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Energy consumption, pollutant emissions and economic growth in South Africa

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ABSTRACT

This paper examines the long-run and the causal relationship between economic growth, pollutant emissions and energy consumption for South Africa for the period 1965–2006 in a multivariate framework which includes labour and capital as additional variables. Using the bound test approach to cointegration, we found a short-run as well as a long-run relationship among the variables with a positive and a statistically significant relationship between pollutant emissions and economic growth. Further, applying a modified version of the Granger causality test we also found a unidirectional causality running from pollutant emissions to economic growth; from energy consumption to economic growth and from energy consumption to CO_2 emissions all without a feedback. The econometric evidence suggests that South Africa has to sacrifice economic growth or reduce its energy consumption per unit of output or both in order to reduce pollutant emissions. In the long-run however, it is possible to meet the energy needs of the country and at the same time reduce CO_2 emissions by developing energy alternatives to coal, the main source of CO_2 emissions. However, the econometric results upon which the policy suggestions are made should be interpreted with care, as they may not be sufficiently robust enough to categorically warrant the choice of an unpalatable policy option by South Africa.

1. Introduction

Like many coal-abundant countries, South Africa is facing a crucial policy dilemma relating to the use of coal vis-à-vis the development of other sources of energy (see Büscher, 2009; Winkler, 2007). It is confronted with the crucial issue of producing more coal to meet its energy requirements, while at the same time grappling with the issue of reducing greenhouse gas (GHG) emissions. The issue is further complicated by concerns over increases in the price of coal relative to other energy sources and coal reserves exhaustion. These issues are forcing South Africa to define an energy strategy that departs from over-reliance on coal-generated electricity (Department of Energy and Minerals, South Africa, 2008). Even nuclear energy, despite its controversies and costs (see Apergis et al., 2010; Menyah and Wolde-Rufael, 2010; Wolde-Rufael and Menyah, 2010), is being promoted as one of the important energy sources of the future. However, critics of the South African energy strategy point out that despite the huge environmental challenges it faces, the country still has a weak environmental policy that is not addressing the issue of greenhouse emissions adequately. According to the critics, policymakers see the cutting of GHG emissions as a "benevolent gesture towards mankind" and not as a serious means for solving the environmental challenges facing South Africa (Sebitosi and Pillay, 2008a).

What makes South Africa an interesting case study is that its economy is heavily dependent on the energy sector which accounts for 15% of the country's GDP with coal being the dominant one (Department of Energy and Minerals, South Africa, 2008). About 70% of South Africa's total primary energy supply is derived from coal, and coal-fired power stations provide more than 93% of electricity production (World Bank, 2008). This over dependence on coal is leading to high levels of CO_2 emissions relative to the size of the South African economy and population (Winkler, 2007). In terms of pollutants, the coal sector accounts for 87% of CO_2 emissions, 96% of sulphur dioxide (SO_2) emissions, and 94% of nitrous oxide emissions. As Table 1 indicates, South Africa is one of the highest emitters of GHG emissions when compared to many developed and developing countries, whether this is measured in emissions per person or per unit of GDP (Winkler, 2007; World Bank, 2008). South Africa ranks the 7th largest emitter of GHG emissions per capita in the world (Sebitosi and Pillay, 2008a) and has experienced almost a 7-fold increase in fossil-fuel CO_2 emissions since 1950, with 80–90% of emissions coming from coal (Winkler, 2007).

Between 1980 and 2006, South Africa's per capita carbon dioxide emissions from the consumption and flaring of fossil fuels increased continuously while they were falling for other major regions of the world (see Fig. 1). To aggravate the problem further, the growth in

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Table 1
Energy efficiency indicators, 2005.
Source: World Bank, World Development Indicators, 2008.

	CO_2 emissions (kg per 2000 US $ of GDP)	CO_2 emissions (kg per 2000 PPP $ of GDP)	CO_2 emissions (metric tons per capita)	GDP per unit of energy use (PPP $ per kg of oil equivalent)
South Africa	2.54	1.03	8.72	3.12
East Asia and Pacific	2.63	0.92	3.59	3.33
Europe and Central Asia	2.65	0.74	7.01	3.32
Euro area	0.38	0.27	8.07	7.45
High income: OECD	0.43	0.37	12.45	6.13
Latin America and Caribbean	0.59	0.28	2.49	7.19
South Asia	1.92	0.52	1.08	4.64
Sub-Saharan Africa	1.53	0.49	0.85	2.91
World	0.80	0.52	4.53	5.04

coal use is expected to continue or even accelerate over the next few years as South Africa is building more coal-powered stations to meet its growing energy needs and also to redress the past inequitable distribution of electricity use among its races (Winkler, 2007; Sebitosi and Pillay, 2008a).

South Africa's energy consumption per capita and CO_2 emissions per capita have been growing faster than real GDP per capita and there is no doubt that the current emission profile poses a significant challenge to the country's energy development strategy (Fig. 2).

Studies that link economic growth, energy consumption and pollutant emissions in the same framework tend not to focus on South Africa. Most of the studies that relate to South Africa only investigate the link between energy consumption and economic growth (see, Ziramba, 2009; Odhiambo, 2009; Wolde-Rufael, 2006, 2009). To our knowledge, there are no specific studies for South Africa that have employed modern advances in time series econometrics of cointegration and causality to test the relationship between energy consumption, pollutant emissions and economic growth in a coherent framework. The aim of this paper is to fill this gap by investigating the relationship between economic growth, energy consumption and pollutant emissions in a multivariate framework by including labour and capital as additional variables. The purpose is to show how environmental degradation and other crucial variables such as energy, combine with capital and labour to affect the growth process. From an econometric point of view, we include these additional variables because the exclusion of relevant variables makes the estimates not only biased but also inconsistent, but the absence of causality in a bivariate system can arise from omitted variables (Lütkepohl, 1982). However, since a five-variable case incorporates more information than a bivariate case, the causal inference drawn may be relatively more reliable (Loizides and Vamvoukas, 2005).

In this paper, tests for establishing the long-run relationship between the variables are carried out by using the cointegration procedure developed by Pesaran et al. (2001), hereafter PSS, while testing for causality is conducted using a modified version of the Granger causality test proposed by Toda and Yamamoto (1995), hereafter, TY which is valid regardless whether a series is I(0), I(1) or I(2), non-cointegrated or cointegrated of any arbitrary order. To reinforce our empirical findings, we also quantify how much feedback exists from one series to the other using the generalized forecast error variance decomposition technique proposed by Pesaran and Shin (1998), which is invariant to the ordering of the variables.

The rest of the paper is structured as follows. In Section 2 we present a brief review of the empirical literature followed by a discussion of the methodology used in Section 3. The empirical evidence is presented in Section 4 while the summary and the concluding remarks are outlined in Section 5.

2. An overview of the literature

While coal is an important source of energy that raises relatively fewer security concerns than do oil and natural gas, many believe that coal consumption is the major source of global warming as power plants that burn coal are the major contributors to rising atmospheric concentration of greenhouse gas emissions (see Wolde-Rufael, 2010). As a result of this, global warming has become an important global environmental challenge facing the world, including South Africa. Primarily motivated by this concern, there have been several studies that have attempted to investigate the causal relationship between pollutant emissions and economic growth (see, Aslanidis, 2009; Galeotti et al., 2009). However, as Ang (2008) rightly argues, even though the relationship between output and pollution has been extensively studied, most of these studies mainly focus on testing the validity of the so-called Environmental Kuznet's Curve (see, Aslanidis, 2009; Galeotti et al., 2009) and do not consider investigating the causal relationship between energy consumption, pollutant emissions and economic growth in the same framework. Since fossil-fuel energy use is the main source of global warming, incorporating energy consumption and other growth determining factors such as labour and capital in the same growth accounting framework can enhance our understanding of the issues that can affect global warming.

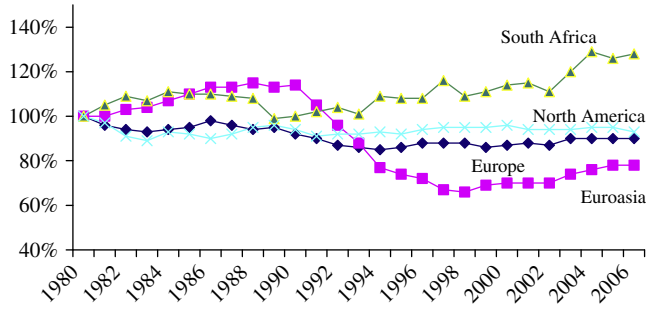

Fig. 1. Trends of variables (1980 = 100). Per capita carbon dioxide emissions from the consumption and flaring of fossil fuels, 1980–2006.

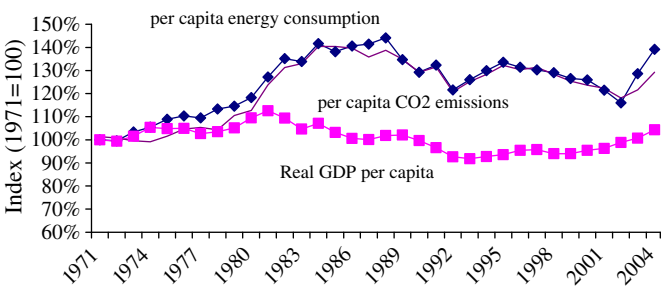

Fig. 2. Trends of variables (1971 = 100).