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Natural gas consumption and economic growth: A panel investigation of 67 countries

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ABSTRACT

This study examines the relationship between natural gas consumption and economic growth for a panel of 67 countries within a multivariate framework over the period 1992–2005. Pedroni's [24,26] heterogeneous panel cointegration test reveals there is a long-run equilibrium relationship between real GDP, natural gas consumption, real gross fixed capital formation, and the labor force. The results of the panel vector error correction model reveal bidirectional causality between natural gas consumption and economic growth in both the short- and long-run.

1. Introduction

Natural gas is a key nonrenewable energy source for the industrial sector and electricity generation for a majority of countries around the world. In addition, natural gas generates less carbon dioxide emissions relative to other fossil fuels. In light of the commitments to reduce carbon dioxide emissions through the Kyoto protocol and other country-specific intiatives, governments are exploring policy options to encourage the use of natural gas over other fossil fuels as well as the viability of renewable energy sources.[1] Indeed, the recent interest in the use of natural gas in the energy policy discussions on reducing emissions raises the question of the role of natural gas consumption in the economic growth process. Though the empirical literature on the causal relationship between energy consumption and economic growth is quite substantial, the literature on the natural gas consumption-growth nexus is rather limited.[2] This study contributes to the literature by examining the causal relationship between natural gas consumption and economic growth for a panel of 67 countries.

Specifically, this short study contributes in several areas. First, the study will include a larger set of countries in the analysis than previous studies, namely, 67 countries. Second, with the exception of the studies by Payne [23], the analysis will be undertaken within a production model framework by including measures for capital and labor. Third, following the studies by Hu and Lin [17], Sari et al. [30], and Payne [23], the sign and magnitude of the respective coefficients will be discussed in relation to the various hypotheses on the natural gas consumption-growth nexus. Fourth, in order to improve upon the reduction in the power and size properties of conventional unit root and cointegration tests when using data of a short time horizon, panel unit root and cointegration tests will be utilized to provide additional power by combining the cross-section and time series data.[3]

Section 2 briefly discusses the hypotheses related to the causal relationship between energy consumption, in general, and economic growth along with a summary of the previous studies related to natural gas consumption. Section 3 discusses the data, methodology, and empirical results. Concluding remarks are given in Section 4.

2. Natural gas consumption-growth literature

The causal relationship between energy consumption, including natural gas consumption, and economic growth can be categorized into four testable hypotheses. First, the growth hypothesis postulates that energy consumption has a significant impact on economic growth directly and/or as a complement to labor and capital. Unidirectional causality from energy consumption to economic growth lends support for the growth hypothesis. In this case, energy conservation policies which reduce energy consumption may

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[1] Chapter 3 Natural Gas, International Energy Outlook 2009, Energy Information Administration, www.eia.doe.gov/oiaf/ieo/nat_gas.html.

[2] See Payne [21,22] for surveys of the literature on the causal relationship between energy consumption and economic growth.

[3] The methodology pursued in this study parallels Apergis and Payne [1–6].

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adversely affect economic growth. Second, the conservation hypothesis suggests that energy consumption is dictated by economic growth. Unidirectional causality from economic growth to energy consumption confirms the conservation hypothesis. Under this scenario, energy conservation policies oriented toward the reduction in energy consumption may not have an adverse impact on economic growth.

Third, the feedback hypothesis emphasizes the interdependent relationship between energy consumption and economic growth. The feedback hypothesis is supported by the presence of bidirectional causality between energy consumption and economic growth. This complementary relationship opens the possibility that energy conservation policies which reduce energy consumption may, in turn, impact economic growth. Likewise, the potential adverse impact on economic growth may well be transmitted back to energy consumption. Fourth, the neutrality hypothesis asserts that energy consumption serves such a minor role in economic growth, it has no significant impact. The absence of causality between energy consumption and economic growth provides support for the neutrality hypothesis. For this case, the reduction in energy consumption through energy conservation policies will not impact economic growth.

The empirical literature on the causal relationship between natural gas consumption and economic growth has employed a variety of econometric approaches with the analysis concentrated on just a few countries. In a multi-country study, Yu and Choi [32] use Sims and Granger-causality tests to find unidirectional causality from natural gas consumption to real GNP for the UK, but the absence of a causal relationship between natural gas consumption and real GDP for the US and Poland. In the case of Taiwan, Yang [31] reveals the absence of a cointegrated relationship between natural gas consumption and real GDP; however, Granger-causality tests indicate unidirectional causality from natural gas consumption to economic growth. Aqeel and Butt [7] do not find cointegration between natural gas consumption and real GDP as well as the absence of a causal relationship for Pakistan. In the cases of Australia and New Zealand, Fatai et al. [13] fail to find a causal relationship between natural gas consumption and economic growth using either the Johansen–Juselius, Toda–Yamamoto, or autoregressive distributed lag (ARDL) approaches to causality testing.

Allowing for endogenously determined structural breaks in testing for unit roots and cointegration, Lee and Chang [19] find unidirectional causality from natural gas consumption to economic growth in the case of Taiwan. In an analysis of disaggregated energy consumption measures for Iran, Zamani [33] finds using a bivariate error correction model bidirectional causality between natural gas consumption and economic growth as well as unidirectional causality from industrial value added to industrial natural gas consumption. Hu and Lin [17] utilize the Hansen–Seo asymmetric cointegraton procedure to reveal asymmetries in the relationship between natural gas consumption and economic growth for Taiwan along with bidirectional causality. In a study of the former Soviet Union, Reynolds and Kolodziej [28] show unidirectional causality from economic growth to natural gas consumption. Sari et al. [30] estimate an autoregressive distributed lag (ARDL) model to find unidirectional causality from industrial production and employment to natural gas consumption in the US. In a study of fossil fuel consumption in the US, Payne [23] finds unidirectional causality from real output to natural gas consumption using the Toda–Yamamoto procedure.[4]

[4] While not explicitly testing for Granger-causality, Ewing et al. [12] use generalized forecast error variance decomposition analysis to show that natural gas consumption explains close to 10% of the forecast error variance of industrial production in the US.

The next section describes the data, methodology, and the results of the panel error correction model with respect to the causal relationship natural gas consumption and economic growth.[5]

3. Data, methodology, and results

Annual data from 1992 to 2005 were obtained from the *World Bank Development Indicators*, CD-ROM and the *Energy Information Administration* for 67 countries: Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Denmark, Ecuador, Egypt, Estonia, Finland, France, Gabon, Georgia, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Italy, Japan, Jordan, Kazakhstan, Kyrgyzstan, Latvia, Luxembourg, Malaysia, Mexico, Moldova, Morocco, Netherlands, New Zealand, Norway, Pakistan, Peru, Poland, Romania, Russia, Slovenia, South Africa, South Korea, Spain, Syria, Sweden, Switzerland, Tajikistan, Thailand, Trinidad & Tobago, Tunisia, Turkey, Ukraine, United Kingdom, United States, Uzbekistan, and Venezuela. The multivariate framework includes real GDP (Y) in billions of constant 2000 US dollars, real gross fixed capital formation (K) in billions of constant 2000 US dollars, total labor force (L) in millions, and natural gas consumption (NG) defined by dry natural gas in billions of cubic feet.[6]

Preliminary tests of dynamic heterogeneity proposed by Holtz-Eakin et al. [16] and Holtz-Eakin [15] indicate that the relationships exhibit heterogeneity in both the dynamics and error variances across the 67 countries.[7] Given the parameter heterogeneity, the Im et al. [18] panel unit root test is used to determine the stationarity properties of the respective variables before testing for cointegration.[8] The Im et al. [18] panel unit root test allows for heterogeneous autoregressive coefficients. Specifically, the Im et al. [18] panel unit root test averages the augmented Dickey-Fuller (ADF) unit root tests while allowing for different orders of serial correlation, $\varepsilon_{it} = \sum_{j=1}^{p_i} \varphi_{ij}\varepsilon_{it-j} + u_{it}$, in the following:

$$y_{it} = \rho_i y_{it-1} + \sum_{j=1}^{p_i} \varphi_{ij}\varepsilon_{it-j} + \delta_i X_{it} + u_{it} \tag{1}$$

where $i = 1, \ldots, N$ for each country in the panel; $t = 1, \ldots, T$ refers to the time period; X_{it} represents the exogenous variables in the model including fixed effects or individual time trend; ρ_i are the autoregressive coefficients; p_i represents the number of lags in the ADF regression and ε_{it} are the stationary error terms. The null hypothesis is that each series in the panel contains a unit root and the alternative hypothesis is that at least one of the individual series in the panel is stationary. Im et al. [18] use a t-bar statistic as the average of the individual ADF statistics which is normally distributed under the null hypothesis.[9] Panel A of Table 1 reports the results of the Im et al. [18] panel unit root tests which indicates that each variable is integrated of order one.

Next, the Pedroni [24,26] heterogeneous panel cointegration test, which allows for cross-section interdependence with different individual effects, is estimated to determine whether a long-run relationship exists:

[5] See recent studies by Apergis and Payne[1–6] and citations therein for additional studies on the use of panel cointegration and error correction modeling within the context of the energy consumption-growth nexus.

[6] Real gross fixed capital formation serves as a proxy for capital in that changes in investment closely align with changes in the capital stock under the assumption of a constant depreciation rate using the perpetual inventory method (see Apergis and Payne [1–6,29] and citations therein).

[7] Tests of dynamic heterogeneity are not reported to conserve space, but are available upon request from the authors.

[8] The Hadri [14], Choi [10], Levin et al. [20], and Carrion-i-Silvestre et al. [9] tests were also performed and confirm the results from the Im et al. [18] panel unit root tests. Results are available upon request from the authors.

[9] Im et al. [18] provide the appropriate critical values.