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Egypt's Exports to the ASEAN Bloc Using the Gravity Model (Comparison Between OLS, PPML)

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ABSTRACT: This study aims to analyze Egyptian exports to ASEAN bloc countries during the period 2001– 2021 by applying the gravity model using two methods: OLS and PPML. The basic variables in the model include Egypt's GDP, ASEAN's GDP, Egypt's population, ASEAN's population, and geographic distance, which measure Egypt's exports to the ASEAN bloc. The results of the gravity model show a positive relationship between Egypt's GDP, ASEAN's GDP, ASEAN's population, and Egypt's exports. Conversely, there is a negative relationship between geographic distance and Egypt's exports. We also explain the differences in the effects of the basic gravity model factors on Egyptian exports to the ASEAN bloc by comparing the OLS and PPML methods. The results from the OLS method are larger than those from the PPML method because the OLS method cannot properly handle zero trade values between countries.

KEYWORDS: ASEAN Bloc, Egypt, OLS, PPML, Gravity model, Zero-Trade.

1. INTRODUCTION

Since the 1950s, countries worldwide (developing or developed) have tended to implement economic blocs as a method to increase growth rates, production, and market access. This approach boosts trade between countries, facilitates trade creation, and helps avoid the effects of trade diversion. The ASEAN bloc (association of southeast Asian) is considered one of the most important successful experiences of economic blocs globally, as it includes 10 countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. ASEAN is a regional governmental organization that facilitates economic, political, security, and social integration among its member countries. It also provides a mechanism to resolve disputes between member countries through peaceful means. ASEAN is an official observer at the United Nations and represents a large market that attracts many countries, including Egypt. It has a population of 640 million people, which is approximately 5% of the world's population. Egypt is working to benefit from the ASEAN bloc market to increase its exports and gain greater access to both ASEAN and African markets. Therefore, Egypt is striving to conclude many bilateral agreements with individual bloc countries, as well as agreements with the bloc as a whole.

This study aims to analyze the basic factors of the gravity model that influence the increase of Egyptian exports to ASEAN bloc countries during the period 2001–2021. Since trade between Egypt and some ASEAN countries was zero in certain years, the impact values of the variables in the gravity model became larger than expected when using the OLS method. This is because OLS either excludes zero-valued trade flows or replaces them with a small constant. Therefore, the PPML method will be used for measurement.

The gravity model is one of the most popular empirical tools for analysis in international trade studies (Anderson and Wincoop, 2003). Tinbergen was the first to propose using the gravity equation in international trade research (Tinbergen, 1962). Later, Anderson (1979) comprehensively examined the model, explaining that bilateral trade between two countries is positively influenced by each country's GDP and negatively influenced by the distance between them.

Therefore, the gravity model gained a new dimension in the literature beyond its theoretical foundations, focusing on "proper" econometric specification and extending the model by adding new variables to the equation (Golovka and Sahin, 2021).

Olivero and Yotov (2012), Eaton et al. (2016), and Anderson et al. (2019) demonstrate the importance of dynamic gravity estimation frameworks. In addition, recent gravity literature is extended by numerous works on structural gravity frameworks (Arkolakis et al., 2012; Fally, 2015; Baltagi and Egger, 2016; Larch and Yotov, 2016; Yotov et al., 2016; Beverelli et al., 2018; Heid and Stahler, 2020). At the same time, many studies, such as Herman and Gee (2019), demonstrate significant differences in the effects of trade determinants over time and propose short-run gravity frameworks.

The gravity model is estimated by OLS in this study, but recent literature argues that OLS is inappropriate for gravity applications for several reasons (Krisztin and Fischer, 2015). The longrun linear specification of the gravity model with OLS is unsuitable because bilateral trade often includes zero flows, making log-linearization infeasible. In many cases, trade between country pairs is zero, which creates problem for standard log transformations (Silva and Tenregro, 2006; Helpman et al., 2008; Burger et al., 2009).

In general, two strategies are implemented in empirical studies to address “the problem of zeros.” One approach excludes all zero trade flows from the sample, assuming zeros contain no information. The other replaces zeros with a small positive number, assuming that zero values arise from statistical errors (Golovko and Sahin, 2019).

However, excluding all zero trade flows from the data leads to the loss of valuable information in the model (Eichengreen and Irwin, 1998). Similarly, replacing zeros with a small positive number is an inefficient approach because the choice of this number is not based on theoretical or empirical justification (Linders and De Groot, 2006).

At the same time, the literature shows that even small differences in the constant added to the dependent variable, “trade flows,” can significantly change the estimation results (Burger et al., 2009).

Among the proposed alternative estimation methods, the PPML method suggested by Silva and Tenreyro (2006) has attracted the most attention. Using the log-linear form in empirical gravity models is a classical approach, but it presents several problems, such as heteroscedasticity and issues arising from zero trade flows. Since the logarithm of zero is undefined, trade flows with zero values are excluded from estimation, leading to bias caused by the logarithmic transformation.

This study focuses on the issue of zero-valued trade flows. The log-linear model cannot handle zero trade flows effectively because the logarithm of zero is undefined. Frankel (1997) argues that the main reason for zero trade flows is the lack of trade between small and distant countries, which can be best explained by large associated variables and fixed costs. Rauch (1999) identifies other factors, such as low GDP per capita and the absence of cultural and historical ties, as possible explanations for the lack of trade between countries.

Although the problems arising in the estimation of the log-linear gravity equation have been recognized for a long time, they have only recently been taken seriously (Helpman et al., 2008). Among the alternative estimation methods proposed, the Poisson pseudo-maximum likelihood (PPML) method suggested by Silva and Tenreyro (2006) has attracted the most attention.
Silva and Tenreyro (2006) compared the PPML estimator to alternative estimation methods. The PPML estimator has been widely used in empirical applications of gravity equations because it effectively addresses problems caused by both heteroscedasticity and zero trade flows. This study will focus on zero trade flows and compare the results of OLS and PPML estimations for trade between Egypt and the Asian bloc.

Due to the above, this study attempts to answer the following question: “To what extent do zero trade flows between countries affect the estimated values of variables when using the OLS method compared to the PPML method?”

The rest of the paper is organized as follows: Section 2 analyzes Egyptian exports to the ASEAN bloc countries and the most important commodities exported from Egypt to these countries during the study period; Section 3 describes the variables and the gravity model; Section 4 presents the empirical results and discussion; and Section 5 provides the conclusions.

2. EGYPTIAN EXPORTS TO THE ASEAN BLOC

It is clear from the data that the most important countries for Egyptian exports are Singapore, Malaysia, and Indonesia. In 2001, Egyptian exports to these countries were 86,125; 9,722; and 9,174 thousand dollars, respectively. These values continued to increase, reaching 112,780; 205,321; and 93,933 thousand dollars in 2010, and further rising to 505,410; 106,183; and 105,031 thousand dollars in 2021, respectively. This growth may be due to the large populations of these countries, as well as their commercial importance within the ASEAN bloc compared to other member countries.

The countries with the lowest Egyptian exports are Laos and Myanmar, where exports amounted to 0 and 20 thousand dollars in 2001, respectively. These values remained nearly the same in 2010, reaching 0 and 21 thousand dollars, respectively. Egyptian exports to Laos showed a limited increase, reaching 57 thousand dollars in 2021.

Table (1) Egyptian exports to the ASEAN bloc

Year	Brunei	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam
2001	7	0	9.174	0	9.724	20	403	86.125	8.790	534
2002	27	6	15.579	0	11.257	18	942	60.486	15.612	228
2003	11	6	37.472	0	13.571	68	1.148	50.734	21.154	551
2004	94	772	20.557	11	10.504	0	10.045	135.245	53.875	1.122
2005	657	1.597	19.056	0	13.627	83	7.155	247.105	14.712	632
2006	249	69	24.015	38	9.108	432	615	53.239	3.605	846
2007	143	118	12.564	0	13.655	10	3.363	164.810	5.224	525
2008	185	39	73.402	0	36.520	0	2.288	285.815	12.372	3.020
2009	273	0	95.651	15	26.428	327	12.720	65.721	65.697	26.416
2010	258	14	93.933	0	205.321	21	12.501	112.780	24.461	18.373

2011	455	45	103.070	0	131.640	29	41.877	88.066	22.755	16.455
2012	928	10	97.141	0	150.271	0	15.473	9.825	31.369	12.731
2013	1.094	102	94.430	0	136.618	0	6.682	12.149	22.781	9.577
2014	2.315	204	61.858	3	88.478	22	3.930	46.117	21.674	12.662
2015	5.389	80	75.351	0	89.585	0	3.251	41.335	34.894	17.913
2016	898	417	66.447	0	65.097	0	6.637	126.749	63.034	24.319
2017	1.489	499	91.482	0	73.627	0	16.728	63.078	68.547	21.813
2018	4.579	671	117.048	0	245.345	0	33.662	59.476	28.978	33.534
2019	7.529	1.570	114.165	0	113.061	0	10.561	119.991	75.177	20.775
2020	3.955	1.273	104.937	5	77.219	17	5.946	132.115	25.935	35.028
2021	1.128	1.421	105.031	57	106.183	----	8.118	505.410	37.412	32.909

Source: www.ITC.org

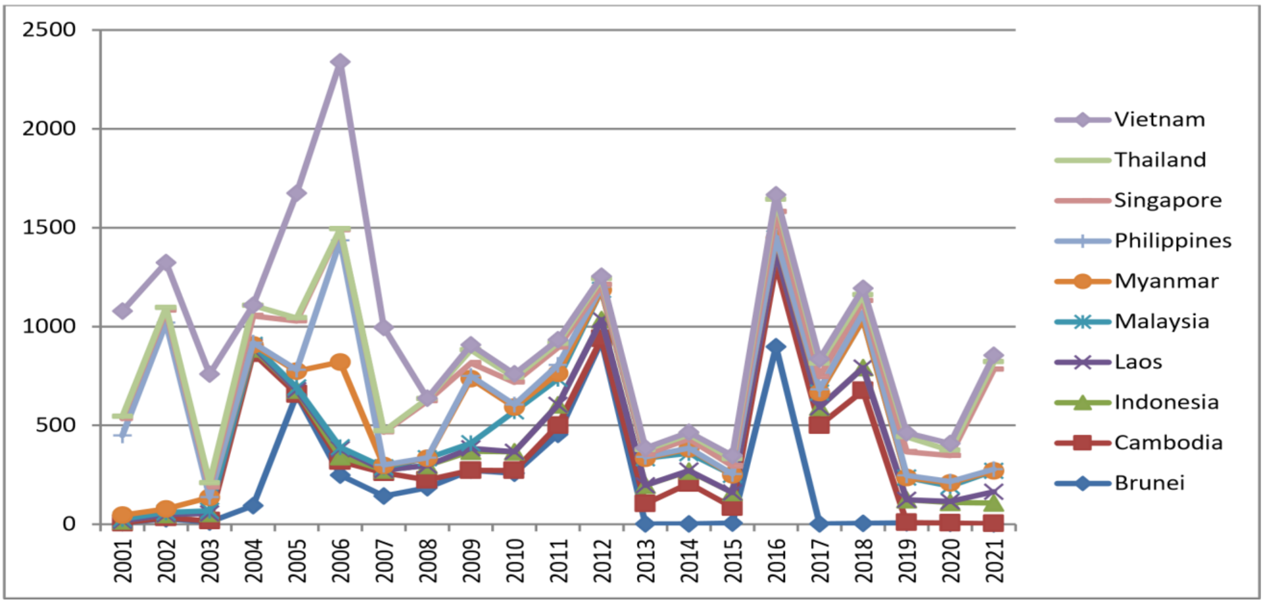

Figure (1)Egypts exports to ASEAN Bloc
Source: www.ITC.org

The most important commodities exported from Egypt to the ASEAN bloc are mineral fuels, mineral oils, and products of their distillation and bituminous substances, which reached 575,038 thousand dollars in 2021; salt, sulfur, earths and stone, plastering materials, lime, and cement, which reached 91,884 thousand dollars in 2021; and edible fruit and nuts, as well as peels of citrus fruit or melons, which reached 83,777 thousand dollars in 2021.

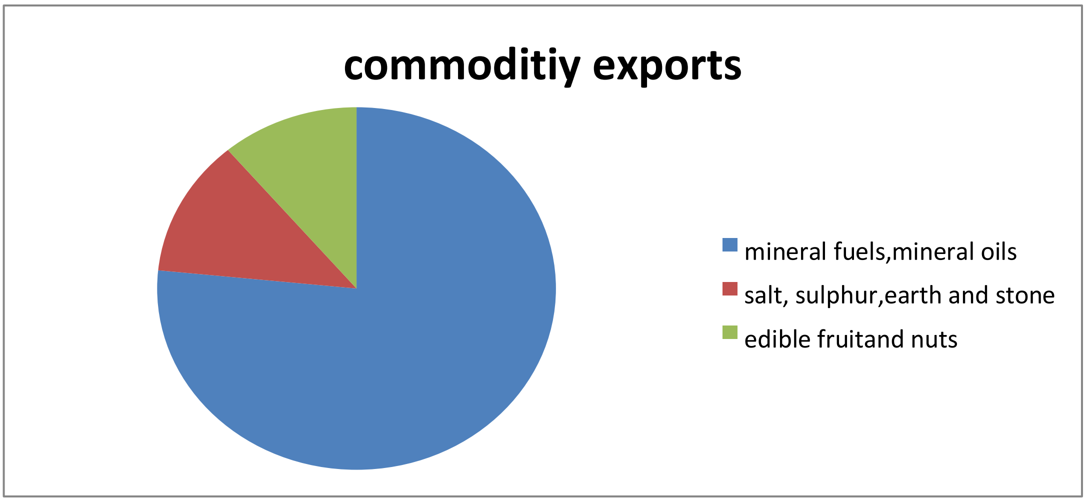

Figure (2) Egyptian commodity exports to ASEAN
Source: www.ITC.org

3. THE GRAVITY MODEL OF EGYPT'S EXPORTS TO ASEAN BLOC

The gravity model of international trade explains bilateral trade flows through the size of trading partners' economies and the distance separating them, which reflects trade costs. The gravity model, used in modern economics since Tinbergen (1962), hypothesizes that the gravitational force between two objects is directly proportional to the product of their masses and inversely proportional to the geographical distance between them.

Thus, the classic gravity model can be expressed by the following equation (Tinbergen, 1962):

$$T_{ij} = g\left(\frac{y\alpha i \;\; y\beta j}{D ij}\right) \qquad (1)$$

Where, T_{ij} is bilateral trade of countries i and j, g is the gravitation constant, y_i (y_j) denotes i (j) country economic size, D_{ij} is the distance between i and j countries, α and ß are parameters. $T_{ij}\ {y_j}^{\beta}$

In recent years, the gravity model has become one of the widely accepted trade models, especially following contributions by Anderson and Wincoop (2003), who added new variables such as population and trade barriers to the equation. Therefore, in this study, we use the classical gravity model equation with the population variable included, expressed in logarithmic linear form as an OLS equation:

$$\text{In } trade_{ijt} = \alpha + \beta_1 + \text{In } GDP_i + \beta_2 \text{ In } GDP_j + \beta_3 \text{ In } P_I + \beta_4 \text{ In } P_J + \beta_5\, D_{ij} + \varepsilon_{ijt} \qquad (2)$$

Where $trade_{ijt}$ is the trade between I(Egypt) and j(ASIAN bloc) at time t
(1999-2022). GDP it indicates GDP of country (i) (Egypt), GDP_{jt} is GDP of countries j (ASIAN bloc), p_i is population of country Egypt, p_j is population of countries ASIAN bloc, D_{ij} is the distance between Egypt and ASIAN bloc 'every country of Asian bloc" , ε_{ij} is the error term, β_1, β_2, β_3, β_4, β_5 are the regression coefficients.

3.1Variables and data sources

We use commodity exports, expressed in thousands of US dollars, as the indicator of bilateral trade flows. Data on bilateral exports are sourced from the International Trade Centre (ITC). The size of each country is represented by the GDP of Egypt and the ASEAN bloc, expressed in millions of US dollars, with data obtained from the International Monetary Fund (IMF). The expected effect of GDP on trade is positive.

The populations of Egypt and the ASEAN bloc countries, obtained from the IMF and expressed in millions, are included, with the expected effect of population on trade being positive. Finally, the distances between Egypt and the ASEAN bloc countries are measured in kilometers between their capitals. This data comes from www.chemical-eclogoy.net, and the expected effect of distance on trade is negative.

We estimate the equation for the period 2001–2022, focusing on trade between Egypt and the ASEAN bloc countries (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam).

3.2 PPML Equation

Several methods have been suggested to deal with the zero flows problem. For example, many empirical studies do not delete zero trade flows but modify the dependent variable using ln(y_{ij} +1) or in (y_{ij}+0.1) to accommodate the logarithmic transformation (Krisztin and Fischer, 2015, p. 8).

To overcome the zero-trade problem, we employed the most common approaches used in the gravity literature. Santos and Tenreyro (2006, 2010) and Martinez (2011) criticized the PPML estimator, suggesting that its results can be biased in the presence of zero trade combined with heteroscedasticity, which may lead to inconsistent estimates. The Poisson probability density is defined as follows:

$\mathbf{Pr(y_i=j/x_i)= exp(-\lambda)\ \lambda^j / j^i\ ,\ j=0,1,2}$ **(3)** Where λ= exp ($x_{i'}\beta$)=exp($\beta_0+\beta_1 x_{1i}$+ ----) (**Santos and tenreyro, 2010, p:1**)

The essential requirement for the PPML estimator to be consistent is the correct specification of the conditional mean E[Y_I|X]=λ=exp($x_{1'}\,\beta$). For this reason, the data do not need to follow a Poisson distribution. More importantly, the PPML estimator is a consistent estimator even when the data are not integers. The vector of parameters of interest β can be estimated by solving the following first-order conditions (Santos and Tenreyro, 2006, p. 645):

$$\Sigma_{i}{}^{n}{}_{=1}\ [y_i - \exp(\ x_i\tilde{\beta})]x_i = 0 \qquad (4)$$

Nevertheless, Poisson estimates tend to under predict the number of zero observations and are generally used in samples with a small number of zeros (Bosker and Garretsen, 2010, p. 209). The PPML estimator allows the estimation of variables without transforming them into logarithmic form (Santos and Tenreyro, 2006).

Since there are zero trade flows between Egypt and some Asian countries, we use the PPML estimator to explain the differences between the OLS and PPML results when zero trade flows are present. The extended gravity model in exponential form, which will be estimated using PPML, is as follows:

$$\mathbf{E}\,(export_{ijt}|\ x) = \exp(\alpha + \beta_1 \text{ In } GDP_{it} + \beta_2 \text{In } GDP_{jt} + \beta_3 \text{In } p_{it} + \beta_4 \text{In } p_{jt} + \beta_5 \text{In } D_{ij}$$

(5) All variables are defined in the variables section.

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Bilateral trade flows were arranged as balanced panel data to estimate the gravity model. Therefore, we conducted unit root tests on the variables using the Levin, Lin & Chu Unit Root Test (Levin et al., 2002, p. 5).

Table (2) Unit root test results

Variables	Statistic	Prob.
E(Export)	-2.978	0.001
GDPi	-1.644	0.050
GDPj	-3.093*	0.001
Pi	-1.998	0.022
Pj	-1.644	0.048

*** The first different**

Based on the results in the table, all variables are stationary at level except for GDPj, which is stationary at the first difference. We also conducted a correlation test using the EViews program to determine whether there are correlations between the variables.

Table (3) Correlation results

	GDPi	GDPj	Pi	Pj
GDPi	1	0.347	0.901	0.058
GDPj	0.347	1	0.359	0.774
Pi	0.901	0.359	1	0.062
Pj	0.058	0.774	0.062	1

Based on the results in the table, the variable (Pi) was excluded due to its correlation with GDPi As is known, two approaches are commonly applied to estimate panel data models: the fixed effects model and the random effects model. Therefore, we conducted the Hausman test:

Table (4) Hausman test results

Test summary	Chi-sq statistic	Chi-sq d.f	Prob.
Cross-section random	0.0000	3	1.000

Based on the results in the table, the p-value indicated that we should use the random effects model rather than the OLS method.

4-Empirical results

We estimate the model using both the OLS gravity model and the PPML gravity model, as shown in Appendix Tables A.1 and A.2. Table 5 presents the estimation outcomes of the gravity model using OLS and PPML methods.

Table (5) OLS and PPML results Comparison

Variable	Coefficient (OLS)	Coefficient (PPML)	t-statistic (OLS)	t-statistic (PPML)	Prob. (OLS)	Prob. (PPML)
C	-3539	15.66	-0.0705	13.528	0.943	0.000
GDPi	0.0327	3.76E-09	1.124	3.187	0.262	0.001
GDPj	0.1379	7.00E-09	50.752	9.752	0.000	0.000
Pj	0.266	1.83E-08	2.641	7.880	0.008	0.000
Dij	-3204.714	-0.00018	-0.5084	-1285	0.611	0.198
R2	0.35	0.31				

The first column reports OLS estimates using commodity exports as the dependent variable. The second column presents PPML estimates using the same data, including zero trade flows between countries.

It is noticeable that the OLS model explains 35%, and the PPML model explains 31% of the total variation (R^2) in Egypt's exports to the ASEAN bloc, both of which are statistically significant. The signs and magnitudes of the coefficients are generally consistent with previous studies. One important point to note is that the coefficients estimated by OLS tend to be larger than those obtained using the PPML estimation.

The table shows the factors affecting Egypt's exports to the ASEAN bloc: GDPi, GDPj, Pj, and Dij. Among these, three variables are highly significant at the 1% level. These include GDPj in both the OLS and PPML models, GDPi in the PPML model, and Pj in both the OLS and PPML models. The coefficients of these variables are positive, while the coefficient for distance (Dij) is negative but not significant at the 1% level.

The estimated coefficient for GDPi in the OLS model is 0.0327, which means that if GDPi increases by 1%, Egypt's exports to the ASEAN bloc increase by approximately 3.27%. In the PPML model, the coefficient for GDPi is 3.076E-09, implying that a 1% increase in GDPi leads to an increase in Egypt's exports to the ASEAN bloc of about 3.07E-07%.

The estimated coefficient for GDPj in the OLS model is 0.137, which means that a 1% increase in GDPj leads to a 13.7% increase in Egypt's exports to the ASEAN bloc. In the PPML model, the coefficient for GDPj is 7.00E-09, implying that a 1% increase in GDPj results in an approximate 7.00E-07% increase in Egypt's exports to the ASEAN bloc.

The estimated coefficient for Pj in the OLS model is 0.266, which means that a 1% increase in Pj leads to a 2.66% increase in Egypt's exports to the ASEAN bloc. In the PPML model, the coefficient for Pj is 1.083E-08, implying that a 1% increase in Pj results in an approximate 1.083E-06% increase in Egypt's exports.

Finally, the estimated coefficient for D_{ij} in the OLS model is 3204.7, meaning that an increase of 1,000 kilometers in distance leads to a 320.47% decrease in Egypt's exports to the ASEAN bloc. In the PPML model, the coefficient for D_{ij} is 0.00018, indicating that an increase of 1,000 kilometers results in a 0.018% decrease in Egypt's exports.

This means that the OLS method generates larger estimates than the PPML method when dealing with zero trade flows between countries because OLS either excludes zero-valued trade flows or replaces them with a small constant.

We therefore accept that the OLS method cannot adequately handle zero trade flows between countries, while the PPML method can address this issue and provide more accurate effects.

5- CONCLUSION

This study aims to demonstrate that the OLS method cannot properly handle zero trade flows between countries, while the PPML method can. We analyzed Egyptian exports to ASEAN bloc countries using the gravity model over the period 2001–2021 with two methods: OLS and PPML. The model included key variables such as Egypt's GDP, ASEAN's GDP, Egypt's population, ASEAN's population, and geographic distance to measure Egypt's exports to the ASEAN bloc.

We compared the effects of these basic gravity model factors on Egyptian exports using both OLS and PPML methods. The results from the OLS method are larger than those from the PPML method because OLS does not handle zero trade flows effectively. As shown in Table 6, there is a positive relationship between Egypt's GDP, ASEAN's GDP, ASEAN's population, and Egypt's exports, while geographic distance has a negative relationship with Egypt's exports.

Table (6) comparison between OLS, PPML result

Variable	Coefficient (OLS)	Coefficient (PPML)
C	-3539	15.66
GDP_i	0.0327	-3.76E-09
GDP_j	0.1379	7.00E-09
P_j	0.266	1.83E-08
D_{ij}	-3204.714	-0.00018

Finally, future studies can explore alternative solutions to the zero-trade problem between other countries and apply different methods within the gravity model framework.

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Appendix

Table A.1 OLS result

Variable	Coefficient	t-statistic	Prob.
C	-3539	-0.0705	0.943
GDP_i	0.0327	1.124	0.262
GDP_j	0.1379	50.752	0.000
P_j	0.266	2.641	0.008
D_{ij}	-3204.714	-0.5084	0.611
R2	0.35		

DW	1.84		
F-statistic	11.523		0.000

We estimate the model using the PPML gravity model to address the zero trade problems. The results are as follows:

Table A.2 PPML result

Variable	Coefficient	t-statistic	Prob.
C	15.66	13.528	0.000
GDP_i	3.76E-09	3.187	0.001
GDP_j	7.00E-09	9.752	0.000
P_j	1.83E-08	7.880	0.000
D_{ij}	-0.00018	-1285	0.198
R2	0.31		
LR-statistic	5.56E+09		0.000