RESEARCH ARTICLE

Is Policy Greasing the Wheels of Global Palm Oil Trade?

Shweta Adhikari   Dikshit Poudel ⓘ   **Munisamy Gopinath** *ⓘ

Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602, USA

Abstract: Oil palm is the major source of edible oil and feedstock consumed in the world. This study examined the determinants of global palm oil trade with attention to the effects of trade policies using a gravity model, PPML estimator, and the data from 1988-2020. Palm oil's dramatic trade growth in recent years can be attributed to the economic growth of large countries, the proximity of partners and policies. Trade agreements increased crude and refined palm oil trade by up to 8 and 4 percent of the global import value, respectively. Further, the effects of policy changes due to COVID-19 and the recent export ban in Indonesia are also quantified.

Keywords: Palm oil; Gravity model; Trade policy; COVID-19; Indonesia's export ban

1. Introduction

Oil seeds form a critical link in the global supply chain by virtue of their wide use—edible oil for consumers, livestock feed, oleochemicals for industrial use, biofuel for transportation, cosmetics and others [1]. Among oil seeds, oil palm (*Elaeis guineensis*) is not only the major source of edible oil consumed in the world but also a major ingredient in biofuel production. In addition, its by-product, palm kernel meal, is a major livestock feed, especially in Asian countries. The annual consumption of palm (and kernel) oil is 82.45 million metric tons, which is 39.43 percent of the global oil consumption [1]. Palm oil is demanded in more than 150 countries but is commercially supplied by about 13 tropical countries.[①] Not surprisingly, palm oil and related products are extensively traded across countries—according to the United States Department of Agriculture, USDA [2], global oil palm imports (quantity) grew by more than 600 percent between 1988 and 2020. Palm oil trade also carries high economic importance to major producers (Indonesia and Malaysia) and major consumers (China and India). That is, the livelihood of millions of smallholders and landless workers in Indonesia and Malaysia, which together contribute 84 percent of the global

---

① Malaysia, Indonesia, Nigeria, Colombia, Cote d'Ivoire, Papua New Guinea, Thailand, Congo, Kenya, Liberia, Brazil, Guatemala, and Mexico.

---

*Corresponding Author:

Munisamy Gopinath, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, 30602, USA;
Email: m.gopinath@uga.edu

production, as well as the composition of Chinese and Indian diets, are interlinked by the palm oil supply chain [3,4].

Various factors have been cited as reasons for this surge in global palm oil trade: Gross domestic product (GDP) growth of large emerging economies hungry for more protein in their diets (China and India)—for example, the Organization for Economic Cooperation and Development (OECD)—Food and Agriculture Organization (FAO) [5] found that per capita income growth raises the consumption of edible oil by 2.7 percent per annum between 2008-2017; price competitiveness relative to other edible oils such as soybean or rapeseed or canola oil (Figure 1); and contiguity of producing, processing and consuming nations, mostly in Asia [6,7]. Likewise, palm oil offers a comparative advantage to producers because unit land of oil palm cultivation can produce more vegetable oil than any other crop [8]. Also, increased plantation, productivity and land expansion programs in major exporting countries have narrowed the supply-side gap [9,10].

Understanding the pattern of the global palm oil trade is critical, as noted above, for the food security and economic well-being of a large share of the global population. To date, most studies on the economics of palm oil and its trade have focused on one or a few major producing and/or consuming regions [11-14]. Therefore, the limited focus on understanding palm oil at the global scale obscures the important contribution of more than 100 free trade agreements (FTA) specifying tariff and non-tariff measures (NTM) on the palm oil trade. In recent years, these policies and agreements have been buffeted by economic nationalism, sustainability concerns, and the COVID-19 pandemic.
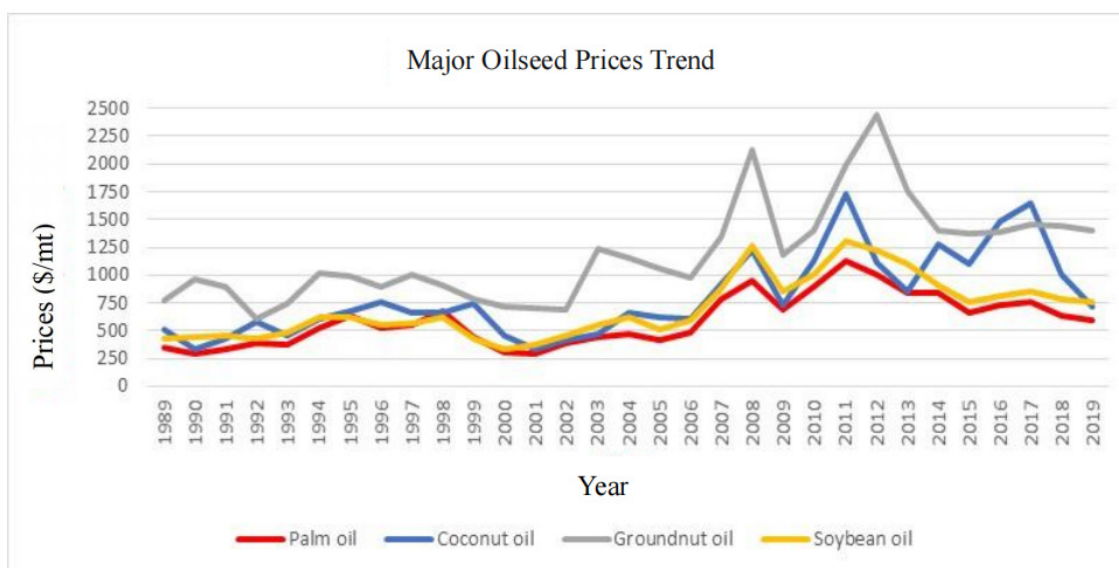

Figure 1. Major oilseeds prices trend (1989-2019).

Source: Global economic prospects, 1989-2019.

Consider the case of India, a major importer of palm oil primarily for food use. Since 1994, India has adjusted its tariff rate to match global price movements of edible oil, swinging between mostly palm oil and occasionally soybean oil [6]. While holding the Most-Favored Nation (MFN) rate at 100 percent, India's applied tariffs on five Association of Southeast Asian Nations (ASEAN) countries—Indonesia, Malaysia, the Philippines, Singapore, and Thailand as part of the ASEAN-India FTA—ranged between 37.5 and 74 percent during 2010-2019 [15].② At

the peak of the COVID-19 pandemic in 2020, India reduced its applied rate to 27.5 percent for a few months before reverting to 37.5 percent in early 2021 [16]. The effects of these trade policy changes, as noted before, have implications for international trade flows, and producers' and consumers' welfare, especially in large developing countries like Indonesia and India [17,18]. In addition, the design of sustainable policies for the future of the palm oil sector requires that the welfare effects of trade policies are evaluated [8].

This study has two-fold objectives. First, it identifies the determinants of global palm oil trade with particular attention to trade policies. For this purpose, a structural gravity model is estimated using the Poisson-Pseudo Max-

---

② Most Favored Nation tariff is a nondiscriminatory tariff charged on imports of all World Trade Organization (WTO) members; ASEAN countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

imum Likelihood estimator at a finer product level—a six-digit Harmonized System (HS)—during 1988-2019. By employing a gravity model of trade flows, commonly used in the international trade literature, this study captures the effect of policies on palm oil trade while controlling for a host of other determinants like population and income growth, and distance between trade partners and any other non-policy association among trading nations. Second, this study identifies varying levels of tariffs (bound, MFN, applied and FTA rates) by country pairs and over time for use in the estimation of the gravity model. The in-depth attention to tariff rates allows for an assessment of the effects of recent trade policy changes attributable to COVID-19 (India) and supply chain issues (Indonesia).

Previewing the results, key gravity variables—economic size, distance, cultural proximity—are major drivers of the global palm oil trade. While policy barriers generally limit trade, bilateral and regional preferential agreements appeared to have alleviated the negative effects of such barriers on the palm oil trade. Specifically, the estimates from the gravity model showed that a major set of trade agreements have been responsible for increasing crude and refined palm oil trade by up to 8 and 4 percent of the global import values, respectively.

The paper proceeds as follows. Section 2 discusses the theoretical gravity model followed by Section 3 explaining the data used in the study, model selection, and estimation procedure. Section 4 presents and discusses the results and estimates the actual effects of trade agreements in the context of the global palm oil trade. Section 5 concludes.

2. Method

The traditional gravity equation specifies the monetary value of bilateral trade as a function of exporter- and importer-specific characteristics including their size and proximity [19-21].③ The multiplicative nature of the above specification allows estimation using natural logarithms of all variables. However, this standard way of estimation will yield biased coefficients because of zero trade flows (those observations will be deleted since the log of zero is undefined). Zero trade flows are critical to assessing trade policy effects, especially for cases of thinner trade relationships that may arise with least developed countries or specific product lines. Specifically, pervasive zero trade values lead to higher conditional variance than the condi-

tional mean [23].

The Poisson-Pseudo-Maximum Likelihood (PPML) estimator is commonly employed for estimation since it retains the multiplicative theoretical structure of gravity models. PPML estimation is robust to alternative patterns of heteroskedasticity and allows the dependent variable to remain in levels (as opposed to logarithms), which permits the inclusion of zero trade flows in the estimation. Following Yotov [24], the PPML specification takes the generic form:

$$Y_{ijt} = \exp\left(X_{ijt}\beta + \delta_{it} + \gamma_{jt} + \theta_{ij}\right) + \epsilon_{ijt} \qquad (1)$$

where,

- i and j denote exporting and importing countries ($i \neq j$), t denotes time in years from 1988 through 2019,
- Y_{ijt} is the dependent variable (the monetary value of bilateral palm oil trade),
- X_{ijt} is the vector of explanatory variables with the corresponding parameter vector β to be estimated,
- ϵ_{ijt} is the error term with mean independence, i.e., E $[\epsilon_{ijt} \mid X] = 0$, and
- δ_{it}, γ_{jt} and θ_{ij} represent the importer- and exporter-time fixed effects, and pairwise fixed effects, respectively.

Previous research has employed economic size, physical distance, policy barriers, cultural, colonial and linguistic ties, memberships in organizations like World Trade Organization (WTO), General Agreement on Tariffs and Trade (GATT), special economic zones, and preferential agreements to represent X_{ijt} in Equation (1) [24-26]. Regarding fixed effects, Anderson and van Wincoop [27] noted that the trade between nations depends on the ease of access to the importer market by exporters given by (a) the direct bilateral resistance and (b) overall resistance to the rest of the world i.e., multilateral resistance. To identify these resistances, i.e. observable and unobservable heterogeneities noted by Feenstra [28], Beckman and Arita [29] and others, the empirical literature has considered adding fixed effects (δ_{it}, γ_{jt} and θ_{ij}) to Equation (1).

A critical issue in estimating Equation (1), particularly with the inclusion of policy variables in X_{ijt}, is the possible endogeneity of regressors. Some studies have acknowledged the difficulty in finding a good instrument set to address the endogeneity problem [30]. However, many studies find that the inclusion of fixed effects such as importer, exporter, time or their interactions can substantially reduce the omitted variables bias [30-32]. Studies on the effects of trade policy (tariff and non-tariff) on aggregate or agricultural trade have employed fixed effects to account for both inward and outward sources of multilateral resistances and unobserved and unconstrained heterogeneity across each importer and exporter [26,30-32].

---

③ Theoretically, the gravity set-up requires intra-national flows, but such data are not available or plagued with significant measurement errors. So, in practice, the traditional gravity equation estimates partial direct effects as advocated by Yotov et al. [19]. Moreover, such specifications are appropriate at the six-digit HS product line, as in this study [20,22].

3. Data, Model Selection and Estimation

3.1 Data

The data assembly begins with the most detailed product classification level—six-digit Harmonized System (HS) classification—for 194 countries over the period of 1988-2019. Trade data (imports in current US dollars) of refined palm oil, RPO (HS-151190), crude palm oil, CPO (HS-151110), and combined RPO and CPO referred to as PO (HS-1511) are from the United Nations Commodity Trade Database [36]. With the focus on product lines and the large number of bilateral pairs over a long period of time, missing data issues are unavoidable. Following the general practice of dealing with zero trade values, data for those pairs that do not trade with each other are filled with zero. The descriptive statistics with mean, deviations, and ranges are presented in Table 1.

The dynamic gravity dataset from the United States International Trade Commission (USITC) version 2 is the source for a majority of gravity variables:

- GDPPC: GDP is the total nominal gross value of goods and services added by all the residents of the country along with added taxes minus any subsidies not included in the value. It is divided by population in the respective period to obtain GDP per capita. These data are primarily sourced from Penn World Table and World Bank's World Development Indicators (WDI) [37].
- Population: Count of all the residents regardless of legal status or citizenship and is a mid-year estimate usually based on the national census.
- Distance: It is measured based on the methodology developed by Mayer and Zignago (2011) [38]. It uses major cities of economic activity and their population for each pair of countries and averages the distance between the pairs weighted by the population.
- Contiguity: It implies that the destination (importer) and origin (exporter) countries share a common border in a particular year. Countries can be bordering rivers or a stretch of land to be contiguous to each other.
- Regions: USITC distinguishes countries into the following 14 regions: Africa, Caribbean, Central America, Central Asia, East Asia, Eurasia, Europe, Middle East, North America, Pacific, South America, South Asia, Southeast Asia, and Southern Pole.
- Language: Data from the Central Intelligence Agency's World Factbook [39] are used to find commonly spoken languages. Languages spoken within each country are broken down according to the population percentage speaking that language as their first language and then ordered according to prevalence. When a language is spoken in both countries, this

Table 1. Descriptive statistics of the variables used (1988-2019).

Variables	N	Mean	SD	Min	Max
Trade value HS-151110 (USD)	1,016,858	222965.70	16600000	0	4280000000
Trade value HS-151190 (USD)	1,016,858	233044.80	9794019	0	2500000000
Trade value HS-1511 (USD)	1,016,858	377358.80	20100000	0	5200000000
GDP per capita importer (USD)	1,016,858	10418.49	18277.47	65.93	198418.30
GDP per capita exporter (USD)	1,016,858	10418.53	18277.47	65.93	198418.30
Distance (kilometers)	1,016,858	7948.71	4522.32	75.82	19734.64
Tariff HS-151110 (%)	54,139	12.53	18.52	0	204.42
Tariff HS-151190 (%)	98,190	8.37	13.75	0	204.42
Tariff HS-1511 (%)	9,271	16.28	25.01	0	204.42
FTA HS-151110 = 1	1,016,858	0.004	0.06	0	1
FTA HS-151190 = 1	1,016,858	0.05	0.21	0	1
FTA HS-1511 = 1	1,016,858	0.001	0.03	0	1
Contiguity = 1	1,016,858	0.02	0.13	0	1
Common language = 1	1,016,858	0.36	0.48	0	1
Same region = 1	1,016,858	0.16	0.36	0	1

Note: HS-151110 and HS-151190 is the harmonized system code for crude palm oil (CPO) and refined palm oil (RPO) at the 6-digit level, and HS-1511 is the harmonized system code at the 4-digit level for CPO and RPO combined. Tariff HS-151110, Tariff HS-151190 and Tariff HS-1511 are the variables used in Equation (2), and FTA HS-151110 = 1, FTA HS-151190 = 1 and FTA HS-1511 = 1 are the variables used in Equation (3). Note that there are 190 exporters involved in the CPO trade and 194 importers (full sample) involved in the RPO trade.

dummy takes value one and zero otherwise.

The missing GDP and population data, about 10 and 4 percent of the total number of observations respectively, are filled from the WDI dataset. Other remaining missing data are filled using the previous years' latest available data from within the dataset. Once the missing values are filled in, there are 1,016,858 observations from combining the gravity and trade data.

Tariff data were not available for all the countries for each year from a single source. A number of sources are used to assemble tariff data. The MFN tariff data are sourced from the World Bank database, which provides a simple average tariff rate for the years 1988-2014 [40]. To acquire data from the years after 2014, WTO's Regional Trade Agreement (RTA) database was used. The two databases (United Nations Conference on Trade and Development, UNCTAD and WTO) had a few overlapping years for a cross-check of MFN rates.

After assembling the MFN tariff data, the next step involved getting applied tariff data that came in different forms: Free trade agreements (FTA), preferential trade agreements (PTA), Regional Trade Agreements, Duty-Free Tariff (DFT) for Least Developed Countries (LDCs) tariffs, and others. Common tariffs applied by or on the same region such as the case of the EU and ASEAN were accounted for by countries' year of entry into such agreements. Apart from the readily available data from WTO's RTA portal, individual country documents were accessed for additional data and verification purposes. Some of the tariff finders that aided the process, especially in the context of trade agreements are Canada Tariff Finder, the FTA tariff tool provided by the United States International Trade Administration, ASEAN Tariff Finder, Indian Trade Portal, New Zealand Foreign Affairs and Trade Tariff Finder, and Australian FTA Portal [41-46]. Table 2 gives an example of the Indian CPO tariff schedule from the ASEAN5—India trade agreement.④

3.2 Model Selection and Estimation

The final specification of the gravity model was arrived at after extensive tests on several dimensions detailed below. Two alternative representations of the trade policy variable, the main focus of this study, yield Equations (2) and (3) in the spirit of Yotov [24], and Yang and Hillberry [47]:

Model A

$$Trade_{ijt} = \exp [\beta_0 + \alpha_1 \, lnTariff_{ijt} + \beta_1 \, lnGDPPC_{ijt} + \beta_2 \, lnDistance_{ijt} + \beta_3 \, Contiguity_{ijt} + \beta_4 \, SameRegion_{ijt} + \beta_5 \, SameLanguage_{ijt} + \delta_{it} + \gamma_{it} \,] + \epsilon_{ijt} \quad (2)$$

Model B

$$Trade_{ijt} = \exp [\beta_0 + \alpha_2 \, FTA_{ijt} + \beta_1 \, lnGDPPC_{ijt} + \beta_2 \, lnDistance_{ijt} + \beta_3 \, Contiguity_{ijt} + \beta_4 \, SameRegion_{ijt} + \beta_5 \, SameLanguage_{ijt} + \delta_{it} + \gamma_{it} \,] + \epsilon_{ijt} \quad (3)$$

where,

- i and j denote exporting and importing countries ($i \neq j$), t denotes time in years from 1988 through 2019,
- $lnGDPPC$: Logarithm of the GDP per capita represents the size of participating economies; it is the ratio of the sum of GDPs of importing and exporting countries and the sum of their population,
- $lnDistance$: Logarithm of the distance between the exporter and importer,
- $lnTariff$: Logarithm of tariff rate applied by importing country on the exporter,
- FTA: Free Trade Agreement which takes the value 1 when a trading pair signed a preferential agreement (within the sample period) and thereafter; otherwise it takes the value 0,
- $Contiguity$: Dummy variable which takes a value of 1 if the two countries are contiguous and zero otherwise,
- *Same region*: Dummy variable that takes the value of 1 if the two countries are in the same region; zero otherwise,

Table 2. ASEAN-5—India bound, most favored nation and preferential tariff rate schedule.

Bound rate	Base MFN	Preferential rate imposed by India on ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore, and Thailand)								
		2010	2011	2012	2013	2014	2015	2016	2018	2019
300	100	76	72	68	64	60	56	52	44	37.5

Source: Association of Southeast Asian Nations—India Free Trade Area (AIFTA) Schedule-India to Association of Southeast Asian Nations 5 CLMV, Annex 1 C.F.R. (2011).

---

④ Association of Southeast Asian Nations-5: Indonesia, Malaysia, Philippines, Singapore and Thailand.

- *Same language*: Dummy variable that takes the value of 1 if some of the residents of exporter and importer countries speak the same language, and zero otherwise,
- *α*'s are estimated effect of trade policy (tariffs) on palm oil trade, which are the parameters of interest, and *β*'s are the coefficient estimates of the remaining variables, and
- δ_{it}, γ_{jt} and θ_{ij} represent the importer- and exporter-time fixed effects, and pairwise fixed effects.

First, several other trade facilitation variables—WTO or GATT membership dummy, type of polity, political stability, environmental stringency, and others—were considered. Data for these other variables were taken from the USITC dynamic gravity dataset as well as other sources such as the World Bank. Many of these variables were highly collinear, especially with the fixed effects included in Equation (1)'s estimation. Second, alternative functional forms (log, levels, reciprocal, polynomial) were tested using likelihood ratio (LR) tests and Akaike and Bayesian Information Criteria (AIC-BIC). LR tests along with theoretical consistency of gravity effects aided in the final selection of the linear-log model as shown in Equations (2) and (3). Continuous independent variables (distance, GDPPC and tariff) have been transformed into natural logarithms while categorical ones are retained in levels. The FTA dummy variable in Equation (3) is created to capture the broader impacts of trade liberalization measures of the agreements, not just the tariff cuts [31]. Third, the dependent variable (import) was specified in levels, i.e., nominal value. Yang and Hillberry [47] report that the statistical inference from the LR test of the PPML estimator is sensitive to data scaling of the dependent variable affecting the test of the significance of the model as well as any restrictions placed on its coefficients. The LR test that all coefficients are equal to zero is conducted using two different scales of a dependent variable (in the standard dollar and in million dollars), but the hypothesis was rejected in both instances.

Fourth, as noted at the end of Section 2, the identification of tariff effects on palm oil trade requires the inclusion of fixed effects [21,28]. Many studies on agricultural trade also control for the endogeneity by including importer- and exporter-time fixed effects, and/or pairwise fixed effects.[5] After extensive specification tests using all

three pair-wise fixed effects, Equations (2) and (3) include time-varying directional (importer-year and exporter-year) fixed effects. That is, they account for time-varying sources of multilateral resistances and unobserved and unconstrained heterogeneity across each importer and exporter [27]. Unfortunately, some variables that vary by exporter but are constant across importers and time or that vary by the importer but constant across exporters and time showed collinearity with the pair-wise fixed effects. Such collinearity led to the exclusion of one set of fixed effects, importer-exporter pair-wise fixed effects, as well as the combining of GDP per capita of importing and exporting pairs to arrive at GDP per capita (*lnGDPPC*).

Finally, the study considered inward measures only, i.e., barriers applied by the importing country to the exporting nations, only. Data on export policies are not consistently available, and those effects are likely included in the exporter-time fixed effects. The PPML method of estimation was chosen over traditional approaches, e.g., ordinary least squares, and the inbuilt robust standard errors are used throughout. As mentioned earlier, the PPML estimator can capture the information in the zero trade flows, accounts for heteroskedasticity and allows the estimation of the model with a large set of fixed effects considered [19].[6] While PPML estimation of Equation (2), Model A, directly yields elasticities to calculate the tariff effect on palm oil trade patterns, and the elasticity of FTA dummy will be computed for Equation (3), Model B [16,46,47].

4. Results and Discussion

Recall that the study aims to identify the determinants of global palm oil trade with particular attention to trade policies. This section, first, describes a host of determinants from the gravity model. Then, the impacts of tariffs and FTAs are discussed.

4.1 Gravity Model

The results of the fitted version of the PPML-estimated gravity model are presented in Table 3. The econometric specification of Equations (2) and (3), after the series of validation and sensitivity analysis noted in the previous section, allowed for a variety of characteristics to affect bilateral trade between the countries. Columns 1, 2,

⑤ Disdier and Maretter [34] include importer, exporter and time-fixed effects (FE) separately to measure the impacts of nontariff measures (sanitary and phytosanitary plus technical barriers) on agricultural trade. Hejazi et al. [33] include importer, exporter and product FEs separately to estimate the impact of phytosanitary policy on fruits and vegetables trade. Wang et al. [32] include country-year and country-product FEs while studying the effect of certification policy on imports. Beckman

and Arita [29] include importer and exporter FEs separately to examine the effect of non-tariff measures and tariff-rate-quota on agricultural trade. Similarly, upon including country-sector, country-year, and sector-year FEs, the exogeneity was assured in Harding and Javorcik [48] while studying the effect of investment promotion strategies on foreign direct investment (FDI) inflows.

⑥ The Poisson distribution is the discrete probability distribution, appropriate for the large proportion of zero in the trade data.

and 3 of Table 3 present the results of Equation (2), i.e., Model A, which uses the actual tariff rate for CPO, RPO, and PO employing 54,139, 98,190, and 9,271 observations, respectively. Likewise, columns 4, 5, and 6 present the result of Equation (3), i.e., Model B, which uses the FTA dummy employing 1,016,849 observations in each column. All columns control for the importer-time and exporter-time fixed effects and present robust standard errors. Most estimates of the gravity model for all three products yielded statistically significant coefficients with signs consistent with the predictions of the underlying economic theory. Recall that the coefficients of the (continuous) explanatory variables are elasticities. The elasticities for categorical variables are computed and they are kept beside each coefficient.

The result from Models A and B are consistent throughout with few exceptions. The following description focused primarily on Model A's results, but relates them to those of Model B wherever appropriate. The coefficient estimate of the logarithm of (combined) GDP per capita is positive and statistically significant for all three products: CPO, RPO, and PO. That is, all else constant, an increase in the combined GDP per capita by 1 percent increases trade by 0.76, 0.94 and 1.24 percent, respectively for CPO, RPO and PO (Table 3, columns 1, 2 and 3). The seminal article on PPML estimation—by Silva and Tenreyro [26]—affirmed the positive effect of importers' and exporters' GDP on trade. Wang [51] also found a positive effect of GDP on the palm, rapeseed, sunflower, and soybean oil trade. Likewise, the distance variable has a negative coefficient, which is statistically significant in all three cases. An increase in distance by 1 percent decreases trade by 1.06, 1.13 and 0.73 percent, respectively. Many studies have found that geographical distance discourages trade between countries [16,48]. In addition to distance, tariffs negatively affect trade flows across countries for all three products. The highest response to a 1 percent increase in the tariff rate, according to Model A in columns 1, 2, and 3, is observed in the CPO case (0.75 percent), followed by those of PO (0.66 percent) and RPO (0.45 percent). Alternatively, FTA effects, according to Model B in columns 4, 5 and 6, are higher for PO (3.276 percent), followed by RPO (1.370 percent) and CPO (0.853 percent). Section 4.3 below employs the tariff effects estimated here to quantify the actual impact of trade agreements with further detail.[⑦]

In Table 3 under Model A, countries that are contiguous trade more of CPO (0.74 percent) and RPO (0.545

percent), but the effect appears muted at the aggregated PO level in column 3. It may arise with the simultaneous export of CPO and re-import of RPO by several South-East Asian economies. However, under Model B, with the higher observations, sharing a national border dictates the increment in the aggregated PO trade by 0.895 percent (column 6), which is also statistically significant. Similarly, countries that share a common language also trade more—by 1.563 for CPO and 1.061 for RPO (columns 1 and 2, respectively)—with each other, given the concentration of production in South-East Asia. Fidrmuc and Fidrmuc [53] and Wang [51] also suggest that if a common language is spoken by even a small share of the two countries population, more trade can arise with easy communication of contract terms.

Finally, the same region dummy has a negative but insignificant effect on CPO trade under model A (column 1), but is negative and highly significant under model B (column 4). Consistent and significant under both models, countries in the same region increase RPO trade by up to 4.20 percent (column 2). Part of the explanation may lie in the trade pattern shown in Figure 2, i.e., globally, all regions import CPO mostly from Asia (1988-2019). Moreover, some of the intra-regional trade is likely picked up by the relatively larger contiguity-effect for CPO.

The above results are well aligned with prior literature as well as the real-world context. The positive GDP coefficient corroborates that the demand for major palm oil players—which are some of the world's largest and fastest-growing economies—has increased trade. India, China, and the EU together accounted for more than 78 percent of the total global imports of palm oil in 2019 [36]. As Frankel, Stein and Wei [54] noted, GDP captures the purchasing power, which led to an increase in the protein-based diet in developing countries like India and China in recent years. In the EU case, the launch of Renewable Energy Directive (RED) in 2009 increased the usage of palm oil in biofuels to meet sustainability goals. On the other hand, Indonesia and Malaysia are large exporters likely driven by comparative advantage and economies of scale [55].

While distance has a negative effect on trade in all three products, contiguity appears to play a distinct role. Contiguous countries that extensively trade palm oil are Indonesia and Papua New Guinea, Guatemala and Mexico, Thailand and Malaysia, Singapore and Malaysia, Peru and Colombia, and Honduras and Guatemala. Moreover, significant vertical trade between Singapore (RPO) and Indonesia (CPO) affirms the importance of contiguity in the palm oil trade. While the topographical requirement of oil palm (mostly concentrated in the tropical region) has enabled inter-regional crude palm trade, refineries for

---

⑦ Another version of Model B using only the sample of Model A, observations with actual tariff rates available (restricted sample size), is shown in Appendix 1. The results are consistent except for FTA effects on CPO trade.

Table 3. Gravity model estimates for crude (CPO), refined (RPO) and overall palm oil (PO) trade, 1988-2019.

Variables↓	With actual tariff						With FTA dummy (Full sample)					
	(1) CPO (HS-151110)		(2) RPO (HS-151190)		(3) PO (HS-1511)		(4) CPO (HS-151110)		(5) RPO (HS-151190)		(6) PO (HS-1511)	
	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity
Ln GDPPC	0.755*** (0.115)	0.755	0.936*** (0.0854)	0.936	1.244*** (0.0911)	1.244	0.473*** (0.0984)	0.473	0.684*** (0.0570)	0.684	0.626*** (0.0762)	0.626
Ln Distance	−1.056*** (0.118)	−1.056	−1.133*** (0.0967)	−1.133	−0.733*** (0.110)	−0.733	−1.446*** (0.0635)	−1.446	−1.184*** (0.0521)	-1.184	−1.104*** (0.0528)	−1.104
Ln Tariff HS-151110	−0.755*** (0.226)	-0.755										
Ln Tariff HS-151190			−0.448*** (0.0645)	−0.448								
Ln Tariff HS-1511					−0.660*** (0.102)	−0.660						
FTA HS-151110 = 1							0.617** (0.293)	0.853				
FTA HS-151190 = 1									0.863*** (0.0947)	1.370		
FTA HS-1511 = 1											1.453*** (0.183)	3.276
Contiguity = 1	0.554* (0.319)	0.740	0.435*** (0.151)	0.545	0.0989 (0.138)	0.104	1.211*** (0.362)	2.357	0.553*** (0.0962)	0.738	0.639*** (0.154)	0.895
Common Language = 1	0.941*** (0.112)	1.563	0.723*** (0.0854)	1.061	1.068*** (0.0782)	1.910	0.528*** (0.0940)	0.696	0.918*** (0.0600)	1.504	0.838*** (0.0578)	1.312
Same Region = 1	−0.369 (0.726)	−0.309	1.648*** (0.183)	4.197	0.541*** (0.183)	0.718	−2.452*** (0.521)	−0.914	1.716*** (0.108)	4.562	−0.155 (0.231)	−0.144
Constant	24.12*** (1.502)		20.86*** (1.053)		16.99*** (1.260)		27.31*** (1.007)		21.24*** (0.691)		22.31*** (0.757)	
Importer-Time FE	Yes		Yes		Yes		Yes		Yes		Yes	
Exporter-Time FE	Yes		Yes		Yes		Yes		Yes		Yes	
Pseudo-R-squared	0.971		0.958		0.963		0.940		0.947		0.932	
Log Likelihood	-2.67×10^{10}		-2.76×10^{10}		-2.75×10^{10}		-1.02×10^{11}		-8.16×10^{10}		-1.75×10^{11}	
N	54,139		98,190		9,271		1,016,849		1,016,849		1,016,849	

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Note: The table presents results from the Poisson-Pseudo-Maximum Likelihood (PPML) Estimator. Actual Tariff Rate of CPO, RPO and PO is the parameter of interest for columns 1, 2 and 3; FTA dummies (taking 1 if a particular transaction is under FTA) for CPO, RPO and PO is the parameter of interest for remaining columns. All the equations control for the importer-time and exporter-time fixed effects and standard errors are obtained from the inbuilt robust procedure. Columns 4, 5 and 6 use full samples, and columns 7, 8 and 9 in Appendix 1 using only samples that have the actual tariff rates available (restricted sample size). Tariff HS-151110, Tariff HS-151190 and Tariff HS-1511 are the variables used in Equation (2), and FTA HS-151110 = 1, FTA HS-151190 = 1 and FTA HS-1511 = 1 are the variables used in Equation (3). Elasticity for the categorical variables is obtained as $(e^{coefficient} - 1)$.
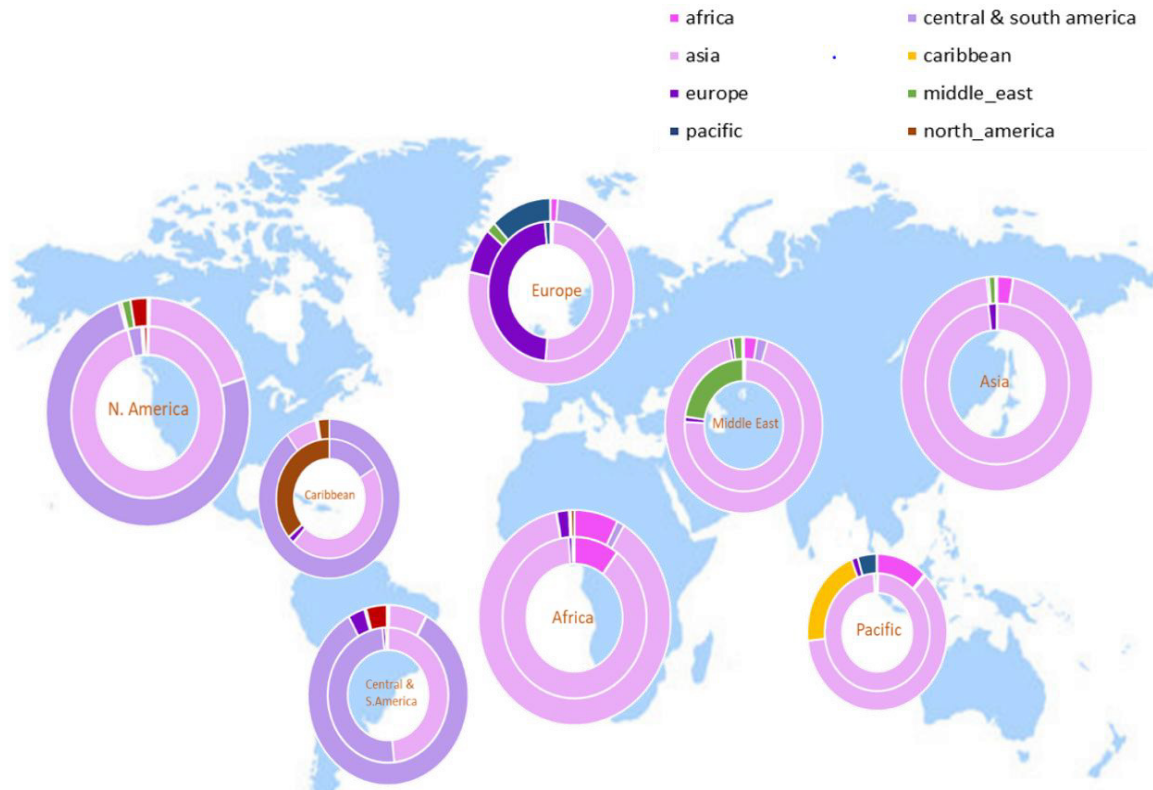
Figure 2. Total palm oil trade flow from 1988 to 2019 between regions.

Note: Outer ring is Crude Palm Oil, and the inner ring is Refined Palm Oil.

Source: World map—iStock by Getty Images; Data—United Nations (2020).

RPO are located throughout the world. For example, refining, bleaching and deodorizing CPO are mainly done by companies like Unilever and Nestle, which have processing plants located across the world [56].

As noted in the introduction, trade policies appear to change more frequently in many countries depending on internal and external events. While India is a case in point, others such as Nigeria and Fiji have also directly altered tariff rates to adjust to domestic market conditions, and the EU trade in palm oil, initially driven by RED, has taken on a revised target, i.e., zero by 2030, on the use of palm oil in biofuel production [6,54,55]. [8] Section 4.3 below takes a closer look at the effect of trade agreements. Prior to that, an attempt is made below to validate the tariff effects estimated in the gravity models using the recent COVID-19 pandemic experience in the Indian context. Also, the sensitivity of palm oil trade to policies is demonstrated using the impact of Indonesia's recent export ban.

4.2 COVID-19, Indonesia's Export Ban, and Palm Oil Trade

Palm oil trade appears sensitive to trade policy changes on the exporter as well as the importer side. To cope with the COVID-19-related price increase of agricultural products, India reduced its palm oil tariff by 10 percentage points in 2020, from the pre-pandemic rate of 37.5 percent on imports from ASEAN-5 countries. The lower tariff came into effect in November 2020. Using the CPO tariff coefficient (elasticity) of −0.75 percent in Table 3, this study estimated that India's import value should have increased by 20.13 percent.[9] Given the 2019 value of imports from Malaysia and Indonesia ($3.28 billion), the lower tariff translated into a $660 million increase in import value. An article from a major Indian newspaper reported that the CPO import jumped by 24 percent in the first quarter of 2020-2021 [61].

---

[8] In Fiji, where the oil is mostly used in food, imports increased by tenfold between 2000 to 2009. To control unexpected increases in obesity (i.e., the high saturated fat content of CPO), the tariff rate was increased from 15 to 32 percent in 2012 [59].

---

[9] Out of India's total edible oil imports, CPO contributes 57 percent in 2020-2021, which is 12.8 percent higher than in 2019-2020 [60]. Note that the change in tariffs from 37.5 to 27.5 equals a −26.60 percent change. Multiplying that with the CPO tariff elasticity gives 20.13 percent.

Another recent event affecting the global palm oil trade is the export ban in Indonesia (April 28, 2022). With Indonesia accounting for 45 (70) percent of CPO (RPO) imports, India again, faced major disruptions. In November 2021, India reduced the tariff on RPO from 32.5 to 17.5 percent owing to supply chain issues and food price inflation [58,59]. [10] Using the RPO tariff coefficient (elasticity) of –0.45 percent from Table 3, this study estimated that India's import value should have increased by 20.67 percent. Given the 2020 value of RPO imports from Indonesia ($82.64 million), the lower tariff translated into an increase in import value of more than $17 million. However, the bilateral trade was suspended for a few weeks until the ban was lifted after three weeks. [11]

4.3 Trade Agreements and Global Palm Oil Trade

Under the original GATT and now WTO, countries impose MFN tariffs on each other but are also allowed exceptions as part of a separate agreement (regional or preferential) with other countries. To interact preferentially, countries form 'blocs' of economic partnership based on geographical proximity, policy alignment and other factors. By signing such agreements countries aim for better market access including trade facilitation, harmonization of sanitary and phytosanitary measures and technical barriers, and protection of intellectual property rights [64]. Many studies have shown that such preferential trading systems increase trade flows [65].

Trade agreements have been one of the key focus areas of major palm oil trading countries. Between 2005 and 2020, major exporters—Indonesia, Malaysia, Thailand, Colombia, Papua New Guinea—have signed FTAs or PTAs with some of the major importers—India, China, European Union Countries, United States—to reduce tariffs and increase trade flows. Few studies have evaluated the effects of such trade agreements collectively or individually in the context of palm oil. Consistently, Table 3 (columns 4, 5 and 6) shows that having FTA can significantly increase the palm oil trade. [12] The positive impact is highest at the aggregated scale, and in RPO followed by CPO. An exception is Wang [51], who found FTA partners traded 77 percent more palm oil than those who did not have such agreements. This study, by focusing on product

lines and directly estimating the tariff elasticity can identify the important role of each of the trade agreements on the palm oil trade. Tables 4 and 5 show the effects of major PTAs and FTAs on CPO and RPO, respectively.

ASEAN-India FTA (AIFTA) came into effect on January 1, 2010. Table 4 shows that the average MFN tariff on CPO imposed by India on ASEAN countries and ASEAN on India before the trade agreement came into effect is 60.37 percent, while the AIFTA tariff is 39.89 percent. The difference between these two tariffs (–33.92 percent) multiplied by the tariff elasticity (–0.75) and further multiplied by the prior year's (2009) trade value ($2751.35 million) quantifies the effect of AIFTA on CPO trade. Table 4 shows that AIFTA is responsible for more than $699.94 million of trade increase in 2010 between ASEAN and India, which is about 3.93 percent of the global CPO trade value. Similarly, ASEAN Trade in Goods Agreement (ATIGA) which was implemented in 2010 was responsible for an increase of more than $583.09 million in palm oil trade within ASEAN countries (3.28 percent of global CPO trade).

South Asian Free Trade Agreement (SAFTA) that came into force in 2004 was signed by seven South Asian countries—India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and Maldives—and later joined by Afghanistan. Table 4 shows that the MFN tariff among these countries averaged 59.51 percent, while the SAFTA rate was lower at 25.16 percent. Thus, SAFTA was responsible for an increase of trade value by 0.44 percent among South Asian countries, but it only yielded a smaller 0.03 percent boost to global palm oil trade compared to AIFTA or ATIGA. Likewise, Colombia which is one of the major CPO exporters signed an FTA with the United States in 2012. Before the FTA, the average MFN tariff between these two nations was 10 percent, which was completely removed in 2012. However, the U.S.-Colombia pact was responsible for only a 0.01 percent increase in global CPO trade.

Table 5 shows the four major trade agreements in the RPO context. ATIGA is responsible for about 1.44 percent of global RPO trade. EU has trade agreements with several pacific States, which supply palm oil and palm kernel oil. Papua New Guinea, one of the top exporters to the EU among pacific states, maintains a duty-free agreement with the EU for major agricultural products including palm oil [67]. EU-Pacific States FTA between Papua New Guinea and EU implemented in 2009 increased RPO trade by more than $140 million, accounting for 1.01 percent of global RPO trade. AIFTA is also responsible for a significant increase in total RPO trade (0.70 percent). Although the EU-Colombia pair had a 36.22 percent difference between MFN and FTA tariff, trade created by their agreement accounted for about 0.01 percent only of global RPO trade.

---

[10] The change in tariffs from 32.5 to 17.5 percent equals a –46.15 percent change. Multiplying that with the RPO tariff elasticity gives 20.67 percent.

[11] Starting January 1, 2023, Indonesia is tightening PO exports by allowing fewer shipments overseas—exporters are allowed to ship six times their domestic supply volume which is two times less than that allowed until 2022 [63].

[12] Harada and Nishitateno [66] report that the import tariff reduction through FTA has increased the wine trade volume in East Asia.

Table 4. Crude palm oil (CPO): Effects of preferential agreements on trade.

Preferential agreement	Year	MFN tariff	FTA tariff	Percent difference between FTA and MFN tariffs	Elasticity	Elasticity × percent change	Prior year trade value ($ million)	Trade increase attributable to FTA ($ million)	Global trade in the year of FTA was implemented ($ million)	FTA induced trade, percent
ASEAN-India Free Trade Agreement (AIFTA)	2010	60.37	39.89	−33.92	−0.75	25.44	2751.35	699.94	17789.00	3.93
ASEAN Trade in Goods and Agreement (ATIGA)	2010	21.50	1.07	−95.02	−0.75	71.27	818.17	583. 09	17789.00	3.28
South Asian Free Trade Agreement (SAFTA)	2004	59.51	25.16	−57.72	−0.75	43.29	2.23	0.97	3632.75	0.03
US-Colombia	2012	10.00	0.00	−100.00	−0.75	75.00	4.20	3.17	23652.26	0.01

Note: The estimated elasticities are obtained from Table 3 using Equation (2).

Table 5. Refined palm oil (RPO): Effects of preferential agreements on trade.

Preferential agreement	Year	MFN tariff	FTA tariff	Percent difference between FTA and MFN tariffs	Elasticity	Elasticity × percent change	Prior year trade value ($ million)	Trade increase attributable to FTA ($ million)	Global trade in the year of FTA was implemented ($ million)	FTA induced trade, percent
ASEAN Trade in Goods and Agreement (ATIGA)	2010	14.80	3.39	−77.09	−0.45	34.69	488.48	169.05	11776.43	1.44
EU- Pacific States FTA (PNG)	2009	12.80	1.98	−84.53	−0.45	38.04	369.86	140.39	13879.26	1.01
ASEAN-India Free Trade Agreement (AIFTA)	2010	55.86	42.23	−24.40	−0.45	10.98	748.26	82.01	11776.43	0.70
EU-Colombia	2012	16.4	10.46	−36.22	−0.45	16.30	8.16	1.33	17193.95	0.01

Note: The estimated elasticities are obtained from Table 3 using Equation (2).

Overall, it suggests that having a preferential trade agreement, FTA in this case, for a specific commodity can increase trade on all three products, significantly. Nonetheless, the net increment in palm oil trade under such trade agreements depends on the magnitude of tariff reduction for specific product lines. With trade policies changing more frequently depending on internal and external events, they potentially cause a steep decline in the global trade of oil palm. These trade-inhibiting measures will likely increase the cost of producers, lower market

prices, and hence, negatively affect the welfare large number of workers engaged in palm and palm oil production, processing and distribution.

5. Conclusions

Despite concentrated production, worldwide consumption via international trade has made palm oil an indispensable link in the global supply chain. This study examined the determinants of global palm oil trade with particular attention to the effect of trade policies, while controlling for a host of other determinants like population and income growth, and distance between trade partners and any non-policy association among trading nations.

Among the key determinants, GDP per capita positively affected palm oil trade in the aggregate as well as its constituents: crude and refined palm oil (CPO and RPO). Distance between countries—often a proxy for transportation costs and implications for infrastructure policies—has negative effects on the import of both CPO and RPO. Likewise, having a common language or being contiguous to a trade partner increased the palm oil trade. As expected, the tariff of the importing country has a significant negative effect on CPO, RPO and aggregated palm oil trade.

To reduce barriers to trade, countries have established bilateral or regional preferential agreements. The effect of having free trade agreements results in significantly higher palm oil trade than that in the absence of such agreements. The estimates from the gravity model allowed for an evaluation of the effects of a selected set of trade agreements. This study found that some of the major trade agreements have been responsible for increasing crude and refined palm oil trade by up to 8 and 4 percent of the global import values, respectively, over the past two decades. Also, the estimated gravity model allowed a simulation of recent policy changes either expanding or limiting trade. For example, recent liberalization by India, due to the COVID-19 pandemic, is found to have increased palm oil trade by up to 20 percent of India's import value. Frequent trade-limiting policy changes will have large negative effects on the global palm oil trade with implications for consumer welfare in India and China, major importers, and the jobs and income of millions in Indonesia and Malaysia, the major exporters.

Author Contributions

Conceptualization: Adhikari and Gopinath; developed methodology: Adhikari and Poudel; data curation: Adhikari and Poudel; formal analysis and tests: Adhikari, Poudel and Gopinath; wrote original drafts: Adhikari; review and edits of the manuscript: Adhikari, Poudel and Gopinath; supervision: Gopinath.

Funding

Data Availability

Data used in this study are available in the public domain. Data were accessed primarily from Penn World Table, World Bank's World Development Indicators, WTO's Regional Trade Agreement (RTA) database, and Central Intelligence Agency's World Factbook. For specific cases, Canada Tariff Finder, United States International Trade Administration (USITA) Free Trade Agreement (FTA) tariff tool, ASEAN Tariff Finder, Indian Trade Portal, New Zealand Foreign Affairs and Trade Tariff Finder, and Australian FTA Portal are used. More detailed information is provided in the Data section of the article.

Conflict of Interest

All authors disclosed no conflict of interest.

References

[1] Oil Crops Yearbook [Internet]. Economic Research Service, United States Department of Agriculture; 2022. Available from: https://www.ers.usda.gov/data-products/oil-crops-yearbook/

[2] Foreign Agricultural Service: Production, Supply and Distribution (PS&D) Database [Internet]. Foreign Agricultural Service; 2020. Available from: https://apps.fas.usda.gov/psdonline/app/index.html#/app/home

[3] Palm Oil [Internet]. Food and Agriculture Organization. Available from: https://ourworldindata.org/palm-oil

[4] Mehraban, N., Kubitza, C., Alamsyah, Z., et al., 2021. Oil palm cultivation, household welfare, and exposure to economic risk in the Indonesian small farm sector. Journal of Agricultural Economics. 72(3), 901-915.

[5] Oilseeds and Oilseed Products [Internet]. Organisation for Economic Co-operation and Development-Food and Agriculture Organization; 2019. Available from: https://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2022-2031_5778f78d-en

[6] Carter, C., Finley, W., Fry, J., et al., 2007. Palm oil markets and future supply. European Journal of Lipid Science and Technology. 109(4), 307-314. DOI: https://doi.org/10.1002/ejlt.200600256

[7] Tandra, H., Suroso, A.I., Syaukat, Y., et al., 2022. The determinants of competitiveness in global palm oil trade. Economies. 10(6), 132.
DOI: https://doi.org/10.3390/economies10060132

[8] Qaim, M., Sibhatu, K.T., Siregar, H., et al., 2020. Environmental, economic, and social consequences of the oil palm boom. Annual Review of Resource Economics. 12, 321-344.
DOI: https://doi.org/10.1146/annurev-resource-110119-024922

[9] Abdul, I., Wulan Sari, D., Haryanto, T., et al., 2022. Analysis of factors affecting the technical inefficiency on Indonesian palm oil plantation. Scientific Reports. 12(1), 3381.
DOI: https://doi.org/10.1038/s41598-022-07113-7

[10] National Academy of Sciences, 2014. The nexus of biofuels, climate change and human health. National Academies Press: Washington DC.

[11] Robins, J.E., 2021. Oil palm: A global history. The University of North Carolina Press: Chapel Hill, North Carolina.

[12] International Policy and Market Drivers of Indonesian Palm Oil Demand [Internet]. International Council on Clean Transportation; 2019. Available from: https://theicct.org/publication/international-policy-and-market-drivers-of-indonesian-palm-oil-demand/

[13] Priyati, R.Y., 2018. Determinants of global palm oil demand: A gravity approach. Economic Journal of Emerging Markets. 10, 148-164.

[14] Rifin, A., 2014. The effect of crude palm oil export tax on export and prices. ASEAN Journal of Economics, Management and Accounting. 2(1&2), 82-95.

[15] Framework Agreement on Comprehensive Economic Cooperation Between the Republic of India and the Association of Southeast Asian Nations, Bali [Internet]. Available from: https://asean.org/framework-agreement-on-comprehensive-economic-cooperation-between-the-republic-of-india-and-the-association-of-southeast-asian-nations-bali/

[16] Oilseeds: World Market and Trade. India Tariff Cut Boosts Palm Oil Imports [Internet]. United States Department of Agriculture; 2020. Available from: https://downloads.usda.library.cornell.edu/usda-esmis/files/tx31qh68h/4t64hc74m/g445d5441/oilseeds__1_.pdf

[17] Euler, M., Schwarze, S., Siregar, H., et al., 2016. Oil palm expansion among smallholder farmers in Sumatra, Indonesia. Journal of Agricultural Economics. 67(3), 658-676.
DOI: https://doi.org/10.1111/1477-9552.12163

[18] Taheripour, F., Hertel, T.W., Ramankutty, N., 2019. Market-mediated responses confound policies to limit deforestation from oil palm expansion in Malaysia and Indonesia. Proceedings of the National Academy of Sciences. 116(38), 19193-19199.
DOI: https://doi.org/10.1073/pnas.1903476116

[19] Yotov, Y.V., Piermartini, R., Monteiro, J.A., et al., 2016. An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model [Internet]. World Trade Organization; 2016. Available from: https://www.wto.org/english/res_e/booksp_e/advancedwtounctad2016_e.pdf

[20] Head, K., Mayer, T., 2014. Gravity equations: Workhorse,toolkit, and cookbook.Handbook of international economics. Elsevier: Amsterdam. pp. 131-195.
DOI: https://doi.org/10.1016/B978-0-444-54314-1.00003-3

[21] A Practical Guide to Trade Policy Analysis [Internet]. World Trade Organization and United Nations Conference on Trade and Development; 2012. Available from: https://www.wto.org/english/res_e/publications_e/practical_guide12_e.htm

[22] Baldwin, R., Ismail, N., 2006. Gravity for Dummies and Dummies for Gravity Equations [Internet]. National Bureau of Economic Research Working Paper No 12516. Available from: https://www.nber.org/papers/w12516

[23] Burger, M., Van Oort, F., Linders, G.J., 2009. On the specification of the gravity model of trade: Zeros, excess zeros and zero-inflated estimation. Spatial Economic Analysis. 4(2), 167-190.

[24] Yotov, Y.V., 2022. Gravity at Sixty: The Workhorse Model of Trade [Internet]. CESifo Working Paper No 9584. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4037001

[25] McCallum, J., 1995. National borders matter: Canada-US regional trade patterns. The American Economic Review. 85(3), 615-623.

[26] Silva, J.S., Tenreyro, S., 2006. The log of gravity. The Review of Economics and Statistics. 88(4), 641-658.
DOI: https://doi.org/10.1162/rest.88.4.641

[27] Anderson, J.E., Van Wincoop, E., 2003. Gravity with gravitas: A solution to the border puzzle. American Economic Review. 93(1), 170-192.
DOI: https://doi.org/10.1257/000282803321455214

[28] Feenstra, R.C., 2015. Advanced international trade: Theory and evidence. Princeton University Press: Princeton.

[29] Beckman, J., Arita, S., 2017. Modeling the interplay between sanitary and phytosanitary measures and

tariff-rate quotas under partial trade liberalization. American Journal of Agricultural Economics. 99(4), 1078-1095.

DOI: https://doi.org/10.1093/ajae/aaw056

[30] Mangelsdorf, A., Portugal-Perez, A., Wilson, J.S., 2012. Food standards and exports: Evidence for China. World Trade Review. 11(3), 507-526.

DOI: https://doi.org/10.1017/S1474745612000195

[31] Baier, S.L., Bergstrand, J.H., 2007. Do free trade agreements actually increase members' international trade? Journal of international Economics. 71(1), 72-95.

DOI: https://doi.org/10.1016/j.jinteco.2006.02.005

[32] Wang, X., Zhang, X., Meng, D., et al., 2022. The effects of product standards on trade: Quasi-experimental evidence from China. Australian Economic Review. 55(2), 232-249.

DOI: https://doi.org/10.1111/1467-8462.12458

[33] Hejazi, M., Grant, J.H., Peterson, E., 2022. Trade impact of maximum residue limits in fresh fruits and vegetables. Food Policy. 106, 102203.

DOI: https://doi.org/10.1016/j.foodpol.2021.102203

[34] Disdier, A.C., Marette, S., 2010. The combination of gravity and welfare approaches for evaluating nontariff measures. American Journal of Agricultural Economics. 92(3), 713-726.

DOI: https://doi.org/10.1093/ajae/aaq026

[35] Disdier, A.C., Fontagné, L., Mimouni, M., 2008. The impact of regulations on agricultural trade: Evidence from the SPS and TBT agreements. American Journal of Agricultural Economics. 90(2), 336-350.

DOI: https://doi.org/10.1111/j.1467-8276.2007.01127.x

[36] United Nations Commodity Trade Database [Internet]. Available from: https://comtradeplus.un.org/

[37] World Development Indicators [Internet]. World Bank; 2020. Available from: https://databank.worldbank.org/source/world-development-indicators

[38] Gurevich, T., Herman, P., 2018. The Dynamic Gravity Dataset: 1948-2016 [Internet]. USITC Working Paper 2018-02-A. Available from: https://www.usitc.gov/data/gravity/dgd.htm

[39] World Factbook [Internet]. Central Intelligence Agency. Available from: https://www.cia.gov/the-world-factbook/countries/

[40] Trade Analysis Information System (TRAINS) [Internet]. Available from: https://trainsonline.unctad.org/home

[41] Canada Tariff Finder [Internet]. Available from: https://www.tarifffinder.ca/en/

[42] FTA Tariff Tool [Internet]. USITA. Available from: https://www.trade.gov/fta-tariff-tool-home

[43] ASEAN Tariff Finder [Internet]. Association of Southeast Asian Nations. Available from: https://tariff-finder.asean.org/

[44] Indian Trade Portal [Internet]. Available from: https://www.indiantradeportal.in/

[45] Tariff Finder [Internet]. New Zealand Foreign Affairs and Trade. Available from: https://www.tariff-finder.govt.nz/

[46] Australian Free Trade Agreements Portal [Internet]. Available from: https://ftaportal.dfat.gov.au/

[47] Yang, A., Hillberry, R., 2022. Variable Scaling and Hypothesis Testing in the Gravity Model [Internet]. Available from: https://www.russellhillberry.net/uploads/6/4/1/0/64104535/variable_scaling_and_hypothesis_testing_in_the_gravity_model_el.pdf

[48] Harding, T., Javorcik, B.S., 2011. Roll out the red carpet and they will come: Investment promotion and FDI inflows. The Economic Journal. 121(557), 1445-1476.

DOI: https://doi.org/10.1111/j.1468-0297.2011.02454.x

[49] Anderson, J.E., Larch, M., Yotov, Y.V., 2015. Estimating General Equilibrium Trade Policy Effects: GE PPML [Internet]. CESifo Working Paper No 5592. Available from: https://www.cesifo.org/en/publications/2015/working-paper/estimating-general-equilibrium-trade-policy-effects-ge-ppml

[50] Larch, M., Yotov, Y., 2016. General Equilibrium Trade Policy Analysis with Structural Gravity [Internet]. Working Paper ERSD-2016-08. Available from: https://www.wto.org/english/res_e/reser_e/ersd201608_e.htm

[51] Wang, J., 2016. Analysis and comparison of the factors influencing worldwide four kinds of vegetable oil trade: Based on Gravity model. Modern Economy. 7(2), 173-182.

[52] Filippini, C., Molini, V., 2003. The determinants of East Asian trade flows: A gravity equation approach. Journal of asian Economics. 14(5), 695-711.

DOI: https://doi.org/10.1016/j.asieco.2003.10.001

[53] Fidrmuc, J., Fidrmuc, J., 2016. Foreign languages and trade: Evidence from a natural experiment. Empirical Economics. 50(1), 31-49.

DOI: https://doi.org/10.1007/s00181-015-0999-7

[54] Frankel, J., Stein, E., Wei, S.J., 1995. Trading blocs and the Americas: The natural, the unnatural, and the super-natural. Journal of Development Economics. 47(1), 61-95.

DOI: https://doi.org/10.1016/0304-3878(95)00005-4

[55] Kumar, S., Ahmed, S., 2015. Gravity model by panel data approach: An empirical application with implications for South Asian countries. Foreign Trade Review. 50(4), 233-249.

DOI: https://doi.org/10.1177/0015732515598587

[56] Pacheco, P., Gnych, S., Dermawan, A., et al., 2017. The Palm Oil Global Value Chain: Implications for Economic Growth and Socialand Environmental Sustainability [Internet]. Working paper 220. Center for International Forestry Research. Available from: https://www.jstor.org/stable/pdf/resrep16294.1.pdf

[57] Gourichon, H., 2019. Analysis of incentives and disincentives for palm oil in Nigeria. Gates Open Research. 3, 580.

[58] EU 28: Biofuels Annual (NL9022) [Internet]. United States Department of Agriculture; 2019. Available from: https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_The%20Hague_EU-28_7-15-2019.pdf

[59] Coriakula, J., Moodie, M., Waqa, G., et al., 2018. The development and implementation of a new import duty on palm oil to reduce non-communicable disease in Fiji. Globalization and Health. 14, 1-9. DOI: https://doi.org/10.1186/s12992-018-0407-0

[60] What Indonesia's Palm Oil Export Ban Means for India [Internet]. The Hindu Business Line, 2022 Apr 29. Available from: https://www.thehindubusinessline.com/blexplainer/bl-explainer-what-indonesias-palm-oil-export-ban-means-for-india/article65366502.ece

[61] Palm Oil Import Up, Soft Oil Down Marginally in Nov-Jan Quarter of 2020-21 [Internet]. The Hindu Business Line, 2021 Feb 12. Available from: https://www.thehindubusinessline.com/economy/agri-business/palm-oil-import-up-soft-oil-down-marginally-in-nov-jan-quarter-of-2021-22/

[62] Christina, B., Nangoy, F. Indonesia President Declares End of Palm Oil Export Ban from Monday [Internet]. Reuters, 2022 May 19. Available from: https://www.reuters.com/markets/commodities/indonesia-mps-seek-palm-oil-export-ban-review-industry-warns-storage-2022-05-19/

article33819733.ece

[63] Indonesia to Tighten Palm Oil Exports from January 1 to Ensure Supply [Internet]. The Economic Times, 2022 Dec 30. Available from: https://economictimes.indiatimes.com/news/international/business/indonesia-to-tighten-palm-oil-exports-from-january-1-to-ensure-supply/articleshow/96612802.cms

[64] Balu, N., Ismail, N., 2011. Free trade agreement—the way forward for the Malaysian palm oil industry. Oil Palm Industry Economic Journal. 11(2), 26-35.

[65] Rose, A.K., 2004. Do we really know that the WTO increases trade? American Economic Review. 94(1), 98-114. DOI: https://doi.org/10.1257/000282804322970724

[66] Harada, K., Nishitateno, S., 2021. Measuring trade creation effects of free trade agreements: Evidence from wine trade in East Asia. Journal of Asian Economics. 74, 101308. DOI: https://doi.org/10.1016/j.asieco.2021.101308

[67] Papua New Guinea Trade Policy Framework [Internet]. Division on International Trade and Commodities, United Nations Conference on Trade and Development; 2006. Available from: https://unctad.org/system/files/official-document/ditctncd200310_en.pdf

Appendices

Appendix 1. Gravity model estimates for CPO, RPO and PO trade, 1988-2019.

Variables↓	With FTA dummy (Model B) with restricted sample size					
	(8)		(9)		(10)	
	CPO (HS-151110)		RPO (HS-151190)		PO (HS-1511)	
	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity
Ln GDPPC	0.763***	0.763	0.940***	0.940	1.186***	1.186
	(0.116)		(0.0861)		(0.0902)	
Ln Distance	−1.057***	−1.057	−1.109***	−1.109	−0.644***	−0.644
	(0.128)		(0.0947)		(0.113)	
FTA HS-151110 = 1	0.233	0.262				
	(0.489)					
FTA HS-151190 = 1			0.790***	1.203		
			(0.172)			
FTA HS-1511 = 1					0.536**	0.709
					(0.246)	

Table Appendix 1 continued

Variables↓	With FTA dummy (Model B) with restricted sample size					
	(8)		(9)		(10)	
	CPO (HS-151110)		RPO (HS-151190)		PO (HS-1511)	
Contiguity = 1	0.595*	0.813	0.488***	0.629	0.181	0.198
	(0.332)		(0.155)		(0.136)	
Common language = 1	0.946***	1.575	0.732***	1.079	1.066***	1.904
	(0.111)		(0.0859)		(0.0792)	
Same region = 1	−0.332	−0.283	1.652***	4.217	0.592***	0.808
	(0.767)		(0.181)		(0.189)	
Constant	22.01***		19.35***		14.88***	
	(1.466)		(1.066)		(1.267)	
Importer-Time FE	Yes		Yes		Yes	
Exporter-Time FE	Yes		Yes		Yes	
Pseudo-R-squared	0.970		0.958		0.963	
Log likelihood	-2.70×10^{10}		-2.77×10^{10}		-2.81×10^{10}	
N	54,139		98,190		9,271	

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.