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The causal dynamics between coal consumption and growth: Evidence from emerging market economies

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ABSTRACT

This study examines the relationship between coal consumption and economic growth for 15 emerging market economies within a multivariate panel framework over the period 1980–2006. The heterogeneous panel cointegration results indicate there is a long-run equilibrium relationship between real GDP, coal consumption, real gross fixed capital formation, and the labor force. While in the long-run both real gross fixed capital formation and the labor force have a significant positive impact on real GDP, coal consumption has a significant negative impact. The panel causality tests show bidirectional causality between coal consumption and economic growth in both the short- and long-run.

1. Introduction

Though coal has been a dependable energy source within the world's energy consumption mix, the environmental consequences of the sustained use of coal has drawn into question the long-term viability of coal in light of the emergence of cleaner, alternative energy sources. Researchers have recently begun to examine the dynamic causal relationship between coal consumption and economic growth and the energy policy implications of their findings.[1] The strong economic growth and the rising energy demands of emerging market economies motivate the study of the coal consumption-growth nexus for these countries. Specifically, this study extends the previous research in an examination of a balanced panel of 15 emerging market economies as defined by Morgan Stanley capital international (MSCI) over the period 1980–2006 in the estimation of a panel error correction model to infer the causal relationship between coal consumption and economic growth.[2]

Table 1 displays some statistics related to the production and consumption of coal along with carbon dioxide emissions attributed to fossil fuels for the 15 emerging market economies. As the table shows, there is a great deal of variation in these statistics across countries. In terms of coal production, China ranks the highest while Morocco ranks the lowest. In the case of coal consumption, again China ranks the highest while Argentina is the lowest. With respect to carbon dioxide emissions, China has the highest rank whereas Peru has the lowest rank. China, India, and South Africa are among the world leaders in both coal production and consumption, not to mention in carbon dioxide emissions from fossil fuel usage. China ranks first in the world in the production and consumption of coal along with carbon dioxide emissions. India ranks third in both coal production and consumption and fourth in carbon dioxide emissions. South Africa ranks sixth in coal production, seventh in coal consumption, and 12th in carbon dioxide emissions. Further examination of Table 1 reveals, though Indonesia is eighth in coal production, it ranks 26th in coal consumption. In fact, Indonesia was the second largest net exporter of coal in the world for 2004.[3] Based on the data reported in Table 1, 12 of the 15 countries are net importers of coal.

The study extends the literature on the causal relationship between coal consumption and economic growth along several dimensions. First, the study includes a larger set of countries in the analysis than previous studies. Second, with the exception of the studies by Yuan et al. [37], Payne [24], Wolde-Rufael [39], and Apergis and Payne [4], the analysis will be undertaken within a production model framework by including measures for capital

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[1] See Payne [21–23], for surveys of the literature on the causal relationship between energy consumption and economic growth. Nel and van Zyl [20] discuss energy-based growth models and through model calibration and forecasting to infer the prospects for energy-constrained economic growth.

[2] Morgan Stanley Capital International characterizes twenty-two countries as emerging markets. Seven countries are omitted from the analysis due to the unavailability of data for all the variables over the entire period 1980–2008: Colombia, Israel, Pakistan, Poland, Russia, Taiwan, and Turkey.

[3] Indonesia's *Country Analysis Brief*, Energy Information Administration.

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Table 1
Coal summary statistics, 2006.

Country	Emerging market economies		
	Coal production	Coal consumption	Carbon dioxide emissions
Argentina	0.051 (58)	0.906 (66)	162.19 (28)
Brazil	6.490 (32)	23.604 (27)	377.24 (17)
Chile	0.437 (46)	6.445 (47)	64.80 (50)
China	2620.498 (1)	2584.246 (1)	6017.69 (1)
Egypt	0.028 (62)	1.425 (60)	151.62 (30)
Hungary	10.970 (28)	13.059 (35)	58.65 (54)
India	500.193 (3)	539.486 (3)	1293.17 (4)
Indonesia	213.174 (8)	24.071 (26)	280.36 (22)
Malaysia	1.164 (44)	16.868 (31)	163.53 (27)
Mexico	12.662 (26)	19.876 (29)	435.60 (13)
Morocco	0.000 (66)	6.478 (46)	34.53 (73)
Peru	0.118 (53)	1.627 (59)	29.93 (74)
Philippines	2.597 (40)	11.117 (37)	72.39 (47)
South Africa	269.828 (6)	195.225 (7)	443.58 (12)
Thailand	21.022 (22)	33.156 (24)	245.04 (24)

Notes: Coal production and consumption denoted in million short tons. Carbon dioxide emissions defined as total from consumption of fossil fuels in million metric tons of CO_2. Numbers in parentheses represent world rank. Data obtained from *Country Energy Profiles* of the Energy Information Administration.

and labor. Third, noting the studies by Hu and Lin [12], Sari et al. [33], Wolde-Rufael [39], and Apergis and Payne [4], the sign and magnitude of the respective coefficient estimates from the panel error correction model will be presented to facilitate the policy interpretation of the findings. Fourth, given the relatively short time horizon of the data, panel unit root and cointegration tests are utilized to provide additional power and size properties over standard unit root and cointegration tests by combining the cross-section and time series data across countries.[4]

Section 2 outlines the policy implications associated with the causal relationship between coal consumption and economic growth along with a summary of the empirical literature to date. Section 3 discusses the data, methodology, and empirical results. Section 4 provides concluding remarks.

2. Overview of the coal consumption and economic growth literature

The identification of the causal relationship between coal consumption and economic growth has a number of policy implications. If an increase in coal consumption causes an increase in economic growth, then energy conservation policies that adversely impact coal consumption may also have an adverse impact on economic growth. On the other hand, if an increase in coal consumption causes a decrease in economic growth due perhaps to the inefficient and excessive use of coal, then energy conservation policies that reduce coal consumption may actually mitigate the adverse impact of coal consumption on economic growth.[5]

Alternatively, economic growth may cause either an increase or decrease in coal consumption. If an increase in economic growth causes an increase in coal consumption, then energy conservation policies that reduce coal consumption may not have an adverse impact on economic growth. However, the case of an increase in economic growth that causes a decrease in coal consumption may be reflective of an economy that is becoming less coal intensive.[6] It is also possible that coal consumption and economic growth exhibit an interdependent relationship as causation may run in both directions. Likewise, it is conceivable that coal consumption plays such a minor role in the economic growth process that no causal relationship can be detected.

Previous studies provide a range of results for a relatively small number of countries on the causal relationship between coal consumption and economic growth.[7] Yang [34] uses the Engle–Granger bivariate cointegration procedure to find the absence of a long-run equilibrium relationship between coal consumption and real output in Taiwan; however, Granger-causality tests reveal unidirectional causality from economic growth to coal consumption. In a follow-up study on Taiwan, Yang [35] employs the same methodology to show bidirectional causality between coal consumption and economic growth. Fatai et al. [9] reveal unidirectional causality from economic growth to coal consumption in the case of Australia with both the Johansen–Juselius and Toda–Yamamoto approaches to causality testing; however, the absence of a causal relationship using the autoregressive distributed lag (ARDL) model. Furthermore, Fatai et al. [9] fail to find a causal relationship between coal consumption and economic growth for New Zealand using either the Johansen–Juselius or Toda–Yamamoto procedures.

Using the Toda–Yamamoto approach to causality testing, Wolde-Rufael [38] presents evidence of unidirectional causality from coal consumption to real output in the case of Shanghai. In another study of Taiwan, Lee and Chang [16] find bidirectional causality between coal consumption and economic growth within a bivariate error correction model. Yoo [36] also reports bidirectional causality between coal consumption and economic growth from a bivariate error correction model in the case of South Korea. Hu and Lin [12] utilize the Hansen-Seo asymmetric cointegraton procedure to reveal asymmetries in the relationship between coal consumption and economic growth for Taiwan along with bidirectional causality. Jinke et al. [14] use a bivariate error correction model to show unidirectional causality from economic growth to coal consumption for China and Japan, but the absence of a causal relationship for India, South Africa, and South Korea.

[4] The panel error correction methodology employed in this study parallels Apergis and Payne [1–4].

[5] Wolde-Rufael [39] alludes to the possibility that industries dependent on coal may have become less efficient over time. Also, the absence of binding legislative restrictions on carbon dioxide emissions may be a contributing factor to the excessive use of coal.

[6] As pointed out by Wolde-Rufael [39], coal as an energy source may be decreasing relative to other energy sources in the production of electricity for example.

[7] A summary of the coal consumption-growth studies is provided in Table 1 of Apergis and Payne [4]. Though not explicitly testing for Granger-causality both Sari and Soytas [30] and Ewing et al. [8] employ generalized forecast error variance decomposition analysis. In the case of Turkey, Sari and Soytas [30] show that coal consumption explains up to 8% of the forecast error variance of real GDP. In a study of the US, Ewing et al. [8] find that coal consumption explains up to 10% of the forecast error variance of industrial production. In an examination of coal production in the former Soviet Union, Reynolds and Kolodziej [29] find unidirectional causality from economic growth to coal production.