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Asian Rice Exports and the European Demand: An Application of the Modified Panel Gravity Model

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Abstract

The purpose of this paper is to investigate the determinants of Asian rice exports to the European market that comprise of 27 member countries. The EU-27 emerged as the net importer of rice as well as the biggest importer of agricultural products. Privileged rice exporting countries including India, Pakistan, Thailand, and Vietnam mainly stem from preferential treatment given by the European Union. Using a 19-year panel data over 2001-2019 for four top rice exporting countries augmented gravity model is tested with additional variables including rice yield, exchange rate, the population of importing region, distance, and rice price indices in importing and exporting regions. Results of the study suggest that rice yield, exchange rate, the population of importing region, distance, and rice price in importing region are statistically meaningful in determining the level of exports of rice to the EU-27 region. Analysis in this paper contends that policymakers in top rice-producing countries should focus on competitive exchange rate regimes as well as set price below what is prevailing in the EU-27 region.

Keywords: exchange rate policy, protectionism, preferential treatment, rice exports, top exporters

1. Introduction

Rice is one of the most widely consumed staples at the global level and is an outstanding source of compound carbohydrates. It is a vital source of calorie intake for about half of the world's population and the mainstay of the rural population in most of the low-income countries. Moreover, it is the source of foreign exchange in many rice-producing economies, especially in Asian countries. The rice exports also play a key role in stimulating economic growth in agricultural-based developing economies (Kang, 2015). However, the rice market is relatively more unstable than other grain markets such as maize and wheat due to higher transaction costs, production concentration, and low level of the world's stock (Dawe, 2002).

Countries are now more globally integrated through trade. Trade liberalization has provided diversified opportunities and mitigate concerns such as food insecurity. Kang (2015) argues that export-led economic growth is backed by rice exports in major rice exporting countries. Using an extended production model based on export-led growth (ELG), the dynamic relationship between the variables is found by Kang (2015) with robust evidence in the favor of rice exports fostering economic growth in Pakistan, India, Thailand, and Vietnam. Similarly, Bui and Chen (2015) reveal factors affecting Vietnam's rice exports to the world by means of the gravity model. They observe that gross domestic product, price, population, and exchange rate are major factors that determine rice exports to the world. In a recent attempt, Kea et al. (2019) explore the factor affecting Cambodian rice exports particularly to 40 selected importing partners. Several approaches are utilized for estimating the parameters of the gravity model. It is found that the exchange rate regime, land reforms, historical ties, and trade expansion especially with the EU, ASEAN, and China are instrumental in determining the level of Cambodian rice exports. In particular, the EU offers robust potential for agriculture exports from developing countries and is being considered as a lucrative market for primary commodities for such economies (Yatsenko et al., 2017).

The European Union can be considered as the world's largest market for agriculture accounting for nearly 20 percent of total agriculture trade (Huchet-Bourdon & Pishbahar, 2009). Although imports of rice in the EU region are highly protected from many developing and least developed countries, at the same time, it is the major rice export destination for some developing countries (Raimondi et al., 2012). The EU region has appeared as a net importer of rice as the area for rice cultivation is rather small relative to Asian rice-growing economies and has been narrowed considerably during the last 25 years (Kraehmer et al., 2017). According to the International Trade Centre, the top four global rice exporting economies include India, Thailand, Vietnam, and Pakistan. All these four countries are provided with some sort of preferential treatment for rice exports to the EU. For instance, the EU approved 9 specific basmati rice varieties (8 Indian, 4 Pakistani and, 3 common) to be eligible to enter into the EU region under the duty-free and quota-free regime in August 2004. The 'basmati' rice is the special long grain aromatic rice having unmatched flavor which is able to fetch price premium in the world markets especially in the EU. Moreover, agreement to preferential treatment to Thailand's rice provided for a Tariff Rate Quota of 13500 tonnes of semi-milled and milled rice at zero duty, applicable since September 2005. Recently under the Europe-Vietnam Free Trade Agreement (EVFTA) effective since August 2020, the EU has offered an annual rice quota of 80,000 tonnes originating in Vietnam and liberalized any trade in broken rice. Nearly two-thirds of the European rice consumption is met through local production and the rest is fulfilled by imports of different rice varieties from the world. Figure-I presents that the EU-27 is a net importer of rice since 2001, moreover, the gap between rice imports and exports at the harmonized system (HS) four digits, *i.e.*, HS-1006 has also widened over the years with the highest trade deficit of US$ 888 million reported in the year 2020. Total imports and exports of rice in the year 2020 were US$ 2,928 million and US$ 2,039 million respectively.

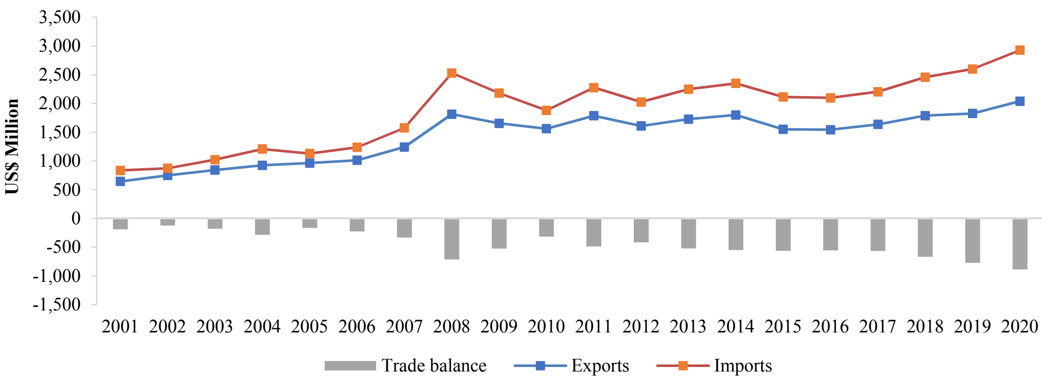

Figure 1. The EU-27 Trade Statistics for Rice (HS-1006)

This research aims to examine the determinants of rice exports in the European Union (EU-27) region by top rice exporting economies namely, India, Thailand, Vietnam, and Pakistan. The motivation of this study is to contribute to the existing literature pertaining to the dynamics of the top four rice exporters and how it complements the import demand of the EU-27 region. Our chosen setting adds value to the existing literature in the following ways. This study would enhance the literature on the determinants of rice exports from the top rice exporters to the typical rice importing region. The prior literature mainly focused on rice exports in the context of a single country such as Thuong (2018), Kea et al. (2019), Bui and Chen (2017), and others. Moreover, this study uses production price indices for rice rather than general price indices. As rice is a staple for many countries, the demand appears relatively inelastic. In extraordinary events such as the Global Financial Crisis of 2007-08 and the COVID-19 pandemic when global trade was slowed down imports of rice in the EU-27 region witnessed a robust increase. In addition, both dynamic and static gravity panel data models are employed and compared for the first time in the context of this unique setting. All of the four top rice exporting economies are developing Asian countries with a sound agriculture base.

Results of the study reveal that rice yield, exchange rate, distance between importing and exporting countries, and rice production price index for importing region are primary determinants of rice exports to the EU-27. Both dynamic and static panel gravity models are statistically meaningful, however, the autoregressive scheme turns out statistically insignificant. The rest of the paper is structured as follows. Section 2 reviews the existing literature. Section 3 discusses the relevant rice regimes in Asian economies as well as in the EU. Data and methodology are discussed in section 4. Results are explained in section 5 and section 6 concludes the study.

2. Literature Review

The academicians and researchers have made multiple attempts to explore the determinants of agricultural trade flows. This section highlights some existing literature that explores the determinants of agricultural as well as rice trade flows. Dawe (2002) reviews the evolving structure of the global rice market during the period 1950-2000. It distinguishes three different phases based on the level of stability, trade orientation, and historical trends. The post-1980s period is marked with low price volatility of rice and remained relatively stable whereas it remained quite unstable since world-war II.

By augmenting the gravity model, Atif et al. (2017) analyze the determinants of agriculture exports of Pakistan. It is found that variables including the effect of common border, culture, colonial history, trade agreements, exchange rate, and customs tariffs are major factors affecting the level of agriculture exports from Pakistan. Their study is based on Pakistan's agriculture exports to 63 countries over the period of 1995-2014 and the study endorses the significance of the stochastic significance of gravity model for the sample period employed. Khalid et al. (2020) point out that gross domestic product (GDP) of trading partners and foreign direct investment (FDI) is directly related to the volume of food trade whereas the exchange rate of importing country has a negative impact on South Asian Regional Cooperation (SAARC) countries including Pakistan, India, Bangladesh, and Sri Lanka. In an attempt to explore a complementary trade relationship between Turkey and the EU, Atici and Guloglu (2006) argue that economic size, EU's local population, the Turkish population in the EU, and being non-Mediterranean are major factors influencing Turkish fruit and vegetable exports to the EU region. Similarly, Yatsenko et al. (2017) contend that the Deep and Comprehensive Free Trade Area (DCFTA) agreement between Ukraine and the EU is instrumental for enhancing the Ukrainian agriculture sector by means of exports and compliance with advanced Sanitary and Phyto Sanitary (SPS) measures. The study conducted by Ghazalian et al. (2012) explores the determinants of beef exports by developing a gravity model and estimate the parameters of the model using the Poisson generalized method of moments (GMM) for trade flows between 42 countries. They observe that cost of production, price of output and production are statistically meaningful factors that determine the level of beef exports. Moreover, it is argued that beef is a differentiated product that faces significant non-tariff barriers and rigidities. Erdem and Nazlioglu (2008) develop a gravity model which entails population, arable land, Turkish population residing in the EU, dummy variable for custom union, and a dummy variable for the non-Mediterranean country as additional explanatory variables. Using data over 1996-2004 for Turkish agricultural trade flows to the EU, their study reveals that economic size, importer's population, Turkish population living in the EU, the non-Mediterranean climatic environment, EU-Turkey customs union, distance, and arable land are determinants of Turkish agricultural trade flows toward the EU.

Researchers also examine the commodity-specific bilateral trade. The pioneering study of the commodity-specific gravity model is carried out by Koo and Karamera (1990) in which they use wheat as a commodity and replace the gross domestic product (GDP) with farm income. Kea et al. (2019) identify the factor affecting Cambodian rice exports using the dynamic panel gravity model. The historical ties, exchange rate policy, agricultural land reforms and export expansion appear as the key factors that promote Cambodian rice exports. Similarly, the impact of trade agreement in boosting Vietnam's rice exports is analyzed by Tran et al. (2019). The structural gravity model is employed in their study to the quantity effect of the trade agreement on exports. It is argued that Vietnamese trade agreements are poorly negotiated at least in the case of rice exports. Koo et al. (1994) demonstrate the utility of the gravity model in examining determinants of meat exports and point out commodity specific. It reveals that subsidies, trade policies, distance, and production capacity of livestock have an important role in explaining global trade patterns. Using select vegetable commodities, Karamera et al. (2011) test the effect of exchange rate fluctuation in determining the level of trade and document the positive effect of both short- and long-term volatility on trade flows of vegetables. In a recent attempt, Nguyen (2020) examines the factors influencing Vietnam's rice and coffee exports to the world. Their research aims to figure out the effect of 'behind-the-border' factor in the stochastic frontier gravity model setting and finds that the 'behind-the-border' factor is statistically significant in explaining the level of rice and coffee exports from Vietnam to the world. The Association of Southeast Asian Nations (ASEAN) group countries are among the major destinations of Vietnamese rice and coffee whereas export opportunities are also available in the EU market for both rice and coffee exports. Thu et al. (2019) investigate the determinants of Vietnamese handicraft exports to the top 50 export destinations over the period 2007-2017. It is found that the GDP of both importing and exporting countries, trade openness of Vietnam, common language, and the common membership of Vietnam and importing country in Asia-Pacific Economic Cooperation are statistically meaningful factors in explaining handicraft exports from Vietnam.

The existing literature is quite rich in exploring determinants of trade flows in the context of the commodity-specific, overall agriculture sector, and in general trade scenarios. Moreover, studies are mostly concentrated in the context of a single country as well as for the overall region. This particular study however explores the unique characteristics of exports from top four rice exporting countries to the EU region.

2.1 Rice Regimes in Top Four Asian Rice Exporters and in the EU

This section reviews the major rice reforms adopted by top rice exporting countries including India, Pakistan, Thailand, and Vietnam. It also outlines the rice importing regime in the EU along with the EU's preferential treatment for importing rice from the above-mentioned top exporting countries.

India is the second-biggest producer and consumer of rice in the world and among one of the only two basmati rice suppliers in the world. India turned from a net importer in the mid-1960s to the net exporter of quality rice by the early 1990s. The major shift in the Indian rice sector is backed by UNDP and FAO-sponsored projects for the development and use of hybrid rice technology. Several international agencies like United Nation Development Programme, Food and Agriculture Organization, Asian Development Bank, and International Rice Research Institute have supported Research & Development carried out by India in the early 1990s. It received USD 8 million between 1990 and 2000. India has also registered Geographical Indication (GI) for many rice varieties including Basmati varieties in the EU providing a competitive advantage over Pakistani counterparts. It allows Indian exporters to earn at least 100 percent more price premium than without having GI. Basmati is a premium product for both India and Pakistan. India has established a specialized entity Basmati Export Development Foundation' for product promotion and specialization. Other notable authorities include Agriculture & Processed Food Products Export Development Authority (APEDA), Cuttack and Indian Agriculture Research Institute (IARI), National Rice Research Institute (NRRI), Indian Institute for Rice Research (IIRR). Since the 1990s, the Indian government has been facilitating rice producers and farmers under different programmes including a subsidy on fertilizer, seeds, energy and water for irrigation, low-interest loans, cheap crop insurance, high tariffs to block food imports, and support prices for more than 20 crops. India possesses 28 research institutes for R&D activities related to rice. It has developed around 490 rice varieties so far which include 93 hybrid rice varieties. Among them, 29 varieties are of Basmati rice. The Government of India has introduced the Merchandise Exports from India Scheme (MEIS) through Foreign Trade Policy which provides a subsidy of 5 percent of the free-on-board value of rice.

Rice is considered as the third-largest crop in Pakistan which accounts for around 19 percent of the total area for food grains. Two major rice varieties produced in Pakistan include long grain aromatic basmati rice and non-basmati coarse rice (also called IRRI rice). The government in the 1970s under their nationalization plan of many domestic privately held industries nationalized rice milling in 1976 and set up the Rice Export Corporation. The corporation set nominal rates of assistance estimates for basmati paddy during the 1960s and 1970s. Farmers barely received half of what they would have under free markets. The newer military regime in 1977 returned the rice mills to the private sector and the rice sector underwent gradual liberalization. Till 1987, provincial authorities were the primary governing body that influenced domestic markets through licensing rules, export quotas, and others. Reforms in the 1990s were instrumental in enhancing rice production and exports from Pakistan. The government-owned organization, that is, the Rice Export Corporation of Pakistan was abolished and a private sector nominated body, that is, the Rice Exporters Association of Pakistan (REAP) came into existence that still stands. Government intervention has reduced substantially since the 1990s and rice production and exports from Pakistan have touched new records.

Thailand's major varieties of rice include white rice and jasmine rice. Thailand's government's efforts remain instrumental in evolving rice sector including (1) Income Guarantee Scheme (2010-11), and (2) Rice Pledging Scheme (2011-12). The income guarantee scheme facilitated rice producers by setting reference prices of un-milled rice every week. It entails that if a farmer sells their rice less than the reference price, they would receive compensation equal to the price difference. In this way, farmers were guaranteed a minimum income even their crops underperformed because of disease or flood. In June 2011, rice prices were at a record high and Thailand was the world's leading exporter when Thailand supplied 28.79 percent of the rice to the world (Poramacom, 2014). The rice pledging scheme refers to buying rice at an above-market price. Farmers use rice as collateral against loans from Bank for Agriculture and Agriculture Cooperation. Farmers need to deliver un-milled rice before they get paid any money. In a recent rice policy of September 2017, the Thai government approved US$ 2.6 billion to implement three schemes to assist rice producers and easing downward pressure on prices at harvest. The first scheme includes an on-farm mortgaging programme for 2.0 million tonnes of main-crop paddy, which ran from 1 November 2017 to 28 February 2018. Under the programme, participating farmers received THB 10 800 (USD 322) per tonne for Hom Mali and glutinous paddy, while producers of white paddy and Pathum Thani fragrant paddy received THB 7 200 (USD 215) and 8 500 (USD 253) per tonne, respectively. Another THB 1 500 per tonne (USD 45) would be availed to compensate farmers for storage costs, while THB 1 200 per rai (USD 223 per hectare) would go to support harvesting and quality improvements, for a maximum of THB 12 000 (USD 358) per household. The other two separate schemes, each running from 1 October 2017 to 30 September 2018, allowed farmers to avail credit to encourage them to delay the sale of 2.5 million tonnes of paddy, and target to stockpile another 8.0 million tonnes of paddy by providing interest subsidies to processors and traders agreeing to store supplies for two to six months.

From being the chronic importer of rice in the 1980s Vietnam has transformed itself among the world's largest exporter. The food security argument has weighed heavily in the balance of policy objectives mentioned and therefore the Government of Vietnam has kept tight control on the volume of rice exports ever since it resumed rice exports in 1989. Vietnam's paddy area is usually kept around 4 million hactar. The Mekong River Delta (MRD) is the largest rice production region in Vietnam, contributing 55% of national rice and 90% of the exports. According to the World Bank, Vietnam owns the highest irrigated land in Southeast Asia. Resolution on food security: Maintain 3.8 million ha of rice land, expected output will be 41-43 million tons with annual quantity for exports is 4 million tons. According to the World Bank, so far there have been 558 licenses foreign investment of USD 2.86 million. The total implemented capital of USD 1.39 billion. Primary investors are Taiwan, Hongkong, France and China. Vietnam owns the highest irrigated agricultural land in Southeast Asia. Most of the rice irrigated areas are applied with an active irrigation drainage system. The government of Vietnam has abolished the rice export quota on May 1, 2001. It boosted Vietnam's rice exports significantly. Before the decision, the rights to export rice under the national quota have been allocated to two regional state-owned trading enterprises, *i.e.*, VINAFOOD I and VINAFOOD II (Neilsen, 2003). Until 1998 the Vietnamese rice regime has also consisted of an export tax. It was levied in a view of shifting some of the rents from quota holders to the government in the form of tax revenue. The government of Vietnam has introduced an export subsidy simultaneously with the removal of the export quota. Rice exporters receive a subsidy of VND 180 per export dollar. The government also operates a Price Stabilization Fund to monitor prices on fertilizer. When international prices rise, funds are disbursed to normalized domestic prices. The policy remained significant in improving rice production (Davidson, 2002).

Rice is imported in the EU region in accordance with the procedures laid out in rice policy. The rice regime in the EU is governed under Common Agricultural Policy (CAP) which has been in effect since 1963. The regulation 16/64 issued during the mid-1960s was the major step towards the establishment of a common market for rice. The CAP liberalized intra-regional rice trade by the gradual elimination of almost all tariff and non-tariff trade restrictions and adopted a common external mechanism for rice imports originating from non-EU member countries. Major reforms related to rice were introduced in 2003. These reforms include lowering the level of intervention price drastically by 50 percent and annual intervention purchases were reduced to 75,000 metric tons. To protect local rice producers within the EU region, the rice farmers were set to be compensated by the provision of an area-based support system which implied a rate equivalent to regional reference yields multiplied by €177 a tonne. It has provided the framework for gradual rationalization of all tariff and non-tariff measures in intra-union trade and set a common frontier for imports from non-member countries.

3. Method

This research employs a panel of four top rice exporting countries, namely India, Pakistan, Thailand, and Vietnam, observed over the period 2001-2019. All these four economies belong to the Asian continent. This study uses aggregate exports of each country to the overall EU-27 region as a dependent variable because of the fact that EU members adopted a uniform policy framework. The data sources used in collecting data on variables are as follows: International Trade Centre (ITC), World Bank, and Food and Agriculture Organization (FAO). The Table 1 provides summary statistics for the full sample as well as for individual countries. Notably, the highest volatility of rice exports (in logarithm form) to the EU correspond to Vietnam which is followed by Pakistan and India. Moreover, the production price index (rice) for exporting countries exhibits greater volatility. In particular, the highest volatility in the rice production price index corresponds to Pakistan. Regarding log area harvest, Pakistan exhibits relatively greater volatility which is followed by Thailand, Vietnam, and India. Similarly, exchange rate volatility is also highest for Pakistan. The average log yield is highest for Vietnam whereas log yield is highly volatile for India.

Table 1. Descriptive statistics

Variables	Full Sample		India		Pakistan		Thailand		Vietnam	
	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.
log (Exports)$_{it}$	4.36	1.19	5.00	0.57	4.37	0.76	5.35	0.39	2.72	0.77
log (GDP)$_{it}$	5.68	1.11	7.22	0.57	5.17	0.45	5.68	0.47	4.66	0.69
log (GDP)$_{jt}$	9.35	0.21	9.35	0.22	9.35	0.22	9.35	0.22	9.35	0.22
log (Area Harvest)$_{it}$	2.28	1.01	3.77	0.02	0.96	0.10	2.36	0.07	2.02	0.03
log (Yield)$_{it}$	10.51	0.23	10.43	0.11	10.43	0.10	10.31	0.03	10.87	0.09
log (Exchange Rate)$_{it}$	5.63	2.58	4.15	0.19	4.60	0.33	3.75	0.11	10.02	0.22
log (Population)$_{jt}$	5.81	0.02	5.81	0.02	5.81	0.02	5.81	0.02	5.81	0.02
Production Price Index (Rice)$_{it}$	8.04	17.73	9.50	13.69	9.86	24.29	5.05	18.47	7.76	13.29
Production Price Index (Rice)$_{jt}$	1.49	12.10	1.49	12.10	1.49	12.10	1.49	12.10	1.49	12.10

Note. Full sample means pooled data for all four top rice exporting countries including India, Pakistan, Thailand, and Vietnam. The time period covered ranges between 2001 and 2019. Where, 't' represents the time period, 'i' reflects importing country and 'j' indicates the exporting region.

The gravity model of international trade has been widely used and remained the most successful tool for empirical studies in international trade. This model mimics the gravitational theory of Newtonian physics which states that two bodies attract each other proportional to the product of their masses and inversely proportional to the square of the distance between them. The gravity model of trade implies that trade flows between two countries are directly related to the income of these countries and inversely proportional to the square of the distance between them (Chaney, 2008). Since pioneering work by Tinbergen (1962), the model has been notorious in explaining international trade flows. Mathematically, it can be expressed as:

$$\text{Trade Flows}_{ij} = \theta_0 \cdot \text{GDP}_{it}^{\theta_1} \cdot \text{GDP}_{jt}^{\theta_2} \text{D}_{ij}^{\theta_3} \quad (1)$$

After taking the logarithm, the linear form of the model is as follows:

$$\ln(\text{Trade Flows}_{ij}) = \theta_0 + \theta_1 \cdot \ln(\text{GDP}_{it}) + \theta_2 \cdot \ln(\text{GDP}_{jt}) + \theta_3 \cdot \ln(\text{D}_{ij}) \quad (2)$$

Some studies have used a cross-sectional modelling approach to estimate the parameters of the gravity model. These studies include Breuss and Egger (1999), Buch and Piazolo (2001), Sapir (2001), and others. However, most of the other studies are based on panel data modelling techniques (such as Nitsch, 2000; Eger, 2002; Fukao et al., 2003). In line with the previous studies, this study employs panel data modelling approaches to estimate the parameters of gravity model. After augmenting standard model with other variables, the modified static gravity model can be expressed mathematically as,

$$\begin{aligned} \ln(\text{Exports})_{it} &= \alpha_0 + \alpha_1 \cdot \ln(\text{GDP})_{it} + \alpha_2 \cdot \ln(\text{GDP})_{jt} + \alpha_3 \cdot \ln(\text{Area Harvest})_{it} + \alpha_4 \cdot \ln(\text{Yield})_{it} \\ &+ \alpha_5 \cdot \ln(\text{Exchange Rate})_{it} + \alpha_6 \cdot \ln(\text{Population})_{jt} + \alpha_7 \cdot \ln(\text{Distance})_{ij} + \alpha_8 \cdot \text{PPI}_{it} + \alpha_9 \cdot \text{PPI}_{jt} + \text{e}_{ijt} \quad (3) \end{aligned}$$

Following Kea et al. (2019), Bekele and Mersha (2019) and others; this study also estimates the dynamic gravity model augmented with other relevant variables. The dynamic model can be expressed as follows:

$$\begin{aligned} \ln(\text{Exports})_{it} &= \beta_0 + \beta_1 \cdot \ln(\text{Exports})_{i(t-1)} + \beta_2 \cdot \ln(\text{GDP})_{it} + \beta_3 \cdot \ln(\text{GDP})_{jt} + \beta_4 \cdot \ln(\text{Area Harvest})_{it} + \beta_5 \cdot \ln(\text{Yield})_{it} \\ &+ \beta_6 \cdot \ln(\text{Exchange Rate})_{it} + \beta_7 \cdot \ln(\text{Population})_{jt} + \beta_8 \cdot \ln(\text{Distance})_{ij} + \beta_9 \cdot \text{PPI}_{it} + \beta_{10} \cdot \text{PPI}_{jt} + \text{u}_{ijt} \quad (4) \end{aligned}$$

where, ln(.) is the natural logarithm. '*i*', '*j*', and '*t*' denote exporting economy, importing region, and time period, respectively. '$Exports_{it}$', the dependent variable, is the exports of four specified Asian economies to the European Union (27) countries and '$Exports_{it-1}$' is the lag of the dependent variable. 'GDP_{it}' is the nominal gross domestic product for four Asian countries whereas 'GDP_{jt}' is the aggregate nominal gross domestic product of EU (27). '$Distance_{ij}$' is the distance in km between considered Asian countries and EU. These three variables are in line with the standard gravity model of Tinbergen (1962). '$Area\ Harvest_{it}$' and '$Yield_{it}$' are areas utilized for harvesting rice crops measured in billion hectares and yield of rice crop for four Asian countries, respectively. Area harvest for the exporter country is expected to be positively related to the level of exports as excess supply of rice is contingent on more area harvested. Studies such as Erdem and Nazlioglu (2008) also argue about the significance of arable land in enhancing level of exports. Similarly, Koo et al. (2006) also reveal statistically significant and positive relationship between agriculture trade flows and arable land available. The crop yield proxy temperature, precipitation, and other environmental factors that affect agriculture production (Backhaus et al., 2015). Tey and Radam (2011) also provide evidence on demand elasticity for rice imports in Malaysia mainly from Thailand and Vietnam. '*Exchange Rate*$_{it}$' is the currency exchange rate corresponding to each of the four Asian countries per unit of euro (EUR). In the economic literature, exchange rate is also an important determinant for level of trade flows. Atif et al. (2016) augment standard gravity model with exchange rate and confirm the role of exchange rate in determining general and agricultural exports. '*Population*$_{jt}$' is the population in millions for EU (27) countries. Many studies including a recent study by Guan et al. (2020) document positive relationship between importing country's population and trade inflows. 'PPI_{it}' and 'PPI_{jt}' are changes in producer price indices for Asian countries and for the EU, respectively. Kraehmer et al. (2017) suggest that prevailing commodity prices in both importing and exporting countries affect the level of rice trade flows between countries. Their study examines the rice prices for the four Asian countries including Cambodia, India, Thailand and Pakistan which was ranged between US$ 355 and US$ 430 for milled rice whereas prices for milled rice in the EU were considerably higher, for instance, similar Italian rice was marked € 640 in March 2015. 'u_{ijt}' is a normally distributed error term.

Before we estimate static panel gravity model as presented in Equation (3), Hausman specification test is used to distinguish between fixed and random-effect panel data approach. It sets the null hypothesis that no statistically meaningful different exists between fixed and random effect models. Random-effects and fixed-effects panel data models however do not allow lagged dependent variables in the model as these models are dynamic. Arellano-Bond (Arellano & Bond, 1991) and Arellano-Bover/Blundell-Bond (Blundell & Bond, 1998; Arellano & Bover, 1995) dynamic panel estimators are notorious but both are generally designed for micro-panel, *i.e.*, small T and large N panels (Roodman, 2006). On the contrary, this study uses a panel of four countries that are observed over 2001-2019. Labra and Torrecillas (2018) argue that a difference generalized method of moment (GMM) is recommendable when the period is long. Therefore, this study uses the said model for estimating the parameters of the modified gravity model as presented in Equation (4).

4. Results and Discussion

Trends in the level of exports of the top four rice exporting countries to the EU-27 are provided in Figure-2. Panel A of Figure 2 presents Pakistan's exports of rice to the EU-27 region. Value of exports was reached to US$ 344.4 million in 2019 witnessing an increase of 5.7 percent as compared to that in 2018 and exhibits an overall increasing trend. Italy remained the top export destination of rice exports by Pakistan which accounts for around 20.3 percent share in Pakistan's rice exports to the EU-27. It is followed by Belgium (18.7 percent) and Netherlands (16.3 percent). An abrupt increase in Pakistan's exports of rice (see panel (a) of Figure 2) is accompanied by a significant drop in India's exports to the EU (see panel (b) of Figure 2) over the period 2018-2020 is mainly backed by the European Commission reduction on maximum residue limit for Tricyclazole to 0.001 parts per million (ppm) from 1 ppm – a fungicide widely used by Indian farmers. Pakistan and India compete in the European market for their shares on basmati rice whereas Vietnam and Thailand are exporting non-basmati rice. As presented in panel (b) of Figure 2, India's exports of rice to the EU-27 region amounted to US$ 208.4 million in 2019 posted an increase of 27.6 percent from 2018. The top export destination in 2020 was the Netherlands which accounts for around 35.8 percent of Indian rice exports to the EU-27 which is followed by France (19.1 percent), Germany (18.6 percent) and others. Similarly, Vietnam's exports of rice to the EU-27 touched US$ 44.1 million in 2020 reflecting an increase of 29.7 percent as presented in panel (c) of Figure 2. France, with a share of 27.7 percent, is the top exporting destination for Vietnam which is followed by Italy (15.1 percent), Germany (12.7 percent), and others. Rice exports from Vietnam to the EU-27 exhibit a volatile but mixed trend with a robust increase in the last couple of years. Panel (d) of Figure 2 illustrates the trend in Thailand's exports of rice to the EU-27. It is evident that exports were reached US$ 249.5 million in 2020 showing a decline of 2.2 percent. Top destinations for Thailand's exports of rice to the EU include France with a share of 32.6 percent, Netherlands (14.7 percent), Belgium (12.6 percent), and others.

The overall trend in rice exports to the EU-27 is favorable for Pakistan, India, and Vietnam however the adverse trend is observed for Thailand since 2008. These four countries together account for around 29 percent of the total rice import in the EU-27 region during the year 2020.

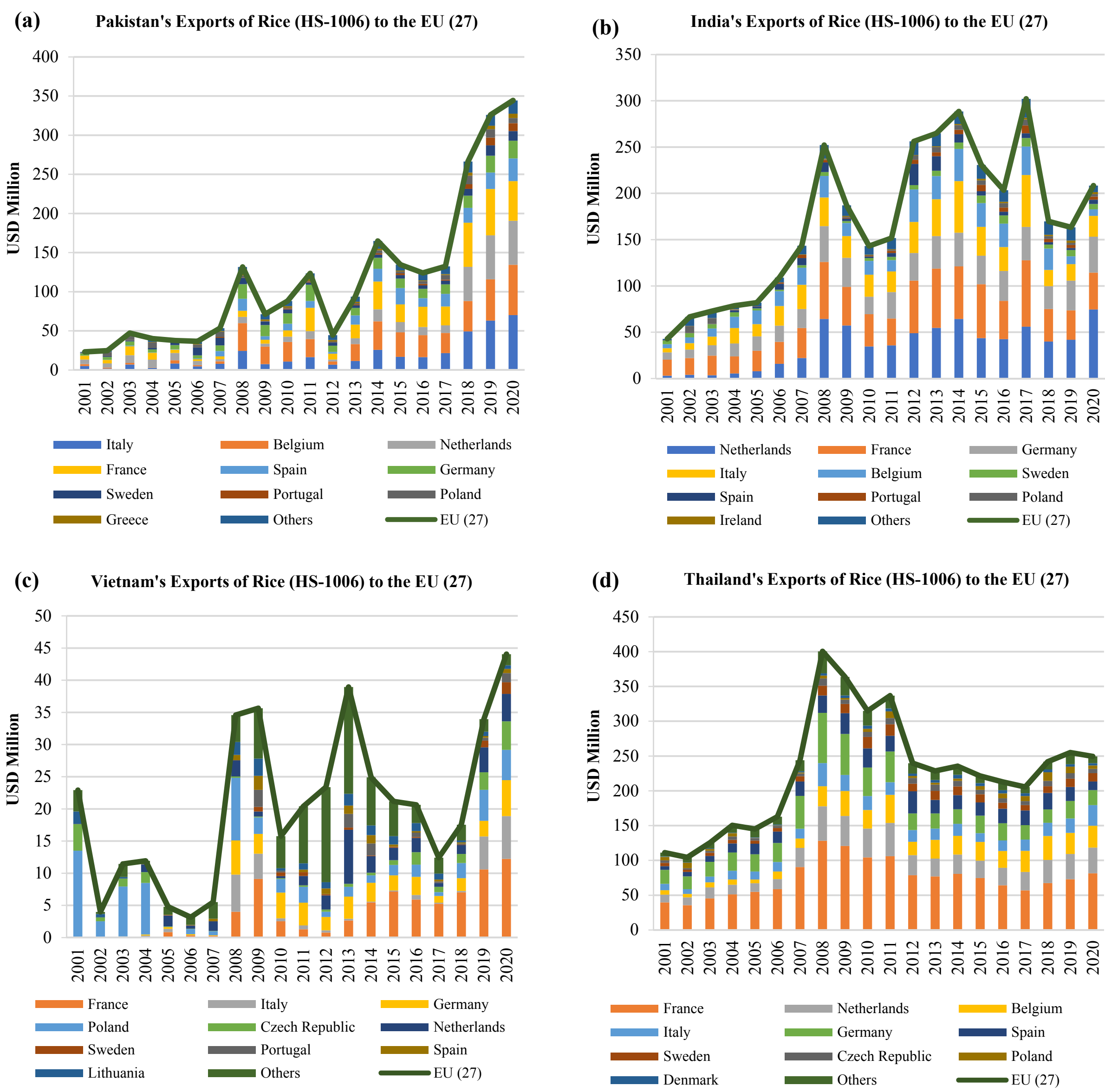

Figure 2. Rice exports of selected Asian countries to the EU

To determine the stationarity of the variables employed in the panel models presented in Equations (3) and (4), this study uses the Breitung type unit-root test (Breitung, 2001) as this study is based on a balanced panel. As presented in Table 2, variables are either stationary at level or at a first difference. Subsequently, variables are introduced in the same form in estimating parameters of the gravity model panel data. Hausman test, as presented in Table 3, does not reject the null hypothesis and highlights the appropriateness of the random-effect approach for modelling static panel data models.

Table 2. Panel unit root tests (Breitung-type unit root tests)

Variables	Test Statistics (at level)	Test Statistics (at first-difference)
log $(Exports)_{it}$	-0.109	-3.072*
log $(GDP)_{it}$	4.693	-3.875*
log $(GDP)_{jt}$	1.417	-4.223*
log (Area Harvest)$_{it}$	-1.671**	-
log $(Yield)_{it}$	0.980	-2.707*
log (Exchange Rate)$_{it}$	1.787	-4.454*
log $(Population)_{jt}$	5.272	-2.376*
log $(Distance)_{ij}$	-	-
Production Price Index $(Rice)_{it}$	-3.948*	-
Production Price Index $(Rice)_{jt}$	-5.239*	-

Note. * denotes coefficients are significant at 1% level of significance, ** at 5% level of significance, *** at 10% level of significance.

Table 3. Results of Hausman Specification Test

	Fixed-Effect Estimates (b)	Random-Effect Estimates (B)	Difference (b − B)	$\sqrt{\text{diag}(V_b - V_B)}$ S.E.
log $(GDP)_{it}$	0.724	0.699	0.024	0.317
log $(GDP)_{jt}$	0.725	0.544	0.181	0.589
log (Area Harvest)$_{it}$	0.780	-0.005	0.786	1.071
log $(Yield)_{it}$	-1.887	-1.857	-0.031	0.296
log (Exchange Rate)$_{it}$	1.326	1.512	-0.187	0.663
log $(Population)_{jt}$	4.471	-1.881	6.352	10.182
log $(Distance)_{ij}$	0.439	-0.166	0.606	0.910
Production Price Index $(Rice)_{it}$	0.001	0.001	0.001	0.001
Production Price Index $(Rice)_{jt}$	0.014	0.015	-0.001	0.001

Note. b (Fixed effect estimator) = consistent under Ho and Ha;

B (Random effect estimator) = inconsistent under Ha, efficient under Ho;

Test: Ho: difference in coefficients not systematic (Random effect model is appropriate);

$\chi^2(4) = (b - B)'[(V_b - V_B)^{-1}](b - B) = 0.80$; $\text{Prob}(\chi^2) = 0.997$.

Results for both static and dynamic panel models are provided in Table 4. As mentioned earlier, the former is estimated using the random effect model whereas the latter is estimated using the difference GMM model. Both models are statistically significant at a 1 percent level of significance as predicated by *p*-value corresponding to χ^2 statistics. The rice yield in the top four rice-producing countries appears to be statistically but negatively related to rice exports to the EU-27. Specifically, a percentage increase in change in yield tends to decrease change in rice exports by 0.94 percent and 1.86 percent when using dynamic panel and static panel model respectively, assuming all other things constant. This result contradicts the economic rationale. A potential justification is a fact that countries use fungicides, pesticide and other chemicals to boost their crop yield, however, dynamic non-tariff measures in the EU restricts entry of rice with certain limits. A prime example is a recent reduction in 'Tricyclazole' limits by the EU which pushed rice exports from India to a downward trajectory.

The official exchange rate is positively associated with rice exports from the top four rice exporting countries to the EU-27 which is in line with the economic theory, that is, the depreciation of local currency makes domestic products cheaper in the international markets. At *ceteris paribus*, a percent increase in change in exchange rate causes changes in rice exports to increase by nearly 1.5 percent as estimated by both dynamic and static panel regression models. The positive relationship between the exchange rate and rice exports is consistent with the prior studies such as Bui and Chen (2017) and Kea et al. (2019). For the distance between exporting countries and importing regions, contrasting relationships are found when coefficients are estimated through dynamic and static panel models. A negative relationship between distance and exports of rice, observed using a static panel approach, makes more sense and is in line with the underlying theory of gravity model of trade (Marti et al., 2014). The coefficient of distance reveals that a percentage increase in the distance leads exports of rice to decrease by 0.17 percent, assuming all other things constant. Finally, the production price index for rice in the EU-27 turns out positively and statistically significant when estimated across both models. Specifically, a percentage point increase in the rice production price index in the EU-27 region tends to increase change in exports by roughly 2 percent, at *ceteris paribus*. This result is fairly logical in a way that the higher price of locally produced rice provides an incentive for substituting cheap imported rice and is also in line with the previous study such as Tey and Radam (2011).

Table 4. Empirical results for panel models—random effect and difference GMM

Variables	Static Panel		Dynamic Panel	
	Coefficients	z-statistics	Coefficients	z-statistics
Δ log (Exports) $_{t-1}$	-	-	-0.03	-0.24
Δ log (GDP) $_{it}$	0.70	0.96	0.43	0.91
Δ log (GDP) $_{jt}$	0.54	0.56	0.63	0.74
log (Area Harvest) $_{it}$	-0.01	-1.19	1.27	1.45
Δ log (Yield)$_{it}$	-1.86 **	-2.09	-0.94 ***	-1.78
Δ log (Exchange Rate) $_{it}$	1.51 *	4.42	1.46 *	4.83
Δ log (Population) $_{jt}$	-1.88	-0.19	21.89 ***	1.89
log (Distance) $_{ijt}$	-0.17 ***	-1.85	0.69 *	4.06
Production Price Index (Rice)$_{it}$	0.01	0.26	0.002	0.79
Production Price Index (Rice)$_{jt}$	0.02 *	3.32	0.013 *	4.59
Constant	1.41 ***	1.92	-9.05 *	-2.86
Wald Chi-squared	25.93		27.96	
p-value	0.000*		0.000*	

Note. * denotes coefficients are significant at 1% level of significance, ** at 5% level of significance, *** at 10% level of significance.

5. Conclusion

Exports of rice are an important source of foreign exchange for major rice exporting Asian economies. This research is particularly devoted to exploring factors affecting rice exports to the European Union (EU-27) region. Using static and dynamic panel data modelling approaches, this study concluded that rice yield; exchange rate regime; distance; rice inflation and population of the importing region are instrumental in determining the level of rice exports from the top four rice exporting economies to the EU-27 region. This analysis is based on the panel of export flows of the top four rice exporting countries toward the EU-27 over 2001-2019.

The contributions of the study are threefold. First, the dataset used in this study is recent and unique. The study tested both dynamic and static models for the aforementioned research problem. The panel data is employed to overcome issues such as heteroscedasticity, serial correlation and multicollinearity. Second, this study adds to the existing literature by exploring determinants for export flows from the top four rice exporters including India, Pakistan, Thailand, and Vietnam to the EU-27 region. These top four countries enjoy some sort of preferential treatment in the EU-27 market which is the largest importer of agricultural products from the world. Third, the augmentation of the gravity model using rice production price indices for both importing region and exporting countries rather than using general price indices. Rice is considered as the second most common staple and fluctuations in prices are very unlikely to proxy the trends in general inflation.

A few recommendations can be made for enhancing rice exports to the EU-27 region. First, rice-producing countries need to minimize the level of aflatoxins such as tricyclazole as SPS measures for agriculture products are far more stringent in the EU-27 as compared to any other region. Second, policymakers should adopt a competitive exchange rate regime and must control rice prices relative to the price prevailing in the EU-27 region in order to boost their exports. Thirdly, more populous countries in Europe have greater demand for imported rice, so exporters need to focus on these markets.

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