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ENERGY CONSUMPTION AND ECONOMIC GROWTH: NEW INSIGHTS INTO THE COINTEGRATION RELATIONSHIP

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OVERVIEW

The question whether energy conservation policies affect economic activity or not is of high interest in the international debate about global warming and the reduction of greenhouse gas emissions. Although the causal relationship between energy consumption and economic growth has been widely studied no consensus regarding the energy consumption-growth nexus has been reached. The direction of causality is highly relevant for policy makers. For instance, if causality runs from energy consumption to economic growth, energy conservation policies will possibly have a negative impact on growth. Our analysis of the relationship between energy consumption and GDP is based on a sample of 25 OECD countries from 1981 to 2007 including energy prices and using recent developed panel-econometric methods. The innovative contribution of this paper is to determine the long-run relationship between energy consumption, GDP and energy prices in more detail. In contrast to other studies concerning the energy consumption-growth nexus, we distinguish between national and international trends as drivers of the long-run equilibrium. Hence, each variable is decomposed into common and idiosyncratic components. Based on this decomposition, cointegration between the common components suggests that international spillovers dominate the long-run relationship. Instead, cointegration between idiosyncratic components refers to developments relevant exclusively on the national level. This distinction has important policy implications because cointegration between the common components indicates that national energy policies may not have a large impact on energy consumption and economic growth. Hence, the first and novel step of our paper is to decompose each variable into the uncorrelated common and idiosyncratic components by principal component analysis. Second, we test both components separately for unit roots and cointegration relations. Lastly, we apply Granger causality tests within a panel error-correction model.

METHODS AND RESULTS

The integration properties of the common components were established by applying the augmented Dickey and Fuller [13], the Phillips and Perron [47] and the Kwiatkowski et al. [28] test. The results suggest that the common components are integrated of order one, I(1). Since the defactored series are independent by construction, stochastic trends in the idiosyncratic components are efficiently explored by first generation panel unit root tests to exploit the additional information due to the cross-sectional data. We apply the tests proposed by [35] (LLC) and [24] (IPS). In contrast to the unit root evidence for the common components, the LLC and IPS panel unit root tests propose that the idiosyncratic components are stationary. The results indicate that random walks in the data are mainly driven by international developments. Cointegration between the common components can be investigated by standard time series tests such as the Johansen [26] reduced rank approach. The Johansen trace statistic and maximum eigenvalue statistic suggest a long-run relationship between the common components of energy consumption, GDP and energy prices. Further, we estimate the provided long-run relationship using the dynamic ordinary least squares estimator proposed by [39]. The estimated models are:

$$\begin{aligned} E_{it} &= \alpha_i + \delta_i t + \beta_i Y_{it} + \gamma_i P_{it} + \upsilon_{it} \\ Y_{it} &= \alpha_i + \delta_i t + \beta_i E_{it} + \gamma_i P_{it} + \varepsilon_{it} \\ P_{it} &= \alpha_i + \delta_i t + \beta_i E_{it} + \gamma_{it} Y_{it} + \eta_{it} \end{aligned} \tag{1}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$ denote countries and time periods, respectively. α_i and δ_i are country specific fixed effects and time trends. Since all variables are in natural logarithms, the estimated long-run coeffcients can be interpreted as elasticities. The income elasticity of energy consumption is 0.55, positive and statistically significant at the 1% level. This implies that a 1% increase in GDP increases energy consumption by 0.6%. Energy consumption is relatively price-inelastic in view of a price elasticity of -0.14, which is statistically significant at the 1% level and negative as expected from theory. Taking GDP as the dependent variable, income also increases by 0.6% if energy consumption grows by 1% (significant at the 1% level). The price elasticity of income reveals a positive sign, but is insignificant as energy prices have no impact on GDP. Having established a cointegration relationship, we estimate a panel-based error-correction model to test for Granger causality. We apply the panel generalized method of moments estimator proposed by [5]. The direction of causality can be determined by standard Wald *F*-tests, which reveals that there are mutual causal relationships between energy consumption, GDP and energy prices. Energy consumption Granger-causes GDP and vice versa, which implies that an increase in energy consumption leads to an increase in growth and the other way around. A rise in energy prices has a negative effect on energy consumption. Growth and energy consumption also have an impact on energy prices. Further, the significance of all error-correction terms indicates that all variables readjust towards a common international equilibrium relationship after a shock.

CONCLUSIONS

Our main empirical finding is that only the *common* components of energy consumption, economic growth and energy prices are cointegrated. This result highlights the relevance of international spillovers to explain energy demand. Hence, policy makers should take into account the international impact on energy demand for designing effcient energy policies. The analysis of the cointegration relationship suggests that energy consumption is relatively price-inelastic. This underlines the theoretical expectation that energy use is mostly a necessity and implies that price regulations are weak tools for energy policies. The established causality in the energy demand equation means that energy consumption readjusts towards an international rather than a national equilibrium relationship as consequence of a shock. In this light, national energy policies may have only a limited impact on energy consumption. The bi-directional causality between energy consumption and economic growth suggests that an increase in energy consumption leads to an increase in economic growth and vice versa. Hence, it seems that OECD countries exhibit a kind of energy-dependence in the sense that an adequate large supply of energy seems to ensure higher economic growth. In order to ease the trade-off between energy consumption and growth energy policies devoted to a reduction of greenhouse gas emissions should emphasise the use of alternative energy sources rather than exclusively try to reduce overall energy consumption. The shift from less effcient and more polluting energy sources to more effcient energy options may establish a stimulus rather than an obstacle to economic development.

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