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CO_2 Emissions, Environmental Degradation, and Healthcare Expenditure: Evidence from Australia

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Abstract

Environmental degradation (measured, for example) by CO_2 emissions has an adverse effect on public health, leading to the need for a higher level of healthcare expenditure. The level of per capita income, which has been identified as a major determinant of healthcare expenditure, is associated with environmental degradation as represented by the environmental Kuznets curve. The results presented in this study show that when a country, like Australia, falls on the declining sector of the Environmental Kuznets Curve (EKC), healthcare expenditure is negatively related to environmental degradation. Although this proposition sounds counterintuitive, it is justified theoretically and supported empirically.

Keywords: CO_2 emissions; Environmental degradation; Healthcare expenditure; Australia.

1. INTRODUCTION

An intricate link exists among economic growth, environmental quality (or degradation), and public health, with implications for expenditure on healthcare. Economic growth produces environmental pollution, at least in the early stages of development when the level of income per capita is low. The negative effect of growth on the environment is transmitted, *inter alia*, through industrialization, urbanization, and the growth of the transport sector, all of which lead to environmental pollution. However, the growth of GDP per capita also leads to the allocation of a higher portion of Gross Domestic Product (GDP) to healthcare, which brings about an increase in healthcare expenditure. Gerdtham and Jonsson (1991) describe the link among the three variables by suggesting that "the costs of environmental contamination are indisputable, and put greater pressure on government budgets, potentially requiring an increase in health care expenditure."

The determinants of healthcare expenditure have been examined extensively (for example, Di Matteo and Di Matteo, 1998; McCoskey and Selden, 1998; Gerdtham and Lothgren, 2000; Murthy and Okunade, 2000; Freeman, 2003; Jerrett *et al*., 2003; Di Matteo, 2005, 2014; Chou, 2007; Narayan and Narayan, 2008; Wang, 2009; Baltagi and Moscone, 2010; Moscone and Tosetti, 2010; Pan and Liu, 2012; Yavuz, Yilanci, and Ozturk, 2013; Yu *et al*., 2013; Khan and Mahumud, 2015; An, Zhao, and Zhou, 2016). The important determinants of healthcare expenditure as identified in the literature include income (as the primary factor), urbanization, population aging, the number of practicing physicians, female labor force participation rate, the proportion of publicly funded healthcare, and foreign aid.

An important determinant of healthcare expenditure that has not received the attention it deserves is environmental degradation, which has an adverse effect on human health, not only in terms of deteriorating quality of life but also in terms of expenditure on healthcare (OECD, 2001). The evidence suggests that the environment-related health costs can add up to as much as $130 billion per year for Organisation for Economic Co-operation and Development (OECD) countries, which is equivalent to 0.5% of their GDP (OECD, 2001). Studies dealing with the effect of environmental degradation on healthcare expenditure, based predominantly on the Autoregressive Distributed Lag (ARDL) approach to cointegration and to a lesser extent on panel cointegration, include those of Yu, Zhang, and Zheng (2016), Hansen and King (1996), Narayan and Narayan (2008), Baltagi and Moscone (2010), Abdullah, Azam, and Zakariya (2016), Boachie *et al*. (2014), Yazdi and Khanalizadeh (2014), and Kiymaz, Akbulut, and Demir (2006). These studies invariably find the coefficients on the variables representing environmental degradation to be positive, implying that a deteriorating environment affects human health adversely, and thus boosting the demand for healthcare.

By using simulation, Moosa and Pham (2019) show that if the relation between income per capita and CO_2 emissions is represented by the environmental Kuznets curve, then the relation between healthcare expenditure and environmental degradation should be positive for low-income countries and negative for high-income countries. This prediction is supported by actual data on eight country groups with a wide range of income per capita. They suggest that their findings represent a departure from the results found in the existing literature that typically portrays a positive relation.

The objective of this paper is to examine empirically the effect of environmental degradation, measured in terms of per capita CO_2 emissions, on healthcare expenditure using Australian data over the period 1995–2017. The hypothesis tested in this paper is that the effect of environmental degradation on healthcare expenditure may be positive or negative, depending on the position on the environmental Kuznets curve. If the country or region under investigation falls on the declining sector of the EKC, indicating that economic growth has a positive effect on environmental quality, then the result typically found in the literature will not hold.

2. MODEL DERIVATION AND EMPIRICAL METHODOLOGY

An equation (1) relating healthcare expenditure, h, to CO_2 emissions, e, can be derived mathematically as follows. Healthcare expenditure is a positive function of income per capita, y, which gives

$$h = \alpha_0 + \alpha_1 y \tag{1}$$

where $\alpha_1 > 0$. The relation between emissions per capita and income per capita depends on the position on the EKC, which gives

$$e = \beta_0 + \beta_1 y \tag{2}$$

where $\beta_1 > 0$ on the upward-sloping segment of the EKC and $\beta_1 < 0$ otherwise. By manipulating equation (2), we obtain

$$y = -\frac{\beta_0}{\beta_1} + \left(\frac{1}{\beta_1}\right)e \tag{3}$$

By substituting equation (3) into equation (2), we obtain

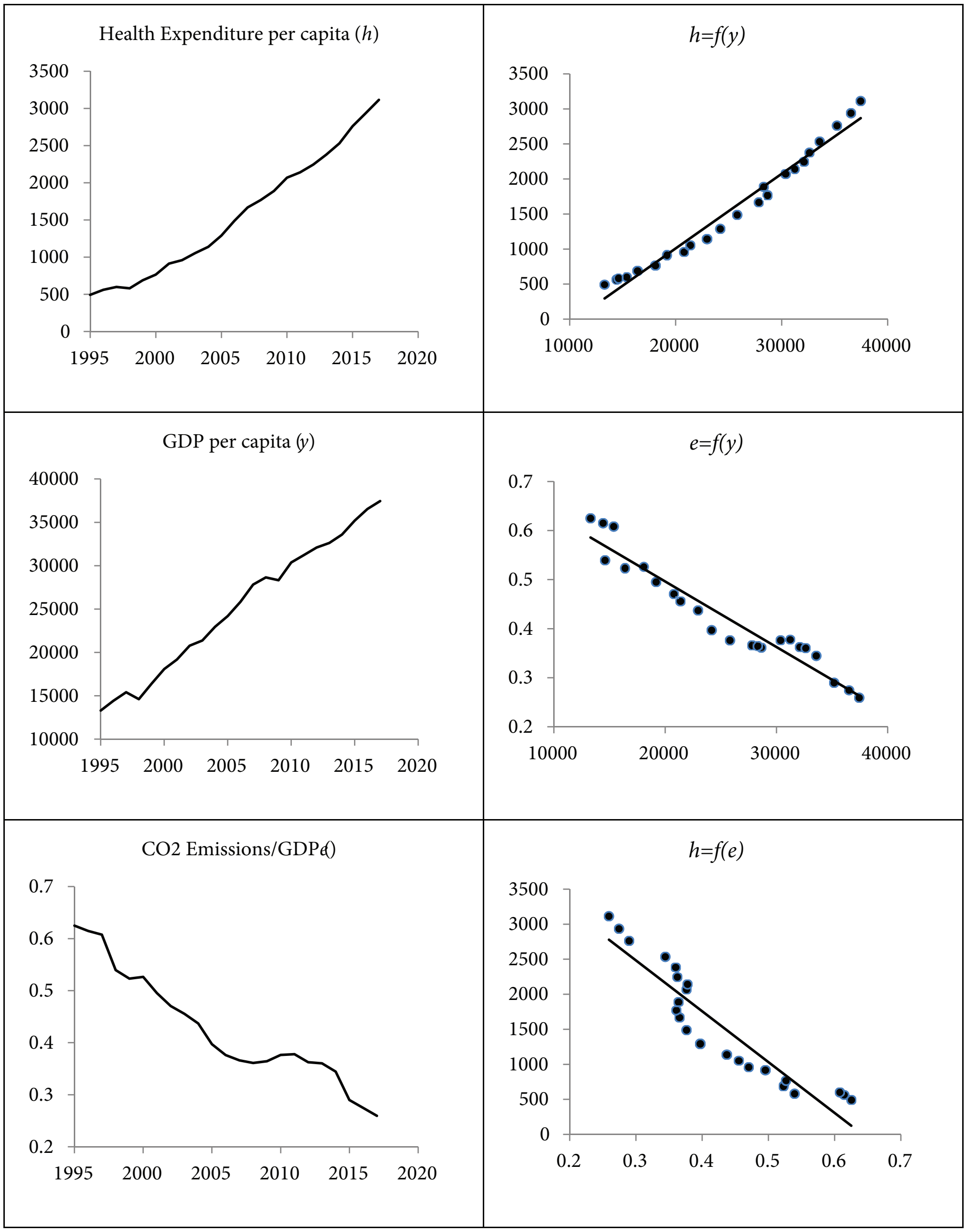
$$h = \left(\alpha_0 - \frac{\alpha_1\beta_0}{\beta_1}\right) + \left(\frac{\alpha_1}{\beta_1}\right)e \tag{4}$$

As $\alpha_1 > 0$, it follows from equation (4) that $(\alpha_1/\beta_1) > 0$ when $\beta_1 > 0$ (the upward-sloping section of the EKC) and $(\alpha_1/\beta_1) < 0$ when $\beta_1 < 0$ (the downward-sloping section of the EKC).

Equations (1), (2), and (4) are estimated by using the Phillips-Hansen (1990) fully modified ordinary least squares (FMOLS) because Ordinary Least Squares (OLS) does not produce valid *t* statistics, whereas FMOLS does. This is because with integrated variables, the OLS standard errors (and hence the *t* statistics) do not follow an asymptotic normal distribution. Consequently, the conventional critical values of the *t* distribution cannot be used to derive inference on the significance of the estimated coefficients. For the purpose of robustness and to utilize the information embodied in the cross correlations of the residuals, equations (1) and (2) are also estimated by seemingly unrelated regressions (SUR).

To determine if the three variables form cointegrating vectors pairwise, the bounds test is used by calculating two test statistics: *F* and *W*. Three outcomes are possible: (i) if the statistic (*F* or *W*) lies between

Figure 1. Variables: Time Plots and Scatter Plots.



the upper and lower bounds, the test is inconclusive; (ii) if it is above the upper bound, the null hypothesis of no cointegration is rejected; and (iii) if it is below the lower bound, the null hypothesis of no cointegration cannot be rejected.

A question arises here is that whether income has an independent effect on healthcare expenditure over and above the effect of CO_2 emissions. Similarly, CO_2 emissions may have an independent effect on healthcare expenditure over and above the effect of income. According to equation (4), the effect of CO_2 emissions on healthcare expenditure is derived mainly from the effect of income. Instead of re-estimating the model with two explanatory variables, we conduct a variable addition test. Equation (4) is estimated with and without *y*; whereas equation (1) is estimated with and without *e*. Three test statistics are calculated to judge the significance of adding *y* to equation (4) and *e* to equation (1): a Langrage multiplier (LM) statistic,

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Table 1. Estimation and Testing Results.

Functional relation	$h = f(y)$	$e = f(y)$	$h = f(e)$
OLS estimates			
Intercept	−1230.2 (−13.76)	0.746 (61.87)	5066.2 (16.12)
Slope	0.1104 (33.09)	−0.000012 (−28.34)	−8268.9 (−11.27)
R^2	0.98	0.93	0.87
SUR estimates			
Intercept	−1122.6 (−11.46)	0.764 (36.12)	
Slope	0.107 (28.67)	−0.000013 (−16.65)	
R^2	0.98	0.93	
Bounds test (ARDL)			
F	11.11	7.31	10.48
W	22.23	12.62	20.97
Variable addition tests			
LM $\chi^2(1)$	5.06 [0.025]		19.57 [0.00]
LR $\chi^2(1)$	5.71 [0.017]		43.80 [0.00]
F(1,18)	5.63 [0.028]		114.34 [0.00]

t statistics are placed in parentheses and *p*-values are in square brackets. The lower and upper bounds for the *F* statistic are 5.60 and 6.62, respectively. The lower and upper bounds for the *W* statistic are 11.21 and 13.25, respectively.

which is distributed as χ^2 (1), a likelihood ratio (LR) statistic, again distributed as χ^2 (1), and an *F* statistic with (1,20) degrees of freedom.

3. DATA AND EMPIRICAL RESULTS

Time series data on three variables were obtained from the World Bank over the period 1995–2017. Health-care expenditure per capita and GDP per capita are measured in US dollar terms on a Purchasing Power Parity (PPP) basis. CO_2 emissions are measured per kilogram per dollar of GDP on a per capita basis. Figure 1 exhibits time series plots of the three variables as well as cross-plots of *h* on *y*, *e* on *y*, and *h* on *e*. Over time, *h* and *y* have been increasing while *e* has been on the decline. The scatter plots show, as expected, strong positive correlation between *h* and *y*. The strong negative relation between *e* and *y* implies that Australia is on the declining sector of the EKC. It follows that *h* is a declining function of *e*.

The empirical results are displayed in Table 1. The OLS and SUR estimates are consistent, showing a significantly positive association between *h* and *y* and a negative association between *e* and *y* (the falling portion of the EKC). It follows that the relation between *h* and *e* is significantly negative. The bounds test results indicate that the variables are cointegrated pairwise, as both the *F* and *W* statistics are above the upper bounds. The three variable addition tests show that *e* and *y* have independent effects on *h*.

The results reveal that the growth of GDP per capita leads to the allocation of a higher portion of GDP to healthcare, which brings about an increase in health expenditure. Beyond a certain level of GDP per capita, environmental quality starts to improve as GDP per capita rises, which brings about a negative relation between healthcare expenditure and environmental degradation as represented by CO_2 emissions. This result is not universal—it is only valid for high-income countries that fall on the declining sector of the EKC.

4. CONCLUSION

The literature on the determinants of health expenditure is extensive; however, very few studies identify environmental quality or degradation as an important determining factor. The importance of environmental degradation stems from the fact that it has an adverse effect on public health, leading to the need for a higher level of healthcare expenditure. The level of per capita income, which has been identified as a major determinant of health expenditure, is associated with environmental degradation as represented by the environmental Kuznets curve. The results presented in this study support these propositions in the case of Australia over the period 1995–2017.

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