Applied Energy 87 (2010) 160–167

Contents lists available at ScienceDirect

Applied Energy

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

Coal consumption and economic growth revisited

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ARTICLE INFO

Article history:
Received 31 October 2008
Received in revised form 1 May 2009
Accepted 2 May 2009
Available online 4 June 2009

Keywords:
Coal consumption
Causality
Toda–Yamamoto
Variance decomposition

ABSTRACT

This paper revisits the causal relationship between coal consumption and real GDP for six major coal consuming countries for the period 1965–2005 within a vector autoregressive (VAR) framework by including capital and labour as additional variables. Applying a modified version of the Granger causality test due to Toda and Yamamoto [Toda HY, Yamamoto T. Statistical inference in vector autoregressions with possibly integrated process. J Econom 1995;66:225–50], we found a unidirectional causality running from coal consumption to economic growth in India and Japan while the opposite causality running from economic growth to coal consumption was found in China and South Korea. In contrast there was a bi-directional causality running between economic growth and coal consumption in South Africa and the United States. Variance decomposition analysis seems to confirm our Granger causality results. The policy implication is that measures adopted to mitigate the adverse effects of coal consumption may be taken without harming economic growth in China and South Korea. In contrast, for the remaining four countries conservation measures can harm economic growth.

1. Introduction

Devising sectoral energy and environmental conservation strategies and policies to produce more secured energy to satisfy energy needs while reducing greenhouse gas (GHG) emissions is a major challenge facing many countries. As global demand for energy continues to increase, energy security concerns have become even more important [1]. Diversifying the sources of energy and finding a stable and a safe energy supply have became one of the main priorities of energy policy for many countries [2–4]. The high degree of concentration of oil supply sources in the volatile region of the world where over 68% of oil and 67% of gas reserves are concentrated respectively in the Middle East and in Russia, clearly involves risks in terms of the reliability of the supply of energy needs for many energy importing countries [1]. After the 1973 oil crisis, supply security has become a primary concern for many oil-importing countries and has made the search for alternative source of cheap domestic energy supply as one of the main deriving forces behind the energy policy of many energy importing countries [2].

Coal plays a unique role in meeting the demand for secured energy, as it is globally the most abundant and economical of fossil fuels [1]. At current production levels, proven world coal reserves are estimated to last 147 years, in contrast to oil and gas which are estimated to last 41 and 63 years, respectively [5]. It is also projected that the greatest demand for fossil fuels will be coal, which will remain the second largest primary fuel source until 2030 [6]. In 2005, the major fossil fuels supplying total world energy were: oil 34.3%, coal 25.1% and gas 20.9% [1]. Coal is one of the major sources of energy for many countries. In 2005, coal accounted for 63.4% of total primary energy supply in China, 38.7% in India, 21.1% in Japan, 23.1% in South Korea, 72% in South Africa and 23.8% in the USA [6]. Furthermore, electricity from coal sources as percentage of total electricity generation accounted for 79% in China, 69% in India, 29% in Japan, 38% in Korea, 95% in South Africa and 51% in the USA [34].

While the combination of the several factors mentioned above makes coal a creditable source of energy, many believe that coal consumption is the major source of global warming as power plants that burn coal are major contributors to rising atmospheric concentrations of the greenhouse gas carbon dioxide (CO_2) which contributes to global warming. Some even boldly claim that: "understanding the causes and curse of global warming is very simple. One word. Coal" [7].[1]

Despite the fact that coal consumption is an important source of energy for many countries, there are only few studies that have employed modern advanced in time series econometrics of cointegration and causality to test the relationship between coal consumption and economic growth [8]. Thus, the importance of coal in energy supply and energy security and also coal as a source of global warming necessitates not only further research but also the use of alternative testing methodologies.

In a previous study on the causal relationship between coal consumption and economic growth [8] suggest that future research should investigate the above relationship using a more generalized

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[1] For an excellent summary of the role of coal as a source of energy and as a source of environmental challenge, see Jinke et al. [8].

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doi:10.1016/j.apenergy.2009.05.001

multivariate system. In this paper, we do exactly that. It is against this backdrop that this paper attempts to fill the gap by examining the casual relationship between coal consumption and real GDP in six major coal consuming countries for the period 1965–2005 by including labour and capital as intermitting variables. We include capital and labour as additional variables as coal alone might not be strong enough to spur economic growth. Further, exclusion of a relevant variable(s) makes not only the estimates biased as well as inconsistent but also no causality in a bi-variate system can result from neglected variables [9]. It is possible that the introduction of a third or more variables in the causality framework may not only alter the direction of causality but also the magnitude of the estimates [10]. In addition, since a four-variable case incorporates more information than a bi-variate case, the causal inference drawn may be more reliable [10]. Thus the various bi-variate causality tests so far conducted may be invalid due to the omission of an important variable(s).

In this paper the empirical evidence is carried out first by testing for causality using a modified version of the Granger causality test due to [11] which is valid regardless of whether a series is I(0), I(1) or I(2), non-cointegrated or cointegrated of any arbitrary order. Secondly, unlike previous studies, this paper attempts to quantify how much feedback exists from one series to the other using the recently developed generalized forecast error variance decomposition technique proposed by [12], which is invariant to the ordering of the variables.

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

2. Brief literature review

Over the past few years the relationship between energy consumption and economic growth has been extensively researched [13] and [14]. Yet there seems to be no consensus regarding the direction of causality between energy consumption and economic growth. Four competing hypotheses are advanced and there is ample evidence to support all these four competing hypotheses. For some countries there is a bi-directional causality while for others there is no causality at all. Still for some countries there is a unidirectional causality running from energy consumption to economic growth while for others there is the opposite causality running from economic growth to energy consumption.

Similar to the relationship between aggregate energy consumption and income, the empirical relationship between coal consumption and economic growth is also conflicting. For instance [8] found a unidirectional causality running from GDP to coal consumption in China and Japan, while they found no causality in any direction in India, South Korea and South Africa.[2] Similarly, [15] found no causality running in any direction between coal consumption and economic growth in China. In contrast, [16] for Korea and [17] for Taiwan found a bi-directional causality running between coal consumption and economic growth, while [18] for Shanghai found a unidirectional Granger causality running from coal consumption to real GDP.

The above conflicting evidences have major implications for coal policy. If there is a unidirectional causality running from coal consumption to economic growth, reducing coal consumption could lead to a fall in economic growth. In contrast, if there is a unidirectional causality running from economic growth to coal consumption, it could imply that policies aimed at reducing coal consumption may be implemented with little or no adverse effect on economic growth. On the other hand, if there is no causality running in any direction, the neutrality hypothesis is accepted, and reducing coal consumption may not affect income and coal conservation policies may not affect economic growth. In contrast, if there is a bi-directional causality running between the two, coal consumption can stimulate economic growth and in turn economic growth may induce more demand for coal. In this case, coal consumption and economic growth complement each other and coal conservation measures may negatively affect economic growth.

3. Methodology and data

Until quite recently, energy as a separate factor input in the production process has been neglected as its contribution to the economy is considered to be marginal because the cost of energy accounts for only a very small proportion of GDP compared to the cost of employment [19]. However, as [20] rightly argues: "it is one thing to correctly cite energy's small cost share in GNP, but an error to conclude, on this account, that energy plays a secondary role. Its role is primary, coequal with capital formation". Recently numerous studies have attempted to highlight the importance of energy in the production process and they have tried to incorporate energy as an addition factor of production in addition to labour and capital [13,19,21–29].

Except few, most of the empirical studies reviewed above were based on the ECM modelling that requires test for unit roots and cointegration before testing for causality. Consequently, the validity of the causality test is conditional on avoiding biases in testing for unit root and cointegration among the variables. Pre-tests for unit root and cointegration might suffer from size distortions, which often imply the use of an inaccurate model for the non-causality test [30]. To obviate some of these problems [11], based on augmented VAR modelling, introduced a Wald test statistic that asymptotically has a chi square (χ^2) distribution irrespective of the order of integration or cointegration properties of the variables. This approach fits a standard vector auto-regression model on levels of the variables (not on their first differences) that give allowance for the long-run information often ignored in systems that require first differencing and pre-whitening [30]. The approach employs a modified Wald test (*MWALD*) for restriction on the parameters of the VAR (k) where k is the lag length of the system. The basic idea of the Toda and Yamamoto approach is to artificially augment the correct order, k, by the maximal order of integration, say d_{max}. Once this is done, a $(k + d_{max})$th order of VAR is estimated and the coefficients of the last lagged d_{max} vectors are ignored [31].[3]

Despite the novelty of the Toda and Yamamoto approach, there are some major weaknesses associated with it. Even [11] themselves warn that their approach is inefficient and it suffers some loss of power since the approach intentionally over-fits the VAR. According [32] when 'we have a small sample, the asymptotic distribution may be a poor approximation to the distribution of the test statistic' (p. 212); but the approach is less distorted than others and may be preferable when the sample size is small. Others have also shown that the Toda and Yamamoto approach exhibits a relatively weak power of the test because of its inefficiency due to an augmented lag regression while its empirical size of the test is acceptable [33].

To undertake the Toda and Yamamoto version of the Granger non-causality test, for VAR (4), ($k = 3$ and $d_{max} = 1$), we estimate the following system equations:

[2] Jinke et al. [8] did not find the USA series integrated of the same order consequently they did not carry out Granger no-causality tests.

[3] The Toda and Yamamoto [11] techniques is widely used, see ([13,18,23–27,29].