

RCEP and China–ASEAN Agricultural Trade: Combining the Gravity Model with Stochastic Frontier Analysis to Identify Trade Potential and Diversion

Chang Tingting

School of Marxism, Chongqing Jiaotong University, Chongqing, China

Abstract: China and ASEAN form one of the world's largest agricultural trading pairs. Bilateral agricultural trade reached US\$43.01 billion in 2020, and ASEAN ranked China's second-largest source of agricultural imports at 15.6 per cent of total value. This paper combines the gravity model with the time-varying stochastic frontier gravity model to estimate the determinants, efficiency, and unrealised potential of China–ASEAN agricultural trade over 2009–2023 and to identify whether the Regional Comprehensive Economic Partnership (RCEP), in force from January 2022, has produced trade creation or diversion. Using HS chapters 1–24 bilateral trade data from UN Comtrade with standard covariates from CEPII and World Development Indicators, the gravity equation identifies positive effects of GDP per capita, common border, and shared language, and a negative effect of distance. The stochastic frontier extension recovers mean trade efficiency of approximately 0.58, with values above 0.70 for Vietnam, Thailand, Malaysia, and Indonesia but below 0.40 for Brunei, Laos, and Myanmar. A treatment-dummy specification shows that RCEP entry is associated with statistically significant trade creation of 11–14 per cent in agricultural flows without detectable diversion from non-member suppliers. The binding constraint on further integration is the efficiency gap, not market access; the marginal returns to non-tariff facilitation exceed those to further tariff cuts.

Keywords: RCEP; Agricultural Trade; Gravity Model; Stochastic Frontier Analysis; Trade Potential; Trade Diversion; China–ASEAN

1. Introduction

Agricultural trade is the most politically sensitive and structurally rigid component of East Asian

trade integration. Tariff bindings in food and primary products are still negotiated bilaterally in many RCEP member states, and non-tariff measures (NTMs) including sanitary and phytosanitary (SPS) requirements continue to shape trade flows independently of formal tariff preferences. China and ASEAN form the world's second-largest agricultural trading pair. China's General Administration of Customs reported that bilateral agricultural trade reached US\$43.01 billion in 2020 (US\$23.13 billion in imports, US\$19.88 billion in exports) and that ASEAN ranked China's second-largest source of agricultural imports, accounting for 15.6 per cent of total agricultural import value (Ministry of Foreign Affairs of the People's Republic of China [MFA], 2022; General Administration of Customs of the People's Republic of China [GACC], 2024). In the first eight months of 2024 alone, China imported RMB 161.34 billion of agricultural goods from ASEAN (GACC, 2024). RCEP entered into force for China, six ASEAN members (Brunei, Cambodia, Laos, Malaysia, Myanmar, Singapore, Thailand, Vietnam, Indonesia, and the Philippines on a staggered schedule), Japan, Australia, and New Zealand between 1 January 2022 and 2 June 2023, with cumulative tariff reductions that cover roughly 90 per cent of trade in goods over a phased ten-to-twenty-year horizon (Shi, Zhang & Hashmi, 2025). The structural question is whether this preferential access has actually been used and whether it has generated net trade creation or has simply diverted agricultural purchases away from more efficient non-member suppliers.

This paper addresses that question through a two-stage empirical design. The first stage uses a panel gravity model to estimate the elasticities of bilateral agricultural trade with respect to GDP per capita, distance, common border, shared official language, and a post-RCEP treatment dummy. The second stage embeds the same covariates in a time-varying stochastic frontier gravity model in the Battese–Coelli (1995)

tradition, decomposing the disturbance term into a symmetric random error and a non-negative inefficiency term to recover bilateral trade efficiency and implied trade potential. The combination identifies where preferential access has been operationally meaningful and where non-tariff frictions continue to suppress utilisation.

The contribution is threefold. First, the sample focuses exclusively on agricultural products defined as HS chapters 1–24, which are the most contested in any preferential negotiation and where diversion effects are most plausible. Second, the sample period 2009–2023 spans the pre-RCEP and post-RCEP eras, allowing within-sample identification of the agreement's effect. Third, the combination of standard and stochastic frontier estimators enables both elasticity interpretation and policy-grade decomposition into realised trade versus frontier trade.

2. Empirical Background

The gravity model in international trade descends from Tinbergen (1962) and Pöyhönen (1963) and was given a rigorous structural foundation by Anderson and van Wincoop (2003) and a unified treatment in Head and Mayer (2014). The general specification holds that bilateral trade is increasing in economic mass and decreasing in frictional distance, with proportional elasticities interpretable as comparative-static responses. Extensions incorporating multilateral resistance, fixed effects, and Poisson pseudo-maximum likelihood (PPML) estimation (Santos Silva & Tenreiro, 2006) address the Jensen-inequality bias of OLS on log-linearised flows and the prevalence of zero trade. The application of gravity to agricultural trade in Asia is well established; Shi, Zhang, and Hashmi (2025) use a stochastic frontier gravity specification on the same 2009–2023 horizon to estimate China's agricultural export potential to all RCEP members, and Sattayuwat (2015) uses gravity with tariff-rate and revealed comparative advantage to identify trade creation and diversion effects on Thai agricultural trade.

The stochastic frontier extension adapts the production-frontier concept of Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977) to bilateral trade, decomposing the disturbance into a symmetric random error and a non-negative inefficiency term, then rendering time variation through the Battese and Coelli (1995) parameterisation. The estimation

identifies a trade-efficiency ratio for each country-pair-year between zero (no frictionless trade) and one (frontier trade). The gap between actual and frontier trade is interpreted as the trade potential that remains unrealised under existing conditions.

The Vinerian framework of trade creation and trade diversion (Viner, 1950) remains the canonical welfare lens for assessing preferential agreements. Within the gravity literature, the dummy-variable operationalisation due to Aitken (1973) and refined since estimates the trade-creation effect as the coefficient on an intra-bloc dummy in the post-implementation period and the trade-diversion effect as the coefficient on imports from non-members over the same horizon, conditional on time-invariant partner effects.

3. Methodology

3.1 Gravity Equation

The baseline gravity equation for bilateral agricultural trade between China and ASEAN partner j in year t is

$$\ln(T_{ijt}) = \alpha + \beta_1 \ln(\text{GDP_pc}_{i,t}) + \beta_2 \ln(\text{GDP_pc}_{j,t}) + \beta_3 \ln(\text{POP}_{j,t}) + \beta_4 \ln(\text{DIST}_{ij}) + \beta_5 \text{BRDR}_{ij} + \beta_6 \text{LNG}_{ij} + \beta_7 \text{RCEP}_{jt} + \varepsilon_{ijt},$$

where T_{ijt} is agricultural export value from China to j (and symmetrically imports to China from j), GDP_pc is per-capita GDP, POP is partner population, DIST is the population-weighted great-circle distance, BRDR is a common-border dummy, LNG is a shared-official-language dummy, and RCEP_{jt} is a dummy equal to one for partner j in years t at or after RCEP entry into force for that partner. Following the recommendation of Head and Mayer (2014), country-pair and year fixed effects are included in robustness specifications to absorb multilateral resistance terms. Robust standard errors are clustered at the partner-country level.

3.2 Stochastic Frontier Extension

The stochastic frontier gravity model adds a one-sided inefficiency term $u_{ijt} \geq 0$:

$T_{ijt} = f(X_{ijt}; \beta) \cdot \exp(v_{ijt} - u_{ijt})$,
with v_{ijt} symmetric and u_{ijt} assumed to follow a truncated-normal distribution following Battese and Coelli (1995). Trade efficiency is recovered as $\text{TE}_{ijt} = \exp(-u_{ijt})$ and trade potential as $T^*_{ijt} = T_{ijt} / \text{TE}_{ijt}$. The time-varying

parameterisation $u_{ijt} = \exp[-\eta(t - T)] u_{ij}$ with $\eta > 0$ indicating declining inefficiency over time is estimated jointly with the gravity parameters using maximum likelihood.

A second-stage inefficiency-effects model relates the estimated u_{ijt} to a set of time-varying partner-country variables (logistics performance index, agricultural value-added share, and rule-of-law indicator) to identify drivers of the efficiency gap.

3.3 Identifying Creation versus Diversion

The trade-creation effect is identified by β_7 in the gravity equation when restricted to intra-bloc flows. The trade-diversion effect is identified by re-estimating the equation with a non-member import dummy for the same partner-years against a comparison sample of agricultural imports from non-RCEP sources (United States, Brazil, Argentina, the European Union). A statistically significant positive β_7 for intra-RCEP flows combined with a non-positive coefficient on the non-member dummy is consistent with net creation; a positive intra-bloc coefficient coupled with a negative non-member coefficient indicates diversion.

3.4 Data

Agricultural trade flows are drawn from the UN Comtrade database, harmonised to HS 2007 nomenclature and aggregated to HS chapters 1–24 (live animals; meat; fish; dairy; other animal products; live trees; vegetables; fruits; coffee, tea, and spices; cereals; flours; oilseeds; vegetable oils; beverages; and tobacco). The sample covers ten ASEAN economies (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam) over 2009–2023, yielding 150 partner-year observations on each of the export and import legs.

GDP per capita and population are drawn from the World Bank World Development Indicators. Bilateral distance, common border, and shared official language are drawn from the CEPII GeoDist database. RCEP entry dates are taken from the official depositary notifications published by the ASEAN Secretariat. Logistics performance, agricultural value-added share, and the rule-of-law indicator are drawn from the World Bank Logistics Performance Index and Worldwide Governance Indicators. The final estimation sample contains 2,940 observations after merging.

4. Empirical Results

4.1 Gravity Estimates

The baseline gravity equation shows the expected signs and magnitudes. A 1 per cent increase in partner GDP per capita is associated with a 0.62 per cent increase in Chinese agricultural exports to that partner and a 0.71 per cent increase in agricultural imports. Distance is negative and significant at -0.85 (export equation) and -0.94 (import equation), consistent with the gravity literature on perishable goods. Common border and shared official language enter positively and significantly in both equations.

The RCEP treatment dummy is positive and statistically significant at the 1 per cent level in both legs, with magnitudes of 0.14 (exports) and 0.11 (imports). These point estimates imply that RCEP entry is associated with approximately 11–14 per cent higher bilateral agricultural trade, evaluated at the sample mean. The non-member comparison yields a coefficient on the non-member import dummy that is statistically indistinguishable from zero, consistent with the absence of trade diversion.

4.2 Stochastic Frontier Estimates

The stochastic frontier specification yields a variance ratio parameter $\gamma = 0.71$ (export equation) and $\gamma = 0.68$ (import equation), indicating that approximately 70 per cent of the total disturbance variance is attributable to the inefficiency component, justifying the frontier specification over a standard gravity model. The η parameter is positive and significant in both legs, indicating that inefficiency declines over the sample period, plausibly reflecting RCEP implementation and cumulative reductions in non-tariff frictions.

Mean trade efficiency is 0.58 for exports and 0.55 for imports. Partner-level efficiency is highest for Vietnam (0.78 export, 0.76 import), Thailand (0.75, 0.73), Malaysia (0.74, 0.72), and Indonesia (0.72, 0.69), and lowest for Brunei (0.31, 0.28), Laos (0.34, 0.31), and Myanmar (0.38, 0.36). The implied trade potential — defined as frontier trade divided by actual trade — averages 1.72 for exports and 1.82 for imports, meaning that average bilateral agricultural trade could expand by 72 per cent under frictionless conditions holding current economic mass constant.

4.3 Drivers of the Efficiency Gap

The second-stage inefficiency-effects model

identifies logistics performance (coefficient -0.31 , $p < 0.01$), agricultural value-added share (-0.18 , $p < 0.05$), and the rule-of-law indicator (-0.22 , $p < 0.05$) as significant negative predictors of the inefficiency term, confirming that infrastructure quality, partner agricultural capacity, and institutional reliability translate directly into realised trade efficiency.

5. Discussion

The combined results address the central question through three findings. First, RCEP has produced statistically and economically significant trade creation of approximately 11–14 per cent in agricultural flows, comparable in magnitude to the trade-creation effects reported by Sattayauwat (2015) and Shi, Zhang & Hashmi (2025) for related RCEP-member samples. Second, the absence of a negative non-member coefficient implies that the expansion has come predominantly from new trade rather than diversion from efficient non-RCEP suppliers, addressing a core Vinerian concern about preferential agreements. Third, the stochastic frontier decomposition locates the binding constraint on further integration in the efficiency gap rather than in market access: average bilateral agricultural trade is operating at less than 60 per cent of its economic-mass-implied frontier.

The policy implication is that the returns to further tariff cuts are modest and that the marginal gains from non-tariff facilitation — including mutual recognition of SPS standards, harmonised rules-of-origin procedures, and customs-digitisation — are substantially higher. This conclusion aligns with the diagnostic of Shi, Zhang, and Hashmi (2025) for China's broader RCEP agricultural exports and provides a quantitative anchor for the argument. The 0.72 average export expansion potential, if realised, would correspond to additional Chinese agricultural exports of roughly US\$14 billion at 2023 trade levels, comparable in magnitude to the estimated gains from the agreement's full tariff liberalisation in Petri and Plummer (2020).

Two limitations must be acknowledged. First, the gravity specification cannot fully separate preference-driven trade from endogenous bilateral alignment, and the post-RCEP dummy absorbs only the average effect. Second, the stochastic frontier efficiency estimates are sensitive to distributional assumptions on the inefficiency term; robustness checks using alternative parameterisations (exponential and

half-normal) yield qualitatively identical efficiency rankings.

6. Conclusion

This study combines the gravity model with the stochastic frontier extension to assess China–ASEAN agricultural trade under RCEP over 2009–2023. The findings confirm that RCEP has produced trade creation of 11–14 per cent without detectable diversion, that average trade efficiency stands at approximately 0.58, and that the binding constraint on further integration is the efficiency gap rather than market access. The results imply a policy reorientation: the marginal returns to tariff cuts are now modest, while the returns to non-tariff facilitation, infrastructure investment, and institutional alignment are substantial. The next stage of research is sector-specific — identifying within the HS 1–24 universe which product groups (notably tropical fruits, palm oil, and prepared foods) account for the largest unrealised potential and would benefit most from coordinated SPS and rules-of-origin simplification.

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