

## Modelling the link between aggregate income and carbon dioxide emissions in developing countries: the case of the Dominican Republic

BY JOSÉ R. SÁNCHEZ-FUNG\*

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### Abstract

*The paper estimates the link between aggregate income and carbon dioxide emissions for the Dominican Republic. The econometric analysis uses time series data spanning half a century and finds evidence of an environmental Kuznets curve revealing that the level of annual real per capita income at which carbon dioxide emissions start to stabilise is around US\$1,600. The estimations support evidence in the literature revealing that the curve has been flattening and shifting to the left.*

*Keywords:* CO2 emissions; Environmental Kuznets curve (EKC); Dominican Republic.

*JEL codes:* Q56.

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\* University of Nottingham, Ningbo, China and University of London, ILAS, UK. Address: 199 Taikang East Road, Ningbo 315100, PRC. T: +86 574 8818 0918; F: +86 574 8818 0125. (e-mail: JoseR.Sanchez-Fung@nottingham.edu.cn). Acknowledgements: I appreciate Richard Woodward's comments on the paper. I also thank Indhira De Jesús, Amelia U. Santos-Paulino, Tiantian Zhang, and seminar participants at Fudan University in Shanghai, China, and at the University of Nottingham in Ningbo, China, for useful discussions. Any remaining errors are my own.

## Modelando la relación entre el ingreso agregado y las emisiones de dióxido de carbono en los países en desarrollo: El caso de la República Dominicana

POR JOSÉ R. SÁNCHEZ-FUNG\*

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### Resumen

*La investigación estima la relación entre el ingreso agregado y las emisiones de dióxido de carbono para la República Dominicana. El análisis econométrico emplea series estadísticas que abarcan medio siglo y produce evidencia sobre la curva de Kuznets para el medio ambiente natural, mostrando que el nivel de ingreso per cápita anual alrededor del cual las emisiones de dióxido de carbono se estabilizan es US\$1,600. Las estimaciones contribuyen con la literatura que sugiere la existencia de una curva de Kuznets más plana y desplazada hacia la izquierda.*

*Palabras clave:* emisiones de CO<sub>2</sub>; curva de Kuznets, medio ambiente;

*Códigos del JEL:* Q56.

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\* Universidad de Nottingham, Ningbo, China y de la Universidad de Londres ILAS, Inglaterra. Dirección: 199 Taikang East Road, Ningbo 315100, PRC. T: +86 574 8818 0918; F: +86 574 8818 0125. (e-mail: JoseR.Sanchez-Fung@nottingham.edu.cn). Agradecimientos: agradezco a Richard Woodward por sus comentarios sobre el trabajo. También agradezco los comentarios de Indhira De Jesús, Amelia U. Santos-Paulino, Tiantian Zhang, y participantes en los seminarios en la Universidad de Fudam en Shanghai, China, y en la Universidad de Nottingham en Ningbo, China. Los errores u omisiones son de mi responsabilidad.

## I. Introduction

Nurturing the conditions to achieve economic growth and development is a primary goal for governments across the world. But in so, doing attention has to be paid to the limits imposed on the pace of economic growth and development by various factors, including the potential adverse impact on the natural environment and the actions required to reverse the damages (Stern, 2015). Therefore, understanding the link between aggregate income and the environment is a pressing task for academics and policymakers (Greenstone & Jack, 2015).

The paper contributes by investigating the Dominican Republic, a country whose economy has been successful in implementing policies to preserve the natural environment vis-à-vis other developing countries. As an illustration, Diamond (2005) discusses concrete historical initiatives by the authorities in the Dominican Republic towards saving the natural environment, starting from the second half of the last century. The policies, including successful schemes to educate people about agriculture's potentially damaging impact on the soil, reveal the preferences of domestic policy makers for encouraging a more balanced development (Faria & Sánchez-Fung, 2009). The precedent of implementing effective policies could also be the foundation to subsequently tackle other dimensions in the domain of environmental policy management, like reducing greenhouse gas emissions.

But there is no contribution assessing the level of pollution, as measured by carbon dioxide (CO<sub>2</sub>) emissions, and its relation to aggregate income in the Dominican Republic, i.e. investigating the existence of an environmental Kuznets curve (EKC). Pursuing that line of research could generate results that serve as a yardstick for gauging the success or otherwise of environmental policies. The investigation seeks to answer the following questions: Is there an EKC for the Dominican Republic? If so, what is the level of income at which the curve becomes negatively sloped, also known as the EKC's turning

point? Is that period related to the implementation of specific policies for safeguarding the natural environment?

The literature contains theoretical and empirical contributions, starting with the seminal work of Grossman & Krueger (1995). They estimate that for a cross-section of countries the turning point for various pollutants happens when real per capita income reaches US\$8,000. But studies focusing on individual developing countries are more difficult to come by; for instance, Vincent (1997) tackles the matter and does not find evidence of an EKC for Malaysia. Therefore, focusing on a country like the Dominican Republic could help in learning from specific experiences on the evolution of greenhouse gas emissions as developing economies grow.

The rest of the paper proceeds as follows. Section II motivates the specification to investigate the EKC and runs the econometric modelling. The exposition relates environmental policies in the Dominican Republic to the findings from the empirical analysis. Section III concludes.

## **II. Estimating an environmental Kuznets curve for the Dominican Republic**

The environmental Kuznets curve arises from the empirical observation of a negative link between the level of output and pollution. The seminal work is Grossman & Krueger (1995) and there is a substantial literature deriving from that work. The EKC can be split into several possible original effects that vary through time, as discussed by Brock & Taylor (2005).

The impact of economic growth can lead to an increase in pollution if the underlying activities rise in proportion to overall growth. If, on the other hand, the underlying activities either grow by less or more than overall growth pollution could decrease or increase in relation to economic performance. The empirical observation of a negative

link between economic growth and pollution could imply that more advanced countries implement environment-friendly production techniques. And that is subsequently reflected in a lower level of pollution at higher income levels, generating the EKC. Ultimately, the nature of the link between income and pollution is an empirical question and what follows attempts to throw light on the matter by examining the case of the Dominican Republic.

The time series for the empirical modelling are obtained from the World Bank World Development Indicators and range from 1960 to 2010. The data are CO2 emissions in metric tons per capita (EN.ATM.CO2E.PC), gross domestic product (GDP) per capita (NY.GDP.PCAP.KN), population density (EN.POP.DNST), and annual % population growth (SP.POP.GROW).<sup>1</sup>

The econometric analysis begins by estimating the following benchmark equation:

$$\log(CO2)_t = \alpha + \beta_1 \log(Y)_t + \beta_2 \log(Y)_t^2 + \delta Trend + \varepsilon_t \quad (1)$$

In equation 1 all the variables are defined as above and log denotes the natural logarithm of a series; 1, 2 are coefficients to be estimated empirically. If a Kuznets curve exists  $\beta_1 > 0$  and  $\beta_2 < 0$ , meaning that CO2 emissions increase with output but decline after reaching a threshold level. The equation also contains a time trend.

Running equation 1 using ordinary least squares (OLS) and annual data spanning from 1960 to 2010 produces:

$$\log(CO2)_t = -89.16 + 17.59 \log(Y)_t - 0.86 \log(Y)_t^2 + 0.01 Trend + \quad (2)$$

(11.90)      (2.34)              (0.11)              (0.01)

$$Adj-R^2 = 0.95$$

$$SER = 0.1369$$

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<sup>1</sup> World Bank codes are inside parentheses.

Equation 2 reports heteroscedasticity and autocorrelation consistent standard errors (HACSE) below each coefficient. The diagnostic statistics under the equation are the goodness of fit (adjusted  $R^2$ ) and standard error of the regression ( $SE$ ). All the coefficients in equation 2 are significant at the 1% level, excepting the time trend which is significant at the 8% level. The coefficients affecting the level and the squared value of GDP are positive and negative, implying that there is an environmental Kuznets curve for the Dominican Republic during the period under investigation. The analysis also runs a RAMSEY test to detect the adequacy of the functional form. The F-test examines the hypothesis that the coefficients on the squared values of the fitted model (equation 2) are zero and the hypothesis cannot be rejected  $\{0.325(0.570)\}$ .

Even if the functional form is correct, there could be reasonable concerns about the lack of ancillary variables in equation 2 so the analysis proceeds to exploring a more general model. The investigation considers the following extended EKC specification:

$$\log(CO2)_t = \alpha + \beta_1 \log(Y)_t + \beta_2 \log(Y)_t^2 + \beta_3 [\log(Y)_t - \log(Y_{t-1})] + \beta_4 PopDent_t + \beta_5 PopGrowth_t + \delta Trend_t + \varepsilon_t \quad (3)$$

The additional regressors in equation 3 are GDP growth ( $Y_t - Y_{t-1}$ ), population density (*Popden*) and population growth (*wth*). Estimating equation 3 using OLS and annual data from 1961 to 2010 generates the following results:

$$\begin{aligned} \log(CO2)_t = & -40.19 + 8.49\log(Y)_t - 0.41\log(Y)_t^2 + 0.53[\log(Y)_t - \log(Y_{t-1})] + 0.05PopDen_t \\ & (17.18) \quad (2.93) \quad (0.13) \quad (0.36) \quad (0.02) \quad (0.37) \\ & - 2.03PopGrowth_t - 0.21Trend_t \quad (4) \\ & (0.08) \end{aligned}$$

$$Adj-R^2 = 0.96$$

$$SER = 0.1130$$

Equation 4 also reports HACSE below each coefficient. In equation 4 all the coefficients are significant at least at the 5% level, excepting the one affecting the rate of growth of GDP ( $Y_t - Y_{t-1}$ ), which is not statistically significant at conventional levels. The key coefficients on the level of output and on squared output carry positive and negative coefficients, confirming the existence of an EKC for the Dominican Republic. Also, the coefficients on the two income measures are smaller than those reported in equation 2, lending support to focusing attention on a more general econometric model. Figure 1 shows the residuals from equation 4 and they reveal a stationary pattern.

Given the importance of the results in equation 4, the investigation computes an F- statistic to test the hypothesis that both coefficients on real output per head are zero  $\{\beta_1 = \beta_2 = 0\}$ : the hypothesis is rejected at the 1%  $\{5.29(0.00)\}$ . The 1% confidence ellipse shown in Figure 2 provides a visual impression of the range of values for 1 and 2 derived from equation 4. Figure 3 shows a cross-plot of the fitted values from equation 4 and the log of real income per head: the graph clearly reveals the EKC pattern implying the existence of a turning point in the income-pollution relationship for the Dominican Republic.

The turning point for the EKC, meaning the level of income at which pollution starts to decline, can be calculated using the following formula:

$$Y_t = -\beta_1 / 2\beta_2 \quad (5)$$

Using the coefficients from equation (4) yields:

$$Y_t = -8.499068 / 2(-0.419991) = 10.11 \quad (6)$$

The calculation implies that for the Dominican Republic the turning point occurs in 1999. The estimated turning point is around the time when the Dominican Republic took concrete steps to boost the government's capacity to regulate the natural environment. This re-

lates to discussions in Dasgupta et al. (2002) and references therein, citing empirical evidence showing that the main factor driving reductions in pollution in countries reaching middle- income status seems to be changes in the pertinent regulatory framework (see also the discussions in Carson, 2010).

In the Dominican Republic, the General Law on the Environment and Natural Resources (Law 60 of 2000) provides the legal basis for the Ministry of the Environment and Natural Resources (see Lizardo & Guzmán, 2005). The Ministry's mandate is to foster policies aimed at preserving and improving the environment and natural resources, with the ultimate goal of securing its sustainability. It is worth noting that, so far, the Dominican Republic's Ministry of the Environment and Natural Resources has been effective and commands considerable credibility with the public.

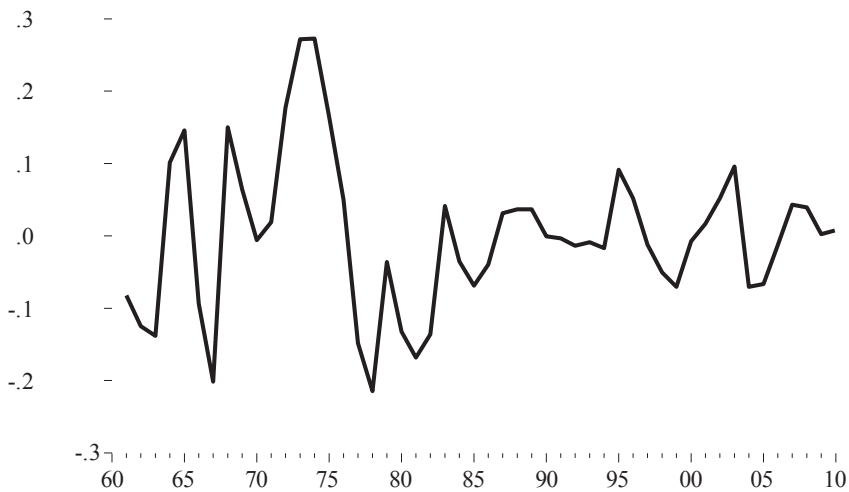
Going back to the results from the empirical modelling, the turning point in the EKC occurs around an annual real GDP per capita of US\$1,600 -calculated at market exchange rates. Considering PPP-based GDP numbers, converted with current dollars, the turning point would amount to an annual real per capita income of US\$5,300 according to data produced by the World Bank. The number is lower than the corresponding figure for the conventional EKC and could help to support evidence suggesting that the EKC has been flattening and shifting to the left (Dasgupta et al. (2002) label this a 'revised EKC'). The EKC's changing pattern could be the result of catch-up growth involving the adoption of environment-friendly technologies in developing countries. But, more likely, it is the outcome of specific policies aimed at preserving the environment.

In that regard, going back to the institutional context, after creating the Ministry of the Environment, the Dominican Republic has taken concrete steps towards reducing greenhouse gas emissions. Concretely, the National Committee on Climate Change and Clean Development Mechanism was created in 2008. The Committee's mandate in-



cludes designing and implementing policies to mitigate and prevent greenhouse gas emissions in the Dominican Republic. The institution also keeps track of the compliance with commitments agreed with the United Nations concerning climate change, notably those derived from the Kyoto protocol.

FIGURE 1. RESIDUALS FROM THE EXTENDED EKC MODEL, EQUATION (4)

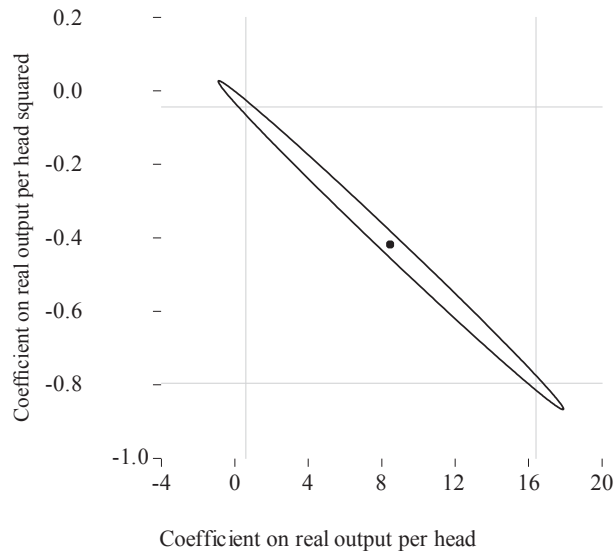


The Dominican Republic is also implementing an economic development plan compatible with climate change in order to keep greenhouse emissions under control, and recently passed new legislation to tax motor vehicles according to their CO<sub>2</sub> emissions, a policy that has been difficult to implement in other Latin American countries. Another example of related efforts is the Dominican Republic's success in reducing ozone depleting emissions of hydrochlorofluorocarbons by 10% during the three years preceding 2015 (according to the United Nations Development Program's office in the country). World-wide efforts in that direction are partly supported by funding from advanced countries pledged via the Montreal Protocol, a treaty focusing on reducing substances that deplete the ozone layer.

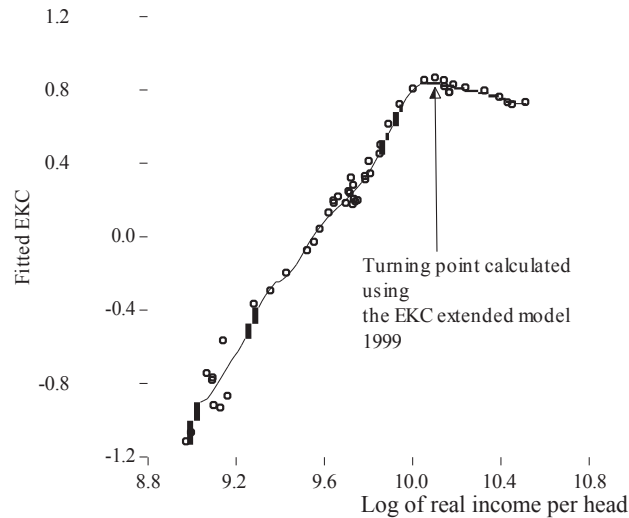
### III. Conclusion

The paper investigates the link between aggregate income and CO2 emissions for the Dominican Republic. The econometric analysis shows evidence of an environmental Kuznets curve revealing that the level of annual real per capita income at which CO2 emissions start to stabilise is around US\$5,300 measured in PPP terms. The level computed for the Dominican Republic is lower than for conventional EKC estimates reported in the literature but in line with the revised Kuznets curve discussed in Dasgupta et al. (2002). The findings may contribute to substantiate the hypothesis that the curve has been flattening and shifting to the left, possibly due to catch-up growth involving the adoption of environment-friendly technologies and specific policies to preserve the natural environment.

**FIGURE 2.** 1% CONFIDENCE ELLIPSE FOR 1 AND 2 COEFFICIENTS, EQUATION 4



**FIGURE 3.** ENVIRONMENTAL KUZNETS CURVE FOR THE DOMINICAN REPUBLIC. CROSS-PLOT OF THE FITTED VALUES FROM EQUATION 4 AND THE LOG OF REAL INCOME PER HEAD, 1961-2010



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