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THE J-CURVE EFFECTS AND THE EU28 BIOENERGY TRADE BALANCE: A CO-INTEGRATION APPROACH

MOHD ALSALEH AND ABDUL SAMAD ABDUL-RAHIM

Faculty of Economics and Management, Universiti Putra Malaysia, Serdang, Selangor, Malaysia.

**Corresponding author: moe_saleh222@hotmail.com*

Abstract: This paper investigates the influence of the economic factors on the bilateral balance of trade (TB) of the EU28 zone bio-energy sector outcomes. Concentration is provided to estimate the J-curve hypothesis: whether the bio-energy output trade balance in the European Union region profits from a minimising of the value of the Euro European (EUR). The study applies the panel-data co-integration test method to regress yearly bilateral TB data of the EU28 regions bio-energy sector productions between 1990 and 2013. To test whether the J-curve effect exists, this research analysed the long-run impact of the real exchange rate (ER) on the level of bioenergy output balance of trade using various estimations; Fully Modified Oriented Least Square (FMOLS), Dummy Oriented Least Square (DOLS), and Pooled Mean Group (PMG) models. The results help the experiential effectiveness of the J-curve by applying FMOLS approach, showing that devaluation has developed the TB of bioenergy outputs. FMOLS analysis does figure demonstration related to the long-term evolution of the bioenergy outputs TB proposed by the J-curve effects. Thus, the results show that the EU28 trade balance of bioenergy has showed the validity of the J-curve manner of modification.

Keywords: Trade balance, sustainability, Fully Modified Oriented Least Square (FMOLS), Dummy Oriented Least Square (DOLS), Pooled Mean Group (PMG) models.

Introduction

Since the oil crisis in the 1970s, modern energy installations have been developed to use more processed biomass. The agricultural crops have been turned into biofuels, manure to biogas, or wood to pellets. In this context, bioenergy is the only renewable energy source able to provide the three main sources of energy needed both by individuals and businesses: bio-heat/cooling, bio-power and bio-fuel. The EU's original Renewable energy directive (2009/28/EC) sets a binding target of 20% final energy consumption from renewable sources by 2020. To achieve this, EU countries have been committed to reaching their own national renewables targets for 2020 ranging from 10% in Malta to 49% in Sweden. They are also required to have at least 10% of their transport fuels come from renewable sources by 2020. In December 2018, the newly revised renewables energy directive (2018/2001) entered into force – establishing a new binding renewable energy target for the EU for 2030 of at least 32%, with a clause for a possible upwards revision by 2023. Figure 1 show different comparisons related to the bio-energy industry development in developing members in comparison to developed members in EU-28 region. The development levels in the developed members have improved sharply, unlike development level in developing members which has shortly increased in EU-28 region in the period from 2000 to 2013.

The imports level of bio-energy output is predicted to achieve 20 percent of the Europe's domestic demand by 2030, through 85 percent of the bioenergy output produced in the European countries and 15 percent imported from different countries. Sustainable energy sources can then meet 45 percent of European countries domestic demand in 2030. One of the most popular phenomena in the field of international economics discourse is that of the J-Curve advent, a process by which currency devaluations lead to temporary reductions in a

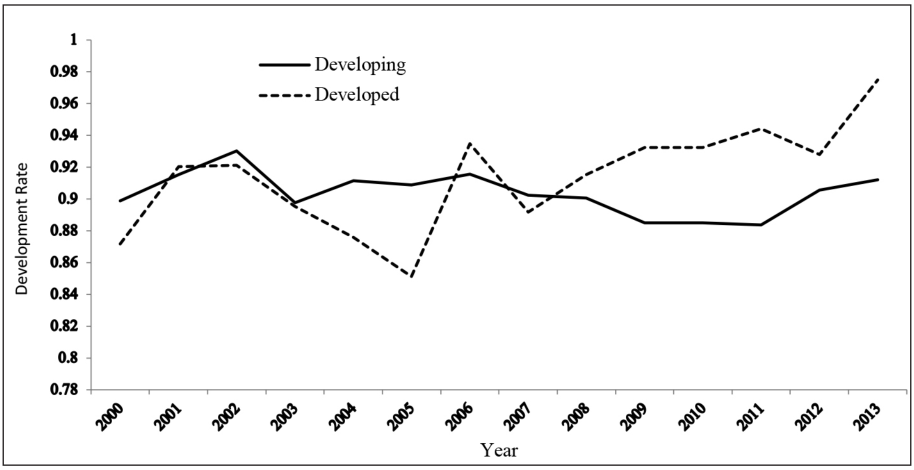

Figure 1: Comparisons of Bioenergy Industry Development in Developing and Developed Countries in EU-28 Countries. Source: Alsaleh *et al.* (2017)

country's TB before the expected development eventually sets in. Should this be attained, great ratios of saving, nearly thousand million Euros, in the European Union on energy imports demand and consequently will raise the living scale and rates of recruitment in the European countries. Therefore, this study investigates the European Union countries as one part for conducting the paper. Reference on previous study done by Susaeta *et al*., (2012), the EU28's evaluations of the bio-energy program scales is needful to meet the NREAP (National Renewable Energy Action Plan) aims 1/12/2020, the means to demonstrate that local demand of bioenergy will enhance in 2005 from 24.7 billion gigajoule (GJ) to reach in 2020 the quantity of 5.65 billion GJ, due to the increment of local consumption. According to earlier investigations by Snieskiene and Cibinskiene (2015), the gross bio-energy commerce was 258333 GWh (gigawatt hour) in 2006. An earlier paper indicated that to correspond with the a persistent enhancement in biomass domestic demand there was a continuous enhancement in the import of biomass from the quantity of 2777 GWh in 1990 to 41666 GWh in 2006, respectively, a gross of 5000 GWh in 1990 to 1055555 GWh in 2006 (Snieskiene and Cibinskiene, 2015).

This drove the trade balance of bioenergy to an unbalanced condition, this statement was justified due to the shortage of produced biomass 277.87 Mboe (Million Barrel of Oil Equivalent) to fill up the local consumption (588.44 Mboe) of biomass for the term between 1991 and 2007. According to previous studies done by Susaeta *et al.,* (2012), the growth of the electricity industry from 2005 and 2020 had witnessed significant improvement in UK, Poland, Netherland, Italy, Germany, France, Belgium with forecasted growths of 0.010 million GWh, 0.017 million GWh, 0.048 million GWh, 0.019 million GWh, 0.016 million GWh, 0.013 million GWh, and 0.025 million GWh, respectively (Junginger, 2011). Reference to the paper done by Snieskiene and Cibinskiene (2015), the shortage in the production of bioenergy and consumption from 1990 and 2007 had a destructive influence on the renewable energy domestic market which drove to a growth in raw biomass import demand and a dwindling in raw biomass export demand to meet the shortage in the European Union region's local biomass markets. This shortage in biomass supply in the domestic market has drove to an enhancement in bioenergy import and a reduction in bioenergy export reflecting imbalanced conditions in the EU-28 region's international bioenergy market. Since the instable condition in the bioenergy local market may lead to a destructive impact on the TB of bioenergy, the current research will further investigate the economic variables of the TB of bio-energy industry in the EU28 area, such as: real income (Y), foreign real income (Y^*), and exchange rates (ER). The import demand and export demand prices influence imports and exports value in the TB of the bio-energy sector. The gross domestic product (GDP) is a significant indicator for the TB development. The ratio of ER has an important influence on import volume and export volume, reflected in the TB. The issue analysed is the instability of bio-energy export and import volume in the foreign market of the EU28 zone, which drives to a bio-energy instable TB and a roadblock to achieve the planned NREAP objectives on 31/12/2030.

This may further affect the value of consumption in the bioenergy international markets of the EU28 region and consequently impact the attractiveness of the bio-energy industry outputs as a significant supplier for sustainable energy to replace the traditional energy in the local market. The primary aim of this paper is to analyse the economic factors of the TB of bio-energy industry in the European Union area. Moreover, an investigation of the balance trade status of the bioenergy shows an enhancement in bioenergy import demand and a reduction in bioenergy export demand. The significance of this research is that it shows the impact of trade balance of bio-energy output on the development and security supply of the bio-energy industry to cover the enhanced consumption and to meet the NREAP aims in 31/12/2020. Moreover, this research also investigates the level of TB of the bio-energy industry in the EU28 members. On the one hand, developing countries may strive to maintain a positive and surplus trade balance during economic crisis compare to developed countries.

This is due to paying a higher price to import bioenergy outputs but receiving a much lower price for the raw materials exported. On the other hand, developed countries have more flexibility to remain a positive and surplus trade balance during economic recession compared to developing countries. This is because bioenergy output is exported at a high price and the raw material is imported at a low price. The studied economic determinants may contribute largely in achieving trade balance of bio-energy to help the EU-28 member states to meet the NREAP objectives on 31/12/2020. The essential questions of the current study are: "Does the EU-28 region have an adequate trade balance of bioenergy to achieve the NREAP by 2020?", and "What are the economic variables of the trade balance of bio-energy in the European Union countries?" The aim and objectives of this research are as the following: firstly, the current paper investigate the economic factors of trade balance of bio-energy in the EU-28 member states for the period between 1990 and 2013; secondly, it provide a general review and summary of the current condition of the EU28 region trade balance of bioenergy from 1990 and 2013 in different EU28 countries.

In this part (Table 1), the authors show previous researches related to TB in the bioenergy foreign market. Also, by analysing TB of bio-energy, this study shed the light on previous researches advancement pertaining to the bio-energy TB. Previous studies (Alakangas *et al.,* 2002; Trømborg *et al.,* 2013; Andersen, 2016) had primarily refers to bio-mass traded worldwide, and the European Union market is the largest importer and exporter of bio-mass worldwide. In 2013, European Union members utilised 85 percent of all world commerce bio-wood. The European Union demand of wood based bioenergy is inclining quicker than the supply, and the European Union import of wood based bioenergy from states outside the EU region rose from below 1.8 Million Tonnes MT in 2009 to over 0.0045 BT in 2012, and then over 0.006 BT in 2013. As result, around 19 MT of wood-based bioenergy was consumed and utilised in energy sector in the EU members in 2013. The traded volume of wood-based bioenergy worldwide is forecasted to increase largely, based on the quantity of the supports and the requirements for the ability to be sustained.

The shortage of the supply role in the domestic market may have negative impact on the TB of bio-energy. As explained by Trømborg and coworkers (2008; 2013) the local supply demand of bioenergy from the wood-based bioenergy in Kingdom of Sweden was around 1.4 million tonnes, where domestic consumption of bio-energy from the bio-mass sources was resulted to be about 1.7 million tonnes. Around 400 kt (kilo tonnes) of biomass from forestry natural sources were imported to fulfil the gap of the domestic consumption of the market. Kingdom of Norway's outlook bio-energy production will count largely on the import outputs of bio-mass because of the shortage in the local production of bio-mass, and will increase the local consumption of bio-mass from natural resources of forestry. This can negatively impact on the TB of bio-energy in Kingdom of Norway. Bioenergy in kingdom of Norway has a lower portion of the conventional fuel and power markets in compare with other regions such as; Kingdom of Sweden and Kingdom of Finland (Trømborg *et al.,* 2008).

Numerous economic determinants may impact the outgrowth of the foreign commerce of bioenergy and drive for TB. Researchers in their studies, investigated the outgrowth of main determinants of the bio-energy foreign commerce in Europe zone (Lamers *et al.,* 2011; Kristofel *et al.,* 2014; Matzenberger *et al.,* 2015). In general, they mostly concluded that the trade of solid biomass industry is developing and growing significantly and has an important contribution in the EU renewable energy industry's goal of achieving the scheduled targets (Alakangas *et al.,* 2012). The NREAP upgraded the bio-energy consumption lately to boost structure of TB movements in the EU zone by involving fees and expenses distinguished through co-partners and outputs (Bottcher *et al.,* 2011). The findings suppose that the 1 percent enhance in gross domestic product, export, and import impact almost 0.32 percent, 0.21 percent, and 0.16 percent increases in fuel consumption, respectively (Dedeoglu and Kaya, 2013). In light of the abovementioned, no previous study has investigated the J-curve effect and trade balance of the bioenergy industry in the EU-28 during the period between 1990-2014 by applying panel data analysis estimations; Panel Fully Modified (FMOLS), Panel Dynamic (OLS) and Panel Pool Mean Group (PMG).

Methods and Material

Various panel data analyses estimators have been used to estimate the J-curve influence on TB such as Koray (1990), Abdul Samad *et al.* (2009) and Dash (2013). The current estimation for the period between 1990 and 2013 is adequate to derive effectual directions, conclusions and suggestions related to TB of bio-energy in the European Union states, which is reconcile with the framework of previous studies. We had reviewed studies done by Demirden & Pastine, (1995), Baek, (2006) and Oskooee & Hajilee (2008), which investigated the J-Curve hypothesis, inclosing domestic and foreign real incomes and real of exchange rates, to identify the economical determinants of the trade balance. The study applied a time series analysis and found no J-curve function is valid in the Malaysian trade forest industry. Also, the long-term investigation referred to indicates that the exchange rate is insignificant in affecting the Malaysians' trade balance of forest industry. Moreover, real income determinants were concluded to be an important variable in determining balance of trade related to forest industry in Malaysia, specifically (Kyophilavong *et al.,* 2013; Abdul-Rahim and Shahwahid, 2014; Oskooee *et al.,* 2016).

Earlier studies by Oskooee & Hajilee, (2008) and Oskooee *et al.,* (2016) have tested the bilateral trade and the J-curve, by applying Auto Regressive Disturbed Lag (ARDL) and error correction approaches. This examines whether the local currency appreciations influence trade industry more widely than do local currency depreciations. The study results indicate that there are significant long-term coefficients for six partners, implying that while local currency depreciations improve the trade balance of Mexico with them, peso appreciation harms it. Jelassi *et al.,* (2017) investigated the J-curve hypothesis, applying a state space specification technique to investigate the TB hypothesis for Tunisia. The study tests the variables of the Tunisian balance of trade and the reaction of the TB to ER from 1993 to 2014. Oskooee & Hajilee (2008) and Oskooee *et al.,* (2016) also analysed the Swedish TB using export and import database either among Sweden and other countries worldwide or among Sweden and every commerce co-partner.

Halicioglu & Ketenci (2016) were the first who presented the empirical time series evidence of the impact of international trade on environmental quality in the case of transition countries. An econometric model between carbon emissions, energy use, incomes and trade openness was formed. This model was estimated via ARDL approach to cointegration and GMM procedures. The econometric results from both econometric techniques support the existence of the EKC hypothesis only in three transition countries: Estonia, Turkmenistan and Uzbekistan. Dash (2013) investigated the long-term and short-term impacts of the exchange rate modifications on trade balance of India Republic with the main international business partners, such as the United States of America, the United Kingdom, Japan, and Germany, applying a co-integrating vector error correction approach. The findings show that there is J-curve impact in the bilateral trade of India with both trade partners Japan Republic and Federal Republic of Germany. Hsing (2003) investigated the validity of J-curve function for three economies located in East Asian countries: Japan, Korea, and Taiwan. This study applied the generalised impulse response model from the vector error correction (VEC) approach to investigate the validity of J-curve influence in Japan, Korea, and Taiwan. On the one hand, the J-curve function validity shows Japan's gross trade. On the other hand, Korea and Taiwan's rate of export demand to import demand rises through the currency contract term.

The most important implication is that, in the long term, ER changes remain as one of the most effective factors of TB. The impact of bilateral ER on the bilateral TB with related commerce co-partners, using the most recently developed panel co-integration techniques, including FMOLS and DOLS Earlier have also been examined (Chang, 2009); Chiu *et al.,* 2010); Phan & Jeong, 2015; Prakash & Maiti, 2016; Bordo *et al.,* 2017). Reference to a study by Geheeb (2007), the NREAP set aims by 2020. The EU-28 members should enhance the green energy outputs by 20% from sustainable suppliers, reduce the domestic demand of conventional energy by 20% from non-renewable sources, decrease by 20% greenhouse gas (GHG) emissions, and develop the efficiency of the energy industry, in comparison with 1990s scale. Therefore, this study analyses the economic factors of the TB of bio-energy production between 1990 and 2013, as it is the aim to cover the available period for this estimation. Based on the available data, this estimation may only include the years between 1990 and 2013.

To construct the panel for co-integration model of this study, the authors first adopted a trade balance model framed introduced by Baek (2006) and constructing on the theoretical framework established by Rose (1989). For this aim, the import function of timberland products at local market and in overseas market is reformulated on Equation (1). M^d refers to the home state import demands, P_m indicates the relative import price of natural resource forestry output to locally generate natural forestry output in the domestic state, and Y points to the real income of the international state. M^{d*} points to the foreign state import demands, $P^*_{m,}$ highlights the relative import price of natural resource forestry output to locally generated natural forestry output in the international state, and Y^* refers to the real income of the domestic state. Likewise, the exports demand of forestry natural resource products at local and in an oversea state is reformulated in Equation (2).

$$M^d = M^d (P_m, Y) \text{ and } {}^{d*} = M^{d*} (_, Y^*) \quad (1)$$

$$X^s = X^s (P_x, Y) \text{ and } {}^{s*} = X^{s*} (_, Y^*) \quad (2)$$

$$M^d = X^{s*} \text{ and } X^s = M^{d*} \quad (3)$$

Table 1: Summary of Previous Empirical J-curve Estimations

Authors (year)	Country	Estimation Period	Estimation Method	Main Finding
ROSE & Yellen (1988)	USA	Last 25 years	Dickey-Fuller, Phillips and Chi-squared tests.	No statistically reliable evidence of a stable J-curve is detected.
Abdul Samad *et al.*, (2009)	Malaysia	1970-2010	ARDL	Do not support the existence of J-curve effects
Dash (2013)	India	1991-2005	VEC	J-curve effect is visible in India's bilateral trade
Chang (2009)	Korea	1991-2008	DOLS and FMOLS	Support the existence of J-curve effect
Koray (1990)	USA	1980-1989	equilibrium model	J-curve effect is visible in bilateral trade
Hsing (2005)	Japan, Korea and Taiwan	1980-1990	VEC	J-curve phenomenon can be observed in Japan's aggregate trade case
Baek (2007)	USA and Canada	1989-2005	ARDL	There is J-curve phenomenon for US trade with Canada
Abdul-Rahim & Shahwahid (2014)	28 countries	1996-2005	random effects and fixed effects	Support the existence of J-curve effect
Jelassi *et al.* (2017)	Tunisia	1993-2014	Kalman filter technique	Support the existence of W-curve effect
Oskooee & Hajilee (2008)	USA and Swede	1962-2004	Short-run and long-run coefficient estimates	J-curve effect is visible in bilateral trade

While X^s (X^{s*}) points to the exported forestry products of the domestic (international) state, and P_x (P_x^*) indicates the domestic (international) state's relative forestry product export value. The market equation of balance conditions for export and import demand is then formed in Equation (3). In regard to one price dominates law in a perfectly competitive bioenergy market in EU-28, the authors thus rewrite the following equation, $P=ER.P^*$, where ER refers to ER among the local currency and the foreign currency. Given the framed Equation 1 and Equation 3, the bioenergy industry balance of trade (TB) identified as the variation among value of export demand and value of import demand may be reformulated in Equation (4). In the last stage, in it is in a reframed form, given Equation 4 reveals the bellow correlation Equation (5). To reveal the panel co-integration test approach, Equation 5 was then illustrated in a log-linear format in Equation (6).

$$TB = X^s (Y^*, ER) - M^d (Y, ER) \quad (4)$$

$$TB = TB(Y, Y^*, ER) \quad (5)$$

$$\ln TB_{it} = \alpha_i + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{it}^* + \beta_3 \ln ER_{it} + \varepsilon_{it}$$
$$i=1,\ldots,N;\ t=1,\ldots,T. \quad (6)$$

The arbitrage equation for the bilateral exchange rate ER may be written as;

$$ER_t = ER_{t+1} (1 + RFT_t)/(1 + RHT_t)(1 + RPT_t) \quad (7)$$

Where in Equation (7), RHT is the interest rate at home, RFT is the interest rate in the partner country, and RPT is a risk premium. It is implicitly being assumed here that the home country is riskier than the partner country. Exchange rates change because one or more of these factors change. The current study defines the Trade Balance (TB) as per the following formula (X_t - M_t), where X_t refers to the value of export demand and M_t refers to the value of import demand. Hence, the authors estimated the dependent variable TB related computations to figure the J-Curve influence. Reference to the related signs of the coefficient in framed Equation 6, it is predicted that $\beta_1 > 0$ and $\beta_2 < 0$, since in short term the enhancement in the European (foreign) real income could drive an enhancement in the European import (export) demand, thus deteriorating (developing) the dependent variable trade balance. On the other hand, in long term there no relation between the European (foreign) real income and the European import (export) demand. Regarding the impact of ER, it is predicted that $\beta_3 > 0$, even after the derogation of the Euro increased export demand and decreased import demand, thereby evolving the dependent variable trade balance. N and T refer to country and year, respectively.

The gross value of export demand and import demand for EU bio-energy were extracted from the European Commission database. The used database is all on annual base time series between 1990 and 2013. The dependent variable European balance of trade (TB) is then revealed as illustrated in the previous section. The European independent variables local real income and the mean international real income (Y_t^M and Y_t^W) are estimated as real gross domestic product per individual indicator are provided from the database related to World Bank. The European-United State of America ratio of (ER_{it}) was gathered through the USA agriculture sector, and (ε_{it}) refers to term of error. The ratio of ER is revealed as Euro (EUR) per USD, a lowering in ratio of ER is not a real devaluation of the USD. This study has chosen Euro per United State Dollar convert rate in view of the fact that all European import and export demands related to bio-energy products are dealt with in USD. Eventually, this study highlighted that as the determinants are transformed into natural logarithm values, the evaluated coefficients may be explained as elasticity.

Results and Discussion

Before regressing the primary model, two preliminary tests were applied; descriptive statistics and correlation matrix. Based on Table 3, the descriptive statistics includes figures related to maximum values, minimum values, standard deviation values, mean values, and observations value, overall the sample and between the sample countries. The findings refer to that there is an important difference within countries and between countries. The results rationalises the implementations of panel egression approach. Table 4 presents the results for the Panel Unit Root (PUR) test for the EU28 countries between 1990 and 2013. The PUR tests show different results in regards the constancy of scale weights of the studied series. All figures points to the investigated periods are constant and highly important at statistical scale in the difference and first difference scales. The studied series are co-integrated of first order approach. This indicates for the potential of a long-time stability correlation among the determinants of TB of bio-energy sector. Hence, this study analysed the linkage between the determinants in the Panel Co-Integration (PCI) tests.

Table 3: Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
TB	672	11.498	0.165	10.048	11.995
Y	672	9.066	0.155	8.862	9.355
Y*	672	9.981	0.755	8.183	11.617
ER	672	4.524	0.285	2.140	7.036

Table 4: Unit Root Test Results Based on Levin Lin Chu (LLC) and Im Pesaran Shin (IPS)

Variable	Level		First Difference	
	LLC	**IPS**	**LLC**	**IPS**
lnTB	-32.713***	-20.851***	-26.867***	-18.340***
	(0.000)	(0.000)	(0.000)	(0.000)
lnY	-4.135***	-11.823***	-12.610***	-9.833***
	(0.000)	(0.000)	(0.000)	(0.000)
lnY^*	-10.108***	-2.818***	-8.466***	-10.391***
	(0.000)	(0.002)	(0.000)	(0.000)
lnER	-4.037***	-2.596***	-3.579***	-5.368***
	(0.000)	(0.004)	(0.000)	(0.000)

Note: ***, ** and * indicated significance at the 1%, 5%, and 10% levels respectively. Levin, Lin & Chu test (LLC) Levin *et al.,* (2002) and Im, Pesaran and Shin W-stat test (IPS) (Pesaran, 2007). Values in parentheses are *p*-values

Table 5 presents the outcomes of the PCI test method for the European countries for the period between 1990 through 2013. According to the PCI approach findings, out of 7 statistical tests, 4 tests are statistically significant at the one percent statistical level and boost the PCI correlation between lnTB, lnY, lnY^*, and lnER. However, not considering the implemented shocks that may impact the investigated sample in the short period, there is highly potential for a stable relationship among the factors of the TB of bioenergy industry in the long period. However, the next stage estimation is to assess the run boundaries accordingly. Thus, the current study regresses the long period determinants employing FMOLS, DOLS, and PMG techniques. Model 1 presents the findings for the European Union countries area for the

Table 5: Panel Cointegration Test Results for the EU-28 Region from 1990-2013.

Dependent Variable: Trade Balance of Bioenergy Industry		
	Without Trend	With Trend
Pedroni Residual Co-integration Test		
Alternative hypothesis: common AR coefficients. (within dimension):		
Panel v-Statistic	1.190	-2.321
	(0.116)	(0.989)
Panel rho-Statistic	-3.073***	-0.100
	(0.001)	(0.460)
Panel PP-Statistic	16.252***	-6.156***
	(0.000)	(0.000)
Panel ADF-Statistic	-2.954***	-6.239***
	(0.001)	(0.000)
Alternative hypothesis: common AR coefficients. (between dimension):		
Group rho-Statistic	1.645	(0.950)
Group PP-Statistic	-7.080***	(0.000)
Group ADF-Statistic	-4.564***	(0.000)

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p* values.

duration between 1990 and 2013, applying various LRP; FMOLS, DOLS, and PMG. Based on the findings of panel FMOLS, the coefficient of lnY, lnY^*, and lnER are significantly positive at the 1 percent statistical level. Only DOLS regression findings support the findings of FMOLS regression, but not PMG regression findings. These results reveal that lnY, lnY^*, and lnER have positive correlations and significantly impact the TB of bio-energy sector in the European Union area from 1990 to 2013 (Table 6).

Model 2 presents the EU28 developed states' results during the period among 1990 and 2013, employing various long term estimators FMOLS, DOLS, and PMG. Both regression methods DOLS and PMG provide encouraging findings to the FMOLS estimation for lnY and lnY^* determinants, but not lnER. Based on the findings of the panel FMOLS approach, the coefficient of lnY and lnY^* is statistically important and positive at the 1% scale. These outcomes illustrate that lnY and lnY^* impact significantly and positively the trade balance of the bioenergy industry in the EU28 developed countries during the period between 1990 and 2013 (Table 7). Model 3 shows the EU28 developing state' results during the period from 1990 to 2013, using different long period approaches FMOLS, DOLS, and PMG. The results significantly indicate that lnER and lnY^* show positive correlations with the TB of the bio-energy industry in the European developing members for the term from 1990 to 2013. According to the results of FMOLS estimator, the coefficient for lnER and lnY^* are statistically important and positive at the 10 percent and 1percent scales, respectively. Both estimators

Table 6: Summary of Panel Regression Model 1 for the EU-28 Region from 1990-2013

Model 1. Panel Data Analysis Estimation for EU28 Region 1990–2013						
Dependent Variable: Trade Balance of Bioenergy Industry						
Long-run coefficient	Panel Fully Modified OLS		Panel Dynamic OLS		Panel Pool Mean Group	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
lnY	0.223***	(0.000)	0.291***	(0.000)	2.486	0.147
lnY^*	0.308***	(0.000)	0.514***	(0.000)	6.663	0.139
lnER	0.070***	(0.000)	0.147 ***	(0.000)	0.301	0.227

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p*-values.

Table 7: Summary of Panel Regression Model 2 for Developed Countries from 1990-2013

Model 2. Panel Data Analysis Estimation for developed countries 1990–2013						
Dependent Variable: Trade Balance of Bioenergy Industry						
Long-run coefficient	Panel Fully Modified OLS		Panel Dynamic OLS		Panel Pool Mean Group	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
lnY	0.493***	(0.000)	0.579**	(0.001)	8.857***	(0.000)
lnY^*	0.667***	(0.000)	0.791***	(0.000)	8.935***	(0.000)
lnER	0.036	0.109	0.207	0.281	1.820***	(0.000)

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p*-values.

DOLS and PMG outcomes support the results of FMOLS panel (please find Table 8).

Table 9 presents the result of HPC investigation for the European Union area, the European developed members, and the European developing members for the duration among 1990 and 2013. The results of the causality test related to heterogeneous panel were improved by earlier study Dumitrescu and Hurlin (2012) by identifying the direction of the correlation among the lnTB and the related variables lnY, lnY^*, and lnER. According to the direct casual investigation outcomes, there is a two-way causal direction correlation in the European Union area among lnTB and lnY^*, and among lnTB and lnER. There is a one-way causal direction correlation in the EU28 region from lnTB to lnY. In developed members, there is a two-way causal direction correlation among lnTB and lnY^*. There is a one-way causality relation in developed states from lnTB to lnY, and from lnTB to lnER. In developing states, there is two-way causality relation among lnTB and lnY^*, and between lnTB and lnER. There is a one-way causality relationship from lnY to lnTB in developing states. Eventually, these outcomes boost the outgrowth, reaction, and naturalised hypothesises among the bioenergy sector and the energy industry development in the European Union countries for the period between 1990 and 2013.

Table 8: Summary of Panel Regression Model 3 for Developing Countries from 1990-2013

Model 3. Panel Data Analysis Estimation for developed countries 1990–2013						
Dependent Variable: Trade Balance of Bioenergy Industry						
Long-run coefficient	Panel Fully Modified OLS		Panel Dynamic OLS		Panel Pool Mean Group	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
lnY	0.0293	0.1234	0.0700	0.1383	0.4998***	(0.000)
lnY^*	0.1334***	(0.000)	0.0676	0.4146	1.6510***	(0.000)
lnER	0.0382*	(0.0801)	0.1213***	(0.000)	0.2982	(0.003)

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p*-values.

Table 9: Summary of Granger Causality Analysis for the EU-28 from 1990-2013.

Heterogeneous panel causality analysis for EU28 from 1990 through 2013						
Null Hypothesis	EU28 Region		Developed Countries		Developing Countries	
	Wald stat.	Probability	Wald stat.	Probability	Wald stat.	Probability
lnY→lnTB	7.301	(9.000)	7.587	(6.000)	6.971***	(0.000)
lnTB→lnY	5.614***	(0.001)	6.108***	(0.003)	5.045	(0.113)
lnY^*→lnTB	20.394***	(0.000)	11.052***	(0.000)	31.173***	(0.000)
lnTB→lnY^*	14.466***	(0.000)	21.552***	(0.000)	6.290***	(0.004)
lnER→lnTB	4.046*	(0.0623)	3.375	(0.890)	6.299***	(0.003)
lnTB→lnER	5.401***	(0.004)	5.561**	(0.022)	5.218*	(0.076)

Note: ***, ** and * indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p* values.

Discussion

This research shows the estimated findings of three panel regression models. The study has divided the EU28 zone into developed states and developing states according on the pertaining macroeconomic foundation and the attribution of the state. This can support the current paper to investigate the influence of the state determinants on the TB of bio-energy output relying on the development status of the state. Model 1 assesses the influence of economic variables on the TB of bio-energy output in the EU28 region from 1990 to 2013 (please see Table 6). Model 2 investigates the influence of economic factors on the TB of bio-energy output in the European Union developed members among 1990 and 2013 (please refer to Table 7). Model 3 analyses the impact of economic variables on the TB of bio-energy output in the European Union developing states for the term among 1990 and 2013 (see Table 8). The results suppose that the influence of domestic real income is positive and significant at the one percent statistical level in Models 1 and 2. In Model 3, no significance correlation between real income and trade balance in developing countries. This is due to the increases in real income will not change the trade balance because income and import change by the same amount.

This is in line with study by Kyophilavong *et al.* (2013), where the regression of domestic real income coefficients is predicted to be positive due to the increase of income drives to a enhance of imports from oversea. In the long term, a one-way direct causal correlation is found among domestic real income and TB of bio-energy industry in the European Union area and related developed and developing members (Table 9). This study resulted that the influence of foreign real income is positive and statistically significant at the one percent level in Models 1, 2, and 3. This outcome is in alignment with previous research done by Chiu *et al.,* (2010), where the coefficients findings of the independent variable foreign real income show a positive and statistically significant relationship. In other words, the improvement of the independent variable foreign real income is predicted to develop the dependent variable TB with the commerce co-partners in the EU in the long term. In the long term, a two-way direct causality correlation is found among foreign real income and TB of bioenergy output in the European Union area and pertaining developed members and developing members (Table 9).

The results of the study point that the influence of lnER on the TB of bio-energy industry is positive and statistically significant in Model 1, Model 2, and Model 3. This is also in alignment with previous research done by Chiu *et al.,* (2010), which indicated that the independent variable real exchange rate is a main variable and can play a significant impact on the dependent variable TB, because its depreciation will fill the gap of trade imbalance. There is a one-way causality relation from TB to lnER in the EU28 developed countries. In the long term, a two-way causal direct correlation is found among real exchange rate and TB of bio-energy industry in the European Union region and the European developing members (please see Table 9). On the other hand, there are no findings for causality relationship from domestic real income to trade balance of bio-energy output in the EU-28 zone and the EU28 developed countries. Also, there is a negative relation from TB to domestic real income in the European developing members. Also, there is no result for a direct causal correlation from lnER to TB in the EU28 developed countries (Table 8).

Conclusion

The findings enhancement the experiential effectiveness of the J-curve influence by mean of FMOLS, pointing to the depreciation that has developed the bioenergy output trade balance. These findings have been confirmed by means of the causality test for each distinguished group of states. FMOLS investigation does figure out evidence of the long term developing the bioenergy output trade balance showed by the J-curve influences. The bioenergy industry trade balance in the EU28 region has simulated the J-curve manner of modification. All lnY, lnY*, and lnER determinants have positive and primary impacts on the TB of the bio-energy industry at the 1% statistical levels. Based on the PCI estimation in Model 1, there is significant positive correlation (1%) level among the economic variables (lnY, lnY*, and lnER) balance of trade related to bio-energy production in the European Union area. In developed members, the findings present that there is a primary and positive relation at the 1 percent statistical level among economic determinants lnY and lnY*, and the TB of the bio-energy industry. In developing members, the results present that there are significant and positive relations at the 1 percent and 10 percent levels between lnY* and lnER, respectively, and a trade balance of bioenergy from 1990 to 2013. In the last section of the current empirical findings, the orientation of the correlation among economic determinants and TB of the bio-energy industry is evaluated by the causal direction analysis for Models 1, 2, and 3. According to the outcomes of the direct causal analyses among foreign real income and TB of bio-energy industry, it is derived that the two way hypothesis is valid in the European Union region and related developed members, and neutrality hypothesis is valid in developing states.

The EU28 countries need to rely on the framed policies dominating the lnER, particularly in regard to the EU28 developed states, where the nominal lnER to the level of aggregate prices meets the desired impacts on the bioenergy output trade balance of bioenergy. The devaluation-based strategy can be affected through the proper modifications in lnER, which must be cooperated with stabilisation framework to maintain the constancy of the local price scale and meet the required standard of the bio-energy industry lnTB. In the European developing states, the devaluation-based policies generated some critical issues. Devaluation-based policies could have negative impacts through increasing the import demand prices of bioenergy output. This could lead to import inflation and could have critical and negative influences on the domestic industry of bioenergy that relied on imported bioenergy inputs. Moreover, the devaluation-based regulations could not be valid in developing the bioenergy industry trade balance, in case other countries adopt the same policies at the same time. However, different policies should be implemented by the countries concentrating on the generated of imported-exchanged output. Import-exchanging regulation has a significant impact on increasing the domestic income and improving the TB of the bio-energy production level, especially in regard to developing countries. Based on the derived conclusions, politicians and decision makers may adopt different policies regarding tax stimulus under the green energy policies that may be implemented to encourage TB of bio-energy by enhanced subventions, which can be adopted for bio-energy sources.

To achieve the need influence on bio-energy lnTB, the European states might depend on rules that control the variable of lnER, particularly in case of the European states which the rate of lnER is. Additionally, various regulations pertaining to devaluation, affected through changes in the average of nominal exchange, ought to align with clear regulations to safe export scale stability and to achieve the needed scale of lnTB of the bio-energy sector. However, various regulations related to devaluation negatively influenced the European developed states. The regulations pertaining to devaluation may enhance the cost of export demand of bio-energy outcomes. This can result to elevated export demand scales of inflation that can negatively affect the foreign sector of bio-energy that consumes the exported material. Moreover, regulations related to devaluation cannot impact primary in improving the lnTB of the bio-energy outcomes, in case another European state also apply the same regulations at the same matter. On the other hand, the European states ought to apply rules that enhance the production of exported items. Export regulation shall be more dynamic in improving the national income of the developed states and the pertaining lnTB of bio-energy outcome. In this subject, senators can affects these policy into framework and methods by developing taxation and tariff systems in coordination with the governmental energy framework, and may be pursued to manage the lnTB of bio-energy through enhanced subsidization system applied for bio-energy different sources. Nevertheless, bio-energy utilisation impulse bio-energy output from various renewable sources can be emphasised significantly. Also, developed technology can provide an access to different bio-energy products such as; bioelectricity, bio-heat, and biofuel items. Various tariff attestations might be provided for bio-energy trade, and ecology trade attestations can be given in this regard. In the long run, policy makers should promote higher bio-energy efficacy and productivity, and direct investments subsidies could be implemented. This study highly recommends that political and decision makers should give extra attention to the exchange rate which plays a vital role to determining the behaviour of EU28 zone and developed countries. This suggests that any fluctuation of the exchange rate of the euro in developed countries in EU28 region will affect the international trade of bioenergy output. On the other hand, in EU28 developing countries real exchange rate does not play significant role to affect the international trade of bioenergy output.

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