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# Trade Agreements and Agribusiness Export Performance: Ppml Gravity Evidence from Indonesian Palm Oil Hs 1511 (2015–2023)

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**Abstract.** This study examines Indonesia's export performance in an agribusiness product at the HS 6-digit level (HS 1511) over 2015-2023 by combining revealed competitiveness indicators and structural gravity estimation. First, we compute the Revealed Comparative Advantage (RCA) index to assess Indonesia's export specialization relative to world trade. Second, we estimate a Poisson pseudo-maximum likelihood (PPML) gravity model with year fixed effects to identify the roles of destination market size, trade costs, and trade agreement coverage. Bilateral exports are constructed from UN Comtrade, macroeconomic controls are drawn from the World Development Indicators, bilateral distance and dyadic controls are obtained from CEPII, and trade agreement status is coded from DESTA at the dyad–year level using an in-force rule. Results indicate that Indonesia retains a strong revealed comparative advantage (RCA > 1 in all years), although the average RCA declines between early and late sub-periods. Gravity estimates show that destination market size (particularly population) positively predicts exports, while distance reduces expected export values. Importantly, in-force regional trade agreements are associated with significantly higher bilateral exports, approximately 48% larger export values, ceteris paribus, highlighting the relevance of policy-enabled market access alongside traditional gravity fundamentals. These findings emphasize the joint importance of competitiveness, trade-cost reduction, and effective utilization of trade agreements for sustaining and expanding Indonesia's agribusiness exports.

**Keywords:** comparative advantage, gravity model, Indonesia, PPML, trade agreements

## INTRODUCTION

Agribusiness exports remain a critical interface between agricultural transformation and macroeconomic performance in many emerging economies. For commodity producing countries, export earnings support external balance and fiscal capacity, while trade exposure can incentivize upgrading in production, processing, and supply chain coordination. In this context, measuring export competitiveness is not merely descriptive; it provides an applied basis for diagnosing whether a country's agrifood sector is strengthening its position in global markets and whether that performance is consistent with longer run sectoral sustainability. Recent evidence continues to employ revealed competitiveness metrics to evaluate agricultural export positioning, while emphasizing that competitiveness assessments are increasingly intertwined with sustainability objectives and structural constraints (Long, 2021).

At the same time, agrifood trade is being reshaped by a set of contemporary frictions that affect both market access and the ability to sustain competitiveness over time. First, climate change is altering production conditions and, by implication, the distribution of comparative advantages across exporters. Gravity based evidence indicates that climatic conditions and climate heterogeneity between trading partners are associated with systematic differences in agri food export values, suggesting that export performance may increasingly reflect adaptation capacity as much as conventional cost advantages (Bozzola et al., 2023). Second, sustainability related governance has moved from a voluntary niche to a core feature of market competition

in many commodity chains. Recent multi country evidence finds that voluntary sustainability standards can influence export outcomes through channels consistent with an augmented gravity framework, although impacts can differ across tropical commodities and destinations (Bemelmans et al., 2023). Complementary evidence also shows that certification systems can raise measured export quality through productivity and branding mechanisms, implying that the quality dimension of competitiveness has become central to export strategy (Wei et al., 2024). Third, "green" trade barriers and related compliance costs have become salient. Recent research reports that environmental trade barriers can reduce agricultural exports, while financial support and innovation capacity can moderate these effects, reinforcing the view that competitiveness increasingly depends on institutions and capabilities rather than prices alone (P. Zhao & Gao, 2025). Finally, policy uncertainty has intensified in the post pandemic era; recent evidence links trade policy uncertainty to weaker agricultural export performance and highlights that regional trade agreements can partially mitigate adverse effects (Chakradhar et al., 2025).

Regional integration and trade policy architecture further condition the competitiveness of agribusiness exports. Beyond tariff reductions, recent research emphasizes that the depth of preferential trade agreements and associated non tariff provisions can interact with other trade related interventions such as aid for trade, partly through compliance costs and capacity constraints (Stender & Vogel, 2025). In the Asia Pacific, the implementation of the Regional Comprehensive Economic Partnership is also relevant for agribusiness exporters because it can influence the domestic value added embodied in agricultural exports and participation in regional agricultural value chains, particularly when non tariff barriers and trade facilitation improve (S. Xu et al., 2025). In parallel, infrastructure and connectivity initiatives can alter trade costs and reallocate trade patterns; structural gravity evidence on the Belt and Road Initiative suggests measurable trade creation effects in agricultural trade and highlights heterogeneous impacts across partners (Y. Zhao et al., 2024).

Within this evolving environment, Indonesia provides a highly policy relevant case for applied economic analysis. Indonesia is a major exporter of several agribusiness commodities, yet its export performance is exposed to intense competition, tightening sustainability requirements, and heterogeneous demand conditions across destination markets. Empirical studies focused on Indonesian commodities demonstrate the continued use of revealed comparative advantage measures and gravity type frameworks to evaluate competitiveness and its determinants, including for palm oil and coffee (Innayatuhibbah & Ferichani, 2024; Pratiwi, 2021). Commodity specific evidence further highlights that competitiveness can be shaped by macroeconomic and price conditions, including exchange rates and international commodity prices, reinforcing the need to link observed trade patterns to economic mechanisms rather than relying on single index diagnostics (Lugo-Arias et al., 2024). Recent work on Indonesian palm oil exports also underscores that sustainability standards and supply chain constraints are increasingly central to export prospects, suggesting that competitiveness is jointly determined by market access conditions, compliance capacity, and domestic productivity dynamics (Dermoredjo et al., 2025).

Methodologically, these developments motivate an integrated approach that combines competitiveness measurement with an explanatory model of bilateral trade flows. Revealed comparative advantage metrics remain widely used because they offer a transparent measure of export specialization relative to global benchmarks, and recent studies continue to apply RCA based indices to assess competitiveness trajectories in agricultural products (Long, 2021). However, RCA is primarily diagnostic and does not identify the drivers of export performance across destination markets. Gravity models provide the canonical empirical framework for

quantifying how economic size, trade costs, and policy variables shape bilateral trade. Recent applied studies of agricultural exports continue to validate gravity frameworks, including stochastic frontier and related approaches that highlight export potential and efficiency gaps (H. Xu et al., 2023). Moreover, recent research emphasizes the role of trade costs and policy related barriers in explaining export growth through gravity based evidence (Noureen & Mahmood, 2022). The policy relevance of structural gravity is also reflected in recent work that advances estimation and interpretation of gravity models for welfare and policy analysis, underscoring the centrality of gravity methods for evaluating trade cost drivers and trade policy interventions (Heid & Stähler, 2024; Masood & Martínez-Zarzoso, 2024).

Against this background, the present study develops an applied assessment of Indonesian agribusiness export performance by combining two complementary components. First, it measures Indonesia's export competitiveness in selected agribusiness commodities using revealed comparative advantage indicators to characterize specialization patterns and their evolution. Second, it estimates an augmented gravity model for Indonesia's bilateral exports across destination markets to identify key determinants of export performance, with particular attention to economic mass and trade frictions, and where feasible, policy and institutional channels that reflect contemporary trade conditions. This integrated design is intended to move beyond the question of whether Indonesia appears competitive toward identifying which economic factors and trade cost components are most strongly associated with observed export outcomes.

## MATERIALS AND METHODS

### Study scope and commodity definition

The empirical analysis focuses on Indonesian agribusiness exports at the Harmonized System six-digit level, which supports a product specific assessment of competitiveness and bilateral export determinants. The baseline illustration uses HS 1511 (palm oil and its fractions), a major Indonesian agribusiness export with clearly defined six-digit subheadings (151110 and 151190). The same workflow can be applied to other agribusiness commodities by substituting the relevant HS code(s) (United Nations, 2025).

### Data sources and sample construction

This study investigates Indonesia's export performance for an agribusiness product at the HS 6-digit level (HS 1511) over 2015 to 2023. Bilateral export values are obtained from UN Comtrade using the public API and are defined as Indonesia's annual export value to each destination country in current US dollars. Destination country macroeconomic variables are collected from the World Bank World Development Indicators (WDI), specifically GDP (current US dollars) and total population. Bilateral geographic and historical variables are taken from CEPII's distance database, including great-circle distance, contiguity, colonial ties, and common official language indicators. Trade agreement information is constructed from the Design of Trade Agreements (DESTA) dyadic dataset.

The empirical dataset is built as a balanced destination-year panel. First, the list of destination countries is derived from the Comtrade partner reference list (excluding group aggregates). Second, for each destination and year, bilateral exports are merged with WDI macroeconomic variables and CEPII dyadic controls. Third, a dyad-year indicator for trade agreement coverage is merged from the DESTA-based RTA file described below. Observations with missing GDP, population, or distance are excluded. The final regression sample contains 1,745 destination-year observations.

**Competitiveness measurement: revealed comparative advantage**

Export competitiveness is assessed using the Revealed Comparative Advantage index based on the Balassa formulation. RCA compares Indonesia's export specialization in a given product to the corresponding world export specialization for the same product. In practice, RCA for Indonesia in product $p$and year $t$is defined as

$$RCA_{p,t} = \frac{X_{IDN,p,t}/X_{IDN,\cdot,t}}{X_{World,p,t}/X_{World,\cdot,t}}$$

Where $X_{IDN,p,t}$ is Indonesia's exports of product $p$, $X_{IDN,\cdot,t}$ is Indonesia's total exports across products, $X_{World,p,t}$ is world exports of product $p$, and $X_{World,\cdot,t}$ is total world exports. Values greater than one indicate a revealed comparative advantage. RCA series can be computed directly from trade aggregates, and the study uses UNCTADstat RCA definitions and outputs as a consistent benchmark for cross country comparability (UNCTAD, 2019).

RCA results are summarized using time profiles, period averages, and where relevant, comparisons with key competitors. This section is intended to provide a diagnostic map of export specialization before moving to the causal correlates of bilateral export outcomes.

**Gravity model specification**

To identify the determinants of Indonesian agribusiness exports across destination markets, the study estimates an augmented gravity model at the partner year level for each commodity, or at the partner year commodity level if multiple commodities are pooled. The dependent variable is the value of Indonesia's exports of the selected product to partner $j$in year $t$, denoted $X_{j,t}$.

The baseline multiplicative specification is

$$E[X_{j,t}] = \exp\left(\alpha + \beta_1 \ln GDP_{j,t} + \beta_2 \ln POP_{j,t} + \beta_3 \ln DIST_j + \beta_4 CONTIG_j + \beta_5 COMLANG_j + \beta_6 COLONY_j + \beta_7 RTA_{j,t} + \gamma_t\right)$$

Where $GDP_{j,t}$ measures importer economic size, $POP_{j,t}$ captures market scale, $DIST_j$proxies bilateral trade costs, $CONTIG_j$, $COMLANG_j$, and $COLONY_j$ capture geographic and historical proximity, $RTA_{j,t}$ indicates trade agreement coverage, and $\gamma_t$ denotes year fixed effects that absorb global shocks such as commodity price cycles and common macroeconomic conditions.

If the analysis pools multiple commodities, commodity fixed effects are included to capture persistent product specific differences in baseline trade intensity.

**Variable definitions and expected signs**

The gravity specification uses a set of standard market size, trade cost, and institutional variables that are widely employed in empirical trade analysis. To ensure transparency and replicability, Table 1 summarizes the variables, their operational definitions, data sources, and the expected direction of association with Indonesia's bilateral agribusiness exports.

As shown in Table 1, the expected signs follow the canonical gravity logic. Importer market size, proxied by GDP and population, is expected to increase demand for Indonesian exports. Geographic distance captures transport and information costs and is therefore expected to reduce trade. By contrast, proximity and relationship variables such as contiguity, common language, and colonial ties are expected to facilitate transactions through lower coordination costs and stronger networks. Finally, the RTA indicator captures the potential for improved market access and reduced policy barriers, implying a positive association with bilateral export values.

### Estimation strategy and econometric considerations

The gravity model is estimated using Poisson Pseudo Maximum Likelihood, which is suitable for the multiplicative form of trade flows and can incorporate zero export observations without requiring log transformation of the dependent variable. This choice is motivated by evidence that gravity estimation can be sensitive to heteroskedasticity and zero trade values under conventional log linear ordinary least squares, and that nonlinear estimators provide more reliable performance under such data features (Hendy & Zaki, 2021; Mnasri & Nechi, 2021).

Table 1. Variables, definitions, data sources, and expected signs

| Variable | Definition | Source | Expected sign |
|---|---|---|---|
| $X_{j,t}$ | Export value from Indonesia to partner j in year t for HS 1511, current US dollars | UN Comtrade | n.a. |
| $GDP_{j,t}$ | Importer GDP, current US dollars | WDI | Positive |
| $POP_{j,t}$ | Importer population | WDI | Positive |
| $DIST_j$ | Bilateral distance between Indonesia and partner j | CEPII | Negative |
| $CONTIG_j$ | 1 if Indonesia and partner j share a border | CEPII | Positive |
| $COMLANG_j$ | 1 if common official or widely used language | CEPII | Positive* |
| $COLONY_j$ | 1 if colonial relationship indicator | CEPII | Positive |
| $RTA_{j,t}$ | 1 if RTA coverage for the Indonesia partner dyad is in force in year t (year ≥ entryforceyear) | DESTA (dyadic, in force) | Positive |

## RESULTS AND DISCUSSION

### Descriptive patterns of Indonesia's exports

Commodity trade data commonly exhibit strong concentration in a small number of destination markets alongside sporadic shipments to many others. This is also reflected in the present sample (1,745 importer–year observations), where export values ($X_{jt}$) are highly dispersed and include zeros. Such features motivate the use of PPML in the gravity analysis, as it accommodates zero trade flows and is appropriate under typical heteroskedasticity patterns in trade data.

Before presenting the regression results, Table 2 summarizes the distribution of the dependent variable and key covariates. This table provides essential context on the scale of variables (particularly $GDP_{jt}$ and $X_{jt}$), the prevalence of zeros, and the rarity (or absence) of certain dyadic indicators.

**Gambar 3.** Grafik pertumbuhan berat mutlak benih udang vaname

| Variable | Observations | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| $X_{j,t}$ | 1,745 | 83,158,129.48 | 367,616,972.27 | 0 | 5,320,584,289.14 |
| $GDP_{j,t}$ | 1,745 | 454,042,205,594.84 | 1,986,558,138,964.20 | 36,811,936.08 | 27,292,170,793,214.30 |
| $POP_{j,t}$ | 1,745 | 38,920,129.75 | 146,223,303.74 | 9,816.00 | 1,438,069,596.00 |
| $DIST_j$ | 1,745 | 10,473.74 | 4,693.85 | 523.0264 | 19,772.34 |
| $CONTIG_j$ | 1,745 | 0.0103 | 0.1011 | 0 | 1 |
| $COMLANG_j$ | 1,745 | 0 | 0 | 0 | 0 |
| $COLONY_j$ | 1,745 | 0.0052 | 0.0717 | 0 | 1 |
| $RTA_{j,t}$ | 1,745 | 0.2699 | 0.444 | 0 | 1 |

Table 2 reveals several features typical of product-level trade panels. First, exports ($X_{jt}$) are highly right-skewed and include zero values, indicating intermittent exporting across destinations and years. Second, destination market size varies widely ($GDP_{jt}$ and $POP_{jt}$), while the mean distance is substantial ($DIST_j \approx 10{,}474$ km), underscoring the relevance of trade costs. Third, dyadic link variables are rare: contiguity and colonial ties appear in a small share of dyads. Finally, $COMLANG_j$ has no variation (always zero) in this product-specific sample; consequently, it cannot be meaningfully estimated in the gravity model and is treated as omitted due to no variation.

**Revealed competitiveness: RCA dynamics**

To assess Indonesia's export specialization in the focal commodity relative to the global benchmark, this study uses the Revealed Comparative Advantage (RCA) index. Values above one indicates revealed comparative advantage. The summary measures in Table 3 provide a concise view of competitiveness over the full sample and across sub-periods.

Table 3 reports the average RCA for the full period, early and late sub-period averages, the implied trend direction, and the proportion of years in which RCA exceeds one.

**Table 3. RCA summary for Indonesia in the focal agribusiness commodity**

| Indicator | Value |
|---|---|
| Average RCA (full period) | 47.7806 |
| Average RCA (early sub-period) | 51.5772 |
| Average RCA (late sub-period) | 43.0349 |
| Trend direction | Decreasing |
| Share of years with RCA > 1 | 100.00% |

As shown in Table 3, Indonesia exhibits a consistently strong revealed comparative advantage (RCA > 1 in all years), with a very high full-period mean. Nevertheless, the decline from 51.5772 (early sub-period) to 43.0349 (late sub-period) indicates a gradual weakening of specialization over time. This pattern is consistent with increasing global competition and/or evolving market conditions, while still confirming that the commodity remains a key area of export strength for Indonesia.

**Gravity estimates: determinants of bilateral exports (PPML)**

The gravity framework is used to quantify how destination market size and trade costs shape Indonesia's bilateral export performance. Table 4 reports PPML estimates with year fixed effects. Model 1 presents the baseline specification; Model 2 adds trade agreement coverage ($RTA_{jt}$); and Model 3 uses an alternative set of market-size controls. PPML is suitable in this setting because it estimates the multiplicative gravity form in levels and naturally accommodates zero export observations.

Table 4 provides several clear findings. Destination market size (especially population) strongly predicts export values: $\ln(POP_{jt})$ is positive and statistically strong across specifications, indicating that Indonesia exports more to larger consumer markets. Distance enters with a negative coefficient; in Model 2, the elasticity of -0.2108 implies that a 10% increase in distance is associated with roughly a 2.11% decrease in expected exports, holding other factors constant. The coefficient on $\ln(GDP_{jt})$ (or $\ln(GDPpc_{jt})$) is positive but comparatively small and not precisely estimated in this sample, suggesting that population-based market size captures much of the cross-destination variation in demand once the remaining controls are included.

Most importantly for this study, the RTA coefficient in Model 2 is positive and statistically meaningful (0.3906 with robust SE 0.1312). Interpreted in multiplicative form, this implies that the presence of an in-force RTA is associated with approximately $\exp(0.3906) - 1 \approx 47.8\%$ higher exports, ceteris paribus. This result is consistent with the idea that trade agreements can reduce policy and information frictions, facilitate compliance and market access, and support deeper trade relationships. Finally, proximity and historical-network variables have large positive effects: contiguity ($CONTIG_j$) and colonial ties ($COLONY_j$) are associated with substantially higher export values, consistent with lower fixed costs and persistent commercial linkages. $COMLANG_j$ is omitted because it is constant in this product panel, and thus its effect cannot be separately identified.

Table 4 presents the estimated coefficients for each specification

| Variable | Model 1 (Baseline) | Model 2 (Plus $RTA_{jt}$) | Model 3 (Alternative controls) |
|---|---|---|---|
| ln $GDP_{j,t}$ | 0.0219 (0.0455) | 0.0496 (0.0429) | - |
| ln $GDP_{pcjt}$ | - | - | 0.0496 (0.0429) |
| ln $POP_{j,t}$ | 0.9268 (0.0675) | 0.8461 (0.0653) | 0.8957 (0.0357) |
| ln $DIST_j$ | -0.1749 (0.0989) | -0.2108 (0.0919) | -0.2108 (0.0919) |
| $CONTIG_j$ | 1.8477 (0.2377) | 1.6289 (0.2212) | 1.6289 (0.2212) |
| $COMLANG_j$ | Omitted (no variation) | Omitted (no variation) | Omitted (no variation) |
| $COLONY_j$ | 2.6798 (0.1945) | 2.7865 (0.2089) | 2.7865 (0.2089) |
| $RTA_{j,t}$ | - | 0.3906 (0.1312) | 0.3906 (0.1312) |
| Year fixed effects | Yes | Yes | Yes |
| Observations | 1,745 | 1,745 | 1,745 |
| Pseudo $R^2$ | 0.696 | 0.7008 | 0.7008 |

## Robustness checks

Robustness checks assess whether the baseline relationships are driven by a particular partner subset or by a specific choice of market-size proxy. Table 5 summarizes three sensitivity exercises: restricting the sample to major destinations, changing the market-size control, and considering alternative coding for agreement coverage where feasible. Table 5 reports the robustness design and whether key coefficients remain stable.

Table 5. Robustness checks (PPML)

| Robustness exercise | Key change | Main coefficients stable? |
|---|---|---|
| Major partners only | Keep top destinations by average export value | No |
| Alternative size control | Replace ln($GDP_{jt}$) with ln($GDPpc_{jt}$) | Yes |
| Alternative RTA coding | DESTA in-force dyadic coding (baseline). Add signed-only variant if desired. | Optional |

The robustness results indicate that restricting the sample to major partners changes the estimated relationships, implying that peripheral markets contain important variation related to trade frictions and entry margins. In contrast, using an alternative market-size proxy yields stable core results, supporting the robustness of the key market-size and distance effects. RTA-related sensitivity is best treated as inconclusive in this product-specific panel given the limited variation in agreement coverage.

## Synthesis and implications

Taken together, the RCA evidence indicates a very strong revealed comparative advantage for Indonesia in the focal commodity, albeit with a gradual decline over time. The PPML gravity results show that realized exports are primarily shaped by destination market size

(especially $POP_{jt}$) and trade costs proxied by distance ($DIST_j$). Where variation exists, proximity and historical linkages ($CONTIG_j$ and $COLONY_j$) are associated with substantial export premia, underscoring the importance of logistics efficiency, information frictions, and durable commercial networks in sustaining market access.

From an applied perspective, maintaining competitiveness in this commodity likely requires sustaining supply-side fundamentals (productivity, quality, and compliance capacity) while reducing trade costs (logistics, documentation, and standards-related fixed costs) to broaden market penetration beyond the concentrated set of high-value destinations.

## CONCLUSION

This study examined Indonesia's export performance in HS 1511 during 2015 to 2023 using two complementary approaches, namely the Revealed Comparative Advantage index and a Poisson pseudo maximum likelihood gravity model with year fixed effects. The RCA results confirm that Indonesia maintained a strong revealed comparative advantage throughout the sample period, indicating persistent export specialization in the product. At the same time, the decrease in average RCA between the early and late sub periods suggests a gradual weakening of relative specialization, which may reflect stronger global competition, changing standards in destination markets, or domestic constraints that affect export capacity. The PPML gravity estimates support standard gravity predictions. Exports increase with destination market size, particularly population, and decrease with distance, consistent with the role of demand scale and trade cost frictions. Importantly, after controlling for market size and trade costs, in force trade agreements are associated with substantially higher export values. The estimated agreement premium is economically meaningful, implying that trade agreements can contribute to improved market access by reducing policy related and information related frictions, as well as lowering compliance and procedural costs. These findings suggest several implications. Sustaining competitiveness in HS 1511 requires strengthening supply side fundamentals such as productivity, quality, and compliance capacity. It also requires continued reductions in trade costs through improvements in logistics, certification readiness, and administrative processes. In addition, exporters and policy makers should enhance the effective use of existing trade agreements to expand into partner markets and deepen market penetration. Future research could extend the analysis to additional products, apply richer fixed effects structures to strengthen identification, and assess heterogeneous agreement effects across partner groups and time.

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