agronomy

MDPI

Article

Research on the High-Quality Development Path of the Cross-Border Agricultural Product Supply Chain between China and Central Asia

Kahaer Abula [1], Buwajian Abula [1,*], Qingjiang Hu [2], Xinyu Chen [3] and Dezhen Wang [1,4,*]

[1] College of Economics and Management, Xinjiang Agricultural University, Urumqi 830052, China
[2] School of International Business and Economics, Xinjiang University of Finance and Economics, Urumqi 830012, China
[3] School of Business Administration, Jiangxi University of Finance and Economics, Nanchang 330013, China
[4] Business School, Yulin Normal University, Yulin 537000, China
* Correspondence: ab320162501@126.com (B.A.); dezhengumei@163.com (D.W.)

Abstract: As a bridge and link between China and Central Asian countries, logistics infrastructure plays an important role in the process of forming a new development pattern of "dual circulation" and mutual promotion. Based on the panel data of Central Asian countries from 2010 to 2019, this paper uses random effect model to analyze the impact on the cross-border agricultural product supply chain between China and Central Asian countries. The results show that the logistics development level, railway transport connectivity, road transport connectivity, economic development level, market size, and common border of Central Asian countries positively affect the development level of the supply chain at different significance levels. Among them, the degree of railway transport connectivity has the greatest impact on the supply chain, followed by the common border, and then the level of logistics development. Moreover, the geographical advantage cannot be underestimated and it plays a positive role in promoting the high-quality development of cross-border agricultural product supply chain. China borders Kazakhstan, Kyrgyzstan, and Tajikistan, and the agricultural product import and export trade quota is significantly greater than that of other Central Asian countries. Based on the analysis, we propose to strengthen efforts to build a high-quality logistics system, build an efficient land transport network, and break through cross-border logistics congestion and difficulties.

Keywords: China and Central Asia; logistics and transportation connectivity; cross-borde agricultural supply chain; high-quality development

Citation: Abula, K.; Abula, B.; Hu, Q.; Chen, X.; Wang, D. Research on the High-Quality Development Path of the Cross-Border Agricultural Product Supply Chain between China and Central Asia. *Agronomy* **2022**, *12*, 2558. https://doi.org/10.3390/agronomy12102558

Academic Editors: Djamilia Skripnuk and Gulnara Romashkina

Received: 24 September 2022
Accepted: 17 October 2022
Published: 19 October 2022

1. Introduction

With the implementation of the "One Belt, One Road" initiative, China and Central Asian countries (Central Asian countries refer to the five countries of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan) have closer cooperation in agriculture, which has injected strong impetus into the development and improvement of cross-border agricultural product supply chains, and has also created a mutually reinforcing "dual cycle" development pattern. On the one hand, the government has played a unique role in macroeconomic regulation and control. By mobilizing and allocating resources, it has improved the efficiency in using resources, so that there is a time node, strategic planning, and development path to achieve the goal, thus laying the foundation for the comprehensive promotion of various fields, and promoting the development of cross-border supply chains. On the other hand, as an important driving force for economic growth and social development, China has established long-term sustainable development plans and long-term goals at different levels for infrastructure investment and improvement [1]. At present, the existing plans mainly focus on the medium and long-term development plans of various industries and sectors, most of which focus on economic development and various sectors.

They further expand and link up the specific indicators of the United Nations Sustainable Development Goals (SDG), especially to strengthen infrastructure construction under the premise of paying attention to sustainable development and environmental friendliness [2]. Moreover, investment in infrastructure is also one of the 17 sustainable development goals covered by the 2030 United Nations Agenda for Sustainable Development. This will better link the transportation system of the international and domestic markets and achieve stronger development, which is crucial to the role of transnational trade partnership [3,4].

China and Central Asian countries not only involve cooperation in the fields of politics, economy, trade system, and international logistics of Central Asian countries, but also include close cooperation in logistics infrastructure in agriculture-related fields. In particular, since the 19th National Congress of the Communist Party of my country, the development level of China's railway, highway, and air logistics industries mainly for Central Asian countries has continued to rise, and agency centers have been set up in important urban airports in Central Asian countries, build the "Silk Road" of air logistics by virtue of Xinjiang's regional advantages, and gradually form a good market pattern of channel logistics, logistics belt economy and trade, and economic and trade industry. Data show that the import quota of agricultural trade between China and Central Asian countries in 2010–2019 increased from USD 669 million in 2010 to USD 1.096 billion in 2019, an increase of USD 427 million. The export quota increased from USD 671 million in 2010 to USD 1.256 billion in 2019, an increase of USD 558 million, indicating that the agricultural trade cooperation between China and Central Asian countries has become increasingly close, and the scale of import and export transactions has continued to expand. For cross-border agricultural product trade, the importance of logistics and its transportation service capabilities to the agricultural products trade between China and Central Asian countries is obvious, and the construction of an interconnected agricultural product supply chain is the key to ensuring logistics transportation and improving transportation service capabilities. In other words, the biggest challenge in the high-quality development of cross-border agricultural supply chains is how to establish a set of low-cost transportation (Thomas Friedman) [5]. This is mainly due to the complex and diverse logistics systems due to the long geographical distance and expensive transportation costs between global supply chains, which require a higher level of logistics infrastructure as support (Sajadieh; Asree) [6,7]. The increased importance of air and highway transportation accessibility in a more time-sensitive economy has been facilitated and congestion may threaten the very bounty that accessibility has delivered, perhaps creating new opportunities for still more distant locations (Bowen) [8]. The rapidly increasing and shifting demands for transportation services results in a longer lead time to make any major changes to infrastructure, and changing external conditions such as energy supplies, all make flexibility increasingly desirable. (Morlok et al.) [9]. SCM requires, among others, the alignment of partner strategies and interests, high intensity of logistics information sharing. These requirements often represent major hurdles inhibiting the full integration of a logistics (Van Der Vorst et al.) [10]. Food traceability should be considered as an important and integral part of logistics management in contemporary food and agricultural supply chains (Bosona et al. and Rentizelas et al.) [11,12]. In recent years, the implementation of the "Belt and Road" initiative has promoted the growth of China's agricultural product import and export scale and the development of the trade supply chain. At the same time, the development of the supply chain also faces certain opportunities and adjustments. On the one hand, the proposal of the "Belt and Road" initiative has brought development opportunities for agricultural related enterprises. On the other hand, with the rapid development of China's economy, the whole cross-border agricultural product supply chain and related node enterprises are also facing many problems. Due to the rapid growth of China's foreign trade, the infrastructure of related logistics hubs is lagging behind and cannot meet the throughput of goods. Therefore, it is necessary to strengthen the supply chain, strengthen the construction of China's high-quality agricultural product production base, improve the status of China's agricultural products in foreign agricultural product markets, and effectively realize the exchange and docking with international agricultural

product trade markets. So, due to the relatively low level of internationalization of Central Asian countries, the supply chains between China and Central Asian countries are affected by various complex factors, which is not conducive to the development of logistics infrastructure between China and Central Asian countries under the Belt and Road Initiative. Cooperation and high-quality development of cross-border agricultural product supply chains still have a long way to go. Therefore, what factors led to the development of the overall cross-border agricultural supply chain, and how much? How to further tap the level of bilateral agricultural trade supply chain cooperation to achieve mutual benefit and win-win results? It is necessary to analyze the issue between China and Central Asian countries.

Therefore, discussing the issue can enrich the relevant theories of the cross-border agricultural product supply chain, and provide guidance and guidance for the supply chain development cooperation between China and Central Asian countries.

2. Literature Review

2.1. Research on International Trade, Investment and Cross-Border Supply Chain

Cross-border supply chains have become an important means of economic and trade exchanges between countries. Some scholars have conducted relevant research on cross-border supply chains from the perspectives of micro-management, meso-industrial economics and macro-national competition. Helpman [13] proposed that international direct investment and international trade are two basic forms of international division of labor, and are also important international economic activities, and there is a substitute relationship between trade and investment. Compared with general developing countries, the bottleneck of development in Central Asian countries lies in the underdevelopment of related transportation and other infrastructure, which not only affects the development of their own foreign trade, but also restricts the flow of capital with other neighboring countries, which is not conducive to international investment and development. Tian et al. [14] also believed that the weak infrastructure of Central Asian countries is a shortcoming that restricts foreign investment in agriculture, which has a negative impact on bilateral trade. Shen [15] pointed out that China and Central Asian countries have complementary geographical advantages and resource endowments. The focus of agricultural investment is to focus on the infrastructure related to agricultural trade. Building inter-industry investment platforms and building a cross-border agricultural industry chain is the key to promoting bilateral cross-border trade; an important way for the development of environmental supply chain. Wang [16] selected variables such as China's direct investment flow to countries along the Silk Road Economic Belt, import trade volume, and the level of overseas engineering cooperation between China and countries along the Silk Road Economic Belt to study the formation of transnational supply chains degree, and explore the influencing factors that affect the development of multinational supply chains. Peng [17] uses the net export and investment indicators to measure the development of cross-border supply chain based on the national trade theory. Dai et al. [18] used the total market transaction volume of fresh agricultural products to reflect the development of the supply chain of fresh agricultural products in the research on the factors affecting the supply chain of fresh agricultural products. It can be found that international trade, foreign direct investment, and the development of supply chains are inextricably linked, and the construction of a high-quality cross-border supply chain of agricultural products needs to take into account the influence of factors such as international trade and foreign direct investment.

2.2. Research on International Logistics Performance and International Trade

International logistics performance largely depends on a reliable supply chain that provides traders with predictable service. However, due to product safety, social environment, and other reasons, the requirements for traders and operators are becoming more and more strict, and the international trade situation is becoming more and more complicated. In today's global business environment, logistics management capability has increasingly become the core competitiveness of enterprises to carry out international trade. There-

fore, international logistics performance is closely related to international trade (Freund et al.) [19]. With the continuous advancement of the "Belt and Road" construction, scholars have introduced gravity models to study the impact of international logistics performance on international trade (Puertas) [20]. The research of Nguyen and Tongzon [21] shows that there is a significant positive correlation between logistics performance and foreign trade. The international logistics performance of trading countries has different degrees of influence on foreign trade. Sun and Li [22] used the gravity model to study the impact of the international logistics performance of the "Belt and Road" on the export of China's intermediate products. The research results show that the improvement of the international logistics performance of the "Belt and Road" can promote China's export trade volume. Liu and Yin [23], Wang et al. [24], Hang [25], and Miu [26] found that the level of international logistics development directly affects the scale of a country's export trade, and a developed level of logistics development can drive the growth of domestic export trade.

2.3. Related Research on Connectivity of Transportation Facilities and International Trade

The connectivity of transportation facilities is the basic condition and important support for increasing the international trade exchanges of various countries. It will reduce the transportation costs of various countries, enhance the vitality of international trade, and promote economic growth. Lu et al. [27] believes that good connectivity of transportation facilities can greatly reduce the cost of goods transportation, reduce transportation time, and improve delivery reliability, and enhance international trade between countries. Eichengreen [28], Kevin et al. [29] pointed out that the improvement of railway transportation services can greatly reduce the cost of railway transportation, increase the profit of international trade, and then promote the development of international trade. Cansino [30] analyzed the statistical data of Spanish air cargo transportation, and the results show that the improvement of Spanish air transportation capacity helps to expand the scale of export trade. Hakim [31] believe that there is a bidirectional causal relationship between national economic growth and air passenger traffic. Liang and Zhang [32] analyzed the relationship between transportation facility connectivity and trade, and found that aviation facilities are a key factor affecting the relationship between transportation facility connectivity and trade. Xu and Li [33] pointed out that the connectivity of transport facilities in the host country has a positive impact on bilateral trade. Among them, the quality of port facilities has the greatest effect on promoting bilateral trade, followed by the quality of road facilities, the least impact of the quality of aviation facilities, and the quality of railway facilities. Jiang et al. [34] used the Almon estimation method to analyze China's import and export trade. The research results show that the level of transportation infrastructure and investment has the greatest effect on China's international trade. Zhang and Hu [35] believe that it is necessary to pay attention to the importance of the connectivity of railway facilities in international trade activities. In the process of cross-border trade activities with neighboring countries, trade activities are affected by their own level of transportation accessibility and investment environment and other factors.

To sum up, international trade, international logistics performance, and connectivity of transportation facilities are closely related to the development of cross-border supply chains. International trade is often accompanied by investment, especially foreign direct investment, which plays an important role in the development of cross-border supply chains. International logistics performance, as a "barometer" of international trade, has a certain guiding role in the development of enterprises' trade, and cross-border supply chain is a key factor in improving international logistics performance, which has a great impact on improving the international competitiveness of enterprises and increasing the scale of trade. At the same time, as an important part of building a supply chain, the importance of transportation infrastructure to international trade is self-evident. There are few literatures on cross-border supply chains, especially for the high-quality development of cross-border agricultural product supply chains. The agricultural trade of countries along the "Belt and Road" is becoming increasingly close, and it is necessary to study the

main issue between China and Central Asia. Therefore, this paper measures the main issue through variables such as agricultural product import and export trade volume, agricultural foreign direct investment, and investment in transportation, warehousing and postal industry, and explores the high-quality development path of agricultural product supply chain, in order to provide agricultural products between China and Central Asia. The high-quality development of agricultural product supply chain and the construction of a "dual circulation" pattern that promotes each other provide theoretical reference.

3. Material and Methods

3.1. Influence Mechanism of Logistics Development Level in Central Asian Countries

The development of cross-border supply chain between China and Central Asian countries is inseparable from the support of the logistics service capabilities of the Central Asian countries. A perfect logistics system can improve the trade efficiency of cross-border agricultural products and closely link the exporters and importers of trade together. Different from other products, agricultural products refer to living animal and plant agricultural products, whose properties are obviously different from industrial products, which also make the transportation and storage of agricultural products more difficult, and it faces the diversified needs of consumers. The quality and freshness of agricultural products are the first elements that consumers need to consider. The characteristics of agricultural products are easy to corrode and the length of fresh-keeping determines that the overall service function of the agricultural product supply chain depends on other products, which require a stronger logistics organization and management system, and has higher requirements for the development level of logistics in Central Asian countries. Specifically, the trade of agricultural products requires a higher level of logistics support, and no pollution and deterioration are the minimum requirements for the circulation of agricultural products.

The international logistics performance index is usually used to measure the comprehensive development level of a country's logistics, which can be based on the efficiency of a country's customs clearance procedures, the quality of infrastructure related to trade and transportation quality, the price of arranging, the difficulty of freight, and the quality of logistics services, the ability to track and inquire the goods, and the frequency of the goods arriving at the consignee within the predetermined time to describe the overall physical management ability and service level of a country. Countries with higher international logistics performance can comprehensively utilize and integrate resources, which can not only avoid excessive investment in resources, but also maximize profits with the least amount of resources. Generally speaking, the level of logistics development is a key link in building a high-quality cross-border agricultural product supply chain. It has functions such as storage, delivery, processing, and distribution, and is an indispensable link in the international trade of agricultural products. A good level of logistics development can greatly shorten the transportation time, and provide a guarantee for the preservation and storage of agricultural products. At the same time, a good level of logistics development is also a necessary condition for deep processing of agricultural products, which plays an important role in improving the added value of primary agricultural products. On the other hand, a good level of logistics development is the basis for the development of cross-border agricultural product supply chains. Usually, it is only necessary to upgrade the original logistics basis to realize the effective connection between logistics and cross-border supply chains without investing a lot of manpower and material resources. It can also realize the diversified utilization of resources and improve the circulation efficiency of agricultural products.

3.2. Influence Mechanism of Transportation Facilities Connectivity

The connectivity of transportation facilities between China and Central Asian countries mainly includes road connectivity, railway connectivity, and air transport connectivity. It is worth noting that China shares common borders with Kazakhstan, Kyrgyzstan, and Tajikistan, which has great advantages for the connectivity and cooperation of road, railway,

and air transportation facilities between China and Central Asian countries. As we all know, transportation infrastructure, as an important guarantee for international trade in goods, plays a decisive role in cross-border agricultural trade. Specifically, transportation infrastructure acts as a means of transportation for the functional connection between nodes and nodes, and between nodes and domains. When conducting trade between regions, the network characteristics of infrastructure can be used to transport commodities from one region to another. A region strengthens the inter-connection and mutual influence of life and production between regions.

The interconnected transportation infrastructure can reduce the construction cost of agricultural product supply chain to the greatest extent, and promote the trade between China and Central Asian countries. The connectivity of transportation infrastructure can facilitate trade in goods, international investment, and cultural exchanges, reduce the cost of factor flow between regions through trade in goods or culture, and at the same time increase the ability of countries to coordinate resource allocation. The improvement of the connectivity of transportation facilities in Central Asian countries can form a comparative advantage in the region, promote the formation and allocation of factors such as labor, capital, and technology among different economies, thereby reducing the construction cost of cross-border agricultural product supply chains. On the other hand, it reduces the cost of enterprise information and increases the profits of enterprises in cross-border agricultural trade. Due to the improvement of transportation, information communication, and energy infrastructure, cross-border agricultural products trading enterprises can reduce transportation losses, reduce storage costs, improve production efficiency and logistics efficiency, and thus increase corporate profits. At the same time, the connectivity of transportation infrastructure enhances the competitiveness of national trade, and the improvement of logistics service capabilities realizes the value and use value of agricultural products, guarantees the quality of agricultural products, and enables agricultural products to realize value-added in logistics and transportation.

3.3. Influence Mechanism of Comprehensive Economic Development Level

The comprehensive economic development factor is also an important factor affecting the supply chain between China and Central Asia, which mainly includes the economic development level, market size and geographical boundaries of the Central Asian countries(Figure 1). When a country has a relatively high level of economic development, as the level of economic development increases, the level of national consumption also increases, thereby increasing the demand for imported products, and the level of economic development of trading partner countries will affect bilateral trade cooperation from the perspective of demand. develop. At the same time, the gross domestic product (GDP) and population size of Central Asian countries reflect the macroeconomic strength and market demand of Central Asian countries, which not only helps to achieve economies of scale, but also provides impetus and space for product research and development, thereby obtaining stronger competitiveness. Geographical borders have a geographical advantage in agricultural trade, and bordering countries can choose a variety of transportation methods to transport goods. The scale effect will increase the trade quota of agricultural products.

3.4. Data Description

Due to the availability of data, the article selects the relevant data of China and Central Asian countries from 2010 to 2019. The data comes from the United Nations Trade Database (Uncomtrade), China's Foreign Direct Investment Statistical Announcement, the World Bank Open Database (World Development Indicators), Ministry of Transport website and Capital International Airport website. Since the International Logistics Performance Index only has data for 2007, 2010, 2012, 2014, 2016, and 2018, the International Logistics Performance Index of similar years is used instead. Before building the model data analysis, for the convenience of subsequent data processing, the development level of the cross-border agricultural product supply chain was indexed by the entropy method, and the

standardized data were multiplied by the weight to obtain a comprehensive score, which was used as the explained variable.

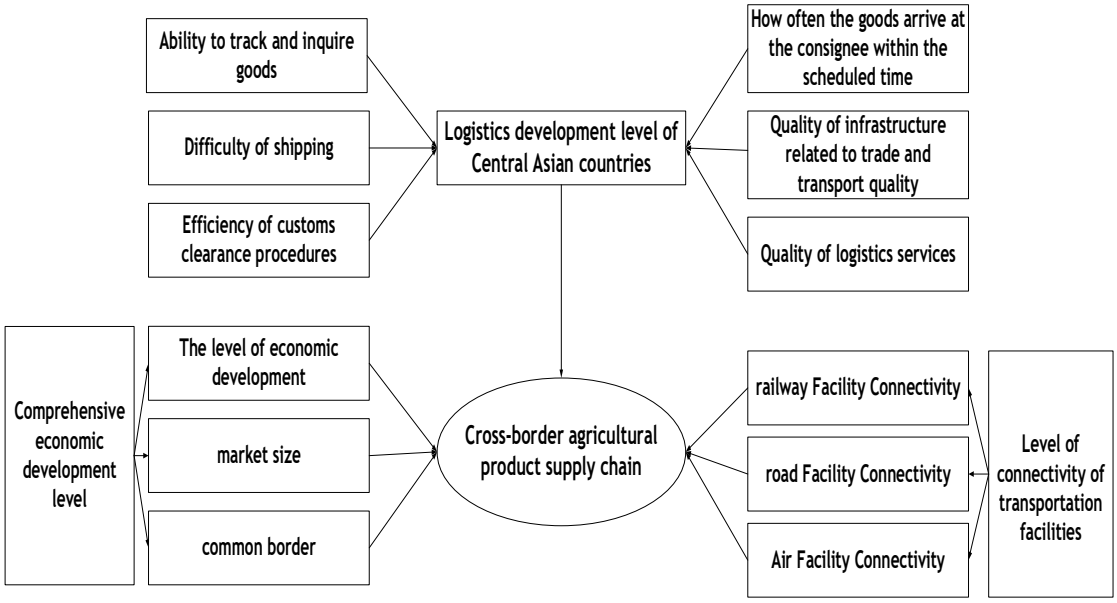

Figure 1. Influence mechanism.

The calculation principle of entropy method is as follows:

Step 1: The dimensions and units of each indicator are different and cannot be directly compared and calculated. Therefore, before calculating the weight of each indicator, it is necessary to standardize it.

When the indicator is a positive indicator, its standardized formula is as follows:

$$x'_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \tag{1}$$

when the indicator is a negative indicator, its standardized formula is:

$$x'_{ij} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}} \tag{2}$$

when the indicator is moderate, its standardized formula is:

$$x'_{ij} = 1 - \frac{\left|x_{ij} - d_i\right|}{\max\left|x_{ij} - d_i\right|} \tag{3}$$

wherein d_i is the determined standard value.

Step 2: In order to eliminate negative values for translation processing, some index values may have smaller or negative values after standardization processing. To unify and facilitate the calculation, the standardized values are translated to eliminate the above situations.

$$x''_{ij} = H + x'_{ij} \tag{4}$$

wherein H is the amplitude of index translation, generally taken as 1.

Step 3: Dimensionless data by specific gravity method:

$$y_{ij} = \frac{x''_{ij}}{\sum_{i=1}^{n} x''_{ij}} \tag{5}$$

Step 4: Calculate the entropy value of the j index:

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n} y_{ij} \ln y_{ij} \tag{6}$$

Step 5: The difference coefficient of the j index:

$$g_j = 1 - e_j \tag{7}$$

wherein $j = 1, 2, \cdots\cdots p$

Step 6: The weight of the j index is:

$$\omega_j = \frac{g_j}{\sum_{j=1}^{p} g_j} \tag{8}$$

wherein $j = 1, 2, \cdots\cdots p$.

Comprehensive score is obtained by multiplying standardized data and weight.

$$Z_i = \sum_{j=1}^{p} \omega_j x'_{ij} \tag{9}$$

3.5. Variable Selection

Based on the previous theoretical analysis, during the development of agricultural product supply chain between China and Central Asian countries, the stable "going out" of Chinese agricultural enterprises is the first. At the same time, China's investment in agriculture and supply chain-related industries in Central Asian countries, and whether Chinese agricultural and foreign-related enterprises can cooperate with the agricultural product supply chain of Central Asian countries, greatly affect the development of agricultural product trade supply chain between China and Central Asia.

First of all, referring to the research results of Wang [16], Peng [17], Puertas [20] Sui and Tian [36], Chen [37], Diao [38], Qian [39] the paper selects the import and export trade volume of agricultural products from China to Central Asian countries, China's agricultural investment in Central Asian countries, and China's investment volume to Central Asian countries in transportation, warehousing, and postal industry. The three variables are indexed by the entropy method to describe the development level (DSC) of cross-border agricultural product supply chain, and use it as the explained variable of the article. Second, logistics factors. In the process of international trade activities, the logistics development level of the trade target country affects its international trade activities to a certain extent. Therefore, in this section, we are using the comprehensive score of the logistics performance index of Central Asian countries to express the logistics development level of Central Asian countries. The comprehensive score of the logistics performance index reflects the recognition of a country's logistics based on the efficiency of customs clearance procedures, the quality of trade and transportation related infrastructure, the difficulty of arranging freight with competitive prices, the quality of logistics services, the ability to track and query goods, and the frequency of goods arriving at the consignee within the scheduled time. With reference to the research results of Wang [16], Peng [17], Sui [40], Yang and Luo [41], the paper selects the international logistics performance index of Central Asian countries to describe the logistics development level (L) of Central Asian countries, which reflects the central Asian countries logistics development level (L). At the same time, China borders Kazakhstan, Kyrgyzstan, and Tajikistan and have geographical advantages, and the level of transport connectivity (TC) is also an important factor affecting the cross-border agricultural supply chain, including railway connectivity (RW), highway connectivity (HW), and aviation connectivity (AV), Zhou [42]. Finally, the comprehensive economic development level reflects the economic and trade status of

Central Asian countries, which has a certain impact on the trade scale and trade volume of agricultural products, including the level of economic development (GDP), market size (M), and common border (B) Chao [43]. The meaning of each variable and the descriptive statistical analysis of each variable are shown in Tables 1 and 2.

Table 1. Meaning of each variable.

Variable Type	Variable Name	Variable Meaning	Data Sources
dependent variable	Development supply chain (DSC)	Import and export trade volume of agricultural products, agricultural investment, transportation, storage and postal industry investment (Ten thousand U.S. dollars)	Uncomtrade, China Outbound Investment Bulletin
independent variable			
Logistics factor	Logistics development level (L)	The composite score of the Logistics Performance Index reflects the efficiency of customs clearance procedures, the quality of trade and transport-related infrastructure, ease of shipment, the quality of logistics services, the ability to track and trace shipments, and the frequency with which shipments arrive at consignees within the scheduled time.	World Bank
Connectivity of transportation facilities	railway transport connectivity (RW)	Whether to open a freight train with China (Yes = 1, No = 0)	Ministry of Transport website
	highway transport connectivity (HW)	Whether to open road cargo transportation with China (Yes = 1, No = 0)	Ministry of Transport website
	Air transport connectivity (AV)	Whether it has opened a flight with China (Yes = 1, No = 0)	Capital International Airport website
Comprehensive economic development level	The level of economic development (GDP)	GDP of Central Asian countries (en thousand U.S. dollars)	World Bank
	market size (M)	Population (person)	World Bank
	common border (B)	Is it bordering (yes = 1, no = 0)	World Bank

Table 2. Descriptive statistical analysis.

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
DSC	0.45	0.17	0.17	0.98
L	0.90	0.12	0.69	1.19
RW	0.20	0.40	0	1
HW	0.60	0.49	0	1
AV	0.76	0.43	0	1
GDP	14.81	1.31	13.08	16.83
M	4.31	0.09	4.14	4.45
B	0.60	0.49	0	1

3.6. Model Construction

In order to further investigate the supply chain between China and Central Asian countries, this paper empirically examines the impact of the logistics development level, transportation facility connectivity level, and comprehensive economic development factors of the Central Asian countries on the cross-border development of China and Central Asia. Three benchmark regression equations were set for the impact of agricultural supply chain:

$$DSC_{it} = \alpha \ln \text{Logitics}(L)_{it} + gTC(RW, HW, AV)_{it} + \beta EDL(\ln GDP, \ln M, B)_{it} + u_i + u_t + \varepsilon_{it} \quad (10)$$

where i is the i_{th} country and t represents the t_{th} period. Among them, *DSC* represents the development supply chain, Logistics represents the logistics level of Central Asian countries, TC represents the connectivity of transportation facilities, *ELD* represents the comprehensive economic development level, u_i represents the individual random error term, u_t represents the time random error term, ε_{it} represents the disturbance term [44,45].

4. Result Analysis

4.1. Correlation Analysis

Table 3 shows the results of correlation analysis on explanatory variables. The results show that there is a certain correlation between the variables, and the multicollinearity test is passed, indicating that the empirical results are meaningful.

Table 3. Correlation coefficient matrix of explanatory variables.

	L	RW	HW	AV	GDP	M	B
L	1						
RW	0.560	1					
HW	0.160	0.408	1				
AV	0.033	0.102	0.642	1			
GDP	0.430	0.720	0.229	0.240	1		
M	0.250	0.359	0.141	0.106	0.673	1	
B	0.160	0.408	0.917	0.167	0.311	0.231	1

4.2. Basic Regression Results and Analysis

First, we need to select an appropriate measurement model. For panel data, we first consider Wald test, Hausman test, and regression of core independent variables. According to fixed effect model and random effect model, random effect regression results: hypothesis test *H*0: difference in coefficients not systematic, Prob > chi2 = 0.8410 > 0.05, indicating that the original hypothesis is accepted at a probability of 5%, that is, random effect model is selected. The estimation results are shown in Table 4.

Table 4. Regression results of explanatory variables of OLS, fixed effect, and random effect.

Variables	OLS	T Value	FE	T Value	RE	Z Value
L	0.273 **	2.04	0.274 *	2.15	0.273 **	2.04
RW	0.355 ***	7.49	0.360 ***	8.39	0.355 ***	7.49
HW	−0.091 **	−2.62	−0.099 *	−1.94	−0.091 ***	−2.62
AV	−0.026	−0.71	−0.031	−0.47	−0.0267	−0.71
Coef	0.208	1.67	0.214	1.26	0.208 *	1.67
N	50	50	50	50	50	50
Adj R2	0.7138		0.7391			
Wald chi2					126.23	
F	31.56		52.18			
p	0.0000		0.0000		0.0000	

Note: *, **, *** represent significant at 10%, 5% and 1% levels respectively, and *p* value is the result of Wald test.

Table 5 reflects the empirical regression results. Among them, model (1) examines the relationship between the logistics development level of Central Asian countries and the development supply chains when the comprehensive economic development level is taken as the control variable. From the estimation results of model (1), it can be seen that the logistics development level of Central Asian countries has a significant positive impact on the development level of cross-border agricultural product supply chains at the level of 1%. The level will increase by 0.32 units, which shows that the level of logistics development is the foundation and important guarantee for the development of cross-border agricultural product supply chains, and a good level of logistics development can improve the supply chain. Models (2)–(4) show the impact of different modes of transportation on the supply

chain of cross-border agricultural products when the comprehensive economic development level is taken as the control variable. It can be found that railway transportation has a significant positive impact on the development level of cross-border agricultural product supply chain at the level of 1%. The degree of influence is increasing. For every 1 unit increase in railway transportation connectivity, the level of cross-border agricultural product supply chain will increase by 1.056 units; road transportation connectivity is second only to railway transportation connectivity, which is positive at the level of 10%. In order to affect the development level of the cross-border agricultural product supply chain, for each unit of road transport connectivity, the supply chain level will increase by 0.151 units; the air transport connectivity has the least impact on the supply chain. It shows that cross-border agricultural products trading enterprises are more inclined to choose railway transportation, probably because the price of railway transportation is lower than that of road transportation and air transportation, and the freight volume is obviously higher than that of road and air transportation, so it is the preferred method of agricultural product trading enterprises.

Table 5. Model regression results.

	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**
L	0.320 ***				0.168 *
	(2.77)				(1.66)
RW		0.883 ***	1.051 ***	1.056 ***	0.930 ***
		(4.16)	(5.31)	(5.31)	(4.44)
HW			0.172 **	0.151 *	0.145 *
			(3.36)	(2.58)	(2.53)
AV				0.045	0.047
				(0.77)	(0.83)
GDP	0.097 ***	0.177 *	0.234 ***	0.238***	0.205 **
	(7.12)	(2.50)	(3.54)	(3.57)	(4.03)
M	0.020	0.124 ***	0.137 ***	0.140 ***	0.127 ***
	(0.86)	(3.70)	(4.49)	(4.53)	(4.05)
B	0.086 *	0.390 **	0.647 ***	0.627 ***	0.564 ***
	(3.28)	(3.18)	(4.81)	(4.57)	(3.00)
Cons	−1.472 ***	2.273 *	3.040 ***	3.027 ***	2.468 ***
	(−9.67)	(2.53)	(3.61)	(3.58)	(2.76)
N	50	50	50	50	50
Wald chi2	172.33	212.18	271.97	270.08	283.81
p	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *, **, *** represent significant at the 10%, 5% and 1% levels, respectively, the brackets are standard errors, and the *p* value is the result of the Wald test.

Model (5) reflects the results of adding all variables to the regression model. The results show that the level of logistics development, railway transport connectivity, road transport connectivity, economic development level, market size, and common boundary are at 10% and 1%, respectively.10%, 5%, 1%, and 1% have a positive impact on the development level of cross-border agricultural product supply chain. Among them, the degree of railway transport connectivity has the greatest impact on the cross-border agricultural product supply chain, followed by the common border, and the third is the level of logistics development. This shows that transportation infrastructure is the main factor affecting cross-border agricultural product trade, and it is also an important part of the construction of the logistics system. The geographical advantage cannot be underestimated. It has a positive role in promoting the high-quality development of the cross-border agricultural product supply chain. China borders Kazakhstan, Kyrgyzstan, and Tajikistan, and the import and export trade volume of cross-border agricultural products is significantly larger than that of other Central Asia countries.

4.3. Robustness Check

In order to examine the robustness of the regression results, this paper further uses the random effects model (RE) on the basis of the Hausman test for empirical analysis, but there may still be two problems that are unavoidable in the panel model, namely the heteroscedasticity between groups and the within-group autocorrelation problems. Based on this, this paper draws on the processing method of Yang Lianxing and Luo Yuhui [41], and further uses the feasible generalized least squares (FGLS) and "OLS + panel correction standard error" (PCSE) for robustness testing. The model estimation results are shown in Table 6. It can be seen from the regression results that this regression result is basically consistent with the above regression results, which shows that the regression results of the article are robust.

Table 6. Robustness test.

	FGLS	**PCSE**
L	0.168 *	0.200 **
	(1.81)	(2.37)
RW	0.930 ***	0.886 ***
	(4.42)	(5.30)
HW	0.145 ***	0.149 ***
	(−3.28)	(3.69)
AV	0.047	0.032
	(4.85)	(0.56)
GDP	0.205 ***	0.190 ***
	(0.91)	(3.47)
M	0.127 ***	0.121 ***
	(2.76)	(5.43)
B	0.564 ***	0.542 ***
	(4.39)	(4.85)
Cons	2.468 ***	2.270 ***
	(3.01)	(3.08)
Greene Wald	0.0000	—
Wooldrige Wald	—	0.0000
R2	0.8711	0.8486
N	50	50

Note: *, **, *** represent significant at the 10%, 5% and 1% levels, respectively.

5. Discussion and Conclusions

This paper explores the path of high-quality development of the cross-border agricultural product supply chain between China and Central Asian countries in the context of building a mutually reinforcing "dual cycle". By analyzing the relationship between the logistics development level, the connectivity of transportation facilities and the comprehensive economic development factors of the Central Asian countries and the supply chain. From the overall regression results, the results show that the logistics development level, railway transport connectivity, road transport connectivity, economic development level, market size, and common boundary have a positive impact on the development level of cross-border agricultural product supply chain at a significant level of 10%, 1%, 10%, 5%, 1%, and 1% respectively. Among the influencing factor indicators, air transport connectivity has a positive impact on the high-quality development of cross-border agricultural product supply chain, but it has not passed the significance test, so the impact is not significant, which is consistent with the basic situation of reality. At the same time, the connectivity of transportation facilities is a key factor in the construction of cross-border agricultural product supply chains. In particular, railway connectivity is closely related to cross-border agricultural product supply chains. Good freight transportation will help to establish a complete transportation system and reduce transportation costs. The geographical advantage cannot be underestimated. It plays a positive role in promoting the high-quality development of cross-border agricultural product supply chain. China borders Kazakhstan,

Kyrgyzstan, and Tajikistan, and the cross-border agricultural product import and export trade quota is significantly greater than that of other Central Asian countries, thereby promoting the development of cross-border agricultural product trade supply chain. The comprehensive economic development factors have a certain role in promoting the development of the cross-border agricultural product trade supply chain between China and Central Asian countries. When the economic development level of Central Asian countries is relatively high, improving the level of facility connectivity and promoting bilateral cooperative relations will further promote the development of cross-border agricultural product trade supply chains. The continuous expansion of the market scale will play an important supporting role in creating economies of scale, and at the same time provide internal drive and broad space for R&D products, thus enhancing competitive advantage.

Based on the above research conclusions, this paper draws the following inspirations: first, for the high-quality development of cross-border agricultural product supply chains, priority should be given to investment in infrastructure related to trade and transportation, such as ports, railways, highways, and airport connections. Advanced technologies should be developed and applied, the speed of railways and highways should be optimized, and increase the density of highways and railway networks, and build an efficient land transport network. To reduce the border effect in the context of international transactions, we should continue to strengthen the flow of building port infrastructure in border cities, promote the innovation of international freight management models, and further reduce the cost of cross-border freight, so as to strengthen the connectivity and interaction with neighboring countries. In addition, the sustainable development of the supply chain should be paid attention to. The United Nations has put forward a global sustainable development agenda and related sustainable development goals, in which the transportation field is regarded as a very important field of global sustainable development. For this reason, the United Nations has also set up a global sustainable cooperative development plan in the transportation field under its treaty organization. Therefore, in China, the interconnection between the development of the "Belt and Road" and the global transportation system needs to be integrated, and attention should be paid to the construction of soft infrastructure, especially the changes in trade, investment environment, infrastructure construction environment, and relevant standards, as well as the development of the cross-border trade system, the establishment of a cooperative partnership between transnational transportation enterprises, and improve the infrastructure to add value to the community. As a partner, we have reduced the cost of the supply chain and improved the circulation efficiency, realizing the leap from building cross-border supply chain transportation infrastructure.

Second, it is necessary to give full play to the coordinating and organizing role of the Shanghai Cooperation Economic Organization to open up the blocking points of cross-border logistics channels. At the same time, China's Xinjiang should give full play to the role of the core area of the "Silk Road" economic belt, and speed up the construction of cross-border transportation infrastructure such as highways and railways between China and Central Asian countries, so as to promote bilateral trade cooperation among these countries. In terms of road transportation, strengthening the connection between the domestic freight base and the international economic cooperation zone affects the domestic trade and foreign transportation. It is not only necessary to improve the accessibility of cross-border transportation, but also to promote the connection between port cities and the core urban areas and developed urban areas of the country, and further strengthen the hinterland support capacity for the development of cross-border agricultural product trade between China and Central Asian countries.

Author Contributions: Conceptualization, K.A.; methodology, K.A.; writing—original draft preparation, K.A.; writing—review and editing, K.A., Q.H., X.C., B.A. and D.W. All authors have read and agreed to the published version of the manuscript.

Funding: Guangxi Education Science "14th Five-Year Plan" 2021 annual special project + Project name: Research on the Three-integration Mode of training Innovative and entrepreneurial talents of

Agriculture and Forestry Economic Management under the background of rural Revitalization—A case study of Yulin Normal University + Project No. 2021ZJY1593).

Institutional Review Board Statement: This study was approved by the school's review committee without any conflict of interest.

Informed Consent Statement: We declare that we have no conflict of interest.

Data Availability Statement: Data openly available in a public repository.

Conflicts of Interest: The authors declare that there is no conflict of interest.

References

1. International Research Center for Big Data of Sustainable Development. 2021. Available online: http://www.cbas.ac.cn/en/ (accessed on 1 September 2022).
2. Shahmohamadloo, R.S.; Febria, C.M.; Fraser, E.D.G.; Sibley, P.K. The Sustainable Agriculture Imperative: A Perspective on the need for an Agrosystem Approach to Meet the United Nations Sustainable Development Goals by 2030. *Integr. Environ. Assess. Manag.* **2021**, *18*, 5. [CrossRef]
3. Estoque, R.C.; Ooba, M.; Togawa, T.; Hijioka, Y.; Murayama, Y. Monitoring global land-use efficiency in the context of the UN 2030 Agenda for Sustainable Development. *Habitat Int.* **2021**, *115*, 102403. [CrossRef]
4. Wang, W.; Xu, Q. Promoting the Integration of Ecological Civilization Construction with the 2030 Agenda for Sustainable Development. *Int. Outlook* **2021**, *13*, 134–151+157–158.
5. Friedman, T. *The World Is Flat*; Hunan Science and Technology Press: Changsha, China, 2010; pp. 122–158. (In Chinese)
6. Sajadieh, M.S. *Global Supply Chain Management: Supply Chain and Logistics in National, International and Governmental Environment*; Physica-Verlag: Heidelberg, Germany, 2009; pp. 43–56.
7. Asree, S. *Challenges in the Global Supply Chain: Exploitation Versus Exploration Strategy*; The University of Toledo: Toledo, Spain, 2010.
8. Bowen, J.T., Jr. Moving places: The geography of warehousing in the US. *J. Transp. Geogr.* **2008**, *16*, 379–387. [CrossRef]
9. Morlok, E.K.; Chang, D.J. Measuring capacity flexibility of a transportation system. *Transp. Res. Part A Policy Pract.* **2004**, *38*, 405–420. [CrossRef]
10. Van Der Vorst, J.G.A.J.; Tromp, S.; Van Der Zee, D. Simulation modelling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics. *Int. J. Prod. Res.* **2009**, *47*, 6611–6631. [CrossRef]
11. Bosona, T.; Gebresenbet, G. Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control.* **2013**, *33*, 32–48. [CrossRef]
12. Rentizelas, A.A.; Tolis, A.J.; Tatsiopoulos, I.P. Logistics issues of biomass: The storage problem and the multi-biomass supply chain. *Renew. Sustain. Energy Rev.* **2009**, *13*, 887–894. [CrossRef]
13. Helpman, E. A Simple Theory of International Trade with Multinational Corporations. *J. Political Econ.* **1984**, *92*, 451–471. [CrossRef]
14. Tian, Z.; Huang, Z.T.; Liang, W. Research on Environmental Evaluation of my country's Agricultural Investment in Central Asia under the Background of One Belt and One Road. *J. Ningxia Univ. Humanit. Soc. Sci. Ed.* **2017**, *39*, 158–163.
15. Shen, Q. An Analysis of Agricultural Cooperation between China and Central Asia under the Background of "One Belt and One Road" Strategy. *J. Henan Agric. Univ.* **2016**, *50*, 140–146.
16. Wang, C.H. *Research on the Formation Mechanism and Influencing Factors of Transnational Supply Chains in the Construction of the Silk Road Economic Belt*; University of International Business and Economics: Beijing, China, 2017.
17. Peng, W. Make good use of e-commerce to solve the problem of mobile vendor governance. *World Labor Secur.* **2015**, *23*, 32–36.
18. Dai, T.L.; Li, Y.F.; Xu, P. Analysis of Influencing Factors of Fresh Food E-commerce Development in my country Based on ISM-MICMAC Model. *North. Hortic.* **2021**, *20*, 155–163.
19. Freund, C.; Rocha, N. *What Contains Africa's Export?* WTO staff working paper; WTO: Geneva, Switzerland, 2010.
20. Puertas, R.; Martil, M.; Garcia, L. Logistics performance and export competitiveness: European experience. *Empirica* **2014**, *41*, 467–480. [CrossRef]
21. Nguyen, H.O.; Tongzon, J. Causal nexus between the transport and logistics sector and trade: The case of Australia. *Transport. Policy* **2010**, *17*, 135–146. [CrossRef]
22. Sun, H.; Li, J.J. Analysis of the impact of "One Belt, One Road" international logistics performance on China's intermediate product exports. *Soc. Sci. Res.* **2016**, *2*, 16–24.
23. Liu, Y.; Yin, B.Q. Analysis of Trade Effect of International Logistics Performance—An Empirical Test Based on Heckman Model. *China Circ. Econ.* **2017**, *31*, 28–36.
24. Wang, D.F.; Dong, Q.L.; Yu, L.X. Logistics performance and China's foreign trade potential in countries and regions along the "Belt and Road". *China Circ. Econ.* **2018**, *32*, 17–27.
25. Huang, X.H. An Empirical Study on the Impact of Logistics Performance on the Import and Export Trade of Countries Along the "Belt and Road". *Logist. Sci. Technol.* **2016**, *39*, 99–102.
26. Miu, H. The impact of the international logistics performance of "One Belt One Road" on my country's export trade. *Bus. Econ. Res.* **2019**, *5*, 133–136.

27. Lu, H.; Luo, E.; Li, X.M.; Lai, H.R. "One Belt One Road" connectivity improvement is crucial for multilateral trade. *Foreign Soc. Sci.* **2019**, *2*, 155–157.
28. Eichengreen, B.; Gupta, P. The two waves of service-sector growth. *Oxf. Econ.* **2013**, *65*, 96–123. [CrossRef]
29. Kevin, X.L.; Mengjie, J.; Guanqiu, Q.; Wenming, S.; Adolf, K.Y.N. Logistics as a driving force for development under the Belt and Road Initiative—The Chinese model for developing countries. *Transp. Rev.* **2018**, *38*, 1–22.
30. Cansino, J.M.; Román, R. Energy efficiency improve-ments in air traffic: The case of Airbus A320 in Spain. *Energy Policy* **2017**, *1*, 109–122. [CrossRef]
31. Hakim, M.M.; Merkert, R. The causal relationship between air transport and economic growth: Empirical evidence from South Asia. *J. Transp. Geogr.* **2016**, *3*, 120–127. [CrossRef]
32. Liang, S.L.; Zhang, M. Influence of infrastructure interconnection on the trade boundary effect between my country and neighboring countries. *Asia-Pac. Econ.* **2016**, *1*, 101–106.
33. Xu, J.; Li, J.Y. The Influence of the Quality of the Host Country's Transportation Infrastructure on Bilateral Trade Cooperation—Based on the Empirical Analysis of the Countries along the "Belt and Road". *Int. Bus. Res.* **2020**, *41*, 5–14.
34. Jiang, S.H.; Liu, K.B.; Liu, W. Research on China's Import and Export Trade from the Perspective of Foreign Transportation. *J. Chang. Univ. Sci. Technol. Soc. Sci. Ed.* **2019**, *32*, 88–93.
35. Zhang, X.J.; Hu, J.C. Current Situation, Problems and Improvement of Cross-border Railway Transport Rules in New International Land-Sea Trade Channels. *Int. Bus. Res.* **2020**, *41*, 67–75.
36. Sui, B.W.; Tian, X. Influencing factors of cross-border agricultural product supply chain vulnerability: An empirical analysis based on China-ASEAN. *China Circ. Econ.* **2019**, *33*, 66–73.
37. Chen, Y.P. Research on the Quality Optimization Path of Agricultural Product Supply Chain—Based on the Analysis of Consumer Quality Demand. *Price Theory Pract.* **2019**, *12*, 116–119.
38. Diao, L.; Chao, Z.; Pang, A.L. Research on the Export Efficiency of Agricultural Products from China to Asian Emerging Market Countries. *Res. Financ. Issues* **2020**, *15*, 106–112.
39. Qian, J.; Wang, T.D. The "Belt and Road" Initiative, the Host Country System and China's Foreign Direct Investment: Empirical Considerations Based on Dynamic Panel Data GMM. *Int. Trade Issues* **2019**, *10*, 101–114.
40. Sui, B.W. The Impact of Relationship Stability on the Performance of Cross-border Agricultural Product Supply Chain Alliance—Based on the Empirical Analysis of Guangxi-ASEAN. *China Circ. Econ.* **2017**, *31*, 65–75.
41. Yang, L.X.; Luo, Y.H. China's Outward Direct Investment and Global Value Chain Upgrading. *Res. Quant. Econ. Tech. Econ.* **2017**, *34*, 54–70.
42. Zhou, J.K.; Dai, Z. Analysis of the Factors Affecting China's Intermediate Product Trade Based on the Grey Relational Analysis Method. *Int. Bus. J. Univ. Int. Bus. Econ.* **2017**, *10*, 16–26.
43. Chao, W.Q.; Hu, J.W.; Wang, X.Y. Research on the influencing factors of intra industry trade in tourism services between China and the United States—Based on the gray correlation analysis. *Econ. Issues* **2018**, *8*, 74–79.
44. Wang, D.Z.; Abula, B.W.J.; Jizuo, A.N.; Si, J.H.; Zhong, K.Y.; Zhou, Y.J. Agricultural Openness and the Risk of COVID-19 Incidence: Evidence from China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6. [CrossRef]
45. Wang, D.Z.; Abula, B.W.J.; Lu, Q.; Liu, Y.; Zhou, Y.J. Regional Business Environment, Agricultural Opening-Up and High-Quality Development: Dynamic Empirical Analysis from China's Agriculture. *Agronomy* **2022**, *12*, 4. [CrossRef]