to deal with some of the problems not accounted for by the traditional EKC. There, the major contributions to growth in environmental demand is left unexplained, set outside the model, by resorting to the income elasticity hypothesis or a structural explanation.

The endogenous interpretation presented here links the overall increase in demand for environmental protection to the "increasing returns" that social participation produces through modifying dynamics. Therefore, in the spirit of some of the models of endogenous growth, social policies not only do not represent obstacle or constraint to growth; they actually increase demand, acceptability and even the efficacy of environmental policies, increasing its "return of scale".[22]

It is the available evidence that strongly suggests the need of exiting the deterministic income-driven approach. There is more than a single, uniquely determined avenue to sustainable

[22] Some of the models of endogenous growth show that, in presence of imperfect capital markets limiting accessibility to the lower income brackets, income redistribution tends to create investment opportunities precisely for those categories where *social* marginal returns are greatest. In such conditions income equalization becomes one of the growth enhancing engines, rather than representing an obstacle to it.

development and, on the other hand, the special double convergence hypothesis implicit in studies on the EKC is far from being supported.

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