Sustainable Economic Development and the Environment: Theory and Evidence

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1 Introduction

Since the seminal paper by Grossman and Kruger (1991) there has been considerable academic interest in the relationship between economic development and environmental pollution. Importantly the authors have shown empirically that the link between these follows an inverted U-shaped pattern, now commonly referred to as the Environmental Kuznets Curve (EKC). This suggests that lower income regions are 'too poor to be green', but as countries become richer they will naturally reduce their generation of pollution. Several recent studies, however, have put the existence and the exact shape of an EKC into question (Stern, 2004). In view of the recent policy developments, resolving this issue seems of particular importance. More precisely,

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the recent Kyoto Protocol has set reduction targets for pollutant emissions to which developed countries are expected to commit themselves to, but from which developing countries are at the first instance exempt. This would suggest that policymakers are of the view that wealth on its own does not result in a - possibly sufficient - reduction in pollution, a stance which as of date has not yet been substantiated in the academic literature.

In the current paper we thus explicitly model how the decision to scrap obsolete technologies affects the relationship between economic development and pollution. In order to do so we build on the Schumpeterian framework of Aghion and Howitt(1998) by introducing a vintage capital structure, where the law of motion of environmental quality will depend on the pollution flow and some upper limit on environmental quality that takes into account the exhaustibility of resources.[1] In this context, we diverge from the existing literature on the pollution-output relationship by making the explicit distinction between environmental quality and pollution. Arguably it is important to do so since the very notion of sustainable development refers to some self regeneration capacity of ecosystems, as originally defined by Daly (1990, 1991) and now commonly used by the World Bank (1991a and 1991b). Finally, we explicitly assume that new technologies are more environmentally friendly, allowing us to shed light on the mechanisms through which the environmental quality affects growth performance following technological adoption.

Using our model we show that a reduction in environmental pollution during the industrialization process is only possible when the optimal rate of technological adoption has been reached. However, reaching this point will not necessarily guarantee that pollution decreases. Rather, we identify the three possible outcomes concerning the relationship between pollution and economic development, where these depend on the rate of growth of investment relative to the rate of growth of environmental friendliness of technological improvement. First, there is the case that we term *weak sustainable development* where investment, consumption, and output increase at a constant rate, the level of pollution stabilizes, but environmental quality improves. Second an economy may achieve *strong sustainable development*, where investment, consumption, and output improve at a constant, but lower rate than under the former scenario, while pollution is decreasing. This latter case is what constitutes the EKC. Finally, there may be the case

[1] The use of vintage capital models, which were launched in the early 1960s' formalize Schumpeter's idea of "creative destruction", have become increasingly popular in the economics literature.

where pollution increases unboundedly and environmental quality reaches its lower bound in finite time, which we refer to as the *catastrophic development*.

Our theoretical predictions have potentially important empirical implications in terms of seeking evidence for the EKC. For one, they suggest that there could be considerable heterogeneity across countries in their pollution-output relationship experience, depending on their relative investment growth rates and the rate at which the environmental friendliness of their technology improves. More preciselys, countries may not only differ in the rate and when they reach the point along their development path at which they could potentially reduce their pollutant emissions, but this reduction is not guaranteed. Thus, the shape of the pollution-output relationship can differ widely across countries, so that the use of cross-country panel data sets to seek evidence for the existence of an EKC - a now common practice in the literature - may be flawed. Instead it may be more insightful to study the pollution-outcome link by examining countries individually. Additionally, if one wants to capture the full pattern of how industrialization affects environmental quality in individual countries, one is likely to require long time series data, since the possibility of achieving a reduction in pollution may feasibly happen at a very early stage of economic development. As a first attempt in this direction, we thus here use individual long time series on carbon dioxide emissions and an indicator of economic development for a number of developed and developing countries and rely on a nonparametric kernel regression estimator, which places little restriction on the functional form of the relationship between pollution and output. Our results do indeed provide evidence of heterogeneous experiences across the countries examined.