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Further evidence on the trade-energy consumption nexus in OECD countries

Mert Topcu[a,1], James E. Payne[b,*]

[a] Faculty of Economics and Administrative Sciences, Nevsehir Haci Bektas Veli University, Nevsehir, Turkey
[b] Office of Academic Affairs, Benedictine University, 5700 College Road, Lisle, IL 60532, USA

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ABSTRACT

The previous literature on the impact of trade on energy consumption has yielded inconclusive results. However, recent studies provide evidence of a nonlinear relationship between trade and energy consumption. Unlike previous studies, we employ a panel framework with allowance for heterogeneity and cross-sectional dependence to investigate the trade-energy consumption nexus for OECD countries for the period 1990–2015. Our results show that the impact of trade on energy consumption exhibits an inverted U-shaped pattern and the nonlinear relationship is robust to estimation methods. On the other hand, the results from linear specifications reveal the importance of cross-sectional dependence in explaining the positive role of trade on energy consumption. In addition, these impacts are consistent across different measures of trade.

1. Introduction

According to the literature, trade can affect energy consumption through several avenues: the scale, technique, and composition effects. The scale effect implies that movement of goods from one country to another increases domestic energy use by increasing aggregate demand and, over time, economic growth. The technique effect postulates that trade allows developing countries to adopt energy efficient technologies from more developed countries, and as a result have an impact on the level of production and energy usage. Finally, the composition effect suggests that trade can affect energy consumption through its impact on the relative energy intensity of various sectors of the economy. As such, the composition effect captures the change in the structure of the economy while the scale and technique effects account for the change in the growth of the economy.

The previous literature has yielded inconclusive results in terms of the influence of trade on energy consumption.[2] Moreover, several studies provide evidence of a nonlinear impact of trade on energy consumption attributable, in part, to the technology transfer process from more developed, industrialized countries to less developed countries as well as sectoral shifts from the manufacturing sectors to the service sectors in less developed countries. Our study re-examines the nonlinear influence of trade on energy consumption utilizing panel data for 34 OECD countries for the period 1990–2015. To the best of our knowledge, Dedeoğlu and Kaya (2013) is the only study that attempts to address this issue in a context of OECD countries. However, our study differs from previous studies in two distinct ways.

First, we re-examine the issue with the inclusion of additional OECD countries to enhance our understanding of the dynamics between trade and energy consumption among OECD countries, which have a major role in international trade and energy usage globally. According to data from the World Development Indicators (2017), OECD members represent two- thirds of the global trade volume over the period 1990–2015. In addition, statistics from the International Energy Agency (2015) report that almost half (47%) of the global energy is consumed by the OECD member states over the same period.

Second, and more importantly, we use recently developed panel data econometrics that recognize both heterogeneity and cross-sectional dependence. Specifically, if cross section-dependence is ignored, the assumption that the slope coefficients are constant across countries will likely produce inconsistent and biased results. Furthermore, we wish to determine if trade has a robust nonlinear influence on energy consumption through the use of several cross-section augmented panel data estimators.

Section 2 provides a brief review of the literature. Section 3 describes the model and data. Section 4 presents the empirical approaches and results. Section 5 discusses the policy implications with conclusions in Section 6.

* Corresponding author.
E-mail addresses: merttopcu@nevsehir.edu.tr (M. Topcu), jpayne@ben.edu (J.E. Payne).

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[2] There is another literature evaluating the impact of trade on emissions. See Halicioglu (2009), Hossain (2011), Shahbaz et al. (2013), Akin (2014), Shahbaz et al. (2014), Al-Mulali and Ozturk (2015), Zhang (2015), Dogan and Seker (2016), Dogan and Turkekul (2016), Ertugrul et al. (2016), Halicioglu and Ketenci (2016), among others.

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2. Literature review

Studies on the impact of trade on energy consumption have yielded mixed results. Using fixed effects panel estimation for 32 countries, Cole (2006) discovers that trade liberalization increases energy consumption by increasing domestic production. For a panel of eight Middle Eastern countries, Sadorsky (2011) uses fully modified ordinary least squares to show that trade has a positive impact on energy consumption. Ghani (2012) employs a fixed effects panel model to find that trade liberalization per se does not affect energy demand in developing countries, but has an indirect effect on energy demand through the capital-labor ratio. Dedeoğlu and Kaya (2013) employ dynamic ordinary least squares to reveal that trade (using either exports or imports) yields a positive influence on energy consumption for 25 OECD countries over the period 1980–2010. The long-run estimates reveal that a 1% increase in exports and imports increases energy consumption by 0.21% and 0.16%, respectively.

Using fully modified ordinary least squares for a global panel for six regions, Al-mulali and Sheau-Ting (2014) show for the majority of the countries that energy consumption increases with trade. Nasreen and Anwar (2014) use both fully modified and dynamic ordinary least squares estimation approaches to find trade has a positive impact on energy consumption for 15 Asian countries. Adewuyi and Adeniyi (2015) demonstrate that the impact of trade on energy consumption varies across six West African countries. For a panel of 64 countries, Omri et al. (2015) apply generalized method of moments estimation to discover that trade is an important driver of renewable energy consumption. Using an autoregressive distributed lag model, Raza et al. (2015) reveal that trade has a positive impact on energy consumption in the case of Pakistan.

Sbia et al. (2014) estimate an autoregressive distributed lag model to show that trade yields a negative impact in both the short-run and long-run on energy use in the United Arab Emirates. Apart from the previous studies that focus on a linear relationship between trade and energy consumption, Shahbaz et al. (2014) entertain the possibility of a nonlinear relationship. Shahbaz et al. (2014) utilize mean group and pooled mean group estimators to show that trade exhibits an inverted U-shape pattern with respect to energy consumption in the case of high-income countries, whereas the results for middle- and low-income countries follow a U-shape pattern.

Furthermore, it is also important to note that several studies explore the causal relationship between trade and energy consumption. Panel Granger-causality results reported by Narayan and Smyth (2009) find unidirectional causality from exports to electricity consumption for a panel of Middle Eastern countries. Using Toda-Yamamoto (1995) and Dolado and Lütkepohl (1996) approaches to Granger-causality, Lean and Smyth (2010a) find unidirectional causality from electricity consumption to exports in Malaysia. In a follow-up study on Malaysia, Lean and Smyth (2010b) estimate a vector error correction model to report unidirectional causality in the long-run from exports to electricity generation. Applying Granger-causality tests within an autoregressive distributed lag model, Halicioglu (2011) reveals unidirectional causality in the short-run from exports to energy consumption in the case of Turkey. For South American countries, Sadorsky (2012) uses a panel vector error correction model to show bidirectional causality between trade and energy consumption in the long-run while unidirectional causality from energy consumption to imports in the short-run.

3. Model and data

A majority of the literature models energy consumption as a function of income and trade (see, for example: Sami, 2011; Dedeoğlu and Kaya, 2013; Raza et al., 2015; among others). However, Sadorsky (2011) and Nasreen and Anwar (2014) augment this basic equation with prices to describe an energy demand equation. Following the studies by Sadorsky (2011) and Nasreen and Anwar (2014), this study models energy consumption (e) as a function of income (y), prices (p), and trade (t) as given in Eq. (1):

$$e_{it} = \beta_i' X_{it} + \nu_i + \varepsilon_{it}, \tag{1}$$

where i denotes the country (i = 1,….,34) and t the time period (t = 1990,…..,2015). $X_{it} = (y_{it}, p_{it}, t_{it})'$ is a (3×1) vector and $\beta_i = (\beta_{1i}, \beta_{2i}, \beta_{3i})'$ is the parameter vector of the slope coefficients. Country specific effects are represented by ν_i and the random error term is given by ε_{it}. In addition, based on the findings of recent studies, we also test whether there is nonlinearity between the variables using the following specification:

$$e_{it} = \theta_i' Z_{it} + \nu_i + \varepsilon_{it}, \tag{2}$$

where $Z_{it} = (y_{it}, p_{it}, t_{it}, t_{it}^2)'$ is a (4×1) vector and $\theta_i = (\theta_{1i}, \theta_{2i}, \theta_{3i}, \theta_{4i})'$ is the parameter vector of the slope coefficients. Note that Eq. (2) refers to nonlinearity in variables but linearity in parameters, which facilities the estimation by standard methods.

The empirical analysis is based on 34 OECD countries.[3] The OECD countries include the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxemburg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States.[4]

Energy consumption (e) is measured by energy use in kg of oil equivalent per capita. Income (y) is given by per capita GDP in constant 2010 U.S. dollars. Energy prices (p) are defined by real oil prices using Brent crude oil prices in U.S. dollars per barrel.[5,6] For robustness purposes, trade is represented by trade openness, exports, and imports. Trade openness (o) is measured as total trade as a share of GDP, while exports (x) and imports (m) are measured as exports of goods and services as a share of GDP and imports of goods and services as a share of GDP, respectively. Finally, to interpret the coefficient estimates as elasticities all variables are converted to natural logarithms. Data were obtained from the World Development Indicators (2017) online database except for oil prices which were drawn from the British Petroleum Statistical Review of World Energy (2017) database.

4. Methods and findings

We begin our empirical analysis by employing Pesaran's (2004) cross-sectional dependence (CD) test given by Eq. (3):

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right), \tag{3}$$

where N is the number of countries; T the time period; and ρ_{ij} the estimate of the pair-wise correlation of the residuals. As shown in Table 1, the null hypothesis of cross-sectional independence is rejected, indicating the presence of cross-sectional dependence.

In light of our findings of cross-sectional dependence, we apply second generation unit root tests that take into account cross-sectional dependence in the residuals using Pesaran's (2007) CIPS unit test as follows:

$$CIPS(N, T) = N^{-1} \sum_{i=1}^{N} t_i(N, T), \tag{4}$$

where CIPS(N,T) is the cross-section augmented IPS unit root test (Im et al., 2003) and t_i(N,T) represents the cross-section augmented Dickey Fuller (Dickey and Fuller, 1979) statistic. The results reported in

[3] We omit Chile due to the availability of data for consumer price index.

[4] The time dimension was selected to include as many observations as possible.

[5] Real oil prices were constructed by deflating the crude oil price by each country's consumer price index (CPI, 2010 = 100).

[6] We estimated the same models using West Texas prices to determine the robustness of the results. The results using West Texas prices are available upon request.