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CO_2 emissions, energy consumption, income and foreign trade: A South African perspective ☆

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HIGHLIGHTS

- A long run relationship between CO_2 emissions, levels of energy use & trade in SA.
- Per capita energy has a significant long run effect in raising SA's CO_2 levels.
- Trade reduces CO_2 emissions through stimulating technological innovations.
- Positive bidirectional causality between per capita energy use & CO_2 emissions.
- Bidirectional causality between trade & income and trade & energy use.

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ABSTRACT

The effect of trade liberalisation on environmental conditions has yielded significant debate in the energy economics literature. Although research on the relationship between energy consumption, emissions and economic growth is not new in South Africa, no study specifically addresses the role that South Africa's foreign trade plays in this context. A surprising fact given trade is one of the most important factors that can explain the environmental Kuznets curve. This study employs recent South African trade and energy data and modern econometric techniques to investigate this. The main finding of interest in this paper is the existence of a long run relationship between environmental quality, levels of per capita energy use and foreign trade in South Africa. As anticipated per capita energy use has a significant long run effect in raising the country's CO_2 emission levels, yet surprisingly higher levels of trade for the country act to reduce these emissions. Granger causality tests confirm the existence of a positive bidirectional relationship between per capita energy use and CO_2 emissions. Whilst the study also finds positive bidirectional causality between trade and income per capita and between trade and per capita energy use, it appears however that trade liberalisation in South Africa has not contributed to a long run growth in pollution-intensive activities nor higher emission levels.

1. Introduction

If South Africa's greenhouse gas (GHG) emissions are compared on a global scale, it is immediately clear that the country is one of the world's most carbon-intensive economies. In fact, South Africa is the world's most carbon-intensive non-oil-producing developing country, measured in per capita CO_2 equivalent emissions in 2010, and excluding island states (Energy Information Administration (EIA), 2010). Furthermore, it is the largest emitter of GHGs in Africa, with 42% of the continents emissions coming from South Africa alone. South Africa is also a bigger emitter of CO_2 than all other Sub-Saharan African (SSA) countries combined (Energy Information Administration (EIA), 2010).

South Africa's total GHG emissions in 2000 were estimated to be 461 million tons CO_2 equivalent of which, 83% of emissions were associated with energy supply and consumption, 7% from industrial processes, 8% from agriculture, and 2% from waste (Department of Environmental Affairs (DEA), 2010). The energy sector is therefore by far the largest sector responsible for emissions in South Africa at 380,988 Gg CO_2e with the sector's combustion of fuel producing 81% of the sector's emissions and fugitive emissions from fuel contributing the remaining 19% (Department of Environmental Affairs (DEA), 2010). Factors which have contributed to South Africa's enormous energy related emissions include: a deliberate strategy by the pre-democratic government prior to 1994 of encouraging investment in energy-intensive industries, including aluminium and other non-ferrous

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metal beneficiation (the so called 'mineral-energy complex' identified by Fine and Rustomjee (1996)); and the carbon-intensity of a largely (90% +) coal-based electricity generation base (Energy Information Administration (EIA), 2010).

Of particular relevance to our work is a finding in an multi-country study on CO_2 embodied in international trade by Peters and Hertwich (2007) that around 40% of South Africa's emissions are due to trade (in particular the export of carbon-intensive goods) rather than domestic consumption. According to this study, this is the highest proportion for any of the countries included in their analysis. Given that most of South Africa's energy needs are met by burning fossil fuels, a strong link between foreign trade and CO_2 emissions is to be expected. This fact makes South Africa vulnerable to trade-induced environmental degradation as a result of an increase in the burning of fossil fuels to meet the energy demands of an expanding export sector. This is particularly relevant given international trade is one of the most important factors that can explain the environmental Kuznets curve (EKC).

In this context, it is important to note that South Africa is both a member of the World Trade Organisation (WTO) since 1995 and a signatory to the 1992 UNFCCC and its Kyoto Protocol. Under Kyoto, the biggest emitters of GHGs are encouraged to implement mitigation measures that catalyse energy efficiency and motivate energy sustainability policies. South Africa is classified as a non-annex developing country and therefore has no mandatory emission reduction targets during the period 2008–2012. Nonetheless, the country is committed to the fight against climate change and has instituted several policies and strategies at the national level to reduce GHG emissions. The South African government is of the view that the country needs to reduce GHG emissions while working to ensure economic growth, increase employment, and reduce poverty and inequality (National Treasury, 2010).

The above discussion suggests South Africa is a compelling candidate for a separate study which investigates the role of trade openness on economic growth, energy consumption and pollutant emissions. Indeed, our study is the first attempt to incorporate foreign trade as a separate determinant of CO_2 emissions in a multivariate framework in the context of South Africa. Whilst there are some studies in the international literature that link economic growth, energy consumption and pollutant emissions in the same framework initiated by the work of Ang (2007) and Soytas et al. (2007) these do not relate to South Africa. Studies that do focus on South Africa investigate either the link between economic growth and emissions (see, Nahman and Antrobus, 2005); or energy consumption and economic growth (see, Ziramba, 2009; Odhiambo, 2009; Wolde-Rufael, 2006, 2009). The only South African study that our research has revealed that employs modern advances in time series econometrics of co-integration and causality to test the relationship between energy consumption, pollutant emissions and economic growth in a coherent multivariate framework is that of Menyah and Wolde-Rufael (2010).

This paper's aim is to fill a gap in research in the South African context by employing the same econometric techniques of Halicioglu (2009) but in addition introducing foreign trade into the analysis as in the work by Baek et al. (2009). To our knowledge this is the first South African study that attempts to specifically understand the role of foreign trade on pollutant emissions through its effect on economic growth and energy consumption in a multivariate framework employing a single cointegration approach.

The remainder of the paper is structured as follows. In Section 2 a brief review of the empirical literature is presented followed by a discussion in Section 3 of the data and methodology used. Section 4 presents the empirical evidence, while the concluding comments are outlined in Section 5.

2. A theoretical review

The economic literature on the subject of economic growth, energy consumption and environmental pollution is well established. Empirically, two dominant research streams have emerged over the last few decades. The first area of research which focuses on pollutant emissions and income is related to testing the validity of the environmental Kuznets curve (EKC) hypothesis. According to this hypothesis, which draws its inspiration from the work of Kuznets (1955) environmental degradation may follow a similar income-dependence as income-inequality and tends to become worse as a country grows out of poverty, stabilises at some middle income levels, and then gradually improves. The EKC hypothesises an inverted-*U*-shaped curve when pollution indicators are plotted against income per capita and was proposed and first tested by Grossman and Krueger (1991). In the first stage of industrialisation, an economy's pollution grows rapidly because high priority is given to increase material output, and people are more interested in jobs and income than clean air and water (Dasgupta et al., 2002). The rapid economic growth puts pressure on the environment through the greater use of natural resources and the emission of pollutants. In this stage of growth, people are too poor to pay for abatement, and there is general disregard for the environmental consequences of growth. In the later stages of industrialisation, as income rises, people value the environment more, regulatory institutions become more effective and pollution level declines. Theoretically, the EKC hypothesis thus identifies a well-defined relationship between the level of economic activity and resulting environmental pressures (either in the form of the concentration of pollution levels, flow of emissions or the depletion of resources, etc.).

According to Harbaugh et al. (2002), the inverted-*U* relation or EKC can however not be generalised for all types of pollutants in that there is little empirical support for an inverted-*U* shaped relationship between income and several important pollutants. Environmental indicators, for which the EKC hypothesis is most plausible, are those pollutants with more short-term and local impacts (like SO_2, suspended particulate matter, NO_x and CO), rather than those with more global, indirect and long-term impacts (like CO_2 emissions, municipal waste, energy consumption and traffic volumes).

The inverted *U*-shaped relationship between income per capita and environmental quality indicators such as CO_2, SO_2, NO_x etc., is known as the EKC and was proposed and first tested by Grossman and Krueger (1991). The hypothesis has subsequently been tested empirically for many countries and regions using a diverse set of environmental measures. Dinda (2004) provides a detailed review of the EKC literature. The basic conclusion according to this review is that the EKC is a country and/or indicator specific phenomenon as the results vary both across countries and across different measures of environmental standards.

The second area of research focuses on the energy consumption and output growth relationship. This link has been examined extensively in the literature since the seminal work of Kraft and Kraft (1978) in an attempt to explore whether economic growth stimulates energy consumption or vice versa. Whilst Kraft and Kraft (1978) find that the causal relationship runs from economic growth to energy in the United States and the reverse does not hold true, studies for other countries reveal conflicting results. The direction of causality may therefore not be determined *a priori*. Ozturk (2010) provides a detailed review of the empirical literature on the subject.

A far more recent and emerging line of literature initiated by the work of Ang (2007) and Soytas et al. (2007) analyses both sets of relationships in the same multivariate framework in order to examine the dynamic links between economic growth, energy consumption and environmental pollutants together. In this