Energy Policy 37 (2009) 2214–2220

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Disaggregate energy consumption and industrial production in South Africa

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ARTICLE INFO

Article history:
Received 1 December 2008
Accepted 23 January 2009
Available online 14 March 2009

Keywords:
Energy consumption
Industrial production
Causality

ABSTRACT

This paper tries to assess the relationship between disaggregate energy consumption and industrial output in South Africa by undertaking a cointegration analysis using annual data from 1980 to 2005. We also investigate the causal relationships between the various disaggregate forms of energy consumption and industrial production. Our results imply that industrial production and employment are long-run forcing variables for electricity consumption. Applying the [Toda, H.Y., Yamamoto, T., 1995. Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics 66, 225–250] technique to Granger-causality, we find bi-directional causality between oil consumption and industrial production. For the other forms of energy consumption, there is evidence in support of the energy neutrality hypothesis. There is also evidence of causality between employment and electricity consumption as well as coal consumption causing employment.

1. Introduction

South Africa is a middle-income country and one of the most industrialized countries in Africa. Energy plays a very important role in the production process. South Africa has highly sophisticated energy production and distribution capabilities, which were developed under circumstances of economic isolation in order to meet the needs of the industrial sector and a privileged white minority. Mineral commodities continued to be the cornerstone of the South African economy throughout the 1990s and into the 21st century (Brown, 2002). Energy plays a very important role in the supply chain as it is both a final good for end-users as well as an input in the production processes of businesses (Sari et al., 2008). This importance of energy calls for attention to the relationship between energy consumption and economic activity.

We use disaggregate forms of energy following Yang (2000), who argued that the use of aggregate energy data does not capture the degree or extent to which countries depend on various energy resources. Further, the use of aggregate energy data may not be able to identify the impact of a specific energy type on industrial output. The use of disaggregate data allows for comparisons of the strengths of causal relationships by energy source (Sari et al., 2008).

In this study, we examine the link between disaggregate energy use, employment and industrial output in South Africa, employing the autoregressive distributed lag (ARDL) approach. The inclusion of employment in the analysis creates a multivariate framework which allows for substitution possibilities between energy use and labor. Our sample period is 1980–2005. The period of analysis is limited by the availability of time series data for all of the energy sources (electricity, coal and oil) we considered. We use the ARDL approach of Pesaran and Pesaran (1997) and Pesaran et al. (2001) to test for a long-run relationship between disaggregate energy use and industrial production. We also use the Granger-causality test developed by Toda and Yamamoto (1995) to test for causal relationships between industrial output and various forms of energy consumption.

The remainder of the paper is organized as follows: the following section gives an overview of the energy sector in South Africa; Section 3 provides a brief review of the empirical literature on the relationship between energy and income or output; Section 4 outlines the specifications of the empirical model that is employed in this paper; Section 5 presents the results of the study, and Section 6 gives concluding remarks and policy implications.

2. An overview of the energy sector

South Africa has a well-developed energy supply and production system. The country has large endowments of coal resources. It has, however, limited natural gas and crude oil production and consequently the bulk of its crude oil is imported. Renewable energy comprises biomass and natural processes that are replenished. Renewable energy plays a limited but significant role in power generation, particularly hydroelectric power generation. The country's abundant sunshine is only beginning to be tapped in more remote areas for electricity generation for domestic and institutional applications (Department of Minerals

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0301-4215/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2009.01.048

and Energy, 2006). The energy sector contributes approximately 15% of South Africa's gross domestic product (GDP) and provides around 250,000 jobs (Davidson et al., 2002). Energy supply is dominated by coal: South Africa is the fifth largest coal producer in the world (Brown, 2002). Other energy supply sources include electricity, nuclear energy, liquid fuels, natural gas and renewable energy. Coal contributes 71% of the total energy supply. The second most significant energy source is petroleum (20%) (Davidson et al., 2002). Fig. 1 shows South Africa's energy resources.

The three major energy-consuming sectors are industry, residential and transportation. In 2002 these three sectors accounted for 80.4% the total energy demand. The industry sector dominates energy consumption in South Africa, using about 36% of the total energy consumed in the country (Fig. 2). Industry is followed by the transportation sector (26%) and the residential sector (18%). The country's electricity consumption is also dominated by industrial consumption, accounting for 63% of total electricity consumption.

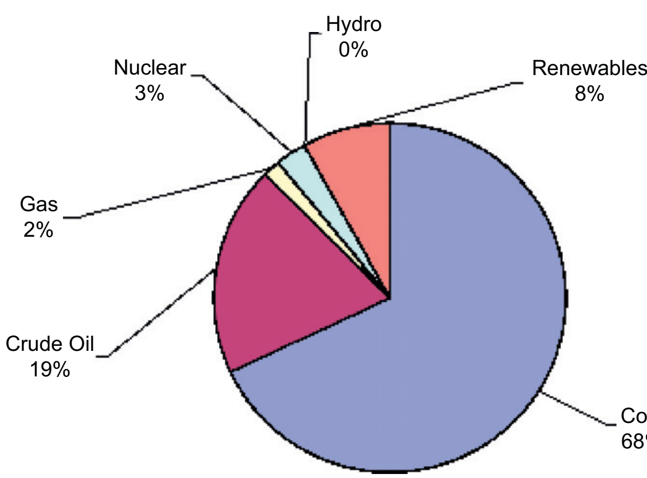

Fig. 1. South Africa's primary energy supply by source, 2004. *Source*: Department of Minerals and Energy (DME), 2006.

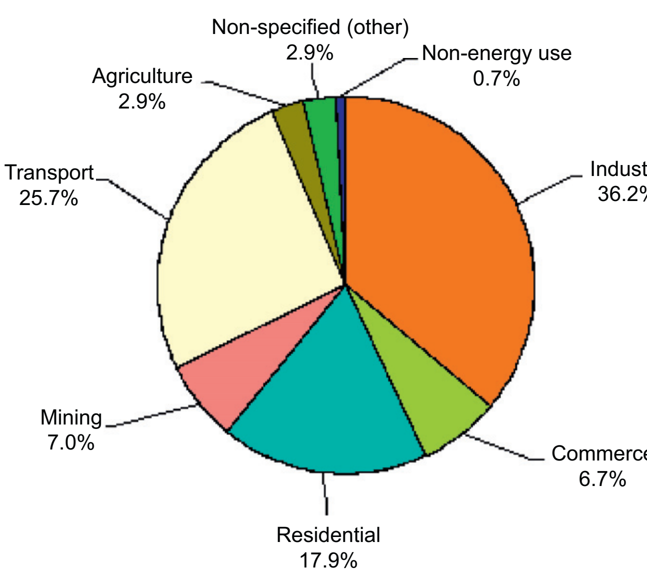

Fig. 2. Total energy consumption by sector, 2004. *Source*: Department of Minerals and Energy (DME), 2006.

3. Literature review

3.1. An overview of the related international literature

Following Kraft and Kraft's (1978) pioneering work on the relationship between income and energy, there have been numerous similar studies in both developed and developing countries. These subsequent studies were conducted at different time periods, using different methodologies, and their outcomes have varied considerably.

Most studies use gross domestic product as the income measure. However, Karanfil (2008) highlighted the problems of using official GDP, namely that it is not measured correctly due to the size of the unrecorded economy. Studies such as Jumbe (2004), who analyzed the energy-income relationship in Malawi, distinguish between overall GDP, agricultural GDP and non-agricultural GDP. A few other studies have used industrial output instead of GDP; these include Ewing et al. (2007) and Sari et al. (2008). Most studies have also used aggregate energy data. There only a few studies which have employed disaggregate data: Yang (2000), Wolde-Rufael (2004), Sari and Soytas (2004), Ewing et al. (2007), Erbaykay (2008) and Sari et al. (2008). Additionally, most studies used bivariate models to analyze the energy-income relationship. Stern (1993) claimed that using a multivariate model to determine causality relationships enables the substitution effect of energy with other inputs to be assessed. A number of studies have included other variables (such as oil prices, government expenditure, employment, capital and labor) in the energy–income relationship analysis. (See Akinlo (2008), Stern (1993, 2000), Glasure (2002), Narayan and Smyth (2005a, c).)

Empirical evidence on the causal relationship between energy consumption and income or output has been rather mixed. This evidence has been synthesized into four hypotheses; the growth hypothesis, the conservation hypothesis, the feedback hypothesis and the neutrality hypothesis (Payne, 2008). The growth hypothesis suggests that energy consumption contributes to economic growth, both directly and indirectly, as a complement to other inputs in the production process. Support for this hypothesis requires unidirectional causality from energy consumption to income. The conservation hypothesis states that energy conservation policies that curtail energy consumption would not adversely affect real income. Unidirectional causality from income to energy consumption provides support for this hypothesis. The feedback hypothesis says that energy consumption and income are interdependent and requires bi-directional causality between the two variables. Lastly, the neutrality hypothesis implies that energy consumption has a minor role in the determination of real income (Payne, 2008). The neutrality hypothesis is supported if there is no Granger-causality between energy consumption and real income or output.

Kraft and Kraft (1978) provided evidence of Granger-causality between income and energy consumption in the United States of America. There are numerous other studies which also found evidence in support of the conservation hypothesis for other countries. These include Soytas and Sari (2003) for Italy, Wolde-Rufael (2005) for five African countries, and Narayan and Smyth (2005a) for Australia.

In contrast, there are also many studies that found unidirectional causality from energy consumption to income (in support of the growth hypothesis) for both developed and developing countries. For example, Stern (1993, 2000) reported data of this nature for the US; Soytas and Sari (2003) for Turkey, France, Germany and Japan; Lee (2005) for eight developing countries; and Wolde-Rufael (2004) for Shanghai.

A number of researchers have also found evidence in support of the feedback hypothesis (or bi-directional causality) between