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The Economic Determinants of Bioenergy Trade Intensity in the EU-28: A Co-Integration Approach

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Abstract: This paper examines the dynamic effect of the economic determinants on bilateral trade intensity of the European Union (EU) region's bioenergy industry outputs. The authors adopt the panel co-integration model approach to estimate annual trade intensity data of the EU-28 countries' bioenergy industry outputs from 1990 to 2013. This study investigated the long-term influence of the rate of real exchange, gross domestic product (GDP), and export price on the trade intensity of bioenergy industry applying fully modified oriented least square (FMOLS), dummy oriented least square (DOLS), and pooled mean group (PMG) models. In the current study, the findings boost the empirical validity of the panel co-integration model through FMOLS, indicating that depreciation has improved the trade intensity. This study has further investigated, through the causality test, a distinct set of countries. FMOLS estimation does find proof of the long run improvement of trade intensity. Thus, the result shows that the gross domestic product (GDP) and the real exchange rate have a positive and noteworthy influence on the EU-28 region trade intensity of the bioenergy industry. Moreover, the export price affects negatively and significantly the trade intensity of the bioenergy industry in the EU-28 countries.

Keywords: bioenergy industry; trade intensity; European

1. Introduction

The world's bioenergy trade has witnessed one of its most challenging periods in the last period as bioenergy output prices fell sharply across the globe to record lows. Oversupply in the market coupled with weaker demand in Europe has been the catalyst for the bearish pricing that has affected bioenergy producers across Europe. However there are reasons to be optimistic as we look towards 2020 and beyond [1]. The Danish bioenergy demand is set to soar with the conversion energy to increase the annual bioenergy consumption to more than 1.8 million tons in different sectors in 2017. While in the Netherlands, the market has been boosted by the return of national subsidies that should see an additional 3 million tons of bioenergy demand. In the bioenergy market, Scandinavia continues to lead the way in terms of demand via bio-heat, bio-cooling and bioelectricity energy projects. In Denmark, the government planned to add 2 million tons of bioenergy products demand by 2019 and in Sweden has started commissioning their new bioenergy plants in Stockholm that will add a further 1 million tons of bioenergy products demand to Scandinavia. Renewables play a minor role in the trade of energy with the import and export of bioenergy products dominating. The EU-28 nations import nine times (59 exajoule) as much energy (mostly fossil fuels) in comparison to the whole African continent. The only significant trade of renewable energy occurs in the bioenergy sector in the form of pellets and liquid biofuels. This is largely due to the overdependence of the EU-28 nations on crude oil and oil products [1].

According to the global bioenergy statistical report in 2017, the bioenergy industry in the European Union (EU-28) region has a high possibility for further growth and development in comparison with other regions due to available resources and applied technology [1]. The bioenergy sector provides the biggest portion worldwide to the green and friendly energy industry, and it is the primary contributor in different renewable energy sectors, such as bio-heat and bio-cooling, bioelectricity and power, and biofuel. According to a study by Susaeta, Lal, Carter, and Alavalapati [2], the EU-28's evaluation for the bioenergy application level has the main requirement to meet the National Renewable Energy Action Plan (NREAP) objectives on 31 December 2020, where bioenergy outputs' local consumption will rise from 2470.21 thousand GJ in 2005 to 5652.18 thousand GJ by 2020 through the domestic demand enhancement. As per previous estimations according to Fritsche, Hennenberg and Hünecke [3], the total bioenergy trades in 2006 was 930 PJ. Biomass fuel is the renewable input utilized in the bioenergy industry. It is harvested from different natural resources, including forestry, agriculture, fishery, municipalities, etc. Biomass is organic raw material and biological waste generated from various natural resources. Land use is a critical factor for bioenergy development. Unlike other renewable energy sources, biomass requires significant land for growing forests and agriculture crops to supply the bioenergy demand globally. In 2014, the total land area globally was 13 billion hectare out of which agriculture area covered 37.6% of the area while forestry covered 30.7%. The World Bioenergy Association's report shows that this can have negative effects on the environment and natural resources through deforestation, farming practices, water use, and air emission [1].

The imports demand of bioenergy from biomass fuels is expected to meet the needed 20% of final energy consumption from renewable sources in 2030, with 85% of the bioenergy produced locally in Europe and 15% of bioenergy outputs imported from different countries [3]. Accordingly, Sustainable and Renewable Energy Sources (RES) will be able to meet 45% of the final energy consumption in Europe by 2030. Such an important transformation from the conventional energy system to the renewable energy system can have significant benefits for the EU countries, specifically, and the world, generally. The EU countries can improve bioenergy trade intensity by converting to independent countries for natural gas imported largely from the Russian Federation, and can largely increase the share of indigenous bioenergy exports. This can achieve high rates of savings, estimated around billions of euros due to the high rate of energy imports from different regions, and thus can enrich the living scales and recruitment scales in the EU countries. Therefore, the authors chose the EU-28 as the region for this study. Furthermore, the EU countries can reduce their Greenhouse Gas (GHG) releases by 50% in comparison with the 1990s standard, thus exploring the idea that worldwide economic welfare and an objective climate change regulation can be co-integrated.

A previous study referred to the continual shortage in biomass fuels production, stating there was a constant rise of the import of biomass from 10 petajoule (PJ) to 150 PJ in 1990 and 2006, respectively (a total of 1800 PJ to 3800 PJ in 1990 and 2006, respectively) [4]. This led to an unstable status in the international biomass market which negatively affected the export demand of bioenergy. This was represented by the shortage of biomass production (1700 PJ) to fill up the local consumption (3600 PJ) from 1990 through 2006. In addition, there were rises in the import demand level of biomass and the export demand rate of biomass, to reach 5 PJ and 70 PJ in 1999 and 2006, respectively [4]. The primary bioenergy fields that result in major rises in demand are the electricity, from 418.68 thousand Giga-joule (GJ) to 837.36 thousand GJ, and transportation, from 586.15 thousand GJ to 1172.3 thousand GJ sectors.

Moreover, the rising level of biomass imports in comparison with the short level of biomass exports is predicted to cause an imbalanced trade status and influence competitiveness of the bioenergy industry compared to conventional energy industries in the international energy markets. According to a study by Bottcher, Frank, Havlik and Leduc [5] pertaining to the timber market, the domestic price factor can have a major impact on the domestic supply and domestic demand decompositions of the biomass local market. However, the import and export price may primarily affect import and export demand in the international trade of bioenergy industry. The gross domestic product (GDP) variable can boost economic growth of the EU-28 region. In addition, according to earlier studies by Bottcher et al. and Kanjilal et al. [5,6], the GDP is an indicator of the trade growth and improvement.

Therefore, GDP is a significant variable in this study which can play a main role in the development of bioenergy trade intensity. The rate of real exchange (EXR) is predicted to largely impact both the country import demand and the country export demand which both reflect the trade [6].

According to an early study, improvements in the bioelectricity production in the short term between 2005 and 2020 are largely obvious in Belgium, France, Germany, Italy, the Netherlands, Poland, and the United Kingdom, with predicted increments of 37.68 thousand GJ, 62.80 thousand GJ, 175.84 thousand GJ, 71.17 thousand GJ, 58.61 thousand GJ, 1.2 50.24 thousand GJ, and 92.10 thousand GJ, respectively [7]. The current study will highlight the macroeconomic and microeconomic variables of the bioenergy trade intensity in the EU-28, including Gross Domestic Product (GDP), Export Price (EP), and real exchange rate (EXR). Referring to a study by Snieskiene and Cibinskiene [4], the shortage in domestic bioenergy supply to meet the domestic demand of bioenergy from 1990 to 2006 has negatively influenced the local bioenergy market and has raised the import demand of biomass and lowered the export demand of biomass to fill up the shortage in the local EU countries biomass fuel markets.

As per the World Bank Database [8], the Trade Intensity (TI) proxy applies logic relatively close to explain comparative advantage, in which partners (countries) have a comparative trading intensity correlation, with respect to the world. Trade intensity points to whether a reporter exports a higher volume, as a rate, to a partner (country) than the world exports on average basis. It is computed as a particular country's exports demand to another country, relative to its gross exports demand divided by the world's exports demand to specific country, relative to the world's total exports demand. The authors Lederman and Xu [8] define the trade intensity proxy as a symmetric export demand share. In other words, the figures show whether a country's exports demand go higher (as a rate) to a provided geographic destination than the world exports demand does on an average basis. It is explained in the same approach as an export portion. It does not experience any 'volume' bias; therefore, the authors can easily compare the statistical results among the regions and in different periods when the exports demand increases quickly [8].

The problem researched is the imbalance of the bioenergy export and import in the international market of the EU-28 region which causes a bioenergy imbalance trade and a barrier against meeting the NREAP aims by 13 December 2020 [2]. This might influence the supply price of bioenergy products in the market of the EU countries and could lead the competitiveness of bioenergy output to a higher level in the energy market as a primary source of renewable energy to substitute the fossil fuel sources in the energy market [9].

The significance of the current study is to show the effect of bioenergy trade intensity on the bioenergy industry's security and sustainability which play a primary role to fill up the high domestic demand of the bioenergy and to meet the NREAP aims by 31 December 2020. The current study investigates the effect of economic determinants on the level of trade intensity of bioenergy in the EU-28 developing countries and developed countries. Since the economic size and performance of a country in the EU-28 region can be measured from the development status of the country, many economic characteristics and specifications can be indicators to measure the development status of the country which can affect the rate of intensity. Separating the EU-28 region into developed countries and developing countries based on economic structure and characteristics of the country can help the current study to properly analyze the influence of the country's specifications and macroeconomic factors on the bioenergy trade intensity, considering the development status of the country.

Anyhow, the motivation for this study can be referred to the ability of economic determinants to achieve the required trade intensity of bioenergy to assist the EU-28 economy to meet the NREAP goals by 2020. Also, this study adds value to the primary objective pertaining to promote the bioenergy output as one of the most economical and affordable renewable energy outputs compared to traditional energy output in international energy trades through an inclusive investigation to the trade intensity of bioenergy output in the EU-28 countries. The above bioenergy trade background reveals the following research gaps. First, the majority of these studies has mainly concentrated on the renewable energy trade of individual countries among the world. Second, empirical evidence on the individual countries, particularly the renewable energy trade sector is scarce. Finally, virtually nothing has been published on the bioenergy trade intensity considering its economic determinants in the EU-28 region for the period between 1990 and 2013. In the light of these knowledge gaps, the present paper seeks to provide new empirical evidence on the bioenergy trade intensity and pertaining to economic determinants in EU-28 nations.

The objectives of the current study are as follows. First, the study analyzes the intensity level of the bioenergy trade in the EU-28 region and related developed and developing countries. Second, this study estimates the macroeconomic and microeconomic variables of the bioenergy trade intensity in the EU-28 countries from 1990 to 2013 using a panel co-integration model. The paper is framed as a review of the background of bioenergy trade, analyses of the related trade flows in the EU-28 region by focusing on the major trading partners of the EU-28 region, detailing the main export demand of the bioenergy industry in the EU-28 region, describing the export price of the bioenergy industry, and discussing the concentricity of the export market. The following sections show the further analytical framework. The findings of trade intensity computing and panel co-integration model regressions are shown next. The paper ends with conclusions and recommendations.

2. Literature Review

2.1. Empirical Review of Bioenergy Trade

This section reviews earlier studies pertaining to the import and export demand of the international bioenergy market. Through analyzing international trade of bioenergy, the authors focus on prior studies related to the biomass and bioenergy industry trade intensity in different regions due to the limitation of the number of prior studies that focused on bioenergy trade intensity in the EU-28 countries. Bioenergy in Norway has a significantly lower share of the energy market than countries like Sweden and Finland. A prior study [10] gives an overview of bioenergy use, prices, markets, and market prospects in Norway. The study's results predict that the rate of the international trade of biofuels will lead the domestic market of bioenergy regarding prices and availability of biofuel domestic supply. This can be prevented through increased import demand and export demand potentials, with less reliance on domestic demand of bioenergy and domestic supply of bioenergy. The findings of the study show realistic medium level of period projections for the bioenergy industry in Norway.

In 2000, the domestic demand of bioenergy output in the EU increased significantly, along with the increment of biomass energy trade. As per an earlier study by Matzenberger, Kranzl, Tromborg, Junginger, Daioglou, Goh and Keramidas [11], in the same manner, bioenergy trade will rise significantly in the future, driven by different determinants related to climate change, GHG emissions, energy security, and favorable environmentally friendly policies. The study derived that the bioenergy output was adopted largely in the EU region but there is a lack of regulation and legalization, along with the absence of a competitive green energy market or a green certification system, all of which are required for a sustainable trade of bioenergy industry in the European Union.

The markets for biomass energy industry are witnessing fast development toward becoming global product markets. A previous study by Heinimo and Junginger [12] suggested that identifying the international traded rate of biomass fuel for bioenergy production is complicated due to the different challenges in this field. The study investigates the traded biomasses for bioenergy and reviews the limitations pertaining to the measurement of the international trade of biofuel. The study finds that the international trade of biofuel was evaluated to be around 0.9 exajoule (EJ) in 2006 and the indirect biofuel trade was evaluated to be around 0.6 EJ. The remaining amount of biofuel products is traded in direct approaches for biofuel productions and services. Between 2004 and 2006, the direct biofuel trade grew by 60%, while the biofuels indirect trade did not change significantly. Currently, the global biomass energy is estimated by 50 EJ yr_1. However, the long-run trading possibility among different main regions worldwide was evaluated at about 80–150 EJ yr_1. The development and growth of international biomass energy trade is in its initial stage, but it is predicted to continue the development and growth progress rapidly [12].

Energy exports and imports can have a primary role in the growth and development of the economy. An earlier study by Dedeoglu and Kaya [13] investigated the relationship between energy-use exports trade and energy-use imports trade in the Organization for Economic Cooperation Development (OECD) countries. The study finds that there are some strong correlations between each pair of energy-use exports and energy-use imports. The results suggest that of the 1% increase in the GDP, export, and import causes almost 0.32%, 0.21% and 0.16% increase in energy use, respectively.

In Austria there is a specific preference due to the important wood industry from forestry land and the completion with domestic demand of the bio-wood energy industry from forestry as a natural resource. A prior study by Kristofel, Strasser, Morawetz and Schmid [14] provides a better understanding for the management of the cost-effectiveness of trade for import demand and export demand of the related countries. The increased domestic consumption for bio-wood and biomass products on an international scale has driven to an increase in the trade of biomass with a large flow of biomass trade among the European countries. The bioenergy market is still immature and needs different prompt improvements, such as the increase of more international trade flow of bio-wood and biomass products, with high potential impact on trade maturity in the coming years.

A previous study by Bottcher, Frank, Havlik and Leduc [5] examines the biomass trade projects structure in the future. The National Renewable Energy Action Plans updated the bioenergy demand recently to improve the representation of bilateral trade flows in the EU region through including both tariffs and transportation costs differentiated among partners and products. The study applied the trade calibration method to reconcile observed bilateral trade flows, regional net trade, prices, and trading costs for the base year. Together with improvements of transportation costs, resulting in better estimates on the development of bilateral trade flows in the future especially for products related to bioenergy.

Many projects have taken a place to find technical, economical, and sustainable solutions for biomass trade and market barriers in EU countries. An earlier report by EUBIONET III [15] refers to the established EUBIONET III project that shed significant light on the sustainability of international biomass fuel trade. The study estimates the yearly produced biomass fuel based in the EU is almost 6600 PJ (6573.28 thousand GJ), where only 48% is used properly. The trade biomass fuels limitations have been investigated and potential solutions were set, including CN codes for biomass and price indexes for bioenergy industry sources. Overall, the study derived that biomass fuel trades are increasing significantly, and are expected to contribute largely to the renewable energy targets of the EU in the nearest future.

Several factors could influence the growth of the international trade of biomass and bioenergy and can lead towards the required trade intensity level. Researchers in studies [11–16] analyzed the growth and improvement of the primary variables of the bioenergy international trade in few European countries. The previous studies presented fast improvement in the bioenergy trade but had limitations pertaining to the bioenergy industry’s output such as bioethanol, biodiesel, and bio-wood. The improvement of the international bioenergy trade is limited by various barriers, including geographical location, import demand tariffs, sustainability, renewable certification systems, supply, and logistics systems, all of which can lead to a trade imbalance of the bioenergy industry. However, different variables can motivate the international biomass and bioenergy trade in European countries; such variables related to certain levels of improvement, soaring prices of energy outputs from conventional resources, and regulations pertaining to environmental pollution reduction which may achieve a trade balance in the bioenergy industry.

According to a prior study by Said and Dickey [10], the level of biomass harvested from the forest pertaining to the domestic bioenergy domestic is much lower than the yearly increment level in Norway. Moreover, biomass from forests is continuously harvested. This has negatively and largely influenced the prices of biomass and the domestic biomass supply to achieve a competitive and feasible bioenergy output in the energy market. Anyhow, according to the implemented bioenergy forecasting investigation in the same study [10], the forecasted future of Norway's domestic bioenergy supply will rely significantly on the import demand of biomass due to the gap in the domestic supply of biomass and the high domestic demand of biomass from forestry. This can have a negative influence on the trade balance of biomass and bioenergy in Norway.

Another study by Alakangas, Hillring, and Nikolaisen [17] points out that biomass fuels are produced, traded, and used in the same geographical EU region. In more recent years, this pattern has been changed in northern Europe by large-scale use of biomass fuels for district heating. Today, solid biofuels are traded largely in European countries and have increased to reach a high rate of almost 50 PJ. In other countries, there is an increasing rate in the traded biomass among the world, due to the provided low price of biofuel output. The biggest traded quantity of biomass is imported from the Baltic countries of Estonia, Latvia, and Lithuania, and exported to the Nordic countries Sweden, Denmark, and Finland. Some biomass materials are also imported from Finland to other Nordic countries, and among neighboring countries in the region of central Europe, including the Netherlands, Germany, Austria, Slovenia, and Italy. The traded biofuel output is generally extracted from bio-wood fuels and industrial by-products in central Europe [17].

A previous study by Andersen [18] states that bio-wood fuels are largely traded among the world, and the EU is the world's biggest supplier and demander for bio-wood fuels. EU countries consume 85% of all traded bio-wood fuels worldwide. The EU countries' consumption rate of bio-wood fuel is increasing faster than the rate of production, and the EU countries' imports demand of bio-wood fuels from overseas countries has risen significantly from less than 1.8 million tons (MT), to about 4.5 MT, to more than 6 MT in 2009, 2012, and 2013, respectively. The total of burned bio-wood fuels in EU countries in 2013 was estimated to approximately about 19 million tons. The traded amount of bio-wood fuels among the world is predicted to grow significantly, depending on the amount of the subsidies and needs for sustainability. Currently, the EU countries import bio-wood fuels primarily from the southern United States, Canada, and Russia [18].

Energy regulations can contribute significantly in upgrading trade intensity of bioenergy in the EU region. A previous study by Magar Pelkonen, Tahvanainen, Toivonen, and Toppinen [19] claims that regulations upgraded the domestic bioenergy outputs and had a large effect on the improvement of the international bioenergy trade during the last few years [19]. In addition, the international bioenergy products trade is controlled by import and export demand. The import demand is motivated by supportive regulations, such as import demand tariffs, eligibility standards within quotas, and main requirements that raise the international trade amount of bioenergy outputs. The imbalance of the bioenergy trade can negatively affect the competitiveness of bioenergy outputs in the local and international markets in the EU countries. As shown in an earlier study by Snieskiene and Cibinskiene [4], EU countries have largely imported biomass fuels from various counties among the world to fill up the bioenergy supply shortage. Hence, domestic bioenergy prices have been negatively influenced due to the enhancement of the biomass fuel prices and the enhancement of the total cost of bioenergy generation.

An imbalance in the local market can negatively influence the trade balance of bioenergy output. As illustrated in a study by Trømborg, Ranta, Schweinle, Solberg, Skjevrak, and Tiffany [20], the local bioenergy supply from bio-wood and natural forestry biomass resources in Sweden was around 1.4 MT, while domestic biomass domestic consumption was evaluated about 1.7 MT. Around 400,000 tons were imported from overseas to meet the shortage of the biomass local market. Anyhow, referring to an earlier study by Trømborg et al. [20] in Finland, the domestic biomass supply from natural forestry resources was around 330,000 tons, and the local biomass consumption was evaluated at around 117,000 tons in 2007, showing a rise in domestic production rates compared to the low domestic consumption rate, and a high export demand level when compared with the demand import level, unlike Sweden.

What determinants influence the rate of trade intensity among the EU-28 countries? Why do the EU-28 countries tend to trade more with some countries than with others? These questions have been highlighted largely in international trade studies, taking into consideration the efforts to understand the decomposition and the volume of EU countries export demand and import demand.

2.2. Theoretical Review of Trade Intensity

There are many previous studies [21–23] that have applied different panel data regressors to find the impact of the economic determinants on bilateral trade intensity. The current regression of 24 years is enough to initiate dynamic regulations and actions pertaining to the trade intensity of bioenergy outputs in the EU countries, in line with what has been completed in earlier studies.

Intra-industry trade in southern Africa can play a key role in the development of the community region. A previous study by Koray [23] investigates the variables of intra-industry trade among the country of Zimbabwe and related trading associates in the region of Southern African Development Community (SADC). The study used the Modified Standard Gravity Equation model and regressed using Ordinary Least Squares (OLS). They investigated different variables, including income per capita, trade intensity of goods and service, geographical distance, the rate of real exchange, and the gross domestic product (GDP) to illustrate intra-industry trade intensity between Zimbabwe and pertaining trading associates. The results reveal that Zimbabwe has been expanding its trade largely with SADC countries. This is explained by the applied trade intensity related determinants. The findings also present that trade intensity, geographical distance, rate of real exchange, and GDP are largely significant in affecting trade industry between Zimbabwe and pertaining trading associates in the SADC region.

Many factors determine the level of trade intensity that occurs between countries. Some countries prefer to trade more with some countries over others, due to economic and political reasons. These points have been discussed largely in different international trade studies, taking into consideration the attempts made to review the decompositions and the countries trade intensity rate. A previous study by Srivastava and Green [24] examines the bilateral trade flows between 45 exporting countries and 82 importing countries to provide insights on the determinants of trade, such as distance, product category, political instability, cultural similarity, colonial past, membership in an economic union, and other standard demographic variables like GDP and population. The results of the study indicate that political instability is found to have a noteworthy influence on exports but negligible effect on imports [24]. Furthermore, the GDP of the exporting country is found to be a powerful explanatory variable in the relative intensity of bilateral trade relations. Also, there is a strong relationship between distance and trade intensity.

South Asia is one of the least incorporated regions worldwide, regardless of the efforts made to drive the trade of commodities to liberalization among the region. Agricultural trade and intra-regional gross trade within south Asian countries are around 8% and 4%, respectively. A preceding study by Dembatapitiya [25] investigates the trade intensities and estimates the external determinants applied to the gravity model. Three models were regressed, taking exporter gross domestic product, importer gross domestic product, exporter rate of population, importer rate of population, geographical distance, World Trade Organization (WTO) countries, regional and bilateral commitments, mutual language, joint colony, and diversification proxy as the independent determinants for the year 2010. The primary model applied total-trade intensities as the dependent factor and included 2490 country pairs. The evaluation of the gravity model approach results show that exporter gross domestic product, importer rate of population, geographical distance, and colonial ties are largely important economic variables of trade intensity model. Bilateral trade commitments have significant effects on boosting trade correlations in agriculture trade intensities in the south Asian region. Export market diversification is a primary economic determinant of trade intensities.

The National Renewable Energy Action Plan (NREAP)'s map of the EU shows two significant international connections among EU countries. The NREAP's map of the EU region allows definition of essential characteristics of the EU members in intra-EU trade and direct investments. A prior study by Folfas [26] analyzes intensities of foreign direct investment (FDI) correlations compared with trade intensities among EU countries for the term between 1985 and 2008. The study conducts ANOVA of foreign direct investment intensity proxies to investigate if the studied values of each proxy differ due to ownership of common boundaries or due to the memberships of the EU region. The study results show the relationship among trade and FDI intensities proxy for each pair of countries, illustrating whether these two types of connections are rather complements or substitutes in bilateral correlations. However, the relationship is clarified by various case studies of foreign direct investment and trade correlations among the selected EU countries. This study relies primarily on a few sources like Eurostat, Organizational Economic Country Development (OECD), and United Nation Trade and Development (UNCTAD) data, all related to bilateral trade and foreign direct investment correlations among EU countries.

Trade manners are identified by trade intensity determinants like applied technology, adopted trade policy, transport method, and transaction costs which have the significant capability to illustrate the varieties of trade intensity. A past study by Gourdon [27] investigates the variations in consumer interest and the variations of returns to scale as main factors of comparative advantage and as primary factors for trade intensity. A case study related to 71 countries for 40 years shows two different return results, before 1980 and after 1980, and takes any amendments separately in the relative significance of traditional and new determinants during the study period under investigation. The results [27] show that the independent variables do not have significant explanatory power from 1980 to 2000, nor from 1960 to 1980. Nonetheless, adding new independent factors to the dependent variable of the study helps a lot to develop the expectation of the characteristics in different produced outputs. The significant of determinant endowments is particularly effective concerning specialization in the human capital endowment. This result has been derived based on distinguishing between the three sets of skills: Unskilled, primarily skilled, and highly skilled [26].

However, as per a previous study by Gourdon [28], the used methodology version permits working on a big dataset model, so the study investigated two different terms, before and after 1980, using a Heckman approach to permit the nonlinearity characteristic in the correlation among the established determinants and exports demand, and between trade intensity and exports demand. This study's findings reveal the relationship between econometric factors that impact the trade intensity over time and among countries. These regressors test for the pertaining factors that significantly influence the trade intensity (that is, the scale of net export demand) along with a nonlinear approach of a comparative advantage method. The export intensity approach as a Heckman selection methodology refers to a country-specific feature or determinant foundation that identifies the comparative advantage (the status of showing positive value for the exports demand), the sizes of local and international markets, the environmental economics, cost of transactions, and establishments defining the export intensity. In addition, the study permitted regressing the trade intensity for the net exporter sub-samples to differ.

An earlier study by Lederman and Xu [8] points to factors that identify trade intensity dependent variables, and can be divided in two categories: Structural determinants and political determinants. First there is the geographical distance from the domestic market to its primary trade associates, and the volume of the domestic market which is scaled by the rate of population and gross domestic product per capita. The other two determinants, local transport structure and arrangement costs, identify the quantity of the export demands of the country. The study findings show that variations in technologies can illustrate trade specialization and the variations in productivity levels can influence trade manners by impacting the rate of trade intensity, since the development in the total factor productivity drive countries to raise their export demand in the produced outputs. Evaluation of the rate of trade intensity presents the following. Firstly, country volume is important as predicted, as the level of trade intensity lowers with the rate of the population. Secondly, a decrease in the index for trade limitations indicates a rise in trade intensity for both net exporter clusters. Thirdly, a decrease in the level of trade limitations enhances trade intensity rates, with a higher influence on structure pertaining costs than for business arrangement and investment costs. Lastly, for produced clusters, a rise in total factor productivity plays a significant role in increasing the net exports demand and decreasing the net imports demand for produced products.

The classical theory of international trade explains that trade is identified through the variations in comparative benefit merges between countries. However, most of the classical trade theories were applied for two-country models. Referring to a previous study by Yamazawa [29], the trade intensity model applied between two countries is mechanistically identified by gross national products (GNP) of export and import demands of the countries and economic distance between the two countries. The gross national products of the export demand of the country represent the quantity of its domestic supply capacity and the import demand of the country its total demand. The size of trade between two countries tends to rise if the gross national products of either country rises, and tends to reduce, if the economic distance between these two countries (scale based on transport cost) rises and this correlation holds between any pair of countries.

The export demand diversification approach had been almost stable over the last decade in east Asian countries, while all the countries have concentrated trade in manufacturing products. According to a previous study by Ferdous [30], the trade intensity proxy compares the portion of a country's export demand to a geographic destination country pertaining to its gross exports demand to the portion of the world's exports demand to that same geographical destination country to the world's gross exports demand. In other words, the trade intensity proxy takes the rate of the trade portion of the source and the world trade portion to the same geographical destination which takes a value between 0 and infinity, with value higher than 1 referring to the export demand correlation that is higher than average. The study results in higher economic incorporation in east Asian countries, driving to export demand diversification, whereas the rate of real exchange and the rate of tariff have a largely negative influence on specialization. In contrast, the gross domestic product of the exporting country demand tends to be positively pertaining to the specialization of that country's economy.

The EU countries committed in 2008 to an incorporated green and friendly energy file called National Renewable Energy Action Plan (NREAP). The NREAP aims to upgrade the EU's energy and environmental regulations to a higher standard, and sketches how the effort will be distributed among the EU countries to achieve the NREAP aims by end of 31 December 2020 [31]. According to the NREAP 2020 aims, the EU countries are required to increase by 20%, the energy production from sustainable and renewable sources, decrease by 20% the energy consumed from conventional sources, increase by 20% GHG mitigation, and enhance the energy industry efficiency when compared with the 1990s scale. Hence, the current study investigates the economic determinants of the trade intensity of bioenergy output from 1990 to 2013, as this study's purpose is to include as many years as possible for this investigation. Anyhow, according to the availability of the data, the investigation includes 1990 through 2013.

3. Methods and Material

3.1. Analytical Framework

The United Nations Economic and Social Commission for Asia and the Pacific meeting in 2009, trade intensity indicator is calculated as the rate of the portion of country's exports demand going to another country over the portion of world export demand going to the same country. The rate of bioenergy trade intensity for EU-28 countries is computed based on the below formula in Equation (1). TI_i^j is trade intensity between in ith country and jth country. X_i^j indicates bioenergy exports from ith country and jth country. X_i points to total bioenergy export from ith country. X_w^j is the mention of bioenergy exports from world to jth country. X_w is the world's total bioenergy export. Following previous studies [24–32], the variables that affect the rate of intensity trade among two countries were evaluated applying panel co-integration model by applying log function on trade intensity as the response factor.

$$TI_i^j = \frac{X_i^j}{X_i} \div \frac{X_w^j}{X_w} \quad (1)$$

$$lnTI_{it} = \alpha_i + \beta 1\ lnGDP_{it} + \beta 2\ lnEXR_{it} + \beta 3\ lnEP_{it} + \varepsilon_{it} \quad (2)$$

where, $i = 1, 2, 3, \ldots, N$; $t = 1, 2, 3, \ldots, T$.

Economic size, population rate, geographical dimension between two countries, World Trade Organization (WTO) countries, current bilateral trade commitments, regional trade commitments, export demand diversification rate, and some same geographical features (mutual colony, joint language) are employed as the independent determinants. This study developed an algebraic specification model relying on the econometric estimation model which is provided in Equation (2) based on a previous study [33]. The total value of exports for the world and European bioenergy were obtained from The Food Agriculture Organization (FAO) and European Statistics (EUROSTAT).

The employed data are on a yearly basis starting from 1990 and going until 2013. The European trade intensity (TI_{it}) is illustrated as pointed above in Equation (1). The gross domestic product (GDP_{it}) and real exchange rate (EXR_{it}) are measured as real GDP per capita (constant 2010 US$) index and are taken from the World Bank Database (WBD). The Europe–USA rate of real exchange (EXR_{it}) was assembled by the research center (economic research service) located in the Department of Agriculture, USA. However, (ε_{it}) is the error term. The export price (EP_{it}) refers to the EU countries bioenergy export price. Since the rate of real exchange is illustrated as Euro (EUR) per USD, a low rate of real exchange can be referred to a real depreciation of the USD. We have adopted Euro per USD for the rate of real exchange because all European import prices and export prices of bioenergy outputs are typically registered in USD. Finally, it is noted that since all the variables are converted into natural logarithms, the estimated coefficients can be interpreted as elasticity.

3.2. Econometric Methodology

3.2.1. Panel Unit Root Tests

In the first stage, as per previous studies [34–39], the authors applied panel unit root tests to investigate whether each variable is stationary (predictable, can be modeled, and autocorrelation are all constant over time) or non-stationary (unpredictable and cannot be modeled or forecasted due to the continuous change over time). The applied panel unit root tests show homogeneity with cross-section correlation [40]. Based on the definition of knowledge gaps and state-of-the-art of the topic [9,41,42], the null hypothesis H_0: $P_i = 1$ of the panel unit root test is that all series containing unit root or all panels are non-stationary.

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{Pi} \theta_{iL}\ \Delta y_{it-L} + a_{mi}\ d_{mt} + \varepsilon_{it}, m = 1, 2, 3 \quad (3)$$

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{Pi} \theta_{iL}\ \Delta y_{it-L} + a_{mi} d_{mt} + \varepsilon_{it}, m = 1, 2, 3, 4, 5 \quad (4)$$

H_0: $\delta = 0$ related to all i (implicates series unit root approach).

H_1: $\delta < 0$ minimum one or several of the i (does not implicate series unit root approach).

Where the alternative hypothesis H_1: $P_i < 1$ is stationary. Following a previous study [43] of a panel unit root test approach, a panel model is formed as follows in Equation (3). In Equation (3), ε_{it} stands uncorrelated throughout the countries. Δ refers to the first differences, d_{mt} shows a dummy variable for each country, a_{mi} shows the countries' parameters, $\Delta y_{it\text{-}1}$ have individual regressions with $\Delta y_{it\text{-}L}$, and residuals are gained. Hence L (L = 1, 2, 3, 4, ..., P_i) points for the most effective lag length identified by the information criterion. Following a previous study [37] of a panel unit root estimator, a panel model framed in Equation (4).

3.2.2. Panel Co-Integration Test

In the second stage, following prior studies [44–49], the findings of the Pedroni co-integration test result in seven different finds. The Pedroni test is one of the most popular tests among panel co-integration tests. The Pedroni test considers the heterogeneity by using specific parameters, which can vary across individual members and cross-section interdependence. The authors followed a common approach in supposing that the null hypothesis of no co-integration is rejected if at least four statistics yield evidence of co-integration [46,47]. Panel co-integration analysis applied by [46,47] is a test that is mostly employed to regress the long-run correlation among the dependent variable and independent determinants in the studied panel data analysis. In the [46,47] panel data co-integration method examines null hypothesis approach and alternative hypothesis approach is identified as the following:

H_0: The authors could not find co-integration correlation related to all *i*.
H_1: The authors could find a co-integration correlation related to all *i*.

3.2.3. Estimations Long Run Parameters

To investigate the presence of a long run correlation among the selected determinants, different panel data co-integration regressions tests have been applied [47–51], Fully Modified Least Square (FMOLS), Dynamic Least Square (DOLS), Auto Regression Disturb Lag (ARDL) test, and Pooled Mean Group (PMG), to examine the contribution of bioenergy industry in energy growth. Following previous studies [47–51], the FMOLS estimator developed by [48,49] is relied on the formed panel regression, as follows in Equations (5) and (6). Equations (5) and (6) shows: y_{it} dependent variable, x_{it} independent variable, α_i constant influence, and β long-run co-integration coefficient that could be evaluated based on the hypothesis that there is no reliance among sections that includes the panel [52,53].

Therefore, FMOLS regressor is established as follows in Equation (7). In Equation (7), $\hat{\beta}^{*}_{FM,i}$ points to the estimated FMOLS results earned for panel cross-section that frames the each *i*'th studied panel. However, co-integration coefficient analysis for the gross panel is evaluated by considering the average of FMOLS coefficients earned for the panel cross section. T statistic for the total panel co-integration coefficient is estimated in Equation (8). Equation (8) refers for $t_{\hat{\beta}^{*}_{GFM}}$ statistic for co-integration coefficient achieved to the gross panel.

3.2.4. Heterogeneous Panel Causality Test

Following a previous by study Koçak and Şarkgüneşi [42], finding the long-run correlation between determinants can be identified through applying causal direction approach. The causal direction (causality) approach established by [50] and accordingly Wald statistics approaches have been applied. The importance of this approach is that it considers the heterogeneity and reliance between the countries. Also, this approach might be applied in case the panel cross-section (*N*) dimension is greater than the time (*T*) dimension. To estimate the null hypothesis and find the causality relationship for each cross-section, the authors calculated individual Wald statistics approaches for each related panel cross-section. These estimations can be obtained by applying the formed Equation (9) as follow. As per a previous study by Dumitrescu and Hurlin [50], the Heterogeneous Causality approach was used with two hypothesis tests; the null hypothesis approach and the alternative hypothesis approach.

$$y_{it} = \alpha_{it} + \delta_{it}t + \beta_i x_{it} + \mu_{it} \tag{5}$$

$$x_{it} = x_{it-1} + e_{it} \tag{6}$$

$$\hat{\beta}^{*}_{GFM} = N^{-1} \sum_{i=1}^{N} \hat{\beta}^{*}_{FM,i} \tag{7}$$

$$t_{\hat{\beta}^{*}_{GFM}} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}^{*}_{FM,i}} \tag{8}$$

where the authors could not find a causality correlation form variable x to variable y; $H_0 = \beta_i = 0\ \Lambda_i = 1, 2, 3, \ldots, N$.

Where the authors could find a causality correlation form variable x to variable y for some cross-sections.

H_1: $\beta_i = 0\ \Lambda_i = 1, 2, 3, \ldots, N_1$.

βi ‡0 $\Lambda_i = N_1 + 1, N_1 + 2, N_1 + 3, \ldots, N$

$$W^{Hnc}_{N,T} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \tag{9}$$

4. Empirical Results and Discussion

4.1. Empirical Results

Table 1 shows the findings for panel unit root estimation for the EU-28 region from 1990 to 2013. Panel unit root tests result in various outcomes regarding the stability of series level values. All statistic indicators show that the series are significant and stable at the 1% level in the difference and first difference levels. This stands for the potential of a long-run balanced relationship between the determinants of trade intensity of the bioenergy industry. Therefore, the authors examined the relationship between the determinants in the panel co-integration test.

Table 1. Panel Unit Root Test Results for the EU-28 Region in 1990–2013.

Variable	Level		First Difference	
	LLC	**IPS**	**LLC**	**IPS**
lnTI	−18.5803 *** (0.000)	−24.4599 *** (0.000)	−2.42415 *** (0.007)	−19.2884 *** (0.000)
lnEP	−16.9164 *** (0.000)	−21.1174 *** (0.000)	−11.4902 *** (0.000)	−15.8303 *** (0.000)
lnGDP	−15.3956 *** (0.000)	−11.8173 *** (0.000)	−13.7294 *** (0.000)	−9.47043 *** (0.000)
lnEXR	−17.1933 *** (0.000)	−16.1728 *** (0.000)	−11.3787 *** (0.000)	−11.2418 *** (0.000)

Note: *** indicate significance at the 1%, level. Levin, Lin & Chu test (LLC), and Im, Pesaran, and Shin W-stat test (IPS). Values in parentheses are p-values.

Table 2 shows the panel co-integration approach findings for EU-28 region from 1990 to 2013. Referring to the test results, five of the seven statistics tests are significant at the 1% level and boost the co-integration correlation between lnTI, lnGDP, lnEXR, and lnEP (see Table 2). In other words, regardless of the economic disturbance and crisis that impacts the trade intensity system in the short run, there is a potential for a co-integration relationship between the determinants of the trade intensity of bioenergy industry in the long run. In this study, the next step test is to estimate the run parameters. Therefore, the authors estimated the long run parameters through FMOLS, DOLD, and PMG tests.

Table 2. Panel Co-Integration Test Results for the EU-28 Region in 1990–2013.

Dependent Variable: Trade Intensity of Bioenergy Industry		
	Without Trend	**With Trend**
Pedroni Residual Co-Integration Test		
Alternative hypothesis: common AR coefficients. (within dimension):		
Panel v-Statistic	−2.964778 (0.9985)	−4.548159 (1.000)
Panel rho-Statistic	−3.346964 (0.0004)	−3.891685 *** (0.000)
Panel PP-Statistic	−14.23219 (0.0000)	−14.81698 *** (0.000)
Panel ADF-Statistic	−10.46545 (0.0000)	−10.81171 *** (0.000)
Alternative hypothesis: common AR coefficients. (between dimension):		
Group rho-Statistic	−2.09666 **	0.018
Group PP-Statistic	−17.53969 ***	(0.000)
Group ADF-Statistic	−11.44241 ***	(0.000)

Note: ***, ** indicate significance at the 1%, 5% levels respectively.

Model 1 shows the results for the EU-28 region from 1990 to 2013 using different panel long run estimators; FMOLS, DOLS and PMG. Reference to the results of the panel regression FMOLS, coefficient for lnEXR and lnGDP, are showing positive correlation and statistically significant at the 1% scale with trade intensity. The coefficient of lnEP results shows negative correlation and statistically significant at the scale 1% with trade intensity. PMG and DOLS estimation method boost the results of FMOLS estimation regarding lnEP, lnEXR and lnGDP. These results reveal that gross domestic product, export price and exchange rate had a positive and significant correlation with the trade intensity of bioenergy industry in the EU-28 region in 1990–2013 period (Table 3).

Table 3. Summary of Panel Regression Model 1 for the EU-28 Region during 1990–2013.

Model 1. Panel Data Analysis Estimation for EU28 Region 1990–2013						
Long-Run Coefficient	**Panel FMOLS**		**Panel DOLS**		**Panel PMG**	
	Coefficient	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
lnEP	−0.0775 ***	(0.000)	−0.1850 ***	(0.000)	−0.0581 ***	(0.007)
lnEXR	0.6213 ***	(0.000)	0.7078 ***	(0.000)	0.4377 ***	(0.000)
lnGDP	0.1102 ***	(0.000)	0.0640	(0.214)	0.3226 ***	(0.000)

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

Model 2 shows the results for the EU-28 developed countries for the term from 1990 to 2013 applying various panel long run approaches: FMOLS, DOLS, and PMG. The estimation method of PMG shows supportive results to FMOLS estimator regarding lnEXR and lnGDP independent variables. Also, the coefficient of lnEP shows negative and significant correlations, at the level 1%, with the trend intensity. Referencing the estimated results of the FMOLS panel, coefficients lnEP, lnEXR, and lnGDP are significant and positive at the statistical 1% level. These results lnEP, lnEXR, and lnGDP suggest strong and positive relationship with trade intensity of the bioenergy industry in EU-28 developed countries from 1990 to 2013 (Table 4).

Table 4. Summary of Panel Regression Model 2 for Developed Countries during 1990–2013.

Model 2. Panel Data Analysis Estimation for Developed Countries 1990–2013						
Long-Run Coefficient	Panel FMOLS		Panel DOLS		Panel PMG	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
lnEP	−0.7467 ***	(0.000)	−0.8695 ***	(0.000)	−0.5040 ***	(0.000)
lnEXR	0.1316 ***	(0.000)	0.0754	0.299	0.0828 *	(0.054)
lnGDP	0.1593 ***	(0.000)	0.0705	(0.448)	0.2610 ***	(0.000)

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

Model 3 shows the results for the EU-28 developing countries from 1990 to 2013, employing different panel long run approaches: FMOLS, DOLS, and PMG. The coefficient of lnEP shows a negative and significant relationship at the statistical 1% level, with the trade intensity. The result indicates that lnEXR and lnGDP show a positive and significant relationship with trade intensity of the bioenergy industry in the EU-28 developing countries from 1990 to 2013. As per the findings of the FMOLS panel, the coefficients lnER, lnEXR, and lnGDP are positive and statistically significant at the 1% level, respectively. Both estimator's DOLS and PMG results encourage the results of FMOLS estimator (Table 5).

Table 6 shows the results of the heterogeneous panel causality test for the EU-28 region, the EU-28 developed countries, and the EU-28 developing countries from 1990 and 2013. The findings of the casual direction of the panel heterogeneous test, improved by [50], identify the causality direction of the correlation among the dependent variable, lnTI, and the independent variables, lnEXR, lnEP, and lnGDP. Referring to the panel causality test results, there is a two-way (feedback) causal relation correlation in the EU-28 region between lnTI and lnEP only. There is a one-way causal direction correlation in the EU-28 region from lnTI to lnEXR, and from lnGDP to lnTI. In developed countries, there is no two-way causality relation between lnTI and related independent variables. There is a one-way causal direction correlation in developed countries from lnTI to lnEP and from lnTI to lnGDP. There are no findings for causal direction correlation from lnEP to lnTI of bioenergy output in EU-28 developed countries.

In developing countries, there is a two-way (feedback) causal direction correlation between lnTI and lnEP only. There is a one-way causal direction correlation from lnGDP to lnTI in developing countries. Lastly, these results boost the growth, feedback, and naturalized hypotheses between bioenergy industry and trade sector growth in the EU-28 region from 1990 to 2013.

Table 5. Summary of Panel Regression Model 3 for Developing Countries during 1990–2013.

Model 3. Panel Data Analysis Estimation for Developing Countries 1990–2013						
Long-Run Coefficient	Panel FMOLS		Panel DOLS		Panel PMG	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
lnEP	−0.1913 ***	(0.000)	−0.2497 ***	(0.000)	−1.4834 ***	(0.000)
lnEXR	0.5656 ***	(0.000)	0.5940 ***	(0.000)	0.4451 ***	(0.000)
lnGDP	0.1399 ***	(0.000)	0.1755 ***	(0.2061)	0.1070 **	(0.0354)

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

Table 6. Summary of Granger Causality Analysis for the EU-28 Region from 1990 to 2013.

Heterogeneous Panel Causality Analysis for EU28 from 1990 to 2013						
	EU28 Region		**Developed Countries**		**Developing Countries**	
	Wald Stat.	**(Prob.)**	**Wald Stat.**	**(Prob.)**	**Wald Stat.**	**(Prob.)**
lnEXR→lnTI	4.0649	(0.393)	4.9299	(0.973)	4.7345	(0.203)
lnTI→lnEXR	4.5888 *	(0.099)	5.3633	(0.696)	4.6134	(0.251)
lnEP→lnTI	4.7112 *	(0.067)	3.9913	(0.460)	6.4333 ***	(0.000)
lnTI→lnEP	5.1800 **	(0.011)	7.5234 **	(0.030)	6.5916 ***	(0.000)
lnGDP→lnTI	5.5401 ***	(0.002)	3.4952	(0.251)	5.9371 **	(0.0120)
lnTI→lnGDP	3.753	(0.701)	9.4983 ***	(0.000)	4.36710	(0.371)

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

4.2. Discussion

In this part of the study, the authors investigate the economic determinants that can impact the bioenergy trade intensity in the EU-28 developing members and the EU-28 developed members from 1990 to 2013. Concerning the regression model, all contain economic determinants lnGDP, lnEXR, and lnEP. This study begins with 1990 and continues through 2013 in the EU members, the point at which most EU-28 countries began to rely on the EUR as the official handled currency and became constant with a solid trade balance, development, and economic growth agreement.

The current study analyzed the effect of the macroeconomic and microeconomic variables on the trade intensity of bioenergy industry in the EU-28 countries, the EU-28 developing members, and the EU-28 developed members from 1990 to 2013. Referring to the international monetary fund (IMF), the EU economy is one of the biggest economies in the world, if considered as one country's economy, and relying on the utilized source [54]. The EU-28 region countries have promised to meet the National Renewable Energy Action Plan aims by the end of 2020 as follows: 20% reduction in the EU-28 energy from traditional sources, 20% increase in the EU-28 energy from renewable sources, 20% improvement in energy industry efficiencies, and 20% cut-down on GHG emissions, all by the end of 2020, thus playing a significant role in improving the renewable and sustainable energy sector in the EU-28.

This study showed the findings from the panel data estimations for the three studied models. Dividing the EU-28 region countries into two categories, developed countries and developing countries, according to the country's pertaining economic foundation and features, may assist the current study in analyzing the impact of the EU-28 member factors on the bioenergy trade intensity, taking into consideration the economic development condition of the country.

Model 1 derives the effect of different economic factors on the bioenergy trade in the EU-28 countries from 1990 to 2013 (Table 5). To be precise, a 1% increase in lnGDP will result in 0.11% improvement in the bioenergy trade intensity in the EU-28 region as shown by FMOLS. Also, a 1% increase in lnEXR will result in a 0.62% development in the bioenergy trade intensity as shown by FMOLS. Nevertheless, a 1% decrease in lnEP will result in 0.07% increase in the bioenergy trade intensity in EU-28 region as shown by FMOLS.

Model 2 analyzed the impact of various economic variables on the bioenergy trade intensity in the EU-28 developed countries from 1990 to 2013 (Table 4). To be specific, a 1% increase in lnGDP will likely result in a 0.15% improvement in the bioenergy trade intensity in developed countries as shown by FMOLS. Moreover, a 1% increase in lnEXR will likely result in 0.13% development in the bioenergy trade intensity as shown by FMOLS. Nevertheless, a 1% decrease in lnEP will likely result in 0.74% increase in the bioenergy trade intensity in developed countries as shown by FMOLS.

Model 3 investigated the influence of the economic variables on the bioenergy trade intensity in the EU-28 developing countries from 1990 to 2013 (Table 5). Specifically, a 1% increase in lnGDP tends to result in 0.13% development in the bioenergy trade intensity in developing countries as shown by FMOLS. Additionally, a 1% increase in lnEXR tends to result in 0.56% improvement in the bioenergy trade intensity as shown by FMOLS. Nevertheless, a 1% decrease in lnEP tends to result in 0.19% increase in the bioenergy trade intensity in developed countries as shown by FMOLS.

The findings suggest that the influence of the export price shows a negative and significant correlation at the statistical level of 1%, in Models 1, 2, and 3 with bioenergy trade intensity. This is aligned with a past study by Alsaleh, Abdul-Rahim and Mohd-Shahwahid [33] which showed that the estimation of export price coefficients is expected to be negative because the decrease of export price leads to a rise of exports demand to other countries. In the long run, there is a two-way causality relationship between export price and trade intensity of the bioenergy industry in the EU-28 region and the EU-28 developing countries (Table 6).

The authors found that the impact of GDP is positive and significant at the statistical level of 1% in Models 1, 2, and 3. This is in line with an earlier study by Srivastava and Green [24], where the coefficients of the GDP exhibit statistical significance and positive signs were found. In other words, an increase in the GDP of the exporter country is expected to improve the bilateral trade intensity with the trading partners. There is a one-way causality correlation from the GDP to trade intensity in the EU-28 developing countries and the EU-28 region (Table 6). Moreover, there is a one-way causal direction correlation from trade intensity to GDP in the EU-28 developed countries (Table 6).

The empirical findings indicate that the influence of a real exchange rate on the trade intensity of the bioenergy industry is positive and significant, at the statistical level of 1%, in Models 1, 2, and 3. This is in line with a past study by Ferdous [30], where the rate of real exchange depreciation drives export demand extension and export demand specialization. Therefore, there is a positive correlation among the rate of real exchange and diversification proxy (the higher the proxy, the more specialized the country). There is a one-way causal direction correlation from trade intensity to real exchange rate in the EU-28 region (Table 6).

However, there are no findings for causal direction correlation from export price to trade intensity of bioenergy output in the EU-28 developed countries. Also, there is no influence for causality relation from GDP to trade intensity in EU-28 developed countries. Moreover, there is no finding for a causality relation from real exchange rate to trade intensity in the EU-28 developed countries, the EU-28 developing countries, and the EU-28 region (Table 6).

5. Conclusions and Recommendations

The trade intensity correlation between countries is a multidimensional event. This study has explained statistically how different determinants are largely pertaining to the trade intensity of the countries' flow. More development in illustrating trade intensity has been conducted through processing the scales of the individual determinants for each country and through the integrations of additional determinants, such as export prices. The extension of past findings provided by this study contributed to the current understanding of bilateral trade intensity relations between countries and can serve as a takeoff point for further studies in the area.

In the last decades, many serious issues related to energy supply, security, global warming, climate change, and limited reserves of traditional energy sources make it compulsory to transfer from conventional energy to renewable energy sources. The bioenergy industry is a primary source of renewable and sustainable energy promoted as one of the most important potential sources of energy to meet the NREAP aims by 31 December 2020. In this context, the influence of the economic factors on the trade intensity of the bioenergy sector from 1990 to 2013 on the EU-28 members is estimated in the frame of the panel co-integration model. Relying on the findings of the study, firstly, it is found that the panel unit root approach is applied to the studied series when the first discrepancy is stabilized. This can lead to an extended period of balanced correlation among the economic determinants, and is applicable via panel co-integration estimation. The parameters for this correlation are investigated by different estimators, FMOLS, DOLS, and PMG. As per the regressed findings, the authors attain the conclusion that lnGDP and lnEXR variables have a positive and significant impact on the trade intensity of the bioenergy sector at the level of 1%. However, lnEP has a negative and significant impact on the trade intensity of the bioenergy sector at the level of 1%.

Regarding the results of the panel co-integration analysis in Model 1, it is found that there is a significant and positive correlation at the level of 1% between the economic factors (lnGDP and lnEXR) and the dependent variable trade intensity of bioenergy output in the EU-28 region. However, there is a significant and negative relationship, at the level of 1%, between lnEP and the trade intensity of bioenergy output in the EU-28 region, whereas developed countries show that there is a positive and significant relationship, at the level of 1%, between economic variables (lnGDP and lnEXR) and trade intensity of bioenergy industry. However, there is a significant and negative correlation, at the level of 1%, between lnEP and the trade intensity of bioenergy output in the EU-28 region. In developing countries, the findings show that there are significant and positive correlations at the level 1% between the economic determinants (lnGDP and lnEXR) and trade intensity of bioenergy between 1990 and 2013. Meanwhile, there is a significant and negative correlation at the level 1% between lnEP and the trade intensity of the bioenergy output in the EU-28 region.

Finally, this empirical study refers to the casual direction of the relationship among the economic factors and trade intensity of the bioenergy industry which is regressed by the panel causality approach for the three Models 1, 2, and 3. As per the results of the panel causality analysis between GDP and trade intensity of the bioenergy industry, it is concluded that a one-way hypothesis from lnGDP to lnTI is supported in the EU-28 region and the EU-28 developing countries; therefore, a neutrality hypothesis is valid in developed countries. According to the results of the panel causality analysis between export price and trade intensity of the bioenergy industry, this study concluded that two-way causality is valid in the EU-28 developing countries and in the EU-28 region. Referring to the findings of the feedback hypothesis in the EU-28 region, economic factors encourage trade intensity of the bioenergy industry and development. These results suggest that the GDP rate is a key factor in terms of the bioenergy trade sustainability development in the EU-28 region.

To meet the required impact on bioenergy trade intensity, the EU-28 countries could rely on regulations and policies that concentrate on the determinant of the rate of real exchange, especially in case of the EU-28 countries which is the rate of real exchange to total price scale. Moreover, different policies related to devaluation, impacted through amends in the rate of nominal exchange, should integrate with constancy policies to secure export demand level steadiness and to meet the required level of trade intensity of the bioenergy industry. Anyhow, many policies pertaining to devaluation negatively affected the EU-28 developed countries. The policies related to devaluation can raise the cost of export of bioenergy output. This can drive to elevated export levels of inflation that can negatively impact the foreign industry of bioenergy that uses the exported inputs. Furthermore, policies pertaining to devaluation may not play a significant role in developing the trade intensity of the bioenergy output, in case another country also adopts the same policies at the same term. Instead, the countries might adopt policies that boost the generation of exported outputs. Export policies can be further effective in developing the domestic income of the developed countries and the related trade intensity of bioenergy output.

In this context, politicians can translate these policies into regulations and legislations through tax stimulants under the political energy regulations, and can be followed to control the trade intensity of bioenergy through increased subsidization implemented for bioenergy sources. Also, bioenergy consumption incentives that promote bioenergy production from different renewable sources can be emphasized. Moreover, support technology that gives prompt and easy permission to the bioelectricity, bio-heat, and biofuel sectors can be developed. Different tariff certificates can be given for bioenergy trade, and environmentally environment trade certificates can be promoted in this regard. In the long-term, policy makers should encourage better bioenergy efficiency and productivity, and financial investments aids should be applied.

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