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Estimating the environmental Kuznets curve for Spain by considering fuel oil prices (1874–2011)

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ABSTRACT

We perform a structural analysis on an environmental Kuznets curve (EKC) for Spain by exploiting long time series (1874–2011) and by using real oil prices as an indicator of variations in fuel energy consumption. This empirical strategy allows us to both, capture the effect of the most pollutant energy on carbon dioxide (CO_2) emissions and, at the same time, preclude potential endogeneity problems derived from the direct inclusion of fuel consumption in econometric specification. Knowing the extent to which oil prices affect CO_2 emissions has a straightforward application for environmental policy. The dynamics estimates of the long and short-term relationships among CO_2, economic growth and oil prices are built through an autoregressive distributed lag (ARDL) model. Our test results support the EKC hypothesis. Moreover, real oil prices are clearly revealed as a valuable indicator of pollutant energy consumption.

1. Introduction

Over time, humankind has contributed to atmosphere contamination through different processes of production and consumption. From the seventies, when a major concern on the environment's deterioration took place at international level, some economists argued that enhancement in per capita income could eventually reduce the level of environment degradation. We can distinguish at least two arguments widely used to explain this possible phenomenon. That is, on the one hand, the variation toward a new productive structure which uses a lower level of polluting energies. On the other hand, the social willingness to pay for the extra cost associated to the cleaner energies. These underlying ideas were enthusiastically accepted when an early set of papers (e.g., Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992; Panayotou, 1993) provided the first formal evidence about an inverted U-shape relationship between per capita income and environmental degradation following, therefore, a Kuznets type curve.[1] Nowadays, we can appeal to many studies that show the existence of an environmental Kuznets curve (EKC) for several countries by using different sample periods, econometric modeling and empirical methods.

With the aim of contributing to the knowledge on the EKC for CO_2 emissions, this paper provides new evidence for Spain by exploiting time series from a large period (1874–2011). We will analyze the possible effect on Spanish CO_2 emissions generated not only from economic growth but also from changes in pollutant energy consumption. However, the direct inclusion of pollutant energy consumption in models would introduce endogeneity problems since the available measures of CO_2 are contemporaneously correlated with that variable. In fact, the Carbon Dioxide Information Analysis Center (CDIAC) calculates the total CO_2 emissions by multiplying different primary energy sources (coal, petroleum, and natural gas) by their respective emission rates. Then, we will consider as an indicator of pollutant energy consumption real oil prices that, in turn, can be conformed as a useful instrument for environmental policy.

The level of real oil prices may presumably affects CO_2 emissions through two ways regardless of their indirect effect via GDP.[2] On the one hand, it is well known that an increase in oil prices could imply a reduction on energy consumption. This might be compensated, in order to sustain GDP levels, by using more units of either labor or capital. On the other hand, we must bear in mind that fuel combustion is, after coal, the most pollutant of all energy alternatives. Thus, higher oil prices may drive toward substitution of fuel

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[1] Kuznets (1955) had originally suggested that a changing relationship between per capita income and income inequality could be represented by an inverted-U-shaped curve.

[2] The effect of oil prices on GDP is widely recognized, and has been received notable attention in the empirical literature (e.g., Lardic and Mignon, 2006; Bachmeier et al., 2008; Kilian and Vigfusson, 2013).

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combustion by other cleaner and more efficient energy resources.[3] Taking into account the potential effect of oil prices to reduce CO_2 emissions, its introduction in the model specification will allow us to know the degree to which taxation on oil products may be considered as a useful environmental policy. Obtaining more accurate estimates of the per capita income effect is another compelling reason to extent the simplest EKC specification. That is, if oil price is a relevant variable and it is correlated with GDP, introduction of oil prices will avoid the estimation bias on the per capita income effect.

The existing empirical literature gives us light on the consideration of oil prices in the EKC framework (i.e., Agras and Chapman, 1999; Heil and Selden, 2001; Richmond and Kaufman, 2006). These authors claim the importance of oil prices and indicate that measures oriented to increase domestic prices on the most polluting energies constitute a valuable tool to reduce the level of CO_2 emissions. Moreover, the results obtained by Richmond and Kaufman (2006) from the US data suggested that including energy prices in the model could have a considerable impact on the estimated income coefficients. In fact, in the analyzed context, the inclusion of energy prices removed statistical support for typical turning points.

The estimation process that we use is the autoregressive distributed lag (ARDL) bounds testing procedure of Pesaran and Shin (1999) and Pesaran et al. (2001). A major advantage of this method is that allows us to make valid inferences on both parameters and functional forms regardless of whether the time series are $I(1)$ or $I(0)$, or a combination of both. This advantage makes the method particularly suitable to our purpose. The reason is that different historical stages included in our long-time series imply presumable presence of structural breaks, which introduces uncertainty as to the true order of integration of the variables. This means that, it is possible that any of the variables used here are stationary around some probable structural breaks,[4] but can be erroneously classified as $I(1)$ from conventional tests. Another noteworthy advantage is that the ARLD bounds testing approach is superior to that of the traditional Johansen's cointegration methodology, which in general, requires a very large sample size. In particular, Pesaran and Shin (1999) demonstrate that the ARDL procedure has better properties in a sample size as the used here (i.e., less than 150 observations).

2. Empirical background

Since the initial empirical studies of the aforementioned economists in the early nineties, a large number of papers have tested the existence of a U-shape relationship between pollution level and per capita income. There are several recent surveys on this topic offering a fairly comprehensive overview of the state of the question (e.g., Kijima et al., 2010; Bo, 2011; Pasten and Figueroa, 2012). The papers surveyed can be classified by those referred to pollutants that would have only local effects (such as sulfur and nitrous oxides) and those associated to pollutants that would have global effects. A key factor that determines if a pollutant is either local or global is mostly based on the kind of combustion system that an industry uses. For example, sulfur oxide (local pollutant) stems basically from coal combustion whereas CO_2 (global pollutant) is derived more from oil combustion. Since our research is addressed to CO_2 emissions, the present paper is confined to the latter group in which there is less of a consensus about the existence of an EKC (Meers and Leekley, 2000). This result should not be very surprising giving that social costs go beyond across time and places where emissions are generated. Therefore, it is more likely that there is a free-rider behavior that makes countries to keep polluting to a larger extent regardless the level of per capita income that can be reached.

Next, we will focus on those papers that are related, in some way, to either the context and/or the type of model specification that are object of our research. The paper by Roca et al. (2001) is the first research that estimates a long-run relationship between income and CO_2 emissions for the Spanish case by using time series analysis. The empirical results, from a sample period that ranges from 1973 to 1996, do not reveal the existence of an EKC since the estimated elasticity between (per capita) income and (per capita) CO_2 emissions is positive and greater than one (1.24). This outcome has been recently questioned by Esteve and Tamarit (2012a) because the long-run relationship is assumed to be stable over time. They introduced potential breaks in a bivariate model and considerably extended the data sample used by Roca et al. (2001). From a sample that goes from 1858 to 2007, the authors found that the long-run elasticity between (per capita) income and (per capita) CO_2 is defined by three regimes where estimates decreased over time. This outcome has been interpreted as the existence of a declining growth path pointing to a prospective turning point even though the EKC does not follow an inverted-U-shaped curve.

Two additional papers are found in the literature using alternative functional forms. Those reexamined the relationship between (per capita) income and (per capita) CO_2 emissions for Spain through the same data sample utilized by Esteve and Tamarit (2012a). More specifically, Esteve and Tamarit (2012b) employ a bivariate model with two threshold regimes in order to combine the idea of cointegration with nonlinearity (in the adjustment) between income and CO_2 variables. The paper does not provide information about a possible turning point as the standard EKC approach points out. However, their results suggested, once more, that economic development is compatible with pollution reduction. By adopting a more complex functional form, where the cointegration relationship between (per capita) income and (per capita) CO_2 is assumed non-linear, such outcome is also obtained by Sephton and Mann (2013).

All the papers described above pay no attention to the potential contribution of energy consumption with respect to the level of CO_2 emissions. It is obvious that the utilization of energy, especially combustion of fossil fuels, is, at the same time, a large source of pollution. Furthermore, disregarding the role of energy use in models may generate estimation bias if energy use and income are related.[5] Thus, the inclusion of an energy variable, which collects the possible effect of the energy consumption, seems to be a reasonable empirical strategy. There are some recent studies which analyze income effects on CO_2 emissions by incorporating an energy variable in countries such as Pakistan (Shahbaz et al., 2012), Indonesia (Shahbaz et al., 2013), and India (Tiwari et al., 2013; Shahbaz et al., 2015).

Due to the standard build procedure of CO_2 variable, energy consumption is contemporaneously correlated with CO_2 emissions. Stemming from it, we can see as some authors have instrumented the energy consumption variable through either the evolution of energy prices (Agras and Chapman, 1999; Heil and Selden, 2001; Richmond and Kaufman, 2006) or a set of indicators to proxy

[3] Shahbaz et al. (2014), for example, show that more electricity consumption has been declining CO_2 emissions in the United Arab Emirates. According to authors, more electricity consumption is linked with the adoption of more efficient technology and cleaner energy in this country.

[4] Moreover, the ARDL will allow us conveniently test whether or not there is underlying structural breaks that affect the long-run stability of estimated coefficients.

[5] Nowadays, a large number of studies reveal causality between energy consumption and economic growth for a large set of countries as can be seen from a review of the literature. See, for example, Payne (2010).