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The impact of the China-Australia free trade agreement on China's agricultural imports

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China and Australia signed the Free Trade Agreement (ChAFTA) in 2015, which aims to eliminate or reduce trade barriers between countries through tariffs or quotas. Eliminating trade barriers has expanded China's agricultural imports from Australia. ChAFTA will strengthen the trade relationship between the two countries, enabling agricultural product imports to have a trade creation effect. This article systematically evaluates the trade effects of ChAFTA on the scale of China's agricultural product imports based on data from 2000 to 2020. Two statistical methods, Ordinary Least Squares (OLS) and Poisson Pseudo Maximum Likelihood (PPML) are applied to estimate the trade effects of agreements. Empirical studies have shown that ChAFTA has a significant trade creation effect on China's agricultural product imports, while the trade diversion effect is insignificant. When time fixed effects and export country fixed effects are controlled, the PPML method exhibits stronger explanatory power compared to OLS and the estimated trade creation effect is more significant. The empirical research results remain robust even after considering the impact of WTO. There are no endogeneity issues in the results after adding lead variables. By incorporating lagged terms, we find there is no phase-in effect. Empirical research on heterogeneity analysis of agricultural product classification found that ChAFTA had the most significant impact on the import of forest products and aquatic products, followed by textiles and agricultural products.

KEYWORDS

free trade agreements, agricultural products trade, import trade, Poisson pseudo-maximum likelihood, trade creation

1 Introduction

Free Trade Agreements (FTAs) are important tools for international economic cooperation, designed to lower trade barriers and strengthen commercial relationships among member countries. Their importance is especially clear in agriculture, which is an sector that often faces high tariffs. The World Trade Organization's (WTO, 2023) Regional Trade Agreements database shows that by the end of May 2024, 369 RTAs (including FTAs, customs unions, and preferential trade areas) were established worldwide. Both China and Australia have actively participated and signed 20 and 18 FTAs, respectively. The China-Australia Free Trade Agreement (ChAFTA), which started on December 20, 2015, began an 11-year process to cut tariffs with the goal of removing tariffs on many goods. China promised to remove tariffs on 1,375 types of Australian agricultural products over 12 years, covering about 93.7% of all agricultural categories. In contrast, Australia will eliminate tariffs on all 1,061 types of Chinese agricultural products within 3 years. When fully implemented, this agreement will reduce China's average tariff on agricultural imports from 15.6 to 13.8%. With its large population, China has a big need for agricultural products, making it a major importer in global agricultural trade. Since 2020, China has been the world's top importer of agricultural products. Countries like Brazil, the US, Australia, New Zealand, and Thailand are key suppliers to China. Known for advanced and efficient farming, Australia plays a big role in global agriculture. It is a leading exporter of wool and lamb, and also exports significant amounts of barley, beef, cotton, sugar, and wheat.

The analysis of trade creation and trade diversion is commonly used to measure the impact of FTAs on trade. Viner (1950) first looked at the economic effects of customs unions, introducing the ideas of trade creation and trade diversion. Trade creation means reducing internal trade barriers so countries can benefit from comparative advantages. Trade diversion happens when consumers buy more expensive goods from member countries instead of cheaper options from non-member countries, leading to inefficient resource use. These concepts laid the foundation for analyzing regional trade agreements. For example, Sun and Reed (2010) found that FTAs significantly boost agricultural trade, though the growth varies by product and time. Wang (2017) studied CAFTA's impact on China's agricultural exports, finding strong creation effects but weak diversion effects. Fu and Cao (2023) examined how environmental rules in RTAs affect trade, showing that strict policies can hurt trade between members while causing diversion toward non-members.

Despite extensive studies on FTAs, the Research on the trade creation and trade diversion effects of trade agreements on China's agricultural trade remain underexposed. Specifically, two gaps emerge, the first one is that existing models (e.g., Grant and Lambert, 2008) may inadequately capture phasing-in effects. The second one is that aggregated analyses (Wang, 2017; Fu and Cao, 2023) obscure sector-specific responses to preferential market access. To address this, we examines how ChAFTA affects China's agricultural imports, focusing on creation and diversion effects. It compares Ordinary Least Squares (OLS) and Poisson Pseudo Maximum Likelihood (PPML) methods. Additionally, the study observes the phasing-in effect and the heterogeneity in import volume changes across different categories of agricultural products in China.

The rest of this study is organized as follows: Section 2 reviews related literature, Section 3 provides background on China-Australia trade, Section 4 describes data sources and model construction, Section 5 presents empirical results, and Section 6 includes the discussion and conclusions.

2 Literature review

Since the 1990s, FTAs have become a primary form of trade liberalization. By reducing trade costs and facilitating cross-border transactions, FTAs can increase the volume of trade between participating countries (Froning, 2000) and enhance the aggregate economic welfare of member nations (Meade, 1955; Ohyama, 1972). The mechanism by which FTAs affect income disparities between countries is complex and can be either positive (Ben-David, 1993) or negative (Quah, 1994).

Many empirical research has revealed the effect of FTAs on bilateral trade between member countries. Several studies have assessed the impact of FTAs by comparing data before and after policy implementation. For instance, Ghazalian (2016) examined the influence of the North American Free Trade Agreement (NAFTA) and the Canada-U.S. Free Trade Agreement (CUSFTA) on various categories of agricultural products, revealing changes in trade flows following the agreements' entry into force. The study indicated that NAFTA and CUSFTA significantly boosted trade growth for certain agricultural categories. It was worth noting that the growth was not evenly distributed across all products or periods.This research highlighted the need for in-depth investigations into specific agricultural categories, thereby addressing gaps in macro-level studies.

Other literature focused on particular commodities or industries. Harada and Nishitaten (2022), for example, concentrated on the sector-specific impacts, specifically analyzing the trade creation effects resulting from reduced wine import tariffs in East Asia. The study focused on the different impacts of FTA preferential tariff rates and Most Favored Nation (MFN) tariff rates. The research results showed that every one percentage reduction in tariffs would lead to a 0.042% increase in wine imports among FTA member countries, which was seven times the effect of the same tariff reduction based on MFN. Lambert and McKoy (2009) explored the effects of multiple Preferential Trade Agreements (PTAs) on food trade. The study focused on how these agreements altered trade patterns within and outside member countries. They found that PTAs notably increased intro-regional trade, especially in agriculture, with significant trade creation effects for agricultural products. However, there was evidence of trade diversion in the food sector for some PTAs primarily involving developing countries. Their research provided more precise guidance for policy formulation by distinguishing between PTAs formed by countries at varying stages of development.

Some studies also considered the role of FTAs within a broader multilateral framework. Grant and Boys (2012) investigated whether WTO/GATT membership truly enhanced agricultural trade among member countries. Although the sensitivity and slow reform progress happened in agriculture, overall positive impacts were observed. The study emphasized the role of FTAs within a multilateral context, offering new perspectives on global trade governance structures. Berlingieri et al. (2021) approached the assessment of new-generation EUFTAs from the angle of consumer welfare, focusing on improvements in product quality rather than price or variety. They discovered that FTAs had improved average product quality by 7%, which corresponded to a cumulative decrease of 0.24% in the Consumer Price Index over the sample period. High-income EU countries experienced stronger quality improvements and greater overall consumer benefits. This study introduced a novel method for evaluating the impact of FTAs through the consumer welfare. Moreover, there is a fact that the implementation of FTAs is carried out in phases. Grant and Lambert (2008) found that free trade agreements such as NAFTA have significant phase-in effects. Therefore the entire treatment effect cannot be fully captured in the current year (Baier and Bergstrand, 2007a). Additionally, there is very different impact on disaggregated data. Timsina and Culas (2020) found that the ChAFTA significantly increased Australia's exports of beef, wine, and edible nuts, but had no significant impact on sugar exports.

The gravity equation is the primary method for quantifying the impact of FTAs on trade volumes[1]. This approach involves incorporating FTAs as dummy variables into the gravity model to assess their impact

1 Anderson and van Wincoop (2003) introduced a multi-variable resistance term into the gravity equation to study the border puzzle in trade. Caliendo and Parro (2015) incorporated a multi-sector Ricardian model into the gravity equation to derive a structured form, examining trade issues within the North American Free Trade Agreement (NAFTA).

on trade flows. Early studies confirmed significant trade creation effects of FTAs (Bergstrand, 1985; Frankel and Wei, 1994; Frankel and Rose, 2002; Bergstrand et al., 2015), but the stability of average treatment effects (ATE) has been questioned (Ghosh and Yamarik, 2004). Magee (2003) attempted to address the endogeneity issue of FTAs variables in cross sectional data using instrumental variable methods but found high error rates. Magee (2008, 2016) further incorporated fixed effects into his research. Given the difficulty in obtaining ideal instrumental variables, Baier and Bergstrand (2007b) suggested that fixed effect models are an effective way to mitigate endogeneity issues. Baier and Bergstrand (2007a) used two-way fixed-effects OLS estimation to examine bilateral trade among 96 countries from 1960 to 2000, finding that considering time fixed effects and bilateral fixed effects significantly enhances the positive impact of FTAs on trade volume among member countries. Pfaffermayr (2019, 2020) explored the tendency of robust standard errors in PPML estimations in cross sectional and panel data gravity models to be significantly downward biased.

Due to its sensitivity and high level of protection, the agricultural sector typically faces much higher tariff rates than non-agricultural sectors before the implementation of FTAs. Therefore, FTAs tend to have a greater trade-stimulating effect on agricultural sectors (Grant and Lambert, 2008). In response to the common issue of zero bilateral trade values in international trade research, some scholars have adopted the PPML method for parameter estimation. Sun and Reed (2010) utilized fixed-effect PPML to investigate the trade creation and diversion effects of FTAs on agriculture across 81 countries at different stages of development, confirming that FTAs significantly boost agricultural trade. Similar studies also found that FTAs effectively increase trade volumes between signatory countries (Bureau and Jean, 2013; Yang and Martinez-Zarzoso, 2014; Hndi et al., 2016; Timsina and Culas, 2020). Recently, more attention has been given to specific terms and depths of trade agreements in FTA research (Mattoo et al., 2022; Howard et al., 2023; Guillin et al., 2023), which is also a direction for my future research.

In the context of deepening global economic integration, as important mechanisms promoting trade liberalization between countries, FTAs have received widespread attention. However, there remains considerable scope for exploring how FTAs specifically affect bilateral agricultural trade, particularly the specific impacts of the ChAFTA on China's agricultural imports. By thoroughly analyzing bilateral agricultural trade data between China and trading partners worldwide from 2000 to 2020, this study fills a gap in the existing literature.

This paper makes three contributions to FTA research: First, while prior studies more focus on aggregate FTA effects (e.g., Baier and Bergstrand, 2007a, 2007b; Frankel and Wei, 1994), industrial goods (Fu and Cao, 2023), or agricultural exports (Wang, 2017), we provide the first quantitative analysis of ChAFTA's impact on China's agricultural imports because agricultural trade is important in China-Australia trade. Second, we have conducted research on the phase-in effects of FTAs, similar to the work of Baier and Bergstrand (2007a) and Grant and Lambert (2008). Third, departing from macro-level analyses (Grant and Boys, 2012; Grant and Lambert, 2008), we conduct heterogeneity analysis by categorizing agricultural products into seven major types from a micro perspective. This approach aligns with Ghazalian (2016), which covers sector-specific responses to preferential market access.

Based on this framework, we propose three hypotheses:

Hypothesis 1: The implementation of the ChAFTA can significantly increase China's agricultural imports.

Hypothesis 2: The effect of ChAFTA on China's agricultural imports exhibits phase-in dynamics.

Hypothesis 3: There are heterogeneous effects of ChAFTA on China's imports of different agricultural product types.

3 Background

The trend lines of Figure 1 show that China's agricultural import market has expanded rapidly. From 2000 to 2020, the import value surged from 12.2 billion to 176.0 billion, demonstrating a remarkable annual growth rate of 15.13%. Meanwhile, Australia's agricultural exports also showed steady growth, though at a slightly slower pace. The total export value increased from 18.7 billion in 2000 to 35.0 billion in 2020, corresponding to an annual growth rate of 3.95%. Notably, the value of agricultural products imported by China from Australia grew at an annual rate of 11.76%. China has absorbed 32.41% of Australia's total agricultural product exports by 2019, highlighting its core position in the Australian agricultural product export market.

China has become Australia's largest trading partner for agricultural products since 2008. The stability of this role became increasingly prominent in the following years. Although the import volume of agricultural products in China has slowed down to an average annual growth rate of 6.09%, it still maintains a strong upward trend after 2015. In contrast, Australia's total agricultural exports have shown an average annual negative growth rate of −3.68%, indicating a contraction in the overall export scale. However, Australia's agricultural exports to China still maintain an average annual growth rate of 2.05% This growth rate further highlights the strategic importance of China as an export market for Australian agricultural products, as well as the resilience and vitality of bilateral trade relations. The agricultural trade between China and Australia is expected to promote sustainable development and prosperity of agriculture in both countries through mutually beneficial cooperation (Zhou et al., 2007).

China is also actively engaging in the negotiation and implementation of FTAs with other countries, aiming to enhance bilateral trade through this approach. The lists of FTAs signed and implemented by China and Australia between 2000 and 2020 is shown in Table 1. China had concluded and put into effect FTAs with a total of 15 countries or regions by 2020. Meanwhile, Australia had signed and enforced FTAs with 12 countries or regions. These trends and agreements highlight the growing importance of bilateral and multilateral trade relationships in shaping the agricultural trade dynamics between China and Australia. The ChAFTA, in particular, has played a pivotal role in enhancing the depth and breadth of trade between the two countries, contributing to the significant growth in agricultural imports and exports.

The signing and implementation of these FTAs are significant measures taken by China to actively participate in global economic governance, promote trade liberalization, and advance economic globalization. Looking at the partner countries involved in these agreements, China has signed FTAs with nations and regions at various

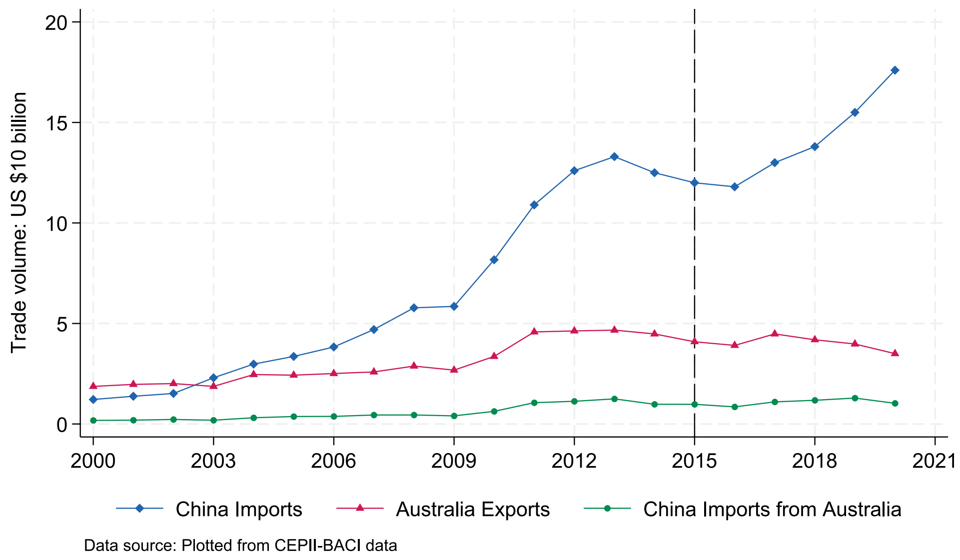

FIGURE 1
Sino-Australian agricultural trade 2000–2020.

TABLE 1 Free trade agreements signed by China and Australia.

China's FTA		Australia's FTA	
Partner country	Time	Partner country	Time
Macau and Hong Kong	2003	Singapore	2003
ASEAN	2004	United States	2005
Chile	2006	Thailand	2005
Pakistan	2007	Chile	2009
New Zealand	2008	ASEAN-New Zealand	2010
Singapore	2009	Malaysia	2013
Peru	2010	Korea	2014
Costa Rica	2011	Japan	2015
Taiwan	2011	China	2015
Switzerland	2014	Hong Kong	2020
Iceland	2014	Peru	2020
Australia	2015	Indonesia	2020
Korea	2015	–	–
Maldives	2018	–	–
Georgia	2018	–	–

Data Source: Compiled from the WTO RTA database.

stages of economic development and geographic locations. For instance, China has entered into FTAs with ASEAN, South Korea, Australia, Chile, and other countries and regions, demonstrating its diversified cooperation within the global trade landscape. In terms of the content covered by these agreements, they not only encompass traditional goods trade but also extend to multiple areas such as services trade, investment, intellectual property protection, e-commerce, and competition policy, reflecting their globality and integration. Some FTAs have set high standards at the regulatory level, introducing advanced international rules in areas like intellectual property protection, environmental protection, and labor standards. These provisions have driven reforms and development in relevant sectors within China.

According to the provisions of the ChAFTA, major agricultural products exported from Australia to China, such as beef, dairy products, wool, seafood, grains, and wine, will gradually enjoy lower or even zero tariffs. Specifically, tariffs on beef will be progressively reduced to zero over 9 years. Various dairy products, including powdered milk, will achieve zero tariffs within 4 to 11 years. Import quotas for wool will be increased, and tariffs on quantities exceeding these quotas will gradually decrease. Most seafood products, such as

TABLE 2 Explanatory variables and expected symbols.

Variable	Description	Explanation	Expected signs
$\ln GDP_{it}$	Log of GDP of import country *i* in period *t*	Reflects the economic size of the import country	+
$\ln GDP_{jt}$	Log of GDP of export country j in period *t*	Reflects the economic size of the export country	+
$\ln Dist_{ij}$	Log of the distance between import country *i* and the exporting country *j*	Reflects transportation and communication costs	−
Adj_{ij}	Dummy variable indicating whether country i and country *j* share a border (1 if true, 0 otherwise)	Reflects trade costs between the two countries; a closer border distance facilitates trade	+
$Lang_{ij}$	Dummy variable indicating whether country i and export country *j* share a common language (1 if true, 0 otherwise)	Reflects the cultural relationship between the two countries;	+
FTA_t	Dummy variable,=1 if import country *i* and export country *j* are part of the ChAFTA in period *t*, 0 otherwise	Reflects the changes in trade volume brought about by the establishment of an FTA between the two countries.	+
$NFTA_{jt}$	Dummy variable, =1 if China has trade with any country j (other than Australia) after 2015	Reflects China's import from countries other than Australia during period t, influenced by the ChAFTA.	−

lobster and abalone, quickly achieved zero-tariff entry into the Chinese market. Tariffs on wine will be completely eliminated within 5 years.

Additionally, the agreement addresses technical barriers to trade (TBT) and sanitary and phytosanitary measures (SPS) in the agricultural sector, ensuring that both parties adhere to international standards while minimizing unnecessary trade restrictions. The aim of these provisions is to facilitate smoother bilateral agricultural trade and provide consumers with a wider variety of product choices.

4 Model and data

4.1 Benchmark model

The gravity equation is the most commonly used model in trade policy research. In order to solve the endogenous problem of free trade agreements, a gravity equation with two-way fixed effects is established according to the method of Baier and Bergstrand (2007a). As shown in Equation 1:

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln Dist_{ij} + \beta_4 Adj_{ij} + \beta_5 Lang_{ij} + \beta_6 FTA_t + \beta_7 NFTA_{jt} + \alpha_t + \alpha_j + \varepsilon_{ijt} \quad (1)$$

Where: $\ln x_{ijt}$ is the log of the bilateral trade volume between import country *i* and export country *j* in year *t*.

$\ln GDP_{it}$ and $\ln GDP_{jt}$ are the log of gross domestic products of import country i and the export country j.

$\ln Dist_{ij}$ is he log of the distance between import country *i* and export country *j*.

Adj_{ij} is a dummy variable indicating whether import country *i* and export country *j* share a border.

$Lang_{ij}$ is a dummy variable indicating whether import country *i* and export country *j* share a common language.

FTA_t and $NFTA_{jt}$ are dummy variables indicating the trade creation and trade diversion between import country *i* and export country *j* in year *t*.

This α_t represents a time fixed effect. The time fixed effect reflects the time trend of trade and any shocks that affect the flow of China's agricultural import trade in a specific year. This α_j represents a export-country fixed effect. Export-country fixed effects measure the impact of unobserved country-specific shocks, such as infrastructure, factor endowments, and so on. ϵ_{ijt} is the error term.

This model allows us to estimate the impact of various factors on bilateral trade volume, particularly the effect of the ChAFTA on China's agricultural imports.

The content of each variable is summarized in Table 2.

In this analytical framework, the import country *i* and the export country *j* encompasses 128 countries that traded agricultural products from 2000 to 2020. $\ln GDP_i$ represent the demand potential for agricultural products and $\ln GDP_j$ represent the supply potential of agricultural products from the exporting country.

Trade costs include two main components. One component is represented by the logarithm of distance $\ln Dist_{ij}$ measures the physical distance between the two countries and its impact on trade costs. Two binary dummy variables, Adj_{ij} and $Lang_{ij}$, indicate whether the import country *i* and the exporti country *j* share a border and a common language, respectively. If the condition is met, the value is 1; otherwise, it is 0.

FTA_t is a binary dummy variable representing the ChAFTA, taking a value of 1 if the importing country *i* and the exporting country *j* are part of the ChAFTA in period *t*, and 0 otherwise. $NFTA_{jt}$ is a binary dummy variable measuring trade diversion, taking a value of 1 if only China has trade with any country j (other than Australia) after 2015, and 0 otherwise.

The core focus of this study is on two key variables:

The first one is FTA_t, the coefficient β_6 aims to evaluate whether the bilateral trade volume between countries within the same free trade agreement is significantly higher than that between non-agreement countries, known as the trade creation effect. The coefficient is in semi-elastic form, so its economic interpretation requires exponentiation using $(\exp(\beta_6)-1) \times 100\%$ to accurately reflect the strength of the trade creation effect.

The second one is $NFTA_{jt}$, The coefficient β_7 is used to explore the existence of trade diversion effects. If the coefficient is significant and $\beta_6 > 0$ $\beta_7 > 0$, it indicates the presence of trade creation effects but no trade diversion effects. If the coefficient is significant and $\beta_6 > 0$ $\beta_7 < 0$, it indicates the presence of both trade creation and trade diversion effects. If the coefficient is not significant or $\beta_6 < 0$ $\beta_7 > 0$, it suggests the absence of both trade creation and trade diversion effects.

TABLE 3 Statistical description.

Variables	Number	Mean	Variance	Minimum	Maximum
$\ln x_{ijt}$	341,376	5.550	4.530	−6.910	17.28
$\ln GDP_{it}$	341,376	18.05	2	12.46	23.79
$\ln GDP_{jt}$	341,376	18.05	2	12.46	23.79
$\ln Dist_{ij}$	341,376	8.740	0.800	4.010	9.900
Adj_{ij}	341,376	0.020	0.150	0	1
$Lang_{ij}$	341,376	0.100	0.300	0	1
FTA_t	341,376	0.000	0.000	0	1
$NFTA_{jt}$	341,376	0.000	0.050	0	1

4.2 Variable selection and data sources

4.2.1 Variable selection

To investigate the impact of the ChAFTA on China's agricultural imports, this study selects the following variables for empirical analysis:

Dependent variable: We choose $\ln x_{ijt}$ as the explained variable to analyze the creation effect and diversion effect.To analyze the creation and diversion effects, 128 countries with bilateral trade are selected[2], because there are 127 countries that maintained continuous agricultural trade relations with China from 2001 to 2021. The 127 countries include Australia and the other 126 non-member countries. This design aims to identify the trade diversion effect by conducting a comparative analysis of the changes in China's imports from Australia (member country) and other countries (non-member countries) before and after the implementation of the ChAFTA.

The datasets initially includes 128 countries (including China) to capture all potential bilateral trade pairs. Since trade occurs between two distinct countries, the total number of country pairs is 128 × 127 = 16,256 (excluding domestic trade). However, our analysis focuses specifically on China's imports from its trading partners.

Key explanatory variables: We choose the dummy variables FTA_t and $NFTA_{jt}$ as explanatory variables to find the FTA how to influence the bilateral trade volume.

Control variables: These include the gross domestic product (GDP) of the import country i and the export country j, the distance between the bilateral countries, and two dummy variables indicating whether the bilateral countries share a border and have a common language. These control variables account for other costs that influence bilateral trade volume.

4.2.2 Data sources

This study focuses on bilateral trade activities in the agricultural sector 128 global trading partners from 2000 to 2020. This period covers multiple stages before and after the implementation of ChAFTA, which allows for a good reflection of the effects before and after the policy implementation. The data over this extended period also helps to capture long-term trends and reduces the disturbance caused by short-term fluctuations. The countries involved are widely distributed across continents, including 25 countries in Africa, 42 in Asia, 32 in Europe, 12 in North America, 10 in South America, and 7 in Oceania. This sample set comprises 341,376 independent observations (128 × 127 × 21),[3] ensuring the breadth and depth of the research.

The agricultural trade data are sourced from the authoritative CEPPII BACI database. The commodity scope includes agricultural products defined under the Uruguay Round Agriculture Agreement, extended to cover aquatic products, specifically the first 24 chapters of the Harmonized System (HS) coding system, as well as chemical products and textiles based on animal and plant materials. This detailed classification ensures the precision and comprehensiveness of the study.

Geographic distance, shared boundaries, and language similarity have fixed and invariant bilateral relationship characteristics. These data are taken from the CEPPII gravity database, providing a stable structural foundation for the model. Meanwhile, the gross domestic product (GDP) and free trade agreements of each country are dynamic trade policy variables. These data are sourced from the World Bank WDI database and the RTAs database of the WTO. The GDP data of Taiwan of China is from CEIC database. These multidimensional data sources collectively construct a analysis framework aimed at delving into the key factors influencing China's agricultural trade pattern. The following Table 3 provides a statistical summary of the data.

In Table 3, since the bilateral trade volume of some countries is less than 1,000 USD, their logarithmic values are negative. As the data represents bilateral trade, the number of importing and exporting countries is the same, hence the data description is consistent. The binary dummy variable representing the ChAFTA has relatively few numbers with a value of 1, therefore its mean and variance are close to 0.

5 Empirical results

5.1 Benchmark results

The parameters of the gravity equation were estimated using both OLS and PPML. The results are detailed in Table 4. Columns (1) to (6) are divided into three groups, presenting estimates without fixed effects, with time fixed effects, and with both time and exporter fixed effects, respectively.

2 A detailed list of countries is provided in the Appendix.

3 Since trade occurs between two distinct countries, the total number of country pairs is 128 × 127 (excluding domestic trade), so the data numbers is 128 × 127 × 21 = 341,376.

TABLE 4 Impact of the ChAFTA on Chinese agricultural imports.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	ppml	ols	ppml	ols	ppml
$\ln GDP_{jt}$	0.516***	0.195***	0.199***	0.200***		
	(45.23)	(372.92)	(22.95)	(376.74)		
$\ln GDP_{it}$	0.683***	0.176***	0.582***	0.181***		
	(61.91)	(337.06)	(66.96)	(339.23)		
$\ln Dist_{ij}$	−1.341***	−0.203***				
	(−45.44)	(−178.92)				
Adj_{ij}	1.670***	0.010				
	(11.64)	(1.61)				
$Lang_{ij}$	1.289***	0.237***				
	(18.08)	(78.67)				
FTA_t	−0.102***	−0.194***	−0.280	−0.216***	0.152***	0.498***
	(−7.32)	(−22.69)	(−0.38)	(−44.03)	(2.92)	(77.90)
FTA_t	0.277***	−0.156***	0.230***	−0.153***	0.669***	0.624***
	(2.72)	(−11.43)	(3.44)	(−11.51)	(7.41)	(20.83)
Constant	−4.496***	−3.389***	−11.616***	−3.516***	4.596***	1.278***
	(−12.57)	(−192.57)	(−6.40)	(−189.33)	(77.60)	(150.53)
Observations	341,376	341,376	341,376	341,376	341,376	341,376
R-squared	0.112	0.480	0.118	0.479	0.104	0.393
Year FE	No	No	Yes	Yes	Yes	Yes
exporter FE	No	No	No	No	Yes	Yes

Robust z-statistics in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The coefficients for the logarithm of GDP of the exporting and importing countries are significantly positive from columns (1) and (2), which are consistent with theoretical predictions. This indicates that an increase in the GDP of bilateral countries enhances the demand for importing agricultural products. The coefficient of the variable representing bilateral distance is significantly negative and consistent with expectations, indicating that trade costs increase with distance, leading to a reduction in bilateral trade. Additionally, the significantly positive coefficients of the dummy variables for shared borders and language are also in line with expectations, suggesting that countries sharing a border and a language experience increased bilateral trade due to reduced communication costs. However, the core parameter—the coefficient of the FTA_t—is significant negative, contrary to expectations. In the case of OLS estimation, the coefficient of the $NFTA_{jt}$, which measures the trade diversion effect, is significantly positive, inconsistent with expectations. Nevertheless, the sum of the two coefficients is positive, this indicate that the total volume of China's agricultural imports is still increasing, the result aligns with reality. In contrast, under PPML estimation, the $NFTA_{jt}$ coefficient is significantly negative, consistent with expectations, but the sum of the two coefficients is negative, suggesting that the total volume of China's agricultural imports is decreasing, which does not align with reality. The underlying reasons may involve endogeneity issues or the impact of zero trade volume data. This combination suggests that the ChAFTA has not produced a significant trade creation or trade diversion effect. Notably, the PPML estimation results exhibit greater robustness compared to OLS, particularly in terms of goodness of fit.

In columns (3) and (4), we estimate the parameters including time fixed effects, so variables that do not change over time were eliminated. At this point, the coefficient of the variable FTA_t in OLS estimation remains negative but does not statistical significance. The coefficient of the variable $NFTA_{jt}$ is significantly positive. Meanwhile, under PPML estimation, the coefficients of both FTA_t and $NFTA_{jt}$ remain significantly negative, with their absolute values changing little compared to the case without fixed effects. However, the inclusion of time fixed effects improves the goodness of fit.

Columns (5) and (6) simultaneously incorporate time fixed effects and exporting country fixed effects. Following Baier and Bergstrand (2007a), the country fixed effects help to account for the endogeneity bias created by prices and the influence of FTAs among other countries. Here, due to perfect collinearity, control variables were removed. When we introduce both time fixed effects and country fixed effects, we assign a unique fixed effect for each pair of countries. This means each country has a specific influencing factor to capture those unobserved but fixed characteristics, such as cultural differences and long-term political relationships. However, due to the issue of perfect collinearity, we cannot include these fixed effects and standard gravity variables that do not change over time in the model at the same time.

This adjustment brings significant changes. Under both estimation scenarios, the coefficients of the variables FTA_t and $NFTA_{jt}$ are positive and statistically significant, but the goodness of fit is higher under

PPML estimation. Specifically, under PPML estimation, the coefficient of FTA_t is 0.498, which means that a one-unit increase in FTA_t can promote China's agricultural imports from Australia by approximately 64.5%.[4] This is four times the effect estimated using OLS(16.4%).[5] The coefficient of $NFTA_{jt}$ is 0.624, which means that a one-unit change in the ChAFTA can promote China's agricultural imports from other countries by approximately 86.6%.[6] Both coefficients being positive strongly support the positive impact of the ChAFTA on trade creation effects, but there is no trade diversion effects. This aligns with the reality of China's agricultural imports.

Overall, the results suggest that while the initial estimates without fixed effects did not show a significant positive impact of ChAFTA, incorporating time and exporter fixed effects reveals a significant positive effect on Chinese agricultural imports. The trade diversion effect, however, is insignificant in these more comprehensive models.

5.2 Robustness checks

5.2.1 Considering the WTO

Before the signing of the ChAFTA, China's accession to the WTO had a significant impact on its import and export trade. Since China joined the WTO in 2001, its import and export trade has grown rapidly, as illustrated in Figure 1, which shows a rapid increase in the import of Chinese agricultural products. This section incorporates a binary dummy variable indicating China's accession to the WTO or China and Australia being simultaneous members of the WTO.

The robustness checks confirm the stability of the estimation results by controlling for the impact of China's WTO accession. A binary dummy control variable is included to represent China's accession to the WTO, resulting in the following equation (Equation 2):

$$\ln x_{ijt} = \beta_0 + \beta_1 FTA_t + \beta_2 NFTA_{jt} + \beta_3 WTO_t + \alpha_t + \alpha_j + \varepsilon_{ijt} \quad (2)$$

Among them, WTO_t represents a binary dummy variable indicating China's accession to the WTO. If China joined the WTO in period t, the value is 1; otherwise, it is 0.

The results are shown in column (1) of Table 5. We find that the differences are minimal, indicating that the estimation results are robust.

The results are significantly positive, indicating that China's accession to the WTO has a significant positive impact on agricultural imports. The coefficient of the variable FTA_t remains significantly positive, with its magnitude similar to that in the baseline model, suggesting robust results for the baseline model. The coefficient of the variable $NFTA_{jt}$ is positive but not significant. The coefficient of the variable WTO_t is significant and much larger than the coefficient of the variable representing the free trade agreement.

From these results, we can draw two conclusions: first, the impact of China's accession to the WTO on agricultural imports is significantly greater than the implementation of the ChAFTA. Second, the increase in imports from countries other than Australia is mainly due to the impact of the WTO. These findings indicate that the ChAFTA has a significant trade creation effect on China's agricultural imports but no trade diversion effect.

5.2.2 Considering the lead effect

In the study of trade agreements, a common issue is reverse causality, where countries that sign trade agreements may already have close trade relationships. While the inclusion of two-way fixed effects is a reasonable method to address this issue, to further test for potential reverse causality, this section introduces a lead FTA variable (Baier and Bergstrand, 2007a) in the regression equation. This approach helps to identify whether there is an endogeneity problem.

The modified equation (Equation 3) is as follows:

$$\ln x_{ijt} = \beta_0 + \beta_1 FTA_t + \sum\nolimits_{s=1}^{3} \beta_s FTA_{t+s} + \alpha_t + \alpha_j + \varepsilon_{ijt} \quad (3)$$

Among them, FTA_{t+s} represents a binary dummy variable for FTA_t with leads of s = 1,2,3 periods. If the free trade agreement is an exogenous variable relative to trade volume, then the coefficient should not be statistically significant, reflecting changes in trade volume before the implementation of the free trade agreement.

Column (2) of Table 5 shows the results of the lead effects. It is found that when there are time fixed effects and exporting country fixed effects, the coefficient of FTA_{t+s} is significantly positive in the third lead period but significantly negative in the second and first lead periods. This indicates that before the signing and implementation of the ChAFTA, there was no significant increase in agricultural trade between China and Australia. The signing of the ChAFTA was not a consequence of increased trade volume between China and Australia. There is no reverse causality issue.

The results provide robust evidence that the ChAFTA is exogenous relative to trade volumes. The significant negative coefficient of the lead FTA variable supports the conclusion that the trade agreement was not driven by preexisting trade trends. This finding strengthens the validity of the earlier results, which indicated a significant positive impact of ChAFTA on Chinese agricultural imports. The inclusion of the lead FTA variable and the use of fixed effects help to mitigate potential endogeneity concerns, ensuring that the estimated effects are reliable and not biased by reverse causality.

5.2.3 Considering the phasing-in effect

In order to capture the effects of ChAFTA change over time, we incorporate the lagged terms of the FTA into the model. As highlighted in column (3) of Table 5, the estimated coefficients of the lagged FTA variables point to no phasing-in effects of FTA, which is consistent with findings from related studies (Bureau and Jean, 2013). The first-order lagged FTA is significantly negative, indicating a reduction in trade volume 1 year after the implementation of the trade agreement. But the reduction is small (1.7%). This result may be due to companies having to adapt to the rule changes. The trade creation effect still remain significant.

4 According to the definition of semi-elasticity, it refers to the rate of change in the dependent variable when the independent variable increases by one unit.so 64.5% = (exp(0.498)-1) × 100%.

5 16.4% = (exp(0.152)-1) × 100%.

6 86.6% = (exp(0.624) 1) × 100%.

TABLE 5 Robustness check results (PPML).

Variable	(1)	(2)	(3)
	WTO dummy	The lead effect	Phasing-in effect
FTA_t	0.494***	0.319***	0.507***
	(76.42)	(54.52)	(92.92)
$NFTA_{jt}$	0.009	0.009	0.009
	(0.92)	(0.92)	(0.92)
WTO_{it}	2.472***	0.615***	0.615***
	(289.37)	(19.32)	(19.32)
FTA_{t+3}		0.347***	
		(126.47)	
FTA_{t+2}		−0.008***	
		(−3.46)	
FTA_{t+1}		−0.006***	
		(−3.07)	
FTA_{t-3}			0.001
			(0.23)
FTA_{t-2}			0.001
			(0.54)
FTA_{t-1}			−0.017***
			(−5.88)
Constant	0.494***	2.472***	2.472***
	(76.42)	(289.59)	(289.37)
Observations	341,376	341,376	341,376
R-squared	0.396	0.396	0.396
Year FE	Yes	Yes	Yes
exporter FE	Yes	Yes	Yes

Robust z-statistics in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

5.3 Heterogeneity analysis

This study utilizes the classification principles of the Central Product Classification (CPC) version 1.1 to categorize agricultural products into seven major categories: agricultural products, forestry products, fishery products, food, beverages and tobacco, textiles, and other agricultural products. Table 6 below presents the estimation results.

From Table 6, we observe that the coefficients of the FTA_t and $NFTA_{jt}$ variables are significantly positive across all seven categories of agricultural products. This indicates that the signing of the ChAFTA had a notably positive impact on the import of these products, demonstrating a trade creation effect without evidence of a trade diversion effect.

The most significant impacts were on forest products and aquatic products, with estimated increases of approximately 473 and 376%, respectively. Following these, textiles and livestock products showed increases of around 361 and 144%, respectively. Observations indicate that food and livestock product categories are those from which Australia imports the most varieties to China.

These results suggest that ChAFTA not only boosted overall imports from Australia to China but also had positive effects on specific sectors. The significantly positive coefficients across multiple categories highlight the broad benefits of the trade agreement, particularly in sectors such as forest products, aquatic products, textiles, and livestock products. The absence of significant trade diversion effects further supports the notion that ChAFTA mainly facilitated the creation of new trading opportunities rather than altering existing trade patterns.

6 Discussion and conclusion

6.1 Discussion

6.1.1 Summarize the main findings

In this study, we examined the impact of the ChAFTA on China's agricultural imports. Our key findings indicate that the implementation of ChAFTA has significantly enhanced trade creation effects in China's agricultural sector, promoting a 64.5% increase in agricultural product import trade volume. The OLS and PPML estimation methods were compared in empirical research, and the results showed that PPML estimation has more advantages in analyzing data with zero transactions. This finding aligns with the first hypotheses and addresses the literature gap by providing causal evidence on agricultural imports.

TABLE 6 Heterogeneity analysis.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Agricultural Products	Forestry Products	Fishery Products	Food	Beverages and Tobacco	Textiles	Other Agricultural Products
FTA_t	0.893***	1.560***	1.745***	0.767***	0.832***	1.528***	1.170***
	(107.87)	(100.73)	(113.12)	(84.37)	(54.15)	(63.33)	(90.62)
$NFTA_{jt}$	0.897***	1.350***	1.322***	0.736***	0.820***	1.979***	1.197***
	(22.37)	(17.56)	(18.67)	(20.00)	(15.23)	(20.95)	(22.69)
Constant	0.717***	−2.988***	−1.423***	−0.388***	−1.567***	−2.630***	−1.490***
	(64.62)	(−133.73)	(−63.96)	(−32.83)	(−78.28)	(−70.34)	(−86.19)
Observations	682,752	338,709	341,376	1,024,128	682,752	333,375	1,365,504
R-squared	0.233	0.247	0.204	0.356	0.304	0.177	0.190
exporter FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust z-statistics in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The empirical research, taking into account the impact of China's accession to the WTO in 2001, remains robust. The result indicate that joining the WTO has had a significant positive impact on China's agricultural product imports. Although, the trade creation effect still significant, but there is no trade diversion effect. This study further investigates whether there is an endogeneity issue in the empirical results by considering the impact of the lead FTA variables. The results showed that there was no endogeneity issue.

We also considered the phasing-in effects by considering lagged FTA variables and found the phasing-in effects is insignificant. This result is inconsistent with the second hypothesis. This phenomenon may be due to the fact that China has immediately reduced tariffs on most agricultural products imported from Australia, enabling Australian agricultural products to quickly enter the Chinese market and reducing the possibility of a phase-in effect.

In heterogeneity analysis, experiments were conducted to test the import of various agricultural products, and the results showed that ChAFTA has a significant positive impact on the types of agricultural products imported to China. This result confirms the third hypothesis. The most significant impact of ChAFTA on the types of agricultural products imported into China is in the forest products and aquatic products, with estimated increases of approximately 473 and 376%. The growth of textiles and livestock products was approximately 361 and 144%, respectively. The trade diversion effect is not significant in all categories. This study supports the research hypothesis that ChAFTA has a trade creation effect on China's agricultural product imports and heterogeneity in agricultural product imports.

From an economic principles perspective, these findings can be explained as follows: Firstly, economies of scale enable countries within an FTA framework to trade at lower costs, thereby promoting bilateral trade growth. Secondly, the tariff reductions and lowering of other trade barriers brought about by the FTA directly decrease transaction costs, further boosting the growth of trade flows.

6.1.2 Compare with existing literature

From the empirical results, the implementation of the ChAFTA has significantly promoted agricultural imports from China to Australia, and this effect is quite stable. This conclusion differs from that of Baier and Bergstrand (2007a), who found in their study of cross-sectional data from 96 partner countries that the trade effects of trade agreements can sometimes be positive and sometimes negative. The coefficient value of 0.498 is higher than the result of 0.33 obtained by Grant and Boys (2012) in their study on the WTO, but it is lower than the findings of Ghosh and Yamarik (2004) on ASEAN (0.7082) and APEC (1.293), as well as lower than Wang (2017) on China's agricultural exports to ASEAN, which had a result of 0.591.

Our results align with previous studies such as Sun and Reed (2010), who found that FTAs have significant creation effects on agricultural trade. However, our research also highlights distinctions, particularly in the observed heterogeneity of impacts across various agricultural product categories. Unlike earlier work by Wang (2017) which focused on the trade effects of CAFTA on China's agricultural exports, our study provides insights into the import side, showing that not all agricultural imports experience equal benefits under ChAFTA. This suggests that while trade creation is evident, its extent varies based on the type of agricultural product involved, indicating a need for more nuanced policy considerations tailored to specific agricultural sectors.

7 Limitations and propose

Despite these contributions, our study faces several limitations. Firstly, our study focuses on the impact of FTAs themselves and does not capture the significant differences that may exist in the content, depth, and scope of trade agreements, such as non-tariff barriers, service trade, and investment rules. Secondly, the use of a binary dummy variable to represent FTAs fails to separate the independent effects of other economic policies implemented alongside the trade agreements, like exchange rate policies or the RCEP.

These limitations suggest that future research should consider a more comprehensive approach to analyzing the impacts of FTAs. Specifically, it is important to account for the diverse elements within trade agreements, including non-tariff barriers, service trade, and investment rules, which can significantly influence trade outcomes. By addressing these gaps, future studies can provide a more nuanced understanding of how different components of FTAs and concurrent policies affect international trade.

By continuing to investigate these aspects, scholars can contribute to a more nuanced view of how FTAs shape global agricultural markets, ultimately benefiting both producers and consumers.

8 Conclusion

This study provides the first systematic evidence of how the ChAFTA reshaped China's agricultural imports through trade creation and diversion. Using a modified gravity model, we find Strong trade creation effects, ChAFTA can increased China's agricultural imports from Australia, with peak effects in sectors like forest products and aquatic products. The limited diversion effects suggest that multilateral trade relationships remain resilient to bilateral FTAs. While this analysis focuses on FTA, future studies should integrate non-tariff measures and environmental clauses to fully capture modern FTA impacts.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

YC: Methodology, Writing – original draft. WC: Data curation, Writing – review & editing. XZ: Writing – original draft, Data curation.

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Supplementary material

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References

Anderson, J. E., and van Wincoop, E. (2003). Gravity with gravitas: a solution to the border puzzle. *Am. Econ. Rev.* 93, 170–192. doi: 10.1257/000282803321455214

Baier, S. L., and Bergstrand, J. H. (2007a). Do free trade agreements actually increase members' international trade? *J. Int. Econ.* 71, 72–95. doi: 10.1016/j.jinteco.2006.02.005

Baier, S. L., and Bergstrand, J. H. (2007b). Estimating the effects of free trade agreements on international trade flows using matching econometrics. *J. Int. Econ.* 77, 63–76. doi: 10.1016/j.jinteco.2008.09.006

Ben-David, D. (1993). Equalizing exchange; trade liberalization and income convergence. *Q. J. Econ.* 108, 653–679.

Bergstrand, J. H. (1985). The gravity equation in international trade: some microeconomic foundations and empirical evidence. *Rev. Econ. Stat.* 67, 474–481.

Bergstrand, J. H., Larch, M., and Yotov, Y. V. (2015). Economic integration agreements, border effects, and distance elasticities in the gravity equation. *Eur. Econ. Rev.* 78, 307–327. doi: 10.1016/j.euroecorev.2015.06.003

Berlingieri, G., Criscuolo, C., and Nomaler, Ö. (2021). Consumer welfare and the quality of imported goods. *Econ. J.* 131, 2279–2314.

Bureau, J., and Jean, S. (2013). "The impact of regional trade agreements on trade in agricultural products" in OECD food, agriculture and fisheries papers, no. 65 (Paris: OECD Publishing).

Caliendo, L., and Parro, F. F. (2015). Estimates of the trade and welfare effects of NAFTA. *Rev. Econ. Stud.* 82, 1–44. doi: 10.1093/restud/rdu035

Frankel, J. A., and Rose, A. K. (2002). An estimate of the effect of common currencies on trade and income. *Q. J. Econ.* 117, 437–466. doi: 10.1162/003355302753650292

Frankel, J. A., and Wei, S.-J. (1994). "Trade blocs and trade flows" in *Macroeconomics annual 1994*, ed. J. J. Rotemberg. (Cambridge, MA: MIT Press), 1–64.

Froning, D. H. (2000). The benefits of free trade: a guide for policymakers. *Heritage Foundation Backgrounder* 1391, 1–11.

Fu, D., and Cao, L. (2023). Research on the trade effects of environmental rules in regional trade agreements: a dual perspective based on trade creation and trade diversion effects. *Int. Trade Issues* 3, 18–35. doi: 10.13510/j.cnki.jit.2023.03.007

Ghazalian, P. (2016). The effects of NAFTA/CUSFTA on agricultural trade flows: an empirical investigation. *Can. J. Agric. Econ.* 65, 219–248. doi: 10.1111/cjag.12119

Ghosh, S., and Yamarik, S. (2004). Are regional trading arrangements trade creating?: an application of extreme bounds analysis. *J. Int. Econ.* 63, 369–395. doi: 10.1016/S0022-1996(03)00058-8

Grant, J. H., and Boys, K. A. (2012). Agricultural trade and the GATT/WTO: does membership make a difference? *Am. J. Agric. Econ.* 94, 1–24. doi: 10.1093/ajae/aar087

Grant, J. H., and Lambert, D. M. (2008). Do regional trade agreements increase Members' agricultural trade? *Am. J. Agric. Econ.* 90, 765–782. doi: 10.1111/j.1467-8276.2008.01134.x

Guillin, A., Rabaud, I., and Zaki, C. (2023). Does the depth of trade agreements matter for trade in services? *World Econ.* 46, 3616–3653. doi: 10.1111/twec.13478

Harada, T., and Nishitaten, K. (2022). The trade creation effect of tariff reduction on wine imports in East Asia. *Pac. Econ. Rev.* 27, 34–51. doi: 10.1016/j.asieco.2021.101308

Hndi, B. M., Maitah, M., and Mustofa, J. (2016). Trade impacts of selected free trade agreements on agriculture: the case of selected north African countries. *Agris on-line Papers in Economics and Informatics.* 8, 39–50. doi: 10.7160/aol.2016.080304

Howard, J. M., Maskus, K. E., and Ridley, W. C. (2023). The impacts of intellectual property–related preferential trade agreements on bilateral patent applications. *Policy Res. Working Papers*. 10320. doi: 10.1596/1813-9450-10320

Lambert, D., and McKoy, S. (2009). Trade creation and diversion effects of preferential trade associations on agricultural and food trade. *J. Agric. Econ.* 60, 17–39. doi: 10.1111/j.1477-9552.2008.00184.x

Magee, C. (2003). Endogenous preferential trade agreements: an empirical analysis. *Contributions Econ. Analysis Policy 2, no. 1.* 2, 1–17. doi: 10.2202/1538-0645.1166

Magee, C. S. (2008). New measures of trade creation and trade diversion. *J. Int. Econ.* 75, 349–362. doi: 10.1016/j.jinteco.2008.03.006

Magee, C. S. (2016). Trade creation, trade diversion, and the general equilibrium effects of regional trade agreements: a study of the European community-Turkey customs union. *Rev. World Econ.* 152, 383–399. doi: 10.1007/s10290-015-0239-4

Mattoo, A., Mulabdic, A., and Ruta, M. (2022). Trade creation and trade diversion in deep agreements. *Canadian J. Econ. Revue canadienne d'économique* 55, 1598–1637. doi: 10.1111/caje.12611

Meade, J. E. (1955). *The theory of customs unions*. Amsterdam: North-Holland Publishing Company.

Ohyama, M. (1972). Trade and welfare in general equilibrium. *Keio Economic Studies*. 9, 37–73.

Pfaffermayr, M. (2019). Gravity models, PPML estimation and the bias of the robust standard errors. *Appl. Econ. Lett.* 26, 1467–1471. doi: 10.1080/13504851.2019.1581902

Pfaffermayr, M. (2020). Constrained Poisson pseudo maximum likelihood estimation of structural gravity models. *Int. Econ.* 161, 188–198. doi: 10.1016/j.inteco.2019.11.014

Quah, D. (1994). Convergence across Europe. London, UK: Mimeo, London School of Economics.

Sun, L., and Reed, M. R. (2010). Impacts of free trade agreements on agricultural trade creation and trade diversion. *Am. J. Agric. Econ.* 92, 1351–1363. doi: 10.1093/ajae/aaq076

Timsina, K. P., and Culas, R. J. (2020). Impacts of Australia's free trade agreements on trade in agricultural products: an aggregative and Disaggregative analysis. *Aust. J. Agric. Resour. Econ.* 64, 889–919. doi: 10.1111/1467-8489.12377

Viner, J. (1950). The customs union issue. New York: Carnegie Endowment for International Peace.

Wang, T. (2017). Trade creation and trade diversion effects of China's agricultural exports under the CAFTA framework. *World Agricul.* 12, 163–168. doi: 10.13856/j.cn11-1097/s.2017.12.025

WTO (2023). RTAs currently in force (by year of entry into force), 1948–2022. Geneva: World Trade Organization.

Yang, S., and Martinez-Zarzoso, I. (2014). A panel data analysis of trade creation and trade diversion effects: the case of ASEAN–China free trade area. *China Econ. Rev.* 29, 138–151. doi: 10.1016/j.chieco.2014.04.002

Zhou, Z. Y., Wu, Y. R., and Si, W. (2007). Evolving patterns of agricultural trade between Australia and China. *Australasian Agribusiness Rev.* 15, 27–45. Available online at: http://www.agrifood.info/review/2007/Zhou_Wu_Si.html