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Econometric analysis of trade, exports, imports, energy consumption and CO_2 emission in six regions

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ABSTRACT

The aim of this study is to explore the bi-directional long run relationship between trade-energy consumption, trade-CO_2 emission, exports-energy consumption, exports-CO_2 emission, imports-energy consumption, and imports-CO_2 emission. 189 countries from six different regions, namely, Asia Pacific, Eastern Europe, the Americas, Middle East and North Africa (MENA), Sub Saharan Africa (SSA), and Western Europe, were selected. The panel fully modified OLS (FMOLS) was utilized taking the period of 1990–2011. The panel results show that all the regions, excluding Eastern Europe, show a long run positive relationship between the trade variables-energy consumption and between the trade variable-CO_2 emission. However, at the country level, the results reveal that the feedback long run positive relationship between the trade variables, energy consumption and CO_2 emission takes place in most cases when the share of trade of goods and services to GDP is significant and the level of the countries' development is high. However, the negative or the non-significant long run relationship between the variables takes place generally in countries when the trade variables do not play a large share in their GDP and when these countries are in early development stages.

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1. Introduction

The relationship between energy consumption, CO_2 emission, and the macroeconomic variables has attracted many researchers, particularly the correlation between energy consumption, CO_2 emission, and GDP growth [1–9]. However, there have been a number of recent studies exploring the relationship between energy consumption, CO_2 emission, and trade. This is because the world had witnessed a substantial growth in international trade of goods, services, and capital over the last two decades. This growth in international trade increased its value over 77% during the period of 1990–2011 [10]. This remarkable boost in international trade made the world economy more dependent on it since its share to the world gross domestic product increased from 39% in 1990 to 59% in 2011 [10]. It is well known that trade cannot be accomplished without the use of transportation. Consequently, the volatility of transportation plays a vital role in international trade

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[11–13]. Nonetheless, despite the importance of transportation sector in international trade, this sector represents a major source of energy consumption and pollution. Therefore, the relationship between international trade, energy consumption, and CO_2 emission may be present. Moreover, there are limited studies that explored the relationship between energy consumption, CO_2 emission, and international trade. The results of these studies varied. For instance, it was found that trade openness has a positive long run and short run impact on CO_2 emission in newly industrialized countries [14]. These results were also established in Turkey [15,16], the Middle East [17], Pakistan [18], and in countries that have different income levels [19]. In addition, exports are deemed as an important factor that increased pollution levels in China [20]. On the contrary, a number of studies found that trade has no effect on CO_2 emission in China and India [21,22] while it has a negative effect on CO_2 emission in Indonesia [23]. Additionally, exports and imports of goods and services have a positive long run and short run effect on energy consumption in the Middle East [24], South America [25], and in OECD countries [26].

From the literature above, it is clear that there is an insufficient number of studies that explored the relationship between energy consumption, CO_2 emission, and trade. Moreover, most of the previous studies had focused on the bi-directional short run causality between energy consumption, CO_2 emission, and trade. Hence, this study will explore the trade, energy consumption, and CO_2 emission relationship in 189 countries that are categorized by six different regions. Unlike past studies, this study will focus on the bi-directional long run relationship between energy consumption, CO_2 emission, and trade since a number of studies [27–29] explained that examining the long run relationship between these variables can have important policy implications.

2. Data and methodology

Annual data were utilized taking the time period of 1990–2011. 189 countries from six regions, namely, Asia Pacific, Eastern Europe, the Americas, Middle East and North Africa (MENA), Sub Saharan Africa (SSA), and Western Europe countries, were selected. Since the main objective of this study is to examine the bi-directional long run relationship between trade of goods and services (aggregate and disaggregate level), energy consumption, and CO_2 emission, this study used total trade of goods and services (TD) which is calculated by the sum of exports of goods and services (EX) and imports of goods and services (IM). The variables are measured in millions of constant 2000 US dollars. Moreover, this study used total primary energy consumption (ENC) that is measured in Quadrillion Btu. Total carbon dioxide emission from energy consumption (EM) is measured in million metric tons. Data for exports and imports of goods and services were retrieved from Euromonitor database [30] while data for total primary energy consumption and CO_2 emission were retrieved from Energy Information Administration (EIA) [31].

This study utilized panel data model to examine the long run relationship between trade, energy consumption, and CO_2 emission. The panel model's popularity increased among researchers due to its several advantages that include controlling the serial correlation and the individual heterogeneity and it can also increase the degrees of freedom and the reliability of the test because panel data increases the power of econometric tests [32].

The first step in the econometric analysis was to test the variables' stationarity. This was achieved by applying the Panel unit root test. The panel unit root test became popular because of its high power. This study utilized two panel unit root tests namely, Levin, Lin and Chu (LLC) [33] and the Im, Pesaran and Shin (IPS) [34]. The LLC test assumes that the variables contain a panel unit root so that the autoregressive coefficient (p_i) is identical across the cross sections. However, the IPS test allows the autoregressive coefficients to vary across the cross sections. Both tests use the following ADF specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{pi} \beta_{ij} y_{it-j} + X'_{it}\delta + \varepsilon_{it} \quad (1)$$

i is the cross sections (number of countries) observed over the periods t (1990–2011), X is the exogenous variables in the model and ε_{it} is the error term.

The difference between the LLC and the IPS unit root test is that the LLC utilizes a common ADF regression (Eq. 1) for the entire cross sections while the IPS uses a separate ADF regression for each cross section.

Both unit root tests work under the null hypothesis and alternative hypothesis. The former shows that the variables contain a panel unit root which signals that the variables are not stationary while the latter indicates that the variables do not contain a panel unit root which signifies that the variables are stationary.

Since this study's main objective is to explore the bi-directional long run relationship between trade (in both aggregate and disaggregate level), total energy consumption, and CO_2 emission, the Panel Fully Modified OLS (FMOLS) was used. The FMOLS was proposed by Pedroni [35]. This cointegration equation can work with variables that are stationary at different levels. Moreover, it can eliminate the long run correlation problem between the cointegrating equations. The FMOLS is unbiased and has a fully efficient mixture normal asymptotics which allow for standard Wald tests to use asymptotic Chi-square statistical inference.

The FMOLS estimator is presented as follows:

$$\hat{\theta} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left(\sum_{t=1}^{T} z_{it} z'_{it} \right)^{-1} \left(\sum_{t=1}^{T} z_{it} y_{it}^{+} - T \begin{bmatrix} \hat{\lambda}_{12}^{+} \\ 0 \end{bmatrix} \right) \quad (2)$$

Z_t is the deterministic trend and stochastic regressors. The estimation of the FMOLS is the construction of the long run covariance matrix estimators.

3. Empirical results

The first step was to test the stationarity of the variables.[2] Thus, the LLC and IPS were used. Tables 1 and 2 (see Appendix A) review the panel unit root test results. The results revealed that all the variables are non-stationary at the level thus the null hypothesis of a panel unit root cannot be rejected. On the other hand, the variables are significant at first difference which rejects the null hypothesis. Therefore, the variables are stationary at the first difference.

3.1. FMOLS test results

Since the variables are stationary, the fully modified OLS (FMOLS) test was utilized to examine the long run relationship between trade in goods and services in both aggregate and disaggregate levels. It should be noted that the lagged value of the dependent variable and the first differences of all variables were used as instruments to control the misspecification, autocorrelation and the heteroscidasticity among the variables.

Tables 3–8 reveal the FMOLS test results (see Appendix B). Tables 3 reviews the FMOLS test results for countries in the Americas. The results indicate the existence of a bi-directional positive long run relationship between energy consumption, and trade of goods and services in both aggregate and disaggregate levels, and between trade,

[2] The stationarity of the variables for each country was also tested by using the Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests and it was found that all the variables for each country stationary but at different levels.