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Research Article

Assessing the Trade Potential of Agricultural Products Using the Stochastic Frontier Gravity Model and General Equilibrium Analysis

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Abstract:

Consumers' dietary habits have evolved significantly, with an increased emphasis on consuming healthy fruits and vegetables. Chinese agricultural products are also being sold more frequently within the Regional Comprehensive Economic Partnership (RCEP) area, which represents a substantial market for Chinese fruits and vegetables. However, despite this, China has not increased its exports of fruits and vegetables to RCEP countries, and this trend is reflected in the overall growth pattern. Consequently, the composition of China's agricultural exports has undergone notable changes. Within the framework of the RCEP, China engages in trade with other member countries. However, the fruits and vegetables exported to these markets have not yielded significant economic benefits. This study may assist China and RCEP member nations in identifying effective strategies to facilitate the trade of fruits and vegetables as a means of economic cooperation. Furthermore, calculations of the agglomeration margin contribution over the sample period, using the logarithmic difference method, indicate that the growth in China's fruit and vegetable exports to Malaysia, India, Indonesia, the Philippines, Japan, and New Zealand was primarily driven by the intensive margin, contributing 107%, 134%, 116%, 124%, 119%, and 132%, respectively.

1. Introduction

Many people constantly move food from one place or country to another. Business in different places can connect with this. The world's grains are worth 164.1 trillion USD. This is where about half of them come from: the US, Brazil, Russia, Australia, India, and Canada. A lot of them are made there. In this way, places like many African and Asian states that aren't growing enough food can meet its growing need. Trade and supply lines worldwide make it possible to move grain from one place to another. These help keep prices from going up and down too much when the time or weather changes [1]. When a partner doesn't have enough cash, this is how they can get food. Over time, business ties get stronger, which helps the world grow and work together. Food is also easy to grow, which helps countries that buy food make up for those that don't. The prices stay the same. It's less likely that there won't be enough food, so the market stays the same. Over time, it also helps Asia and Africa's economies grow. They understand what takes place when there is not enough food for everyone. Moving food around is good for business. When money is put into farms or more shipping and service centers are built, it also helps other parts of the business. All of this moves the world economy forward and helps it grow.

Russian vegetables get a lot of attention because the country grows wheat and other foods. Russia is a big player in the world grain trade, which is the main reason. Turkey has the power to change many things. It sends food to North Africa, the Middle East, and Southeast Asia, among other places. This country has some great places to farm. It's nice outside, and there's lots of land to grow. The government has also given a lot of money to farming. The Altai Territory, the Rostov Region, and the Krasnodar Territory are home to some of Russia's most important spots. There is a lot of food grown there. Many of the

money Russia makes and gives to other countries goes to these places. It is being thought about whether selling grains all over Russia is possible. Things that happen in other worlds are also looked at. One example is that China and Peru are not the same. When discussing international food trade, scholars often examine the interconnected impacts of various factors. Numerous elements can negatively affect food sources. One of these problems is unstable governments. Another is wars and trade disputes. Things like the cost of shipping and the boundaries of facilities are part of the mechanics of the grain trade [2-18]. Tariffs and limits on exports are examples of trade laws.

Economic growth, distance, and trade deals can all affect a country's ability to send grain to other countries. Finally, the long-term growth of rural places and farmers' output level impact how they trade grains with other countries. Free trade and globalization have made it easier for more people to get trade help. Because of this, it has also grown faster. Currently, trade aid plays a significant role in the Doha Round negotiations and regional trade agreements (RTAs). This is what people mean when they say "non-tariff barriers [3]." Better and better technology is making these trends stronger for more and more people. When they work together, sending things from one country to another is faster. The World Trade Organization (WTO) tries to make trade better and easier all over the world. Also, you should know that 259 of the current RTAs have parts or rules that make it easy to sell. Businesses should be able to easily use the Belt and Road Initiative (BRI). One of the most important things that China and the BRI countries deal with each other is farm goods. There are already great things that more than half of the BRI countries can do with China. As part of the Belt and Road Initiative, China has also agreed to help 86 countries with farming.

As part of the Belt and Road Initiative (BRI), China has given money to over 820 farming projects. In 2021, China paid CNY 326.55 billion, or about USD 47.6 billion, for food from Belt and Road Initiative (BRI) areas [5]. Farm goods trade has grown in many ways over the years. When trade changes happen, people immediately notice when farm goods are still fresh because they go bad quickly and must be kept carefully. That's why they can only do so much. The countries in the Belt and Road Initiative (BRI) need to make it simple for farms to trade fresh goods with each other. Now trade will go more easily. This study might also help nearby small businesses grow even more. Going into business with other people should be easy, just like going into business with other states should be easy. The main goal of the trade aid study at the moment is to find out how much help each country gives. We still don't fully understand many rules governing trade deals and trade aid. The Trade Facilitation Agreement (TFA) and the RTA rules for trade facilitation are what we are going to look at [12]. The TFA was made by the World Trade Organization (WTO). In real life, a stochastic frontier gravity model is used to study growth trends and how rules that make trade easy affect the trade of fresh farm goods between China and BRI countries.

Every important rule has a number next to it. It also tells them how to get along better with other countries [9]. Even more so in the last few years, Peru's agro-export business has grown very well. It has worked hard to become more modern and improve quality growth. This is because it is in a great place and climate. More farm goods are being sold in the country, which lets them grow and move quickly. This study is important for Peru's agro-export business because it looks at four main things that the government sends abroad. You can use it to discover how well Peru is known in industry. It's not just about how good a country is that the study looks at. It also checks out how things have changed over time. Looking at the numbers behind the growth of trade helps us understand things better. One way to do this is to look at the companies participating and watch how the markets change. Because of this, there is a big difference in how much study is done in trade [16]. Researchers and students can use it to find out how countries like Peru that are growing, deal with the goods they sell. That's why you need to know more than just how the agro-export business works. One of the most important things that the world's markets can do is lift the prices of farm goods.

The above list shows a few main issues affecting farming and the companies that make and sell agricultural goods worldwide. Two things that worry me the most are climate change and damage to the earth. The amount of food that can be grown changes with the weather, like when it gets hot or cold or how much rain falls. Going green with your growth is becoming more and more important. Don't hurt the land, and use the natural resources well. Pollution of the land, lack of water, and the loss of wildlife are some environmental problems that could end the agro-export business in the long run. This makes people also wonder if the ways things are done now will last [2]. The market is also hard to win because of trade with other countries. A farmer needs to quickly change their plans and look for ways to save money to meet the market's needs. Fees on farm goods worldwide greatly impact the budgets of places that sell goods. You need to think of ways that can be used in many places. Trade hurdles, on the other hand, are very bad for businesses. They can be things like price barriers or other types of walls. It

may also be harder to get into big markets in some countries because they are very conservative and have strict rules about cleaning and keeping plants healthy. Putting too much faith in trade deals between countries or between countries and their own could also make products less safe.

Also, new tools help make things better and more useful. But most of the time, people can't quickly learn how to use new technology because they don't have enough money, space, or professionals to teach and assist them [6]. This is mainly because wealthy and poor nations do not share the same technology. The second part says that managing poor countries' shipping and supply lines is harder. You must ensure that things that go bad quickly stay fresh and of good quality, so ship and process things well. Costs can go up a lot when getting around is hard and expensive. It can also change how well a country does business with other countries. It's also important for small and medium-sized farms to be able to get money.

The remainder of this paper is structured as follows: Section 2 presents the theoretical analysis and research hypotheses, Section 3 outlines the research design, Section 4 discusses the results, and Section 5 provides discussions and conclusions.

2.Theoretical Analysis and Research Hypotheses

2.1 The Mechanism of the Impact of Capital Structure on Financing

When a business makes money, it pays for itself through its cash. It has loans and stock in it. This changes how much cash costs and how the company plans to pay for things. This is why it's very important. TDSMEs often need to spend a lot of money to get new tools and grow. To put it another way, they need to be able to get cash elsewhere [8]. Too much debt makes it morerisky for a business to receive money, costing it more because it has to repay its loans faster. When they have a lot of debt, it's also hard for them to get more money. People in debt are more likely not to want to give money or buy something (loan sources). On the other hand, companies whose capital comes from stock may have more ways to get cash, like selling more shares. But it can be pricey to finance stock, which could make it tough for these types of companies to keep track of who owns what. TDSMEs should make sure that their capital structure fits their unique ideas. If the capital system is too careful, people might be unable to think of new things. However, it could cost more money and slow down the company's growth if it's too dangerous. We believe the following because of this study:

H1. When a business gets money from other businesses, its debt-to-asset percentage decreases. But when it gets money from outside sources, it goes up.

2.2 The Mechanism of the Impact of Information Asymmetry on Financing

Regarding money, "information asymmetry" means that a company and its customers don't know the same amount about it. Due to the information gap, buyers often don't know how the company is doing financially or its plans. Most buyers want bigger returns to balance the risk they think they are taking. It costs more to borrow money now because of this. The cost of cash often goes up because of this [17]. Also, there might be less money if not everyone can get the same information because people who want to spend might not do so if they don't understand the business well enough. Now, they will be pickier about how they pay for it. It also depends on how much information is given and how long it takes to finish the funding process. When people don't know what will happen, they must wait longer for cash. Buyers are more likely to do a lot of research because of this. This research could include reading reports and reviews. It was used to determine how much information was missing in this study. These views show how open and honest a company is about its money. This is what we want to say:

H2. People inside the company can easily give money to the business when everyone knows the same things. For a business to get money from outside its ranks, it needs to share details with other people less.

2.3 The Mechanism of the Impact of Firm Size on Financing

The bigger a business is the more money it makes. A bigger company looks better, is safer, and has more stable finances, so people will give them more money. SMEs that are TD, on the other hand, have a harder time getting cash. When they first start, they don't have much to protect. Because of this, it might be hard for these small and medium-sized businesses to get loans through debt funding. Banks are more likely to give money to bigger firms because they have more things that can be used as collateral. People think a bigger business is better and more stable, which helps it get loans and stock [15]. Put your money into a bigger company to get better deals in the stock market. They can buy stock now that they have more money. Since they're bigger, they can get better deals. When small and medium-sized businesses (SMEs) are open to new ideas, they can grow, improve their assets, and do better in the

market. This helps them make more money. All of its assets were added up to determine the company's size. The following case was made in this study:
H3. Not getting money from inside the company is bad for business. Getting money from outside the business is linked to having a lot of assets.

3. Research Design

3.1 Data Sources

This research used Open Street Map (OSM), CORINE Land Cover (CLC), and the World Database on Protected Areas (WDPA). They will use these data sources in future studies examining the whole world and small parts of it. Open Street Map (OSM) is free software for a group working together in 2004. Geo Fabrik is the name of the company that gives the information. The CLC keeps track of what the land is made of. This is a project of the European Union. It has 44 different theme groups and changes every six years. People can look at this Worldwide Diversity and Protection Areas (WDPA) list to learn how protected areas are set up and run. The Western European Settlement Map (CEMS) and the Soil Quality Rating (SQR) were used for the study without cost. It was sent by Spots 5 and 6 and comes from the area map. Why do you think the land is good (SQR)? This picture, which shows how good the dirt is on farms, was made by the Federal Institute of Geosciences and Natural Resources. We used the German government data source Basis-DLM to help when we looked at other open-access data sources [14]. Because it is more straight, this source makes it easy to find important things. Based on the Basis-DLM method, topographic maps show the whole environment, with cities, farms, forests, and road networks. It ranges from ±3 to ±15 meters for different traits, based on what they are used for. Check out Table 1 to see what data sources were used for the comparison study.

3.2 Variables Selection and Extraction

Three kinds of things were found to be able to change how far apart space race tracks are. These came from facts and books in the same area. These are the streets, the view from outside, and how people see them (Table 2) [10]. Point-of-interest (POI) and spatial vector information (SVI) data were two types of area big data used to find and pull out factors that might have an effect.

3.3 Stochastic Frontier Gravity Model

This is the LR test, which stands for the odds ratio test. How do you do it? It had to work, and the numbers it gave had to make sense. What were they thinking? In random border analysis, the model must have a useful shape.

Table 1. *Overview of data sources applied in the comparison.*

Data Sources	Open-Access	Accuracy/Resolution	Data Type	Coverage
Basis-DLM	No	depend on the trait, between ±3 and ±15 m	Vector	Germany
CLC	Yes	100 m of straight phenomena and 25 ha of areal phenomena	Vector	Europe
OSM	Yes	unknown	Vector	Global
CEMS	Yes	10 m	Raster	Global
WDPA	Yes	unknown	Vector	Global
SQR	Yes	250 m	Raster	Germany

Table 2. *Forms and sources of data.*

Types of	Variables	Source of Method or Data
Built Environment	Density of the population (Pop Den)	Census figures and data on the number of social media users
	The number of roads (Road Den)	The number of roads, the angle distance-based mobility based on Space Syntax.
	Taking the bus or train	How many bus stops and subway stations there are
	Density of facilities (Poi Den)	Density of POIs
	Variety of facilities (Poi Mix)	Shannon entropy of POIs
	The number of places to play sports	How many sports places are there
	Density of homes (Resi)	Density of neighborhoods with homes
	Park (*Park*)	Distance to park
	Nighttime lighting (*NTL*)	The mean DN value of NTL
	Building density (*BldDen*)	Total building base area divided by total area
Street Perception	Green view index (*Green*)	The mean pixel ratio
	Sky view index (*Sky*)	The mean pixel ratio
	Wall (*Wall*)	The mean pixel ratio

	Perceived safety (*Safe*)	The mean of road/grid
	Perceived liveliness (*Live*)	The mean of road/grid

To test, there was both a null hypothesis and an alternative hypothesis. LR = -2 [L (H0) - L (H1)] tells you how likely something is. When the null hypothesis is true and the alternative hypothesis is wrong, it looks like this: L (H0) and L (H1). This was the first thing we did to ensure the deal was good. The null hypothesis said there wasn't any kind of one [11]. That's what it meant for **Z**=0. Then, we considered whether the model that changed over time was right. The trade loss term wasn't supposed to change over time, so the LR test was based on that idea. This idea was shown by the number 0 (□). It was also thought about adding the variable showing the shared language to the model being watched (Table 3). It shows all of the model's LR tests. This had a name, as indicated by the p-value for the LR1 measure. Also, it showed that business wasn't done right. Because of this, the random frontier gravity model would be good for our project. We chose the time-variant stochastic frontier gravity model to see how well it worked in the real world. "Trade inefficiency" has meant different things at different times, as shown by the LR2 measure and its p-value. Both countries should know if their people speak the same language before they do business together.

This may This may change how people buy and sell digital things. Based on the chance measure LR3 and its p-value, we knew we needed to add the variable showing the languages people share to our model. The second model stays the same, but the first model changes. They both agreed that the amount was good and important after they worked it out. The internet service company also lost money because things didn't go as planned. The $\boldsymbol{u}$ coefficient was 0.879 for the model that didn't change over time and 0.885 for the model that did. Also, these two numbers were very important. We could guess the numbers better when we added the trade inefficiency factor to the stochastic frontier gravity model. The guess results made it clear that the model that changed over time was better for our study. This is because, at the 1% level, the coefficient of i was significantly positive.

The other regression model changed over time, but the first didn't. A country with a higher GDP and GDP per person could sell more digital services to a country with a lower GDP and GDP per person. It was easier for these economies to compete on the world stage when they grew faster, were bigger, and could offer more goods and services. More people wanted internet service when a country was bigger and better developed. It was usually because these places made and sold more things. They were too far apart to do business. Countries that bought digital goods couldn't do business with countries that sold them. Digital tools facilitate information retrieval and communication; however, the expansion of international trade remains a gradual process. People no longer trust each other or share information. The number $\boldsymbol{X}\mathrm{B}Nij$ was good, and it was also statistically significant. States that deal with each other might get along better if they all spoke the same language. This will allow more trade in digital services in the long run.

3.4 Model Construction

That's a wonderful way to think about trade between countries. However, the gravity model doesn't show how much money each country has. This way of moving things isn't always used because it costs too much. Instead, the room between them is used. You should also consider other things if your pay differs from someone else's. Many people believe that the things that can't be tracked make the economies of different countries special. Some people wanted to do the test because they thought the gravity model would be wrong if these things weren't considered [13]. He used a method with a stacking error term that was very close to the chance of guessing the value of the output function. The random border gravity model is the name of this method. The line separates trade that happens from trade that might occur. You need something you can only find in one place to see how the queue moves. If you don't know much about what economic distance means, this can help. This is one way to write the random border gravity model

$$EX_{ijt} = f\left(Z_{ijt}\right)\exp(v_{ijt} - \mu_{ijt})$$

The number i shows that many digital services were sent from country i to country j in the year t. When two countries trade, these things are known as movers. These include language, distance, economies of scale, and other natural things that don't change much over the short term. You need to guess the number $\beta.\,ijt$ and ijt both mean "mistake." The random error term and the waste error term that is not negative make up this term. This "economic distance" comes from what we've discussed. These kinds of things separate trade from trade that might take place. The variable ib has a normal distribution. What does it mean when the mean is 0? It would look like this: $iiti.d.N$ (0,2□^). The fact that ijt = + ($\mathbf{W}jt$,2) makes it clear that it has a reduced semi-normal distribution. It is also thought that k and n don't link. Eq. (2) shows that the factor ijt is the

mean of Sijt. This is the name of a function whose base is e.

$$w_{ijt} = \exp(\mu\alpha_0 - \tau S_{ijt})$$

Where zero always means the same thing. We have to guess what the field's value is. The word "inefficiency term of trade" is stored in the variable "inefficiency term of trade." Because of how this method is set up, there are a lot of possible trash names. Now, we can look at the things that make trade better. Any number from 0 to 1 will do. If the economic distance exceeds zero, real things won't be able to do as well as possible. Digital things won't work as well in other places as possible. There are no mistakes in the numbers as long as there are nos. That's when you can buy the most internet services. Every country should be able to do business with every other country. This is why the amount of real trade to possible trade shows how well trade works. Equation (3) makes it easy to see this scale:

$$TE_{ijt} = \frac{f(Z_{ijt};\beta)\exp(v_{ijt}-\mu_{ijt})}{f(Z_{ijt};\beta)\exp(v_{ijt})} = \exp(-\mu_{ijt}) = E[\exp(--\mu_{ijt}) \vdots \varepsilon_{ijt}$$

Any number from 0 to 1 could be Z. Things worth more help two countries deal with each other. At first, people think the word for being slow will stay the same. These days, it's more likely that the word "inefficiency" will change. To show how siit is put together, use equation (4). This backs up the idea that it changes over time.

$$\mu_{ijt} = \{\exp[-n(t-T)\}\mu_{ijt}, t = 1,2,\dots,T$$

The rate of decay can be seen by. How does the word "waste" change over time? Things that can only be found here are what are making the changes we see now. The word for not being useful will be used less over time. If it is greater than 0, we know that trade will go better. This is known as the waste term. Over time, doing business with other countries will be harder if the number is not zero. There will be less trade because of this. When i = 0, it is said that the model doesn't change over time. This is still right because the word "inefficiency" doesn't change. This is how most people understand the word "inefficiency":

$$\gamma = \sigma_\mu^2/(\sigma_\mu^2 + \sigma_v^2)$$

Find the trash that doesn't lose two rupees. Write 2_0 to show the wrong word's range. You can write any number from 0 to 1. If there isn't one, it won't be bad. There will be things made that aren't on the trade line. All the changes will be made by the waste term if 1. You can check the number to see if the trade has been lost or the stochastic border gravity model is correct. You can get a rough idea of what "trade trash" means by looking at two things. To use the "two-step method," you must first guess how much something is worth. The regression model will then use your guess to figure out how much it's worth. The two-stage method doesn't use enough strong factors, so it might not work well because these cons come from two different points of view that don't go together. After this first step, the average of the trade efficiency term is likely to stay the same. You can see this by. Some people think the next step is to guess. The random border gravity model says they are not different, which is why they differ. The trade waste model says that they do. But it doesn't always happen. The stochastic frontier gravity model-based one-step method is better than the two-step method because of this. This is an easy way to find the slope of the trade loss factor in the stochastic frontier gravity model. It only takes one step. This is how the subject was looked into. The word "trade inefficiency" is made up of "trade efficiency" factors ($Oijt$) and a random mistake term (ijt).

$$\mu_{ijt} = \alpha K_{ijt} + \delta_{ijt}$$

In this case, i and j are the logarithms of the GDPs of country i, which exports, and country j, which imports, in the year t. The sizes of countries' economies that send and receive things are based on these two things. In the year t, these numbers, i and j, show the logarithm of the GDP per person in country i, which shipped goods, and country j, which bought them. They could show the advanced economies of places that send and receive things. The sign $\boldsymbol{TT}DA Sij$ shows how much it costs to trade digital goods between countries i and j. The letter v stands for the fake variable. The number of the phony variable is one if market country i and market country j speak the same language. Figure 1 shows parts of a Watt–Strogatz curve with a death rate of -16%. This makes a picture of how a normal spreading process works. There is only one wave of sickness this time, and many people get sick more than once. It's more likely that they will also die because of this. Because of this, a lot (√) of walkers die in the end, as the number 99% shows. But a very small number (√) of those who keep walking, as shown by the line Se (√)≈1%, don't. The steady state is shown here (Atif, et al 2017). This is reached when the illness is gone, as $\boldsymbol{XO}$=$L\boldsymbol{T}$=0 shows. It can first take over a big part of the network. This fits with the fact that X was very high in this case. The virus is no longer around because many people got it in the first wave. Think about the plague, which has many

of the same symptoms and kills many people. You can find a short film. The process you can see in this movie is shown in Figure 1.

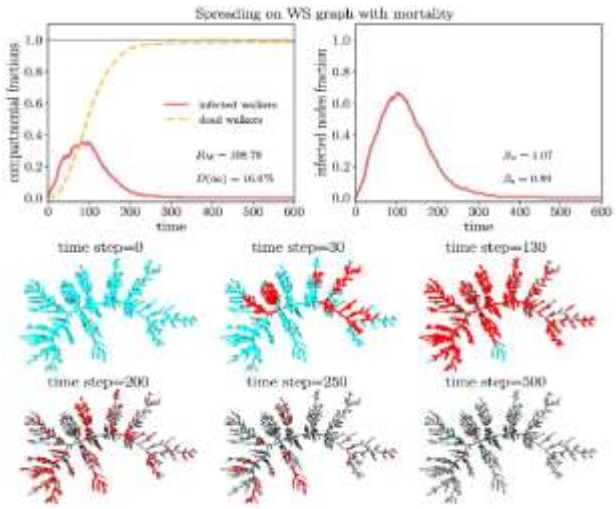

Figure 1. *Snapshots of spreading in a WS graph (𝒵=2000walkers, 𝒩=2000 nodes, connectivity parameter 𝓂=2) and mortality parameter ξ𝑀=0.4 with 𝒟(∞) ≈16%.*

4. Results

4.1 Model Applicability Testing

Before making any estimates, it is important to do a chance ratio test on building the model to ensure it is correct. Table 4 shows how these tests turned out. The test shows that the LR statistics for the two hypotheses are 360.89 and 16.18, respectively. This lets us know if the model works. The first thoughts that trade waste terms don't exist and don't change over time are also thrown out at a 1% value. The facts show that the stochastic border gravity model was well made [7]. You should also use a random border gravity model that changes over time to ensure that the ways you measure trade efficiency are correct.

China has been a significant contributor to global apple production and a considerable exporter. Figure 2 illustrates that during the study period, China's apple production has seen a substantial increase, rising from 17.23 million tons (30.76% of global production) in 1997 to 47.57 million tons (49.64% of global production)—a remarkable growth of nearly 276.14%.

Table 3. *Estimation results of stochastic frontier gravity model.*

Variable	Time-Invariant Model		Time-Variant Model	
	Coefficient	t-Value	Coefficient	t-Value
$lnGDPit$ln GDP it	760 ***	34.90	658 ***	28.62
$lnPGDPit$ln PGDPit	291 ***	8.31	193 ***	5.48
$lnGDPjt$ln GDP jt	848 ***	39.63	771 ***	34.49
$lnPGDPjt$lnPGDPjt	174 ***	5.09	921 **	2.63
$lnDISij$lnDISij	−1.179 ***	−34.62	−1.150 ***	−33.08

Table 4. *Results of experiments on the model's applicability.*

Original Thoughts	Model with Limits	Model Without Any Limits	LR Statistic	1% Threshold	Test Conclusion
There aren't any trade wastes.	−204.66	−24.21	360.78	8.21	Turning down
Intrade that doesn't work well stays the same.	−24.21	−16.12	16.17	11.345	Turning down

Table 5. *Results of experiments on the model's applicability.*

Variables	Model That Doesn't Change Over Time		Changeable Time Model	
	Rate of return	T-Values	Rate of return	T-Values
GDP $_{et}$	4.355 ***	29.627	5.401 ***	16.832
GDP $_{jt}$	0.147	922	134	977
POP $_{et}$	−51.923 ***	−152.324	−54.732 ***	−95.220
POP $_{jt}$	118	1.045	896 ***	4.065
DIST $_{ej}$	738	−1.054	517 **	−1.960
LAND $_{ej}$	27	−0.067	2.553 ***	−2.870
Constant term	90.612 ***	91.173	98.535 ***	85.857

Table 6. *Outcomes of the trade inefficiency model's estimation.*

Model for the Stochastic Frontier of Gravity			Making models of trade inefficiency		
GDP et	3.635 ***	233.416	TDF $_{jt}$	20 ***	−2.44
GDP jt	161 ***	−8.812	IVF $_{jt}$	16	615
POP et	−52.769 ***	−845.577	GVS $_{jt}$	63 **	−1.853
POP jt	393 ***	25.363	GVC $_{jt}$	73 ***	−4.184
DIST $_{ej}$	137 ***	−3.302	SHIP $_{jt}$	138 ***	−6.957
LAND $_{ej}$	295 ***	21.832	FTA $_{ejt}$	141 **	−2.117
Constant term	80.672 ***	81.007	Constant term	14.072 ***	4.883

Table 7. *Efficiency market classification of fruit and vegetable products exported from China to RCEP countries.*

Type of Market	value range for trade efficiency	Name of the Country
Iceberg stores	3	Australia, Philippines, Cambodia, New Zealand, India, Brunei, Laos, Myanmar
Building up markets	3–5	Singapore, Indonesia
Markets that are expanding	5–8	Thailand, Vietnam
Aged markets	8–1.0	Malaysia, Korea, and Japan

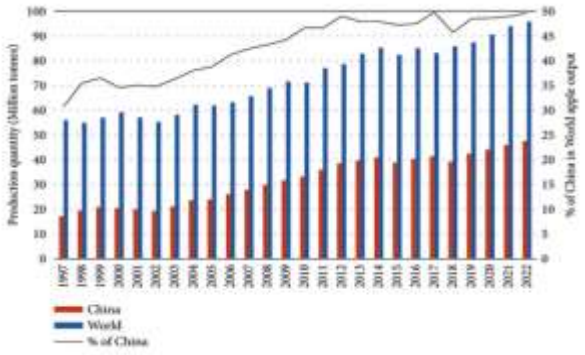

Figure 2. *China and world apple output 1997–2022.*

Figure 3 shows the trend in apple import and export volume in China and the world. Due to the increasing demand for apple consumption, the import and export trade of apples in China and the world is generally increasing. In terms of trade value, the export value of apples in China and the world increased from $101.34 million and $2,811.22 million in 1997 to $1,071.58 million and $6,859.68 million in 2022, respectively. This represents a significant increase in China's apple trade. China's apple export share in global apple exports increased from 3.6% in 1997 to 15.62% in 2022, an increase of nearly 4.34 times. The import value of apples in China and the world increased from $181.38 million and $2,960.17 million in 1997 to $688.5 million and $8,604.18 million in 2022, respectively. Compared to the increase in exports, China's apple import share has experienced slight growth (from 6.13% in 1997 to 8% in 2022), representing an increase of about 15%. It can be seen that China's apples have a relatively large export potential, and the export value of apples will further increase in the future. Similarly, Mordor Intelligence shows that global demand for apples is increasing due to consumers' growing health concerns. Consequently, this fruit is in high demand among consumers worldwide, particularly in developing countries, the United States, and Europe. Business Wire found that the increase in fresh apple consumption in China can be attributed to a variety of factors. These factors encompass the rising income levels of the population, heightened awareness of health and dietary choices, shifting preferences in food consumption, innovative marketing approaches, and advancements in cold chain logistics. Moreover, the development of e-commerce, fruit chain stores, and WeChat businesses has made fruit consumption more reachable, thus enhancing the consumption value of third- and fourth-tier cities in China. China has been the main consumer of fresh apples in the global market, followed by the United States, and the EU.

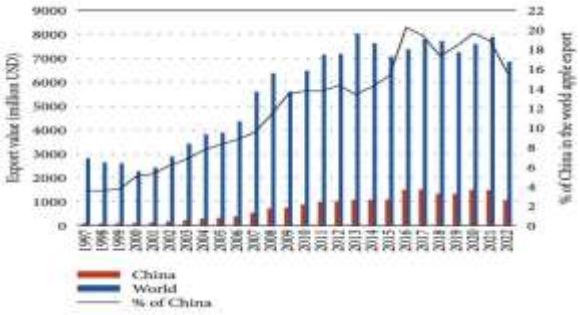

Figure 3. *China and the world apple export/import trend 1997–2022.*

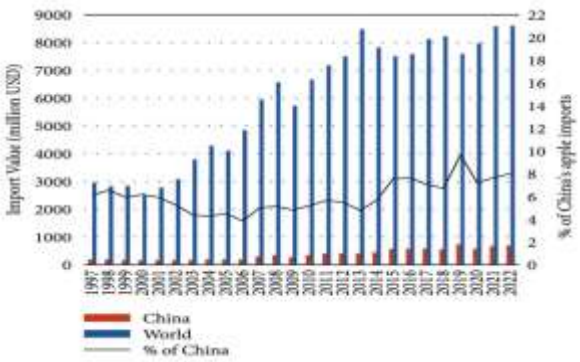

Figure 4. *China and the world apple export/import trend 1997–2022.*

Figure 4 shows China and the world apple export/import trend 1997–2022. Figure 5 shows that Indonesia, Thailand, Russia and Vietnam are the major export destinations for China's apple export flows. Between 1997 and 2022, these four countries import China's apple worth $275.49 million annually and accounted for 42.54% of the market share. Demonstrating that China's top ten apple terminal are as follows: Indonesia (11.43%), Thailand (10.95%), Russia (10.54%), Vietnam (9.62%), Philippines (9.61%), Bangladesh (7.20%), India (5.40%), Kazakhstan (5.38%), Malaysia

(4.05%), and Myanmar (3.37%). The yearly mean export flow from China to its top ten key terminal is valued at $502.29 million.

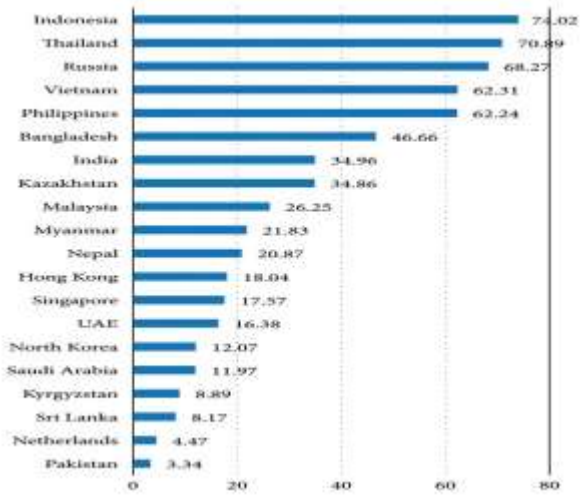

Figure 5. *Mean value of China's top apple market 1997–2022 (million USD).*

4.2 Analysis of Stochastic Frontier Gravity Model Results

The new fuzzy border gravity model must be graded and compared to other models. Both constant and evolving aspects will be discussed. Once the practice test is passed, the study will move on to the next step. Table 5 shows that what was said was true. There is a 1% chance that the model that changes over time will have ³ values of 0.996, but a 99% chance that the model that stays the same over time will have ³ values of 0.989. Do not forget these amounts. Using the random border gravity model is possible, which means that trade loss is real. It's not good to set the · to change over time to 1%. It's also harder to trade now than it was before.

If China has more people, its economy grows faster, and it shares a border with other RCEP countries, the amount of fruit and vegetables it gives them changes over time. China's economy is very big, as shown by the GDP it is 1%. This fits the idea that what China sends to other countries will help its economy grow. This number tells us how far along the countries' economies in the RCEP group are. If two economies grow faster, people may buy more fruits and veggies. It's not clear what this effect is, though. The number is good, but this is still true: it's not statistically important. There is no doubt that POP et and POP jt are not the same, even though they both pass the 1% test. Now that more people are living in China, more people may buy fruits and vegetables. China would be less likely to send those foods after this. A country with many people might need more fruits and vegetables when it gets more. China might send more goods to other places because of this. Both are important, as shown by the 5% and 1% tests. Their names are Idyll and Land. Countries that send goods are far away from countries that receive them, even if they share a border. It may be harder for countries that buy and sell fruit and vegetables to do business with each other if the DIST ej index is negative. Because they have to pay more and go farther, China sends fruits and veggies that aren't always in the best shape. -0.517, on the other hand, is a very low link number that shows distance doesn't stop trade going both ways as much as it used to. This is also true at sea, where more ships mean better service.

4.3 Analysis of Trade Inefficiency Modeling Results

The trade trash model is found in this work in a single step. The point of the study is to find out what hurts trade. Many things can make or break trade, as shown in Table 6. These include trade freedom, political spending, government honesty, and the liner link index.

The trade freedom index (TDF jt) and the investment freedom index (IVF jt) make trade work better, according to people studying it. Based on these facts, a trade openness system that works could help trade go more smoothly. It's very bad for a business that the government spends a lot of money, and there is a lot of corruption. This means that the country's government buying the goods could make things easier for companies by improving policies and services. Then China can sell more veggies and fruits worldwide. Since SHIPjt is less than 1%, it is negative. Based on this, RCEP member countries could make trade muchsmoother by improving their armed bases and networks. Since SHIPjt is less than 1%, it is negative. Based on this, RCEP member countries could make trade muchsmoother by improving their armed bases and networks. It is even harder to trade because of these deals, which are called free trade agreements (FTAs). They hurt a lot of people. When two countries that buy and sell goods agree to a free trade area (FTA), trade is easier and faster. And this is another reason why the Regional Comprehensive Economic Partnership (RCEP) deals need to be signed. From what we've seen, getting rid of trade hurdles in the RCEP zone is about making it easier for businesses and traders to do business and for ships to dock. From what we've seen, getting rid of trade hurdles in the RCEP zone is about making it easier for businesses and traders to do business and for ships to dock.

4.4 Trade Efficiency and Potential Analysis

China sells its fruits and vegetables to other RCEP countries all at the same time. The random border

gravity model is used to see how well China does at this. It's also used to determine how big of a market China could have for bringing vegetables and flowers to RCEP countries. Fruit and veggie trade between China and RCEP member countries was 44.16% more efficient than trade with other countries. The RCEP member countries engage in communication through various channels and mechanisms. China can do a lot to help these places. The trade efficiency numbers used in this study were used to split the markets of RCEP member countries into three groups: iceberg, rising, and expansionary. This grouping turned out as shown in Table 7.

Many goods in the "iceberg market" come from eight countries. This list includes Australia, Japan, India, Brunei, Laos, Nepal, Myanmar, and Nepal. These are fifty of the RCEP countries. China can do business in the iceberg market, but their prices aren't quite where they could be. As part of the RCEP deal, China could also change its rules to make trading fruits and vegetables easier for other countries. This also makes trade between the two countries better for farm goods. Singapore and Malaysia are both getting bigger. These countries are more likely to trade with China because China doesn't send them as many fruits and vegetables. I thought about how Thailand and Vietnam are both getting bigger. These places are getting better at getting food from China. China has a lot of room to grow because of this. China sends more fruits and veggies to Vietnam yearly, but it's not as good for business as other places. The speed of trade has now reached a safe level. VN generally doesn't look as good, but this is still true. The economies of Malaysia, South Korea, and Japan are all "mature." But China does send these places food and vegetables, and business has been good between them. Foods can be grown in lots of different ways. This is how they will get bigger and better.

5. Discussions and Conclusions

First, this study's results are mostly the same as those of other studies examining how fresh foods, mostly fruits and veggies, grow. Some say China is bringing more food to ASEAN countries because it has a lot of extra food. The big gap didn't matter as much for export growth in the past. The government says China can send more vegetables to other countries. China has more things, so this is true. Tan says China can send more farm goods to Vietnam because the prices differ. This will make Vietnam bigger. China and New Zealand grow very different things on their farms. This is true because the piece turned out well. Also, they show that plants do better with bigger spaces between them than with smaller ones. What makes it work or not to sell fruits and vegetables? That's what this study's second part is all about. RCEP countries don't get as many farm goods from China as they could because of the studies he looked at. Each country has a lot of work to do. Being far away makes things grow, but not in a good way. In China, people, farms, and businesses are all linked. They're not in the US. The government doesn't do enough to help businesses and trade, and some government workers aren't always honest. China and the other countries in the Regional Comprehensive Economic Partnership (RCEP) area share many farm goods. These things take place because of their companies and the workers who do them.

The study also found that sending farm goods to countries that are very far away might be hard. This is because there aren't many rules in trade. Chen believes the Chinese gardening tools sent to the RCEP area are not very good at what they should do. He believes there are lots of ways to get things better. Countries that buy stuff from China also make money. This goes well with wheat-based goods made in China. Two of the most important things that help trade grow are free trade agreements (FTAs) and government spending. Things sent by China for farms in the RCEP area are notas useful as those sent by other countries. These are the only ones like them that you can buy. When China's economy is strong, its goods sell better. But China is not near places where people buy and sell things, so there is not as much trade there. When trade is open, there are free trade agreements (FTAs), and the government spends money; trade mistakes happen less often. But these are some ways that this study's results don't match up with earlier ones: You can learn a lot about how trade grows, how efficient trade is, and the things that change these trends when you use both the binary margin model and the stochastic frontier gravity model together in study tests. People from and have looked at how China's farm goods have been getting bigger in the past.

They don't check out what trade is or how well it works now. Researchers tried to determine why Chinese goods sold well or poorly in the area by looking at how well or poorly they sold. However, it wasn't used to examine how China's trade with the region is connected to the trade trend. It wasn't clear if China sent more farm goods abroad or if they sent different kinds of goods. The study is mostly about fruits and veggies raised on farms. There are also some study gaps and places in this work where more in-depth research could be done in the future. In this study, things are looked at by putting them into groups. The binary margin analysis method is also used to find the difference in trade growth between a big margin and a rising margin for this study. We now have the right tools to divide the big profit into price and volume growth so that we can study them

separately later. Find out what plants need to grow. That could make the study's results stronger and more accurate.

5.1 Conclusions

The HK binary marginal decomposition analysis method has two types of rising margins. Both help China send more fruits and veggies to other RCEP countries. The main reason for this is the growth gap. The other RCEP countries are getting more fruits and veggies from China. Put another way, farm things are different from fruit and veggie things. China needs to grow a lot more fruits and veggies, and the old plan of "focussing on quantity but not quality" isn't working any longer. Fruits and vegetables are always getting better, and they're also kept in better shape. The study of the stochastic border gravity model also shows that as China's economy grows, more people buy fruits and vegetables. Food from China is hard to send to other countries because the country is so big, and people buy and sell things everywhere. The line is also shared. People in the country who buy Chinese food may have better money. More goods could be sent from China to other places. This has to do with other things, like having enough resources and being able to meet demand. Third, China could send more fruits and veggies to RCEP countries with more free trade agreements (FTAs), stricter trade rules, a more honest government, and a better ship-link score. For RCEP countries to get more loans, China might send more fruits and vegetables. China wants to trade more with RCEP countries that buy Chinese fruits and veggies.

This is about making it easier to trade in places that buy stuff. One way to do this is to make it easy for countries to ship things and do business with each other. If RCEP members let investors come in whenever they want, Asia can buy more fruits and vegetables from China. But this chance won't change much. Some other countries, mostly European along the Belt and Road, want to invest money into China's services and technology. This might not be very important. This is why it's not been easy to make a living farming in the RCEP zone. China sent 0.44 times as many fruits and veggies to RCEP member countries as it got in the last 10 years. You need to remember that once the Regional Comprehensive Economic Partnership (RCEP) is up, there will be many chances for business and economic growth. This country is not like other places when it comes to trade. If China joined the Regional Comprehensive Economic Partnership (RCEP), it would be easier and faster for vegetables and flowers to get to Japan, South Korea, Malaysia, and Vietnam. Trade and market growth happen faster here. Indian, New Zealand and Cambodia can all deal with each other and grow. They don't depend on outside forces too much, though. Farming 13 of 2023, 1908, 16 of 19. They don't slow down China's fruit and veggie exports because they don't bring in many other things. More and more things are being sold in places like Japan, Thailand, Vietnam, and the Philippines. If we work together more, the trade in fruits and vegetables will improve.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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