

A Study of the Factors Influencing Cooperation Between the Grain Industry in China and ASEAN Countries: An Analysis Based on the Trade Gravity Model

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Abstract: ASEAN countries are located in the tropical monsoon climate, which is the most suitable region for rice growth. The unique geographical and climatic advantages as well as cheap labor resources have created the world's major food exporting countries, Thailand, Vietnam, Myanmar and Indonesia. China is one of the world's most populous countries, although China is also an important food producer, but the large population base makes the domestic food production cannot be completely self-sufficient, need to rely on imports from other food-producing countries. The establishment of CAFTA for China and ASEAN countries in the food industry cooperation provides more policy support, strengthen China and ASEAN countries in the food industry of the regional cooperation, and the establishment of CAFTA for China and ASEAN countries to reshape the food industry, and to strengthen China and ASEAN countries in the food industry. It is of great significance for China and ASEAN countries to reshape the food industry chain and solidify regional food security. This paper introduces the current situation of the development of food industry cooperation between China and ASEAN countries, analyzes the influencing factors affecting the development of food industry cooperation between China and ASEAN countries by using the trade gravity model, and finally, puts forward some suggestions for food industry cooperation between China and ASEAN countries under the background of CAFTA according to the conclusion of the influencing factors.

Keywords: China; ASEAN Countries; Food Industry.

1. Introduction

The lockdown measures that countries worldwide implemented during the pandemic have posed challenges to cross-border food supply chains. According to the 2024 Global Food Crisis Report by the Food and Agriculture Organization of the United Nations (FAO), approximately 281.6 million people in 59 countries and regions experienced severe food insecurity in 2023. Russia and Ukraine are major global grain producers and exporters, primarily exporting wheat. The conflict between Russia and Ukraine has disrupted agricultural production in both countries, leading to unstable wheat supplies and driving up global grain market prices. This has exacerbated the worldwide food security crisis and introduced significant uncertainties into the global food supply chain. ASEAN nations are major producers and suppliers of staple crops such as rice and corn. Thailand, Vietnam, and Myanmar—key rice-producing countries—share borders with China. China has geographical advantages for agricultural cooperation with ASEAN. Amid the severe global food crisis, strengthening this collaboration is important for ensuring food security in China, promoting economic development in ASEAN, and maintaining food security in the Asia-Pacific region[1]. The China-ASEAN Free Trade Agreement (CAFTA) facilitates agricultural trade by reducing tariffs and non-tariff barriers. The “Early Harvest Program,” for example, has achieved zero tariffs on certain agricultural products, and preferential tariff measures have further promoted economic and trade cooperation in the food industry between China and ASEAN. Within the CAFTA framework, China and ASEAN countries have intensified their collaboration on food security. This includes the establishment of emergency rice reserves, food security information systems, and early warning mechanisms.

Designated the "China-ASEAN Year of Agricultural Development and Food Security Cooperation," 2023 aims to improve agricultural production and supply capabilities [2].

2. Current Status of the Grain Industry in China and the ASEAN Countries

The National Bureau of Statistics classifies grains into three categories: cereal crops (e.g., rice, wheat, corn, and sorghum), tuber crops (e.g., sweet potatoes and potatoes), and legume crops (e.g., soybeans, broad beans, peas, and mung beans). Rice, wheat, and corn are the three primary staple grains. Consequently, grain production and trade between China and ASEAN countries primarily revolves around these three staple grains.

(1) Distribution of China's Grain Industry

China's vast territory spans tropical, subtropical, and temperate zones, providing favorable climatic conditions for grain cultivation. These natural resource advantages have fostered extensive rice and wheat production areas across the country. Arable land is primarily concentrated in plains, intermontane basins, and extensive hilly regions, such as those in Northeast and North China, the middle and lower reaches of the Yangtze River, and the Pearl River Delta. These regions account for approximately 90% of the nation's total cultivated land. The five provinces with the largest cultivated areas are Heilongjiang, Inner Mongolia, Henan, Jilin, and Xinjiang, collectively accounting for about 40% of the nation's total arable land. According to data from the National Bureau of Statistics, China's grain crop planting area reached 118,968.54 thousand hectares in 2023. Rice, wheat, and corn accounted for 28,949.10, 23,627.20, and 44,218.90 thousand hectares, respectively. In terms of exports, China's primary

grain export products are rice and milled rice, wheat, and soybeans. The main categories of grain imports are soybeans, corn, and wheat, with soybeans holding a dominant position. In 2021, China's total grain output was 682.851 million metric tons. Corn production amounted to 272.552 million metric tons, accounting for 43.1% of total grain output. Rice production was 212.843 million metric tons, ranking second in total grain output. Wheat production reached 136.946 million tons, ranking third.

Table 1. shows the annual grain production in China from 2010 to 2021, including the output of the three major staple crops: rice, wheat, and corn.

China's Annual Grain Production (Unit: 10,000 tons)				
Year	Grain	Rice	Wheat	Corn
2010	55911	19727	11609	19075
2011	58849	20288	11857	21132
2012	61223	20653	12248	22956
2013	63048	20629	12364	24845
2014	63965	20961	12824	24976
2015	66060	21214	13256	26499
2016	66044	21109	13319	26361
2017	66161	21268	13424	25907
2018	65789	21213	13144	25717
2019	66384	20961	13359	26077
2020	66949	21186	13425	26066
2021	68285	21284	13694	27255

Data Source: China Statistical Yearbook 2022

(2) China's Grain Industry Trade Situation

In 2020, China was the world's largest rice importer, followed by the Philippines and Saudi Arabia. The world's largest wheat importers were Indonesia, Turkey, and China. Mexico, Japan, and China were the world's largest corn importers. China ranks among the top importers of all three major staple grains. Since 2004, China's grain trade has shifted from net exporter to net importer, and the trade deficit has widened significantly since 2009. China's grain imports consist mainly of soybeans, corn, wheat, and rice. Brazil, the United States, and Argentina are the main sources of soybean imports, while Ukraine and the United States supply corn, and Russia and Ukraine supply wheat. In 2020, China's total grain production reached 617.48 million tons, ranking first among the world's top ten grain-producing countries. However, the grain trade deficit expanded to \$94.77 billion, indicating a continued need for substantial imports.

Table 2. Top Ten Grain Producing Countries in the World in 2020

Top 10 Grain Producing Countries in the World in 2020	
Country	Country Grain Production (10,000 tons)
China	61748
United States	43488
India	33503
Russia	13004
Brazil	12557
Argentina	8657
Indonesia	7715
Canada	6501
Ukraine	6434
Bangladesh	5996

Data Source: Statistical Yearbook 2022 of Food and Agriculture

According to data released by the General Administration of Customs, China imported 164.54 million tons of grain and exported 3.31 million tons in 2021, resulting in a net import

of grain of 161.23 million tons. This net import accounted for 24% of China's total grain production that year.

From 2015 to 2019, trade data categorized by grain type reveals that imports of rice and paddy rice dominated China's grain imports. However, beginning in 2020, the import value of wheat and corn significantly exceeded previous years' figures. Since then, wheat and corn imports have surpassed rice imports every year, maintaining this trend for four consecutive years. On the export side, rice exports remain dominant, while wheat and corn exports account for a relatively small proportion. Notably, China has maintained a persistent trade deficit for its three major grain staples, with import volumes substantially exceeding exports [3]. The trade deficit for paddy and rice has remained relatively stable, whereas the deficits for wheat and corn have increased year over year.

In 2023, China's top five sources for paddy and rice imports were Vietnam, Thailand, Myanmar, Cambodia, and India. Imports from these four ASEAN countries—Vietnam, Thailand, Myanmar, and Cambodia—accounted for 86.09% of the total. The primary sources of corn imports were Bulgaria, Myanmar, and Laos. Four of the top ten import sources were ASEAN countries: Myanmar, Laos, the Philippines, and Indonesia. Australia, Canada, the United States, and France were China's primary sources for wheat imports in 2023. Regarding grain exports, rice, wheat, and corn primarily flowed to ASEAN nations, such as Indonesia, the Philippines, and Malaysia, as well as to other countries, including South Korea, North Korea, and Japan.

(3) Distribution of Food Industries in ASEAN Countries

Due to its unique geographical location and climatic conditions, Southeast Asia has become one of the world's major food-producing regions. ASEAN countries generally have abundant agricultural resources. Their hot and rainy climate, with rainfall coinciding with the warm season, is ideal for rice production[4]. Thailand and Vietnam, for example, can harvest rice three times per year. The region also has a competitive advantage in producing tropical fruits, palm oil, and other crops. Rice is the primary staple crop across ASEAN, particularly in Thailand, Vietnam, Myanmar, and Cambodia. There, it serves as the main food source for local populations and a vital export commodity. Furthermore, ASEAN nations extensively cultivate other staple crops, such as corn and soybeans, as well as cash crops, including natural rubber[5]. This establishes the region as a major food exporter. Indonesia stands out among the ten ASEAN countries with its vast land area of 1.92 million square kilometers, far exceeding other members, and it is also the most populous nation[6]. It is followed by Thailand, Vietnam, Malaysia, the Philippines, Laos, Cambodia, Brunei, and Singapore. Land area significantly influences the scale of food cultivation and production. In 2021, Indonesia cultivated rice on 10,411.8 thousand hectares, Thailand cultivated rice on 11,244 thousand hectares, and Vietnam cultivated rice on 7,219.8 thousand hectares. All other ASEAN nations had cultivation areas below seven million hectares. In 2021, Myanmar cultivated 700,000 hectares of wheat; Thailand cultivated 1,240 hectares; and all other ASEAN nations cultivated less than 1,000 hectares. The top three ASEAN countries by wheat cultivation area were Indonesia, the Philippines, and Thailand.

A comparison of China's and ASEAN's rice production figures from 2016 to 2021 reveals that China's annual rice output has remained remarkably stable, consistently surpassing 200 million tons and exceeding the production of

any single ASEAN nation. Rice production among the ten ASEAN nations varies significantly. Indonesia, Vietnam, Thailand, Myanmar, and the Philippines produce far more rice annually than Cambodia, Laos, Malaysia, Brunei, and Singapore combined. Brunei and Singapore are small island nations in Southeast Asia[7]. Although they have tropical rainforest climates ideal for rice cultivation, their limited land area lacks extensive farmland for rice farming. Consequently, these two countries primarily rely on imported rice to meet domestic demand[8].

(4) Grain Industry Trade in ASEAN Countries

According to data from the Food and Agriculture Organization of the United Nations (FAO), grain imports and exports in the Association of Southeast Asian Nations (ASEAN) region have steadily increased. In 2022, the ASEAN region's total grain imports reached \$142 billion, with rice, wheat, and corn being the primary crops imported. Rice exports from Thailand, Vietnam, and Myanmar accounted for the majority of these imports.

Thailand's rice exports play a significant role in the global market and are a vital part of the country's economy. Primary export destinations include China, the Middle East, and Africa. According to United Nations Commodity Statistics, Thailand has consistently led ASEAN's rice exports among its ten member states. Although Thailand's rice export volume has declined since 2019, it remains the top exporter within ASEAN. Thai Headline News reports that Thailand's rice exports reached 8.76 million tons in 2023, marking a 13.62% year-on-year increase and the highest level since 2019. The total value was US\$5.144 billion, representing 28.43% year-over-year growth.

Vietnam's rice exports have also shown a consistent

upward trend, with expanding trade volumes solidifying its position as the second-largest rice exporter in ASEAN[9]. Amid heightened food security concerns due to the Russia-Ukraine conflict, some nations have imposed rice export restrictions, while others have increased grain reserves. Consequently, Vietnam's rice exports are experiencing a period of rapid growth. From January to July of this year, Vietnam exported over 5.1 million tons of rice, worth \$3.2 billion, marking a 25% increase in volume and a 5.8% increase in unit price year-over-year, according to the Grain Information Network. For the first time, Vietnam surpassed Thailand in export volume, becoming the ASEAN country with the highest rice exports in the first half of 2024.

Myanmar ranks third among ASEAN nations in rice exports, behind Thailand and Vietnam in volume, though it maintains relatively stable shipments. It remains a primary source of rice and broken rice for China.

Notably, although Indonesia ranks first among ASEAN countries in both land area and arable land, its substantial domestic consumption and underdeveloped agricultural production result in grain exports that are far below those of Thailand, Vietnam, and Myanmar. The grain produced is primarily intended for domestic consumption.

3. Current Status of Grain Industry Cooperation and Development Between China and ASEAN Countries

(1) Grain Industry Trade Between China and ASEAN

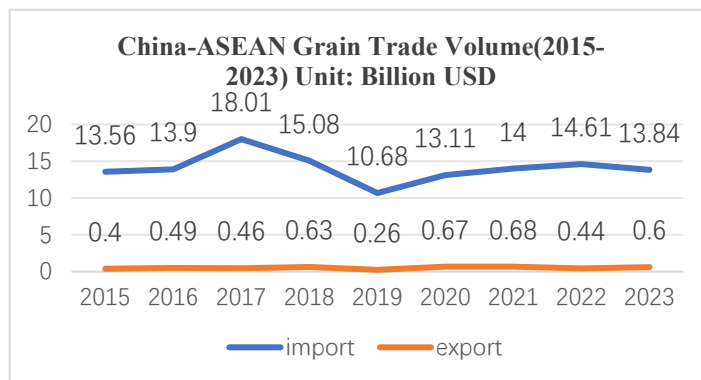


Figure 1. China-ASEAN Grain Trade Volume, 2015-2023
Data source: General Administration of Customs of China

Most residents of China and ASEAN countries consume rice as their staple food, and most rice is cultivated in tropical regions that are not suitable for wheat growth [10]. Consequently, grain trade between China and ASEAN focuses on two crops: rice and corn. According to China's 2023 import trade data for major grain crops from ASEAN nations, China only imports grain from select ASEAN countries. Singapore and Brunei do not export grain crops due to their limited land areas. Similarly, China's grain exports to ASEAN cover only select member states. Thailand and Vietnam, for example, are major grain producers capable of achieving self-sufficiency. From 2015 to 2023, the grain import and export trade volume between China and ASEAN reveals that China has maintained a persistent trade deficit in the grain industry with ASEAN countries. China imports substantial quantities of grain from ASEAN while exporting

only minor amounts; import values consistently exceed export values. Import values consistently exceed US\$1 billion, while export values remain below US\$100 million.

(2) China-ASEAN Cooperation in the Grain Industry

Due to China's rapid industrialization and urbanization, the amount of land dedicated to agricultural production has decreased year after year. More young people are leaving rural areas to seek employment in cities, which puts pressure on China's grain production. Meanwhile, ASEAN countries have become key partners for China in ensuring food security and promoting grain industry trade, leveraging their natural advantages in crop production and supply, as well as their friendly cooperative relationship with China. The consensus reached by both parties regarding food security encompasses production, trade, and emergency response. Together, they safeguard food security in the Asia-Pacific region and

promote the development of the China-ASEAN food industry[11].

4. Factors Influencing Grain Industry Cooperation Between China and ASEAN Countries

Trade in the grain industry primarily involves primary grain products. Grain trade between China and ASEAN countries is relatively concentrated in terms of product variety. Due to the differing resource endowments of ASEAN nations, China's grain imports and exports vary across individual ASEAN member states. This study treats ASEAN countries as a unified entity, using factors influencing grain trade volumes between China and ASEAN to characterize the factors affecting grain industry cooperation between China and ASEAN countries.

(1) Model Construction

The gravity model is widely used in empirical analyses of economic and trade topics. It serves as a crucial framework for examining the factors that influence bilateral trade. In 1962, Dutch economist Jan Tinbergen derived the fundamental form of the gravity model, or the trade gravity equation, based on the universal gravitational formula.

$$T_{ij} = \alpha \frac{(GDP_i \cdot GDP_j)^{\beta_1}}{D_{ij}^{\beta_2}}$$

In this model, the ASEAN countries are treated as a single entity. T_{ij} represents the trade flow of imports and exports between China and the ASEAN countries. α is a constant coefficient that characterizes the economic scale of both economies using their combined gross domestic product (GDP). The denominator, D , denotes the average distance between China and the ASEAN countries and reflects how grain import-export trade flows between China and the ASEAN countries are influenced by factors such as economic scale and distance-related costs.

The trade gravity model derives a linear relationship by taking logarithms.

$$\ln Trade_t = \alpha + \alpha_1 GDP_{ct} + \alpha_2 GDP_{at} + \alpha_3 Population_{ct} + \alpha_4 Population_{at} + \alpha_5 \ln Distance + \alpha_6 \ln Tariff + \varepsilon$$

Trade represents the volume of grain trade between China and ASEAN countries in year t , where t ranges from 2015 to 2022. GDP_{ct} represents China's GDP in year t , and GDP_{at} represents the average GDP of ASEAN countries in year t .

Distance is the logarithm of the distance between China and the capital of each ASEAN country, resulting in a constant. "Population" represents China's and the ASEAN countries' population size in year t , and "Tariff" indicates the tariff factor affecting China-ASEAN food industry cooperation and is treated as a random disturbance term. This study examines China's food imports and exports with ASEAN countries, leading to the establishment of two models. China's Grain Import Trade Model with ASEAN Countries

$$\ln IMP_t = \alpha + \alpha_1 GDP_{ct} + \alpha_2 GDP_{at} + \alpha_3 Population_{ct} + \alpha_4 \ln Distance + \alpha_5 \ln Tariff + \varepsilon$$

China's Grain Export Trade Model with ASEAN Countries

$$\ln EXP_t = \alpha + \alpha_1 GDP_{ct} + \alpha_2 GDP_{at} + \alpha_3 Population_{at} + \alpha_4 \ln Distance + \varepsilon$$

The dependent, independent, and dummy variables are set as follows:

Dependent variable: Total grain trade imports and exports between China and ASEAN countries.

Explanatory variables:

1) China's GDP (USD). During its rapid industrialization phase, China's continuous economic development and technological innovation progressively replaced outdated farming methods with advanced agricultural techniques. This boosted domestic grain production and drove grain exports to ASEAN countries. Rising living standards and economic growth also create demand for premium grains, such as Thai jasmine rice, in ASEAN markets, stimulating grain imports from the region.

2) ASEAN countries' GDP (USD): Most ASEAN countries are major agricultural producers, with only Brunei and Singapore relying entirely on grain imports. Higher average GDP indicates greater overall economic development within ASEAN countries and increases the likelihood of upgrading agricultural technology to boost grain production. This, in turn, enhances grain exports, creating a positive feedback loop that stimulates further GDP growth in ASEAN nations.

3) Population Size: The export model uses population data from ASEAN countries, while the import model uses population data from China. In the food industry, population size is intrinsically linked to the scale of food production and consumption. China's population is second largest in the world, which significantly influences its food imports and exports.

4) Trade Distance: Since grain is not a high-value product, its trade value fluctuates with distance. China shares land borders with some ASEAN countries and faces others across the sea. Shorter trade distances between neighboring countries increase the likelihood of substantial grain trade. This study measures trade distance as the geographical distance between China and the capitals of major ASEAN countries that import or export grain. This distance is calculated based on each capital's latitude and longitude and is a fixed value independent of year. In the model, the logarithm of trade distance is treated as a constant.

Dummy variables:

5) Tariff Changes (Tariff). Under the CAFTA framework, preferential tariffs have consistently been applied to grain imports between China and ASEAN countries. Prior to 2018, the tariff rate was 5%, increasing to 50% thereafter. Tariffs directly impact grain trade between China and ASEAN countries. Therefore, this variable is assigned a value of 1 before 2018 and 0 thereafter.

(2) Data Sources:

The data primarily originates from UNCOMTRADE and the International Monetary Fund. Due to the availability of data and the development of grain industry trade between China and ASEAN countries, the empirical analysis uses data from 2022 to 2023.

(3) Empirical Results Analysis

The results of the model regression show that China's grain imports from ASEAN countries are significantly and positively correlated with China's population size, but significantly and negatively correlated with the distance between the two regions. This implies that the larger China's population, the more likely it is to import grain from ASEAN countries to meet domestic demand. Similarly, the closer China is to ASEAN countries, the more likely grain trade becomes. Secondly, tariff policies also play a role. China's

preferential tariff rates for grain imports from ASEAN countries are significantly correlated with grain trade. More favorable tariff arrangements have stimulated grain industry trade between China and ASEAN nations.

Table 3. Empirical Results of the Model for China's Grain Imports from ASEAN Countries

	(1)	(2)	(3)	(4)	(5)
	IMP	IMP	IMP	IMP	IMP
PopulationC	33.63***	51.32***	64.11**	59.91**	7.443
	(3.80)	(3.65)	(2.18)	(2.08)	(0.07)
GDPA		-1.649	-1.664*	-1.059	-0.965***
		(-1.62)	(-1.65)	(-0.99)	(-2.60)
GDPG			-0.788	-0.923	12.05*
			(-0.47)	(-0.56)	(1.79)
distance				-18.17*	-11.69***
				(-1.75)	(-4.70)
Tariff					8.200***
					(5.81)
_cons	-694.2***	-1024.0**	-1269.1**	-1045.1*	-389.8
	(-3.72)	(-3.71)	(-2.24)	(-1.84)	(-0.18)
N	82	82	82	82	82

t statistics in parentheses

* p < 0.05, ** p < 0.01, *** p < 0.001

Table 4. Empirical Results of the Grain Export Trade Model from China to ASEAN Countries

	(1)	(2)	(3)	(4)
	EXP	EXP	EXP	EXP
PopulationA	0.983**	0.709	0.871	0.197
	(1.99)	(0.98)	(1.09)	(0.25)
GDPA		0.449	0.208	1.132
		(0.54)	(0.23)	(1.19)
GDPG			1.476	1.006
			(1.00)	(0.68)
distance				-7.171*
				(-1.74)
_cons	-5.318	-12.16	-53.35	7.113
	(-0.62)	(-0.79)	(-1.22)	(0.13)
N	82	82	82	82

t statistics in parentheses

* p < 0.05, ** p < 0.01, *** p < 0.001

The results of China's grain export trade with ASEAN countries suggest that the population size of these nations influences China's grain trade with them. However, the GDP of China and ASEAN countries has little impact on bilateral grain industries. Geographical distance, on the other hand, plays a certain role in bilateral grain trade.

5. Conclusion

(1) The Food Security Situation in the China-ASEAN

The global grain export market is dominated by a few countries. Specifically, the United States, Brazil, and Argentina collectively account for nearly two-thirds of the corn export market, with their combined exports reaching 64% of the global total. Similarly, India, Vietnam, and Thailand

account for 57% of global rice exports. Russia, the United States, and Canada together contribute 45% of global wheat exports. These figures demonstrate that a handful of nations play a pivotal role in global food exports.

China and the Association of Southeast Asian Nations (ASEAN) collectively have a population exceeding 2 billion, accounting for approximately one-quarter of the global population. This underscores the critical importance of food security in the China-ASEAN region. Since last year, global food security has faced severe challenges, including natural disasters, insufficient fertilizer supplies, and market volatility caused by supply chain disruptions. These factors have collectively driven up the number of people facing food crises. According to the 2022 State of Food Security and Nutrition in the World report, 139 million people in Southeast Asia, representing 20.7% of the region's total population, are affected by moderate to severe food insecurity. These figures highlight the urgent need for effective measures to address current challenges and ensure food security.

(2) China and ASEAN Countries Strengthen Grain Trade Cooperation by Leveraging Their Respective Advantages

China and the ASEAN countries share geographical proximity and land-sea connectivity. China borders Vietnam, a major grain producer, and is close to Thailand, Myanmar, and Cambodia. This provides a convenient transportation network and low logistics costs for grain trade, facilitating the rapid circulation of grain products between China and the ASEAN countries. Cooperation in developing infrastructure—including ports, railways, and highways—has increased the efficiency of regional grain transportation and trade. For example, the ASEAN Highway Network (AHN) and the Singapore–Kunming Railway (SKRL) aim to create multiple efficient, integrated, secure, and environmentally sustainable land transport corridors that connect all ASEAN member states and neighboring countries.

Regional economic integration, including the establishment of the China-ASEAN Free Trade Area, has provided preferential policies, such as tariff reductions, for grain trade between China and ASEAN countries. China has granted special preferential treatment for grain imports from major ASEAN grain-producing countries, lowering import tariffs. Grain-exporting ASEAN countries—including Vietnam, Thailand, Myanmar, and Cambodia—have also developed agricultural plans to increase regional grain production, promote grain export trade, and gradually reduce export tariffs. These measures promote the liberalization and facilitation of grain trade between China and ASEAN nations.

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