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The Regional Heterogeneity of the Impact of Agricultural Market Integration on Regional Economic Development: An Analysis of Pre-COVID-19 Data in China

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Abstract: The abrupt onset of the COVID-19 pandemic in late 2019 significantly disrupted China's domestic agricultural production and supply chain stability. Local governments, responding to urgent circumstances, implemented various trade restrictions that profoundly affected regional economic development. This study, covering data from 2010 to 2019 across 31 provinces, investigates agricultural market integration and regional economic development. Employing a dynamic spatial panel Durbin model, it systematically analyzes the complex relationship between these variables. International trade variables related to agricultural products are then introduced to examine their "substitution effect" in promoting regional economic development through agricultural market integration. The research findings are summarized as follows: (1) disregarding international agricultural trade, a one-unit increase in the agricultural market integration index corresponds to a 0.156% rise in regional economic development. (2) In an open economy, the substitution coefficients for agricultural imports, exports, and total trade concerning market integration are −0.00097, −0.0012, and −0.0038, respectively. (3) The strength of the substitution effect from the international agricultural market to the domestic market varies regionally, with coefficients of −0.00099 and −0.00217 for the eastern and western regions, respectively.

Keywords: agricultural market integration; agricultural foreign trade; substitution effect; regional economic development

Citation: Miao, X.; Wang, S.; Han, J.; Ren, Z.; Ma, T.; Xie, H. The Regional Heterogeneity of the Impact of Agricultural Market Integration on Regional Economic Development: An Analysis of Pre-COVID-19 Data in China. *Sustainability* **2024**, *16*, 1734. https://doi.org/10.3390/su16051734

Academic Editors: Fotios Chatzitheodoridis, Efstratios Loizou and Achilleas Kontogeorgos

Received: 7 December 2023
Revised: 17 January 2024
Accepted: 7 February 2024
Published: 20 February 2024

1. Introduction

The abrupt onset of the COVID-19 pandemic in late 2019 significantly disrupted the stability of China's domestic agricultural production and supply chain. Due to lockdown measures, various stages of agricultural activities, including planting, harvesting, processing, and transportation, were affected [1,2]. This led to a reduction in agricultural production and supply shortages, resulting in price fluctuations in the agricultural market. Consumers faced food shortages and rising prices, while farmers encountered difficulties in selling their agricultural products [3,4]. Simultaneously, the Chinese government implemented a series of measures to strengthen quarantine and health requirements for imported agricultural products to prevent the spread of the pandemic. It restricted agricultural product exports to ensure domestic market supply. These measures created uncertainty and difficulties in international agricultural trade. In the post-COVID-19 era, overcoming the downward pressure on China's domestic economic development caused by the severe global economic recession, accelerating the construction of agricultural market integration, and implementing a series of policies to support farmers and agricultural producers to alleviate the negative impact of the pandemic on them and promote regional economic development will be key issues [5,6].

The total volume of China's agricultural import and export trade increased from USD 121.96 billion in 2010 to USD 228.427 billion in 2019, with an average annual growth rate of 6.48%. In 2020, the total volume of agricultural imports and exports amounted to USD 246.83 billion, representing a year-on-year increase of 8.0%. The trade deficit reached USD 94.77 billion, reflecting a growth of 32.9%. China's domestic agricultural market is closely connected with the international market and is significantly influenced by the international agricultural market. From the perspective of the domestic market, the sales revenue of agricultural products increased from CNY 267.848 billion in 2010 to CNY 1858.08 billion in 2019, with an average annual growth rate of 21.37%. In 2020, the sales revenue of agricultural products amounted to CNY 2220.53 billion, representing a 19.5% increase. However, the growth rate declined. Against the backdrop of a significant increase in the agricultural trade deficit and a decrease in the sales scale of the domestic agricultural market, this situation is not conducive to the improvement of per capita disposable income for residents. Some scholars argue that significant fluctuations in agricultural product prices can lead to chaotic transactions in the agricultural market and a reduction in overall social welfare [7,8]. They emphasize that market integration, including the agricultural market, is a necessary condition for achieving cross-regional price stability, ensuring agricultural supply security and thereby improving the well-being of the population [9].

Regional economic development demands stable market prices [10] and seeks to avoid market segmentation. Agricultural markets are closely tied to residents' welfare and exert a substantial impact on economic development [11]. From 2012 to 2020, there was significant fluctuation in the retail prices of agricultural products nationwide, with even more pronounced volatility in fresh agricultural product prices. Taking the average wholesale and retail prices of 15 vegetables (potatoes, tomatoes, cucumbers, bell peppers, eggplants, carrots, Chinese cabbage, cabbage, green beans, hot peppers, leeks, radishes, celery, garlic sprouts, and rapeseed) as an example, the price difference increased from CNY 1.92/kg to CNY 2.20/kg. Considering the average wholesale and retail prices of four fruits (Fuji apples, bananas, citrus, and watermelons) as another example, the price difference rose from CNY 1.88/kg in 2012 to CNY 3.71/kg in 2020. Historical experience suggests that the cause of this phenomenon is the excessively high circulation costs of agricultural products between regions [12]. Statistical data also confirm this point. In 2016, logistics costs in China accounted for 14.9% of GDP, and by 2020, this proportion had only decreased by 0.2%. In contrast, logistics costs in the United States have consistently been kept below 10% of GDP. The high circulation costs reflect a low level of agricultural market integration among regions and a severe state of market segmentation in China. This ultimately poses challenges to regional economic development [13].

The segmentation of agricultural markets is the result of the combined influence of factors such as local government policies, information technology levels, and geographical location [14–16]. It manifests in three specific categories: the first category involves the motivation of local governments to protect their local agricultural markets and ensure the market share of local enterprises [17]. This protective policy leads to market segmentation [18]. The second category is the lag in the development of information technology. It prevents timely and effective communication of production costs and sales prices between agricultural producers and consumers in different regions [19]. This communication barrier results in the invisible isolation of two markets. Producers cannot adjust production strategies promptly based on consumer demand information, and consumers cannot purchase satisfactory agricultural products. This leads to efficiency losses in agricultural markets [20,21]. The third category arises from the geographical differences between regions, leading to high transportation costs for the sale of agricultural products between different areas [22]. Breaking this segmentation and establishing an integrated agricultural market depend on transportation infrastructure. This is evident in two aspects: first, the development of transportation shortens transit time, enhances the circulation efficiency of agricultural products, and reduces the likelihood of price fluctuations in agricultural markets due to geographical distances [23]. Second, convenient transportation helps lower agricultural transportation costs, strengthen economic connections between regions, and enhance the level of agricultural market integration [24,25]. In conclusion, even advanced economies experience segmentation in agricultural markets, but the trend towards market integration is inevitable [26].

China, with its vast land area and large population, boasts a massive consumer market for agricultural products. The spatial geographic conditions and climatic environments vary significantly among different regions [27]. This diversity provides an excellent research context to explore the regional heterogeneity of agricultural market integration and its impact on regional economic development under complex natural and socio-economic conditions. The impact of the COVID-19 pandemic has revealed the vulnerability of the existing agricultural production and market supply chains [28]. Simultaneously, it has created a demand to identify new "points of equilibrium" for agricultural market integration and regional economic development in the post-pandemic era [29,30]. Based on this, the analysis focuses on the impact of agricultural market integration on regional economic development from a regional heterogeneity perspective. At the same time, the research incorporates international trade variables to explore their "substitution effects" in promoting regional economic development through agricultural market integration, while considering variations across different regions. In comparison to existing research, our marginal contributions are primarily evident in three aspects. Firstly, we provided a precise estimation of the agricultural market integration index and analyzed its temporal trends. Secondly, we constructed a dynamic spatial Durbin model to investigate the spatial effects of agricultural market integration on regional economic development and regional heterogeneity. Finally, we introduced variables related to international trade of agricultural products to examine their "substitution effects" in promoting regional economic development through agricultural market integration, with a specific focus on differences between the eastern and western regions. Furthermore, to ensure the model accurately describes the relationships between variables, we addressed estimation biases caused by endogeneity issues within the model. Additionally, we utilized officially published statistical data from 31 provinces, municipalities, and autonomous regions in China from 2010 to 2019 to ensure the scientific validity and accuracy of the results.

The structure of this paper is organized as follows: the first section comprises the introduction, the second section presents the conceptual framework, the third section outlines the research hypotheses, the fourth section details the research design, the fifth section reports the results, the sixth section delves into the extended analysis (substitution relationships and regional heterogeneity), the seventh section engages in discussions, and the final section provides the conclusion.

2. Conceptual Framework

2.1. Meaning and Key Features

2.1.1. Agricultural Market Integration

Agricultural market integration refers to the process of consolidating dispersed agricultural markets from different regions into a unified and coordinated market system. This process aims to eliminate barriers caused by local government policies, information technology levels, geographical locations, and other factors. The goal is to enable the free and efficient circulation and trade of agricultural products across diverse regions [31]. The core objective of agricultural market integration is to establish a unified domestic market for agricultural products, encompassing the production, distribution, and sales stages. This is aimed at enhancing the operational efficiency of the agricultural sector and the overall economy [32]. Key features of agricultural market integration include market consolidation, information sharing, smooth supply chains, and consistent government policies [33,34]. In summary, agricultural market integration is expected to facilitate easier market access for agricultural products, reduce transaction costs, enhance the competitiveness of agricultural products, improve food supply, and ultimately increase the welfare of farmers and other market participants [35].

In existing research, three main methods measure the level of agricultural market integration. The first method is the price index approach, which compares prices of identical commodities in different regional markets, analyzes the trend of price changes, and assesses the degree of market integration [36]. This method typically takes into account transaction costs, taxes, and other factors affecting prices to more accurately evaluate the state of market integration. Studies indicate that prices for similar goods in different regions of developed countries tend to remain stable over long periods. For example, in the United States, the time required for price convergence is 5 to 10 years [37]. Conversely, in developing countries such as China and India, the time for price convergence is shorter [38,39]. The second method is the production approach, measuring the level of market integration by evaluating factors such as output structure and production efficiency in different regions [40,41]. Large differences in economic and industrial structures between regions imply a high degree of regional specialization in production, requiring close collaboration between regions and leading to an increase in the degree of market integration.

2.1.2. Regional Economic Development

Regional economic development refers to the process, within a specific geographical area, of achieving economic growth, enhancing the standard of living for the population, and improving social welfare through effective resource allocation and economic policies. It is typically measured at the level of cities, states, provinces, counties, or urban agglomerations. Regional economic development differs from regional economic growth [42], wherein economic growth focuses on increasing the regional gross domestic product (GDP) and creating more employment opportunities, fostering the development of import and export trade, including agricultural products [43]. It is evident that regional economic growth is only a component of regional economic development and cannot fully replace indicators of regional economic development in research. It is essential to identify indicators that encompass both economic growth and the development of social welfare [44].

Regional economic development involves the effective allocation of resources to ensure that the region's resources are fully optimized and utilized [45]. The process and purpose of optimizing various resources aim to improve the quality of life for local residents [46], including enhancements in education, healthcare, housing, and food security. It also typically considers the sustainability of development to ensure that economic growth does not adversely affect the environment, society, and future generations [47]. It is evident that regional economic development emphasizes a broader, comprehensive set of goals, encompassing factors related to the economy, urban and rural areas, and the environment [48,49]. In this study, residents' disposable income is chosen as an alternative indicator for economic development because it considers not only economic growth but also the potential to enhance overall societal and individual well-being, improve the quality of life, and promote environmental sustainability.

2.2. Positive Effects of Agricultural Market Integration on Regional Economic Development

Summarizing existing research findings, the positive effects of agricultural market integration on regional economic development mainly include the following four aspects.

2.2.1. Facilitating Price Discovery

Agricultural market integration, achieved through the amalgamation of market information and the interconnection of markets across diverse regions, facilitates a more precise and equitable determination or discovery of market prices for agricultural products. This process enhances the efficiency of agricultural markets, assisting farmers and other market participants in making informed decisions. Simultaneously, it contributes to the equilibrium of supply and demand, thereby maintaining the stability of the agricultural product market. These outcomes are primarily achieved through four key approaches and methods: firstly, providing transparent market information to assist stakeholders in gaining a better understanding of market conditions [50]; secondly, balancing supply and demand to prevent excessive fluctuations in various agricultural product prices [51]; thirdly, mitigating information asymmetry and enhance market transparency [52]; lastly, implementing additional positive measures, such as supporting contract pricing and exploring international markets, thereby fostering international trade in agricultural products [53].

2.2.2. Reducing Transaction Costs

Agricultural market integration, overcoming geographical barriers, enhances market efficiency, transparency, and competitiveness, thereby contributing to the reduction in various transaction-related costs. This not only benefits farmers, agricultural producers, wholesalers, retailers, and consumers but also fosters the growth of agricultural markets and the development of agriculture. The impact of market integration on reducing costs related to agricultural products is evident in three key aspects: firstly, it reduces storage costs, decreasing both product loss and quality deterioration [54]. Secondly, it minimizes intermediary trading links, improving the operational efficiency of agricultural markets [55]. Thirdly, it enhances payment convenience, providing more flexible payment options that can shorten transaction cycles [56]. Lastly, it supports e-commerce and online transactions, further lowering transaction costs for agricultural products and enhancing market efficiency [57].

2.2.3. Increasing Farmers' Income

Agricultural market integration can enhance farmers' income through various means, such as providing more sales opportunities, improving supply chain management, and boosting both yield and quality. These factors collectively contribute to enhancing farmers' economic conditions and rural community livelihoods, fostering sustainable agricultural development. The role of agricultural market integration in increasing farmers' income is predominantly evident in the following three aspects: firstly, it improves agricultural output and quality. Increased production is fueled by the expanding market demand [58], and the enhancement of agricultural product quality is linked to the adoption of food safety standards, which are often required in integrated agricultural markets. This fosters the branding of agricultural products, leading to a significant boost in farmers' income [59]. Secondly, market diversification plays a crucial role. By enabling farmers to sell their products to more distant regions, this strategy diversifies production and business risks, augments the sales volume of agricultural products, and stabilizes farmers' income [60]. Thirdly, supply chain optimization is a vital factor. This enhances the turnover rate of goods and reduces the backlog of agricultural product inventory [61].

2.2.4. Improving Food Supply

Agricultural market integration positively influences the food supply by improving the sustainability, diversity, and traceability of agricultural products. This is accomplished through elevating food safety standards, ensuring a higher-quality food supply for consumers. It plays a crucial role in addressing the continually increasing demand for food, proving essential for nutrition and health and contributing significantly to the overall well-being of individuals. Its specific effects are evident in the following: firstly, the diversification of supply channels ensures a varied source of agricultural products for the public, reducing the risk of food shortages [62]. Secondly, the integrated agricultural market facilitates the prompt handling of food safety incidents, aiding in the swift identification and resolution of food safety issues, thereby reducing health problems resulting from food quality concerns [63]. Thirdly, it promotes sustainable agricultural production by encouraging farmers to adopt sustainable agricultural practices, minimizing the adverse environmental impact of agriculture, and ensuring a long-term food supply [64].

In summary, agricultural market integration stands as a pivotal driver for regional economic development. It optimizes the allocation of resources in the agricultural industry, boosts the scale of domestic agricultural trade, and ensures regional food security. This is accomplished through initiatives such as promoting price discovery, reducing transaction costs, increasing farmers' income, and enhancing food supply. Collectively, these efforts play a vital role in fostering robust regional economic development.

2.3. Theoretical Analysis

The theoretical foundation of how agricultural market integration promotes regional economic development includes the following aspects.

2.3.1. Allocation Efficiency Theory

Agricultural market integration can unite diverse regions into a cohesive whole, strategically allocating resources across different areas to maximize overall benefits, guided by principles of efficiency [65,66]. This approach is designed to cater to the optimal requirements of various agricultural producers for production factors. When resources, including land, water, and labor, are fully optimized, farmers and other producers can enhance the efficiency of agricultural output [67]. In essence, agricultural market integration facilitates the optimal utilization of agricultural resources throughout the entire industry chain—from production and transportation to consumption—preventing the waste of limited agricultural resources. Agricultural products from different regions can be cultivated in the most efficient locations, thereby reducing unnecessary redundancy and enhancing the operational efficiency of different regions and the entire domestic economy.

2.3.2. Specialization and Comparative Advantage Theory

Different regions exhibit diverse geographical conditions, resources, climates, and production technologies [68]. According to the theories of specialization and comparative advantage, the key to promoting regional economic development through agricultural market integration lies in each region focusing on the production of agricultural products where it holds a relative advantage. This approach aims to achieve more efficient output and enhance regional economic benefits. The comparative advantage theory suggests that each region should concentrate on producing agricultural products in which it has endowment advantages [69], meaning products with lower production costs and higher quality in that specific region. Consequently, each region can enhance its production efficiency. The theory of specialization in production holds that agricultural market integration encourages different regions to meet the specific demands of certain markets through specialized production [70]. This implies that each region leverages industry chain advantages developed over time, concentrating on producing specific types of agricultural products for sale. With producers possessing in-depth knowledge of the products they cultivate, they can employ the most suitable production equipment and techniques, thus reducing costs and increasing their output. Furthermore, specialized production within the context of agricultural market integration promotes the standardization of agricultural product quality standards, as well as the rapid dissemination and progress of production technologies, fundamentally driving regional economic development [71].

2.3.3. Economies of Scale Theory

The most direct outcome of agricultural market integration is the creation of a vast market scale, capable of encompassing a larger consumer base. This, in turn, generates increased demand for agricultural products and encourages all producers to expand their production scale to gain more profits [72]. Engaging in large-scale agricultural production allows individual farmers or producers to reduce unit production costs and enhance economic efficiency [73]. Large-scale production often provides greater capacity to invest in new technology research and development as well as the adoption of innovative methods to improve production efficiency and the quality of agricultural products [74]. Since the fixed production costs of individual producers can be spread across a greater number of products, this directly reduces unit production costs, ultimately lowering the prices of agricultural products and making them more competitive in the market. Importantly, participants in the entire agricultural market have a profit motive to reduce production costs and product prices, ultimately benefiting consumers and fostering regional economic development.

2.3.4. Risk Theory

From the perspective of farmers and other producers, agricultural market integration introduces diversification into demand markets, effectively averting sales crises in individual regions caused by preferences or other changes in demand [75]. On the side of agricultural market supply, integration encompasses a multitude of producers from different regions, helping to alleviate the supply impact on the entire agricultural market in the face of natural disasters or seasonal production fluctuations in a specific region [76]. For example, if a particular region experiences a natural disaster, other regions can promptly reallocate agricultural products to ensure a stable supply in the affected area. This shared risk helps reduce the risks for specific regions or agricultural producers, boosting their confidence in participating in production activities and market competition. Consequently, this contributes to the stable operation of the agricultural product market and the sustainable development of the regional economy [77].

3. Hypothesis

3.1. Hypothesis 1

Geographical distance creates impediments to regional trade, resulting in market segmentation [78]. According to the resource allocation theory, this market segmentation significantly impedes the economic development efficiency of both the local region and neighboring areas [15]. Studies on the market segmentation of agricultural products and its impact on China's economic growth reveal a substantial negative correlation between this segmentation and the actual per capita agricultural GDP and per capita GDP. This leads to the conclusion that market segmentation is detrimental to the coordinated development of the economy [79]. Furthermore, when examining 12 Chinese cities and the prices of six major commodity categories, it has been demonstrated that interprovincial market segmentation hampers the economic growth rates of respective provinces [80]. Synthesizing existing research findings, market segmentation has been identified as having a severe negative impact on economic growth [81]. This is primarily due to its reduction in resource allocation efficiency, resulting in increased production costs while simultaneously diminishing market transaction efficiency [82]. Ultimately, market segmentation affects the well-being of the population and imposes constraints on regional economic development [83].

In the late 1980s, China initiated its reform efforts by introducing the land contracting system in rural areas. Subsequently, the agricultural industry underwent a gradual process of marketization [84]. Specifically, the introduction of market mechanisms to agricultural product transactions enabled farmers and businesses to participate in free trade [85]. As transportation infrastructure was constructed and improved, the rapid development of China's integrated agricultural product market contributed significantly to the increase in agricultural output [86]. The domestic integration of markets, encompassing agricultural products, in China has been verified to have a noteworthy impact on the rate of economic growth [87]. More importantly, it consistently contributes to enhancing income levels for residents in the regions, particularly fostering accelerated income growth for farmers in less developed areas [88]. This not only alleviates poverty but also mitigates economic imbalances between regions [86]. Based on these observations, we propose the following hypothesis:

Hypothesis 1. *The agricultural market integration has a positive impact on regional economic development.*

3.2. Hypothesis 2

In the context of free trade, the inclination and policy decisions of local governments to establish trade barriers are influenced by the current level of international trade in the region [89]. Common indicators of international trade levels encompass total imports, total exports, and total trade volume. In diverse conditions of international trade in agricultural products, the positive impact of China's integration of the domestic agricultural product market on regional economic development varies [90]. The theory of comparative advantage suggests that the international trade level of agricultural products reflects both the competitive advantage of the agricultural product industry and the ability to leverage international market resources [91]. Conversely, risk theory posits that the international trade level of agricultural products mirrors the degree of regional economic dependence on foreign or non-regional economies [92]. Specifically, this dependence manifests in varying degrees of impact on regional economic development due to international trade in agricultural products.

According to the economies of scale theory, a large scale of international trade in agricultural products implies a high degree of dependence of the agricultural industry on foreign markets [93]. When closely connected to foreign economies, the domestic economy's economic development relies on the economies of scale gained from foreign markets [94]. This explains why, when the level of foreign trade in agricultural products is high, the role of domestic agricultural product market integration in promoting regional economic development is relatively weak. In a sense, international trade "substitutes" the role of promoting regional economic development through domestic agricultural product market integration [93]. However, in regions lacking a competitive advantage to enter foreign agricultural product markets, it is necessary to strengthen market connections with other domestic regions. This is done to enhance the level of agricultural product market integration, aiming to gain spatial spillover effects [95] and scale effects [96] from domestic agricultural product market integration. This, in turn, facilitates the sustained development of regional agriculture and the agricultural product industry. Based on these observations, the following hypothesis is proposed:

Hypothesis 2. *In different regions, the "substitution relationship" wherein domestic agricultural market integration is replaced by agricultural foreign trade to promote regional economic development varies.*

3.3. Hypothesis 3

In addition to the consumer utility theory in economics, the "substitution effect" theory finds widespread application in agricultural markets and international trade, albeit with a unique interpretation. This interpretation encompasses three aspects: firstly, a substitution effect exists between the international agricultural product market and the domestic agricultural product market [97,98]. The development and changes in the international agricultural product market can lead to corresponding changes in the domestic market, and vice versa. Specifically, businesses and consumers must make choices between the domestic agricultural product market and the international market. If a particular agricultural product becomes more competitive or experiences a lower price in the international market, it will impact the demand in the domestic market. Secondly, changes in international agricultural product trade can have an impact on the import and export of domestic agricultural products [99]. If there is an increased demand for domestic products in the international market, domestic farmers or producers may ramp up exports, thereby reducing the supply to the domestic market. Conversely, if the demand for domestic agricultural products rises in the domestic market, producers may decrease exports and increase domestic supply [100]. Thirdly, changes in international trade policies related to agricultural products can also influence the substitution relationship between the international and domestic markets [101]. For example, trade protectionist policies may restrict the import of foreign agricultural products, ensuring a demand for domestic agricultural products.

Due to geographical, climatic, and historical factors, China's administrative regions are categorized into the eastern, central, and western parts. The levels of economic, social, and trade development generally align with this regional division [102]. Specifically, the eastern region is the most developed, the western region is the least developed, and the central region falls in between. Research indicates that the level of agricultural product market integration in these three major regions corresponds to these developmental differences [83]. Using the price index method, the calculated agricultural product market integration indices for the eastern, central, and western regions in 2019 were approximately 2.3, 1.8, and 1.0, respectively [103]. Further analysis reveals that, owing to varying levels of economic and trade development, the impact of agricultural product market integration on regional economic development exhibits regional differences [104]. Domestic agricultural product market integration can effectively promote regional economic growth [105]. However, in the economically advanced eastern regions, the promotional role of the domestic agricultural product market on the local economy is often overlooked due to their close ties to international markets.

The eastern region, being in proximity to overseas markets, incurs lower export trade costs, facilitating easier access to international markets, and exhibits a higher dependence on foreign trade, as promptly reflected in the international market environment [106]. Provinces with higher levels of economic openness, such as Shanghai, Jiangsu, and Shandong, tend to utilize foreign trade as a lever for promoting the development of the local agricultural industry [107]. Comparative studies suggest that international trade plays a more significant role in the economic growth of coastal regions, while domestic market integration has a more pronounced impact on inland areas [108]. The western inland regions, characterized by lower levels of external openness, are unable to substitute domestic market demand with international markets. Consequently, they rely more on domestic market integration to propel economic development [109]. This implies that the role of domestic agricultural product market integration is primarily concentrated in the less externally open western regions. In the eastern regions, international markets substitute a portion of the domestic agricultural product market, reducing the demand for agricultural products from other domestic regions. In this sense, it may adversely affect the economic development of other domestic regions. Based on these observations, the following hypotheses are proposed:

Hypothesis 3a. *Regional heterogeneity exists in the promoting effect of agricultural product market integration on regional economic development.*

Hypothesis 3b. *The substitutive role of agricultural product foreign trade in promoting economic development through regional agricultural product market integration exhibits regional heterogeneity.*

4. Materials and Methods

The empirical research framework of this article encompasses three key aspects. Firstly, we provided a precise estimation of the agricultural market integration index and analyzed its temporal trends. Secondly, we constructed a dynamic spatial Durbin model to investigate the spatial effects of agricultural market integration on regional economic development and regional heterogeneity. Finally, we introduced variables related to international trade of agricultural products to examine their "substitution effects" in promoting regional economic development through agricultural market integration, with a specific focus on differences between the eastern and western regions. Furthermore, to ensure that the model accurately describes the relationships between variables, we addressed estimation biases caused by endogeneity issues within the model. Additionally, we utilized officially published statistical data from 31 provinces, municipalities, and autonomous regions in China from 2010 to 2019 to ensure the scientific validity and accuracy of the results. These three aspects represent the marginal contributions of this article compared to existing research.

4.1. Data Source

We utilized annual data from 2010 to 2019 for 31 provinces in China. The data are primarily sourced from the "China Statistical Yearbook" and the China Stock Market & Accounting Research Database. Data not available in the aforementioned statistical yearbooks are obtained from various provincial statistical yearbooks and the official website of the Ministry of Commerce of the People's Republic of China. The empirical analysis of the paper was conducted using Stata (16.0, StataCorp, College Station, TX, USA).

4.2. Variables

4.2.1. The Dependent Variable

Regional economic development ($\ln pergdp$) encompasses various indicators, such as total GDP, economic growth rate, industrial added value, per capita disposable income, and the level of social welfare. The per capita disposable income indicator not only captures the economic growth trend but also reflects the relative prosperity of each resident and their ability to utilize social resources. Hence, the natural logarithm of per capita disposable income is employed as the proxy variable for regional economic development.

4.2.2. Explanatory Variable

Agricultural market integration (*together*) contrasts with the segmentation of agricultural markets, and its measurement involves an initial assessment of the agricultural market segmentation index. In this study, the agricultural market segmentation index for 31 provinces is constructed using the relative price method [110]. The relative price method refers to using the relative prices of agricultural products as a tool to measure the degree of agricultural market integration. After obtaining the prices of agricultural products, the volatility of relative price differences is calculated to estimate the level of agricultural market integration between regions. When agricultural products can freely move, the prices in various regions will eventually converge. Therefore, using the relative price method to measure the degree of agricultural market integration is an effective approach.

Before calculating the relative price index of agricultural products, it is necessary to construct a three-dimensional ($t \times m \times k$) panel dataset, where t represents the years, m represents the regions and k represents the various types of agricultural products. The original data are sourced from the annual Provincial Statistical Yearbooks of China, covering the years 2010–2019. This dataset spans a decade and includes data from 31 provinces, municipalities, and autonomous regions nationwide (excluding Hong Kong, Macao, and Taiwan due to missing data). It encompasses seven major categories of agricultural products: cereals, oils and fats, meat and poultry and their products, eggs, aquatic products, vegetables, and fresh and dried fruits (classified according to the China Statistical Yearbook). The utilized dataset comprises three dimensions: time, location, and type of agricultural product ($10 \times 31 \times 7$).

a. Calculate the absolute value of relative prices

We utilize the retail price index of agricultural products for each province to calculate relative prices, as shown in Formulas (1) and (2):

$$\Delta Q_{ijt}^{k} = \ln\left(\frac{p_{it}^{k}}{p_{jt}^{k}}\right) - \ln\left(\frac{p_{it-1}^{k}}{p_{jt-1}^{k}}\right) = \ln\left(\frac{p_{it}^{k}}{p_{it-1}^{k}}\right) - \ln\left(\frac{p_{jt}^{k}}{p_{jt-1}^{k}}\right) \tag{1}$$

$$\left|\Delta Q_{ijt}^{k}\right| = \left|\ln\left(\frac{p_{it}^{k}}{p_{it-1}^{k}}\right) - \ln\left(\frac{p_{jt}^{k}}{p_{jt-1}^{k}}\right)\right| \tag{2}$$

In Equation (1), ΔQ_{ijt}^{k} denotes the relative price of any two provinces for the k_{th} agricultural product in year t. Here, i and j represent any two provinces, t denotes the year, and k signifies the specific agricultural product. Additionally, p_{it}^{k} stands for the retail price index of the k_{th} agricultural product in province i in year t, p_{it-1}^{k} represents the retail price index of the same product in province i in the previous year, p_{jt}^{k} signifies the retail price index of the k_{th} agricultural product in province j in year t, and p_{jt-1}^{k} denotes the retail price index of the same product in province j in the previous year. Equation (2) encompasses 465 pairs of any two provinces or municipalities for the years 2010–2019, resulting in the computation of 32,550 different differentials in the form of relative prices $\left|\Delta Q_{ijt}^{k}\right|$. The utilization of absolute values in this context ensures that the variance of relative prices remains unaffected by the order of provinces or municipalities in the combinations.

b. Eliminate the mean

Given the heterogeneity in agricultural products between two provinces, the fact that $\left|\Delta Q_{ijt}^{k}\right|$ is not solely influenced by interprovincial market characteristics, we employ a method of demeaning to address this heterogeneity in agricultural products [111]. The procedure is as follows: assuming that $\left|\Delta Q_{ijt}^{k}\right|$ comprises two components α^{k} and ε_{ijt}^{k}, where α^{k} is related to the characteristics of the k_{th} agricultural product itself and ε_{ijt}^{k} reflects the market features of provinces i and j. To eliminate the influence of α^{k}, we calculate the average relative price for the k_{th} agricultural product for 465 pairs of provincial combinations in year t, denoted as $\left|\Delta \overline{Q_{t}^{k}}\right|$. Subsequently, we subtract this mean from $\left|\Delta Q_{ijt}^{k}\right|$ to obtain $q_{ijt}^{k}=\left|\Delta Q_{ijt}^{k}\right| - \left|\Delta \overline{Q_{t}^{k}}\right| = (\alpha^{k} - \overline{\alpha^{k}}) + (\varepsilon_{ijt}^{k} - \overline{\varepsilon_{ijt}^{k}})$, thereby obtaining the relative price variation component used for calculating the variance, denoted as q_{ijt}^{k}. It is solely associated with the market characteristics of the agricultural products in the two provinces and some random factors.

c. Market segmentation index

Var (q_{ijt}) represents the variance in the relative price fluctuations for the seven categories of agricultural products. By summing the relative price variances for each province with any other province and dividing the result by 30 (as each province has 30 different combinations), we obtain the agricultural market segmentation index for each province: Var $(q_{nt}) = (\sum_{i\neq j} \mathrm{Var}\left(\mathrm{q}_{ijt}\right))/30$. Since there is an inverse relationship between agricultural market segmentation and market integration, the reciprocal of the square root of the agricultural market segmentation index can be used as the agricultural market integration index for each province, denoted as $together = \sqrt{1/\mathrm{Var}(q_{nt})}$. It is important to note once again that existing research calculates the national average index of agricultural integration for the years 2010 to 2019 to be approximately 1.3, which slightly differs from the calculation method employed in this study [103]. Specifically, after obtaining the reciprocal of the agricultural segmentation index, there is no multiplication by $1/1000$; instead, the square root of this reciprocal is taken directly. Both calculation methods, when subjected to the corresponding inverse operation, can be converted into indices with a consistent measurement scale.

4.2.3. Control Variables

According to previous studies, the following control variables have been selected [86,112–115]; the government intervention level variable (*govern*), calculated using the proportion of general public budget expenditures to GDP; The level of agricultural development (*agri*), measured by the proportion of the added value of the primary industry to GDP; the level of urbanization (*urban*), measured by the proportion of the urban population to the total population; agricultural labor supply (*labor*), measured by the number of people engaged in agriculture, forestry, animal husbandry, and fishery; agricultural fixed asset investment (*invest*), measured by the proportion of total fixed asset investment in agriculture, forestry, animal husbandry, and fishery to GDP; population density (*density*), reflected by dividing the year-end population by the administrative area.

4.2.4. Instrumental Variables

Firstly, the transportation network density ($traffic$) is calculated by dividing the total mileage of highways, railways, and inland waterways by the administrative area of each province, drawing on existing research [87]. Secondly, the interaction term between the annual sunshine hours and the agricultural market integration index for each province (*sun*) is employed as an instrumental variable. Annual sunshine hours are highly correlated with crop yield and diversity, and they are mutually independent of the agricultural market integration index, making them a suitable choice as an instrumental variable.

4.2.5. Moderating Variables

The foreign trade volume of agricultural products is measured by the total import and export volumes, including separate assessments for imports and exports.

The specific meanings and descriptive statistics of each variable are shown below (Table 1).

Table 1. Introduction and descriptive statistics of regional economic development, agricultural market integration, and related control variables in China from 2010 to 2019.

Variables	Variables Interpretation	Mean	Standard Deviation	Minimum	Maximum
ln *pergdp*	Per capita GDP	10.75	0.463	9.482	12.01
together	Relative price index method	32.72	6.176	16.51	45.97
govern	Government budget expenditure/GDP (%)	27.93	20.83	10.58	137.9
agri	Primary industry value added/GDP (%)	9.459	4.957	0.281	25.28
urban	Urban population/total population (%)	56.09	13.39	22.67	89.60
labor	Labor supply in the agricultural category (persons)	791.6	594.1	23.61	2559
invest	Social fixed asset investment in agriculture (CNY)	3.407	2.548	0.00520	15.16
density	Year-end resident population/administrative district land area (persons/square kilometers)	517.7	690.5	3.376	3913
$traffic$	Total mileage of roads, railroads and inland waterways/land area of administrative region (ten thousand kilometers/square kilometers)	1.298	0.875	0.0695	5.344
sun	$together *$ annual sunshine hours (hours)	1996	577.0	257.1	3163

Data source: calculated by the author.

4.3. Trend of Agricultural Market Integration

By averaging the agricultural market integration index across the 31 provinces and municipalities in China, we derive the agricultural market integration index for China (nation) for the decade preceding the COVID-19 pandemic, along with its temporal trends. Concurrently, Figure 1 illustrates the average changes over time in this index for the eastern (east), central (middle), and western (west) regions.

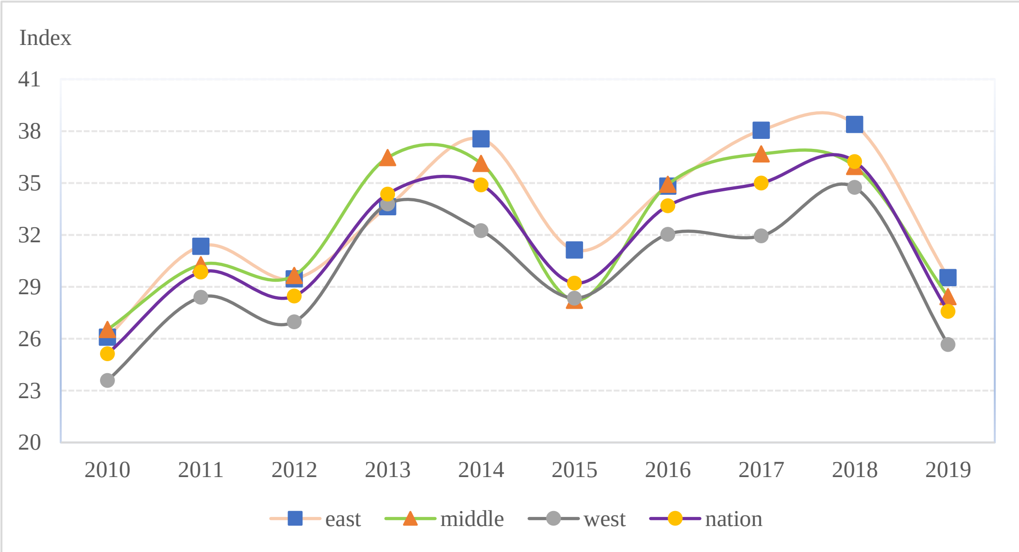

Figure 1. Agricultural market integration trends in China as a whole and in the eastern, central, and western regions from 2010 to 2019. Note: east (eastern regions): Beijing, Tianjin, Hebei, Liaoning, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan; Middle (central regions): Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan; west (western regions): Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

It is evident that from 2010 to 2019, the national agricultural market integration index exhibits a cyclical trend with a periodicity of approximately 5 years (Figure 1). Analyzing regional differences, the cyclical fluctuation trends in the eastern and central regions are essentially similar to the national trend. In contrast, the western region has the lowest agricultural market integration index, and its fluctuations show no clear pattern.

4.4. Spatial Econometric Models

In accordance with the resource allocation theory and economies of scale theory discussed in Section 2.3, a higher level of agricultural market integration, denoted by an elevated agricultural market integration index, implies a stronger degree of integration for resources related to agricultural products [67,68]. This heightened integration is associated with a greater impact on regional economic development [73]. The role of agricultural market integration in regional economic development is reflected through the construction of a panel econometric model (Equation (3)).

$$\ln pergdp_{it} = \beta_1 together_{it} + \beta_2 govern_{it} + \beta_3 agri_{it} + \beta_4 urban_{it} + \beta_5 labor_{it} + \beta_6 invest_{it} + \beta_7 density_{it} + \lambda_t + \alpha_i + \varepsilon_{it} \quad (3)$$

$lnpergdp_{it}$ represents regional economic development, $together_{it}$ stands for the agricultural market integration index, β_2–β_7 are control variables, representing the 31 provinces ($i = 1, 2, \ldots, 31$), t is the year (t = 2010, 2012, . . . , 2019), and λ_t and α_i denote time and regional effects, respectively. ε_{it} represents the random error term.

The level of agricultural market integration in one province affects the economic development of other provinces, indicating the presence of spatial spillover effects. The examination of such spatial effects can be conducted using a spatial Durbin model. Additionally, due to the time trend characteristics of regional economic development, it is necessary to establish a dynamic spatial Durbin model to investigate the relationship between agricultural market integration and regional economic development. The formula is as follows:

$$\begin{aligned}\ln pergdp_{it} = \varphi \ln pergdp_{i,t-1} + \vartheta \textstyle\sum_{j=1}^{n} W_{ij} \ln pergdp_{j,t-1} + \rho \textstyle\sum_{j=1}^{n} W_{ij} \ln pergdp_{jt} + \\ \beta_1 together_{it} + \beta_2 govern_{it} + \beta_3 agri_{it} + \beta_4 urban_{it} + \beta_5 labor_{it} + \beta_6 invest_{it} + \beta_7 density_{it} + \\ \gamma_1 \textstyle\sum_{j=1}^{n} W_{ij} together_{jt} + \gamma_2 \textstyle\sum_{j=1}^{n} W_{ij} govern_{jt} + \gamma_3 \textstyle\sum_{j=1}^{n} W_{ij} agri_{jt} + \gamma_4 \textstyle\sum_{j=1}^{n} W_{ij} urban_{jt} \\ + \gamma_5 \textstyle\sum_{j=1}^{n} W_{ij} labor_{jt} + \gamma_6 \textstyle\sum_{j=1}^{n} W_{ij} invest_{jt} + \gamma_7 \textstyle\sum_{j=1}^{n} W_{ij} density_{jt} + \varepsilon_{it}\end{aligned} \tag{4}$$

φ and ϑ represent the coefficients of time and spatiotemporal lag terms for regional economic development, W_{ij} is the spatial weight matrix, ρ is the coefficient for spatial spillover effects on regional economic development, and γ_1–γ_7 represent coefficients for the spatial lag terms. The meanings of the other variables remain consistent with the previous context.

4.5. Spatial Weight Matrix

The interdependence and correlation among spatial units can be represented using a spatial weight matrix. Various types of spatial weight matrices include matrices based on proximity distance, geographical distance, economic distance, and economic–geographic embedding. The proximity-based spatial weight matrix enumerates other provinces that are adjacent to it and assigns corresponding weight values to reflect the strength of their relationship. The geographical distance spatial weight matrix calculates the actual geographical distances between different provinces and assigns weight values. Typically, provinces that are closer have higher weights, while those that are farther away have lower weights. The economic distance spatial weight matrix is based on economic factors to measure the correlation between different provinces and then assign weight values. The economic–geographical embedding spatial weight matrix integrates the influences of economic distance and geographical distance to represent the complex relationships among different provinces. Essentially, it reflects the spatial connections between regions in terms of both economic and geographical aspects. Selecting the appropriate spatial weight matrix is crucial for studying the relationship between the agricultural market integration index and regional economic development.

The spatial weight matrix based on proximity distance refers to designating the k (k = 1, 2, . . ., 31) nearest provinces as neighboring regions. In this matrix, elements corresponding to pairs of adjacent provinces are assigned a value of 1, while others are set to 0. Considering that although Guangdong and Hainan provinces are not contiguous on land, their maritime areas are connected, and they share close agricultural trade activities and other economic and social connections. Therefore, the model assigns a value of 1 to the elements of the spatial weight matrix between these two provinces. The formula is as follows:

$$W_1 = \begin{cases} 1 \text{ region } i \text{ and } j \text{ are adjacent} \\ 0 \text{ region } i \text{ and } j \text{ are not adjacent} \end{cases} \quad i = 1,\ 2,\ \cdots,\ 31; \quad j = 1,\ 2,\ \cdots,\ 31 \tag{5}$$

In the spatial weight matrix based on geographical distance, the distance relationship between province i and province j adheres to the following conditions: when $i \neq j$, $W_2 = 1/d_{ij}$; when i = j, W_2 = 0. d_{ij} represents the spherical distance between the two provinces, calculated based on latitude and longitude data. The formula is as follows:

$$W_2 = \begin{cases} 1/d_{ij} & i \neq j \\ 0 & i = j \end{cases} \qquad i = 1,\ 2,\ \cdots\ 31; \quad j = 1,\ 2,\ \cdots,\ 31 \tag{6}$$

The spatial weight matrix based on economic distance uses the reciprocal of the difference in economic levels between two provinces, where $\overline{X_I}$ and $\overline{X_j}$ represent the mean per capita GDP for provinces i and j in the sample period, respectively. The formula is as follows:

$$W_3 = \frac{1}{\left|\overline{X_i} - \overline{X_j}\right|}\ (i \neq j) \qquad i = 1,\ 2,\ \cdots,\ 31;\ j = 1,\ 2,\ \cdots,\ 31 \tag{7}$$

The economic–geographic spatial weight matrix not only takes into account the spatial influence of geographical distance between provinces but also reflects the factual connections and spatial spillover effects in their economic development. Therefore, adopting the economic–geographic spatial weight matrix is essential for accurately capturing the spatial relationships among provinces. The diagonal elements of the economic–geographic spatial weight matrix are the product of the spatial weight based on geographical distance and the proportion of GDP for each region, where $\overline{X}$ represents the mean per capita GDP for all provinces during the sample period. The formula is as follows:

$$W_4 = \frac{1}{d_{ij}} * diag\left(\frac{\overline{X_1}}{\overline{X}}, \frac{\overline{X_2}}{\overline{X}}, \cdots \frac{\overline{X_n}}{\overline{X}}\right) (i \neq j) \;\; i = 1, 2, \cdots, 31; \quad j = 1, 2, \cdots, 31 \tag{8}$$

4.6. Global Moran's Index

We employ the Global Moran's Index to examine the spatial correlation of regional economic development. In this context, n represents the number of administrative divisions nationwide (n = 1, 2,..., 31), where x_i and x_j denote the per capita GDP of provinces i and j, respectively. $\overline{y}$ represents the national per capita GDP, S^2 is the sample variance, and W_{ij} is the spatial weight matrix. The calculation formula is as follows:

$$\text{GlobalMoran'sIndex} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} D_{ij}(x_i - \overline{y})(y_j - \overline{y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{9}$$

5. Results

5.1. Spatial Correlation

Equation (9) illustrates the Global Moran's Index for regional economic development under four distinct spatial weights (Table 2). It is noteworthy that the Global Moran's Index for regional economic development, spanning from 2010 to 2019, exhibits positivity across all four spatial weights, and all values successfully pass the 1% significance test. This observation implies that, irrespective of the spatial weight matrices employed, a discernible spatial correlation exists in the economic development of diverse provinces and regions.

Table 2. Global Moran's Index.

	Adjacent Distance Spatial Weight Matrix		**Geographical Distance Spatial Weight Matrix**		**Economic Distance Spatial Weight Matrix**		**Nested Economic Geospatial Weight Matrix**	
Year	Moran's I	Z Value	Moran's I	Z Value	Moran's I	Z Value	Moran's I	Z Value
2010	0.4440 ***	4.0080	0.1600 ***	5.5640	0.4970 ***	5.7580	0.1810 ***	5.5440
2011	0.4360 ***	3.9350	0.1580 ***	5.4890	0.4910 ***	5.6920	0.1770 ***	5.4560
2012	0.4170 ***	3.7760	0.1520 ***	5.3300	0.4920 ***	5.6950	0.1730 ***	5.3510
2013	0.3990 ***	3.6170	0.1460 ***	5.1510	0.5000 ***	5.7760	0.1690 ***	5.2320
2014	0.3750 ***	3.4160	0.1370 ***	4.8740	0.5110 ***	5.8880	0.1600 ***	4.9960
2015	0.3630 ***	3.3150	0.1290 ***	4.6660	0.5180 ***	5.9680	0.1530 ***	4.8270
2016	0.3730 ***	3.4090	0.1240 ***	4.5171	0.5150 ***	5.9530	0.1480 ***	4.7070
2017	0.3970 ***	3.6190	0.1230 ***	4.5010	0.5020 ***	5.8290	0.1480 ***	4.6960
2018	0.3570 ***	3.3040	0.1080 ***	4.0940	0.4670 ***	5.4870	0.1200 ***	3.9990
2019	0.3571 ***	3.3110	0.1080 ***	4.1090	0.4610 ***	5.4140	0.1190 ***	3.9760

Note: The significance level of Moran's I index is tested according to the Monte Carlo simulation method (999 times). ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

5.2. Model Testing

The dynamic spatial panel Durbin model provides an accurate estimation of the spatial spillover effects on regional economic development resulting from agricultural market integration. However, its application necessitates the use of empirical data and rigorous statistical scrutiny. The Lagrange Multiplier Test (LM) and Likelihood Ratio Test (LR) are two major testing methods in econometrics, both of which can be used to examine the model selection. The test results are shown below (Table 3). Upon conducting statistical tests on the data, LM tests and their robust LM forms for spatial lag models and spatial error models did not achieve statistical significance. Consequently, spatial error models and spatial lag models are deemed unsuitable for this study. Employing the LR test to scrutinize the model allows verification of whether the impact of agricultural market integration on regional economic development is best analyzed using the spatial Durbin model. The estimation results reveal that the LR test decisively rejects the null hypothesis, signifying the dismissal of the assumption that the spatial Durbin model can be simplified into spatial lag models and spatial error models. The Wald test further corroborates this conclusion, affirming the appropriateness of choosing the spatial panel Durbin model.

Table 3. LM and LR tests: examining the suitability of the model for assessing the impact of agricultural market integration on regional economic development in China from 2010 to 2019.

	Test	*p*-Value
LM spatial lag	0.1650	0.6850
Robust LM spatial lag	0.1810	0.6710
LM spatial error	0.5660	0.4520
Robust LM spatial error	0.5500	0.4590
LR spatial lag	46.240 ***	0.0000
LR spatial error	83.9700 ***	0.0000
Hausman chi2	77.3000 ***	0.0000
Wald test	1499.3563 ***	0.0000

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

Considering the temporal continuity and spatial transmission of regional economies, neglecting these characteristics can lead to biases in model estimation. By setting up a dynamic spatial panel Durbin model, we can control for the factors influencing regional economic development in both the temporal and spatial dimensions, yielding robust estimation results [116]. The estimated time lag term for regional economic development indicates the impact of the previous period's economic development on the current period [117]. The estimated spatial spillover term for regional economic development signifies the impact of economic development in other provinces on the economic development of the focal province [118]. The estimated spatiotemporal lag term for regional economic development reflects the influence of economic development in other provinces in the previous period on the economic development of the focal province in the current period [119]. The estimated spatial spillover terms for key explanatory variables and control variables indicate the impact of these variables in other provinces on the economic development of the focal province [120]. This research further undertakes a comparative analysis of the influence of agricultural market integration on regional economic development, employing both non-spatial panel models and static spatial panel Durbin models. Given the diverse natural resource endowments and varying levels of socio-economic development across provinces, the use of a fixed-effects model is deemed appropriate. The results of the Hausman test also affirm that both the non-spatial panel model and the dynamic spatial panel Durbin model in this study are suitable for estimation using fixed effects.

5.3. Regression Analysis

We specified the models in the following forms, including a pooled regression model, a fixed-effects regression model, a static spatial Durbin model, a dynamic spatial panel Durbin model based on time lag, and a dynamic spatial panel Durbin model based on both time and spatial double lags. The results of each model are sequentially presented in Table 4, labeled as (1)–(5).

Table 4. Regression results of the impact of agricultural market integration on regional economic development in China from 2010 to 2019.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
	Pooled Regression Model	**Fixed-Effects Regression Model**	**Static Spatial Durbin Model**	**Dynamic Spatial Durbin Model (Time Lag)**	**Dynamic Spatial Durbin Model (Time-Space Lag)**
together	0.00396 ** (0.00155)	0.00176 ** (0.00088)	0.00182 ** (0.00079)	0.00060 (0.00052)	0.00156 *** (0.00053)
govern	0.00223 *** (0.00063)	−0.01828 *** (0.00199)	−0.01664 *** (0.00185)	−0.00148 *** (0.00025)	−0.00101 *** (0.00025)
agri	−0.01528 *** (0.00267)	−0.02860 *** (0.00437)	−0.02987 *** (0.00390)	0.01085 *** (0.00107)	0.00427 *** (0.00108)
urban	0.02878 *** (0.00179)	0.01655 *** (0.00379)	0.01742 *** (0.00407)	−0.02643 *** (0.00102)	−0.01218 *** (0.00103)
labor	0.00009 *** (0.00002)	−0.00003 (0.00007)	−0.00010 (0.00006)	−0.00008 *** (0.00001)	−0.00004 *** (0.00001)
invest	−0.01551 *** (0.00482)	0.00737 ** (0.00309)	0.00329 (0.00292)	0.00409 *** (0.00158)	0.00219 (0.00159)
density	−0.00005 *** (0.00002)	0.00080 *** (0.00023)	0.00108 *** (0.00022)	0.00012 *** (0.00001)	0.00007 *** (0.00001)
$W \times together$			0.00208 (0.00209)	0.01876 *** (0.00146)	0.01158 *** (0.00147)
$L.\ln pergdp$				2.39660 *** (0.02526)	1.41647 *** (0.02621)
$L.W \ln pergdp$					0.61438 *** (0.13705)
$Spatial\ rho\ (lambda)$			0.67575 *** (0.05644)	0.26735 *** (0.06252)	0.30633 ** (0.12378)
N	310.00000	310.00000	310.00000	279.00000	279.00000
R^2	0.88894	0.92808	0.61377	0.76800	0.80374

Note: The values in () are the heteroskedasticity robust standard errors. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

In models (1) and (2), where spatial effects are not considered, it is evident that agricultural market integration exerts a positively facilitating influence on regional economic development, with all regression coefficients passing the 5% significance test. In models (3) to (5), incorporating the economic distance spatial weight matrix, a comparable positive promoting effect of agricultural market integration on regional economic development is identified. Notably, in model 5, the coefficients of the time lag and spatial lag terms for regional economic development are both significantly positive at the 1% level. The ensuing discussion will center on the estimation results of model 5.

5.3.1. Testing Hypothesis 1

Drawing upon the regression results from model 5 (Table 4), the coefficient associated with agricultural market integration is found to be 0.00156, successfully passing the 1% significance level test. This observation signifies that agricultural market integration plays a positive role in promoting regional economic development, thereby substantiating Hypothesis 1. The specific interpretation of this coefficient suggests that a one-unit increase in the agricultural market integration index corresponds to a 0.156% rise in the level of economic development. The rationale behind this finding, rooted in theory and empirical evidence, lies in the ability of agricultural market integration to enhance the efficiency of the agricultural supply chain, broaden the market for agricultural product sales, optimize agricultural product prices, encourage specialization in agricultural production, mitigate the risk of agricultural trade defaults, reduce the overall cost of agricultural products from production to consumption, and ultimately stimulate economic development.

5.3.2. Spatial Spillover Effects of Agricultural Market Integration

The coefficient of the spatial lag term for agricultural market integration is 0.01158, passing the 1% significance test. This suggests that a one-unit increase in the level of agricultural market integration in neighboring provinces would lead to a 1.158% increase in the level of regional economic development in the province under consideration. It is evident that the spatial spillover effects of agricultural market integration are significant. This can be primarily attributed to the frequent agricultural trade between provinces and the close interconnection of the upstream and downstream sectors of the agricultural production chain, which optimizes the rational allocation of agricultural and production factors. This allows provinces to engage in production and sales based on cost and technological comparative advantages, while simultaneously gaining access to new markets and consumers, thereby substantially promoting economic development.

5.3.3. Spatiotemporal Effects of Regional Economic Development

Model 5 reveals that regional economic development manifests both temporal lag effects and spatial spillover effects. Firstly, the coefficient of the time lag term for regional economic development is significantly positive at the 1% level, signifying that if the regional economic development level of the province in the previous period was high, the economic level in the next period will continue to increase. This growth trend intensifies over time, demonstrating a pronounced "time effect". Secondly, the coefficient of the spatial lag term for regional economic development is positive and passes the 1% significance test, indicating that the economic development level of neighboring provinces exerts a promotional effect on the economic development of the province under consideration. This implies the presence of spatial connections between provinces in economic development. On average, a 1% increase in the economic development level of neighboring provinces promotes the economic development level of the province under consideration by approximately 0.614%, as elucidated by the analysis.

5.4. Robustness Test

To ensure the robustness of the estimated parameters, three methods were employed in this study for robustness testing.

5.4.1. Weight Transformation

In the regression analysis, the economic distance spatial weight matrix was primarily utilized. For the robustness testing in this section, three additional matrices were constructed: proximity distance, geographical distance, and economic–geographical spatial nesting. The results indicate that, whether in the short term or long term, the promoting effect of agricultural market integration on regional economic development remains robust when employing these three spatial weight matrices (Table 5). In the short term, with the adoption of these three weight matrices, the regression coefficients are 0.01108, 0.05603, and 0.05164, respectively, with the geographical distance spatial weight matrix having the largest coefficient. This suggests that, in the short-term impact of agricultural market integration on regional economic development, the actual geographical distance between two provinces exerts the greatest influence. In the long term, the regression coefficients are 0.00915, 0.01310, and 0.01617, respectively, with the economic–geographical spatial weight matrix having the largest coefficient. This indicates that, in the long-term impact, the economic connection between two provinces and the actual geographical distance both play crucial roles. In conclusion, while there are differences in the magnitude of coefficients between the short term and long term, the signs and significance levels remain fundamentally unchanged, demonstrating the robustness of the research results.

Table 5. Regression results of the impact of agricultural market integration on regional economic development in China from 2010 to 2019 based on weight matrix transformation.

Variables	Short-Term			Long-Term		
	Adjacent Distance Spatial Weight Matrix	Geographical Distance Spatial Weight Matrix	Nested Economic Geospatial Weight Matrix	Adjacent Distance Spatial Weight Matrix	Geographical Distance Spatial Weight Matrix	Nested Economic Geospatial Weight Matrix
together	0.01108 *** (0.00363)	0.05603 *** (0.01981)	0.05164 *** (0.01489)	0.00915 *** (0.00293)	0.01310 *** (0.00280)	0.01617 *** (0.00306)
govern	0.00495 *** (0.00192)	−0.02562 ** (0.01101)	−0.01872 ** (0.00877)	0.00409 *** (0.00154)	−0.00598 *** (0.00184)	−0.00584 ** (0.00232)
agri	−0.04546 *** (0.00929)	−0.18295 *** (0.05977)	−0.16620 *** (0.04569)	−0.03756 *** (0.00723)	−0.04265 *** (0.00569)	−0.05193 *** (0.00792)
urban	0.03206 *** (0.00718)	0.05915 ** (0.02422)	0.03414 ** (0.01461)	0.02647 *** (0.00557)	0.01375 *** (0.00372)	0.01064 *** (0.00368)
labor	0.00005 (0.00006)	−0.00103 ** (0.00041)	−0.00115 *** (0.00040)	0.00004 (0.00005)	−0.00024 *** (0.00006)	−0.00036 *** (0.00009)
invest	−0.00241 (0.01020)	0.12934 *** (0.04873)	0.07688 ** (0.03606)	−0.00199 (0.00838)	0.03028 *** (0.00772)	0.02405 ** (0.00961)
density	0.00011 * (0.00007)	0.00059 ** (0.00025)	0.00029 ** (0.00012)	0.00009 * (0.00006)	0.00014 *** (0.00004)	0.00009 *** (0.00003)
N	310.00000	310.00000	310.00000	310.00000	310.00000	310.00000

Note: The values in () are the heteroskedasticity robust standard errors. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

5.4.2. Model Transformation

To further validate the promoting effect of agricultural market integration on regional economic development, spatial lag models (SAR) and spatial error models (SEM) were chosen for data estimation and analysis. In the spatial lag model (SAR), the addition of the spatial lag term for regional economic development as an explanatory variable signifies the spatial impact of economic development in neighboring provinces on the economic development of the province under consideration. This approach, distinct from the dynamic spatial panel Durbin model, can once again verify the role of agricultural market integration in promoting regional economic development. Column (1) reveals that the coefficient for agricultural market integration is 0.00318 and passes the 5% significance test (Table 6). In the spatial error model (SEM), unobserved factors influencing the regional economic development of neighboring provinces are incorporated as spatial error terms. Introducing this spatial error term as an explanatory variable into the model serves the same purpose as the spatial lag model (SAR). Column (2) shows that the coefficient for agricultural market integration is 0.00447 and passes the 1% significance test (Table 6). In conclusion, by analyzing the results of the spatial lag model (SAR) and spatial error model (SEM), Hypothesis 1 is once again confirmed.

Table 6. Robustness test of the impact of agricultural market integration on regional economic development in China from 2010 to 2019.

Variables	Model Transformation Test		Variable Transformation Test	Endogeneity Test
	(1) SAR Model	(2) SEM Model	(3) Dynamic Spatial Durbin Model	(4) 2SLS Estimation
together	0.00318 ** (0.00134)	0.00447 *** (0.00142)		0.00309 *** (0.00105)

Table 6. *Cont.*

Variables	Model Transformation Test		Variable Transformation Test	Endogeneity Test
	(1) SAR Model	(2) SEM Model	(3) Dynamic Spatial Durbin Model	(4) 2SLS Estimation
seg			−0.00256 *** (0.00064)	
$W \times seg$			−0.00949 *** (0.00189)	
$L.\ln pergdp$			1.39564 *** (0.02512)	
Spatial rho	0.51365 *** (0.07051)		0.12300 ** (0.06270)	
Spatial lambda		0.48326 *** (0.09334)		
Control variables	Yes	Yes	Yes	Yes
N	310.00000	310.00000	279.00000	310.00000
R^2	0.87055	0.80516	0.94763	0.97972
D–W–HEndogenous test				4.00021 [0.0455]
Kleibergen–Paap rk LM statistic				76.81 [0.0000]
Kleibergen–Paap rk Wald F statistic				58.85 {19.93}
Anderson–Rubin Wald statistic				15.39 [0.0005
Sargen–Hansen statistic				2.659 [0.1030]

Note: The values in () are the heteroskedasticity robust standard errors, the values in [] are the *p*-values of the corresponding test statistics, and the values in {} are the critical values at the 10% level of the Stock–Yogo test. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

5.4.3. Variable Transformation

By appropriately transforming the explanatory variables through mathematical formulas, the influence of outliers in the data can be effectively mitigated, thereby verifying the robustness of the results (Table 4). In this research, the reciprocal of the square root of the agricultural market integration index represents the fragmentation index of the agricultural product market. From an economic perspective, when the level of agricultural market integration is low, local regional markets are relatively closed, indicating a high degree of fragmentation in the agricultural product market. According to the theories of resource allocation and economies of scale, it can be inferred that a high degree of fragmentation in the agricultural product market will adversely affect regional economic development. Conducting a robustness test with the fragmentation index of the agricultural product market as the core explanatory variable provides a reverse verification of the impact of agricultural market integration on regional economic development, as demonstrated in column (3) (Table 6). The analysis of these results indicates that when the fragmentation index of the agricultural product market in a province increases by one unit, the level of regional economic development will decrease by 0.256%, and this passes the 1% significance test. This once again confirms the robustness of the results presented in Table 4.

5.5. Endogeneity Test

From a practical standpoint, the elevation in agricultural market integration fosters regional economic development. Conversely, regional economic development may also contribute to an increased level of agricultural market integration, suggesting a potential bidirectional causal relationship between them. This bidirectional causal relationship among variables can lead to endogeneity in the estimation model, resulting in biased outcomes. To address this endogeneity concern, instrumental variable methods can be employed to control for the relationships between variables. We select traffic network density ($traffic$) and the interaction term between annual sunshine hours and agricultural market integration (sun) as two instrumental variables for agricultural market integration.

This selection is based on two considerations: first, traffic network density ($traffic$) reflects the impact of geographical factors on agricultural market integration, satisfying the exogeneity condition. The more developed the transportation infrastructure in each province, the lower the transportation costs for agricultural products. Consequently, consumers can obtain the required products at a lower cost in the agricultural market. Therefore, this variable fulfills the conditions of exogeneity and correlation with agricultural market integration. Second, annual sunshine hours, as a natural condition closely related to agricultural production, also satisfies the exogeneity and correlation conditions with agricultural market integration. Considering that the annual sunshine hours in each province generally remain stable, using a time-invariant instrumental variable would not yield meaningful estimation results. Therefore, we construct an interaction term as an instrumental variable, namely the product of the annual agricultural market integration index and annual sunshine hours. This effectively addresses the endogeneity issue in the regression model, ensuring the correctness and robustness of the estimation results.

Column (4) reports the Two-Stage Least Squares (2SLS) estimation results using the traffic network density and annual sunshine hours as instrumental variables (Table 6). To examine the effectiveness of the instrumental variables, several statistical tests were conducted. First, the *Durbin–Wu–Hausman* (*D–W–H*) endogeneity test results indicate rejection of the exogeneity assumption for agricultural market integration at a 5% significance level. Second, the *Kleibergen–Paap rk LM statistic* for the underidentification test rejects the assumption of insufficient instrument identification at a 1% significance level. Furthermore, the *Kleibergen-Paap rk Wald F statistic* is 58.85, exceeding the critical value of 19.93 for the *Stock–Yogo* test at a 10% significance level, thereby rejecting the weak instrument assumption. Simultaneously, the associated probability of the *Sargan–Hansen* overidentification test is 0.103, indicating no rejection of the null hypothesis that the instrumental variables are not overidentified at a 10% significance level. This suggests that there is no issue of overidentification with the instrumental variables. Lastly, the *Anderson–Rubin Wald statistic* at a 1% significance level substantiates the reasonableness of the instrumental variable assumption. In summary, the aforementioned statistical tests affirm the rationality of selecting traffic network density and annual sunshine hours as instrumental variables. The 2SLS regression results reveal a coefficient of 0.00309 for agricultural market integration, signifying its promoting effect on regional economic development.

6. Extensibility Analysis: Substitution Relationships and Regional Heterogeneity

6.1. Substitution Relationships: Testing Hypothesis 2

The foundational regression results have conclusively affirmed the positive impact of domestic agricultural product market integration on regional economic development under closed conditions (Table 4). In this context, we introduce the agricultural product foreign trade volume (import volume, export volume, and total trade volume of agricultural products) as a moderating variable. By incorporating the levels of agricultural product market integration, regional economic development, and agricultural product foreign trade volume into the moderation effects model framework for analysis, we aim to explore the variations in the role of domestic agricultural product market integration in regional economics under conditions of an open economy. To delve into this, we employ a dynamic panel spatial

Durbin model with time lag terms, as depicted in column (4) (Table 4). This model allows us to scrutinize the interaction terms between agricultural product import trade volume and agricultural product market integration, as well as the interaction terms between agricultural product export trade volume and agricultural product market integration. We assess the magnitude and significance of these coefficients, and the outcomes are elucidated in columns (1) and (2) (Table 7). Subsequently, we utilize the dynamic panel spatial Durbin model with time and space lag terms from column (5) (Table 4), introducing the interaction term between the total volume of agricultural product import and export trade and agricultural product market integration. Once again, we examine the size and significance of the interaction term coefficients, and the findings are presented in column (3) (Table 7).

Table 7. Effect of agricultural market integration on regional economic development in China from 2010 to 2019 under the influence of agricultural product foreign trade.

Variables	(1)	(2)	(3)
$together \times import$	−0.00097 *** (0.00026)		
$together \times export$		−0.00120 *** (0.00041)	
$together \times overall$			−0.00380 *** (0.00036)
$W \times together \times import$	−0.00377 *** (0.00110)		
$W \times together \times export$		−0.01266 *** (0.00180)	
$W \times together \times overall$			−0.02201 *** (0.00157)
$L.\ln pergdp$	1.55856 *** (0.02697)	1.65591 *** (0.02588)	1.47874 *** (0.02689)
$L.W \ln pergdp$			2.00517*** (0.13973)
$Spatial\ rho\ (lambda)$	0.28222 *** (0.06602)	0.27936 *** (0.06870)	0.57710 *** (0.12446)
$Control\ \ variables$	Yes	Yes	Yes
N	279.00000	279.00000	279.00000
R^2	0.45805	0.96205	0.95019

Note: The values in () are the heteroskedasticity robust standard errors. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

In columns (1) and (2) (Table 7), the interaction terms between the volume of agricultural product imports and agricultural product market integration, as well as between the volume of agricultural product exports and agricultural product market integration, are both negative, measuring −0.00097 and −0.0012, respectively. Importantly, both of these values pass significance tests in econometrics. Analyzing the results in column (3) (Table 7), we find that the coefficient for the interaction term between the total volume of agricultural product imports and exports and domestic agricultural product market integration is −0.0038, passing the significance test at the 1% level. This indicates that as the level of foreign trade in agricultural products increases, the promoting effect of agricultural product market integration on regional economic development will decrease. Conversely, when the level of foreign trade in agricultural products decreases, the role of domestic agricultural product market integration in regional economic development will increase. Clearly, if the speed of regional economic development remains constant (at equilibrium), a "substitute relationship" exists between international trade of agricultural products and domestic agricultural product market integration in promoting regional economic development. In summary, all three coefficients for the interaction terms are negative, suggesting that foreign trade in agricultural products can indeed substitute for some of the effects of domestic agricultural product market integration on economic development, supporting the validity of Hypothesis 2. However, it is crucial to note that the regulation of the types of agricultural products in the domestic market differs between agricultural product imports and exports, influencing their respective impacts on domestic agricultural product market integration.

The distinct structures of agricultural product imports and exports can yield varying degrees of substitution effects in international trade [121]. The top three categories in the 2019 agricultural product import trade, by proportion, were edible oils and fats (35%), meat and poultry and their products (33%), and aquatic products (17%) (Figures 2 and 3). This signals that the demand for these three types of agricultural products surpasses domestic supply, necessitating imports to meet consumption needs within China. In the 2019 agricultural product export trade, the leading categories were aquatic products (38%), vegetables (30%), and dried and fresh melons and fruits (14%). This implies that the demand for these three types of agricultural products in the domestic market is lower than the supply, indicating a competitive advantage and effective demand in the international market. It is crucial to note that China predominantly imports aquatic products such as fish fry, fresh or chilled freshwater products, and dried fish. On the other hand, exported aquatic products encompass fish fillets, mollusks, frozen fish, and crustaceans. In conclusion, a precise analysis of the types of agricultural products in imports and exports is essential for a thorough evaluation of the opportunities and risks posed by agricultural foreign trade to diverse agricultural sectors and provincial economic development. Such an analysis also facilitates the development of appropriate response policies.

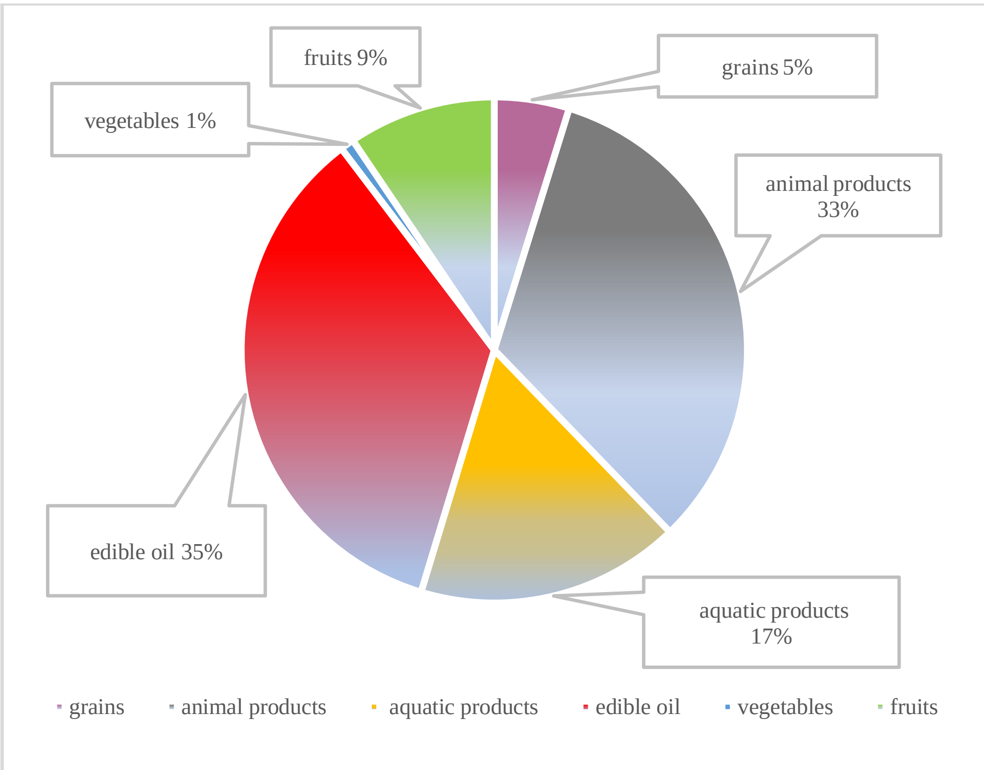

Figure 2. The import proportion of major agricultural products in China for the year 2019. Data source: General Administration of Customs of the People's Republic of China. http://stats.customs.gov.cn/ (accessed on 30 June 2020).

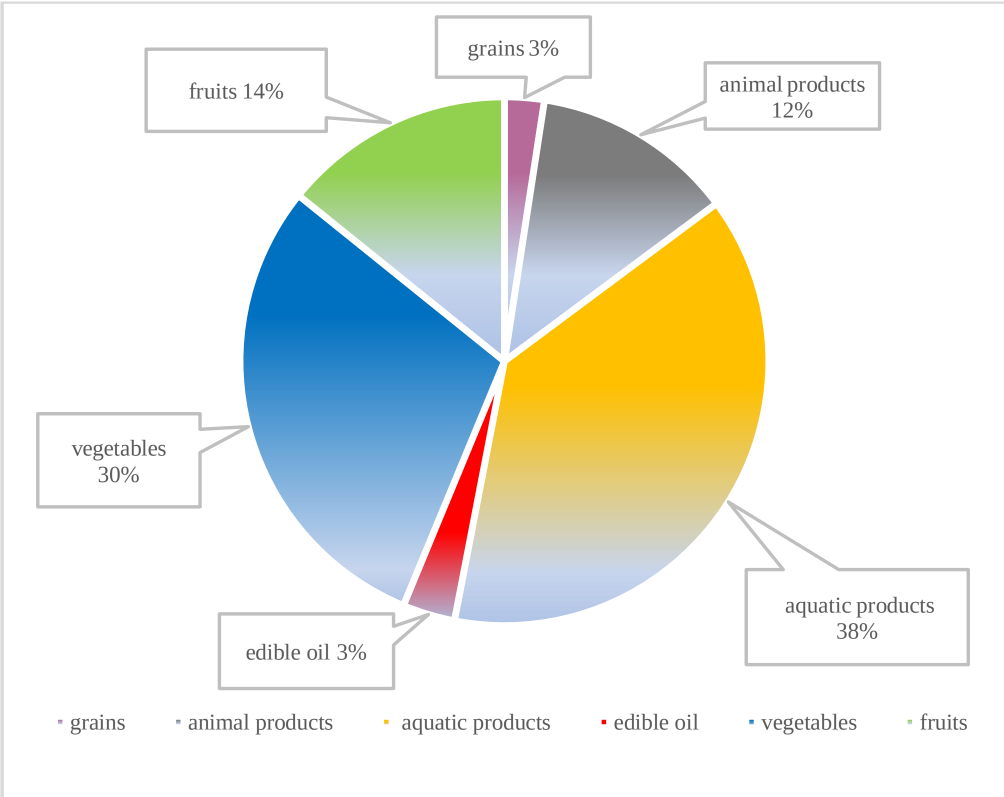

Figure 3. The export proportion of major agricultural products in China for the year 2019. Data source: General Administration of Customs of the People's Republic of China. http://stats.customs.gov.cn/ (accessed on 30 June 2020).

6.2. Heterogeneity Analysis: Testing Hypothesis 3

The economic development disparity between the eastern and western regions of China is substantial, marked by variations in the sophistication of agricultural market mechanisms and distinct levels of agricultural foreign trade development. In contrast to the western region, the eastern region exhibits advanced economic development, characterized by a considerable total volume of agricultural imports and exports. According to data released by the National Bureau of Statistics of China, the average total volume of agricultural imports and exports in the eastern region from 2010 to 2019 amounted to USD 13.826 billion, while in the western region, it stood at USD 1.411 billion, representing a nearly tenfold difference. In this context, drawing on the theories of resource allocation efficiency and specialization, the role of agricultural product market integration in economic development is likely to diverge between the two regions. Consequently, it becomes imperative to scrutinize and ascertain the impact of different levels of agricultural international trade on the relationship between these regions. The central region's diverse development indices fall within the spectrum delineated by the eastern and western regions. Thus, it is adequate to conduct a comparative analysis of the disparities between the eastern and western regions to meet the testing requirements for Hypothesis 3.

The regression coefficient for agricultural product market integration in the eastern region is 0.01804, while in the western region, it is 0.02354 (Table 8). This suggests that a one-unit increase in the level of agricultural product market integration corresponds to a 1.804% and 2.354% increase in the economic development levels of the two regions, respectively. The regional impact of agricultural product market integration on economic development exhibits heterogeneity, with a more pronounced effect in the relatively closed western region, confirming Hypothesis 3a. The coefficient of the variable "*together* × *overall*" signifies the magnitude of the positive effect of agricultural international trade substituting for regional agricultural product market integration on economic development. The results show that the interaction term coefficients for the eastern and western regions are −0.00099 and −0.00217, respectively, indicating differing substitution effects of agricultural international trade in these regions and confirming Hypothesis 3b. This discrepancy is attributed to the high overall openness of the eastern region, limiting the positive impact of agricultural international trade as a substitute for agricultural product market integration in promoting economic development. Conversely, the relatively closed western region has significant potential for increased openness, and agricultural international trade can play a crucial role in deepening economic openness, thereby substantially promoting economic development in the western region.

Table 8. Heterogeneity of agricultural market integration on regional economic development in China from 2010 to 2019 under the influence of agricultural product foreign trade.

Variables	**(1)**	**(2)**
	Eastern Region	**Western Region**
$together$	0.01804 (0.01528)	0.02354 *** (0.00535)
$overall$	0.05344 (0.04161)	0.05761 *** (0.01573)
$together \times overall$	−0.00099 (0.00112)	−0.00217 *** (0.00047)
$L.\ln pergdp$	1.44172 *** (0.07188)	1.22098 *** (0.03602)
$W \times together$	0.30812 *** (0.11839)	0.13842 *** (0.02886)
$W \times overall$	0.85030 *** (0.26373)	0.44810 *** (0.09133)
$W \times together \times overall$	−0.02134 ** (0.00846)	−0.01322 *** (0.00257)
$Spatial\ rho\ (lambda)$	0.40622 ** (0.17840)	1.85951 *** (0.21567)
$Control\ \ variables$	Yes	Yes
N	99.00000	108.00000
R^2	0.78104	0.07547

Note: The values in () are the heteroskedasticity robust standard errors. ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively. Data source: calculated by the author.

7. Discussions

According to data released by the Food and Agriculture Organization of the United Nations, China's Gross Domestic Product accounted for approximately 16% of the global total in 2019. Against the backdrop of economic globalization, the level of agricultural product market integration among China's provinces has intensified, fostering close supply chain connections for agricultural production and consumption across different regions [122]. Unlike industries such as domestic tourism, manufacturing, and energy, the agricultural product market is more severely impacted by disruptions in the supply chain and a reduction in effective demand. This is partly due to the intricate nature of the agricultural product supply chain, involving producers, consumers, inputs for agriculture and fisheries across regions, as well as various stages such as processing, storage, transportation, and marketing. Furthermore, the complexity of the agricultural product value chain and its dependence on trade and transportation render agricultural production and supply highly susceptible to external shocks. Such disruptions not only affect the daily lives and food supply security of ordinary citizens but also pose a threat to social stability [123].

In late 2019, the sudden outbreak of the COVID-19 pandemic profoundly impacted agricultural markets across various provinces in China. Stringent nationwide traffic lockdowns played a crucial role in curbing the spread of the disease. However, a substantial volume of agricultural, livestock, and horticultural products could not be promptly sold within local and cross-regional markets due to these measures, leading to severe stockpiling and missing the optimal market entry timing [124]. This not only increased the storage costs of agricultural products but also diminished their freshness and edible value, resulting in significant economic losses for farmers and other producers and hindering economic development in different regions [125]. Various restrictive measures implemented by local governments to control the COVID-19 pandemic adversely affected the development of agricultural product market integration. During this period, various indicators of agricultural market development failed to reflect its normal state and trends, rendering them unsuitable as reference standards for the recovery and improvement of agricultural production and sales supply chains in the post-pandemic era. Therefore, assessing the pre-pandemic level of agricultural product market integration and conducting comparative studies among different regions and provinces can provide valuable theoretical support for formulating effective policies to restore the damage caused by the pandemic to regional economic development.

7.1. Analysis of Positive Effects Based on Different Theories

The research findings of this study suggest that, in a closed state without considering agricultural import and export trade, agricultural product market integration positively contributes to regional economic development. Through calculations, it was determined that a one-unit increase in the agricultural product market integration index corresponds to a 0.156% rise in economic development. This conclusion aligns with previous research outcomes [126]. Analyzing from the perspective of economies of scale theory, agricultural product market integration directly introduces new cross-regional markets to farmers and other producers [127]. The substantial consumer demand arising from these new markets inherently motivates them to expand their operations. The adoption of new technologies supports larger-scale production operations, leading to reduced unit costs, ultimately boosting profits for producers and enhancing overall industry productivity [128].

According to the Resource Allocation Efficiency Theory, agricultural product market integration helps rectify the inefficient allocation of agricultural resources caused by the COVID-19 pandemic, distributing resources reasonably across different regions to meet diverse production and consumption needs [30]. With optimal utilization of agricultural resources such as land, water sources, and labor, producers can more effectively manufacture agricultural products and enhance the efficiency of the agricultural supply chain. Specifically, agricultural product market integration can guide the optimal utilization of agricultural resources throughout the entire industry chain, spanning production, transportation, and consumption, thus preventing the wastage of limited agricultural resources. Consequently, agricultural products from different regions can be concentrated in areas most suitable for their production, reducing unnecessary redundancy and resource wastage [129]. In summary, agricultural product market integration creates favorable conditions for the swift recovery of regional economies after the pandemic and improves the operational efficiency of the economy.

7.2. Analysis of Substitution Effects Based on Different Theories

When contemplating international trade in agricultural products or, in other words, opening the domestic agricultural product market, the international arena may replace a portion of the domestic market. The regression coefficients for the three interaction terms between agricultural product import and export trade (import volume, export volume, and total trade volume) and the agricultural product market integration index are -0.00097, -0.0012, and -0.0038, respectively. This suggests that as the level of agricultural product foreign trade increases, the promoting effect of agricultural product market integration on regional economic development will diminish. The opposite holds true as well. In summary, a "substitute relationship" exists between international agricultural product trade and domestic agricultural product market integration in fostering regional economic development. In simpler terms, agricultural product foreign trade substitutes for some of the effects of domestic agricultural product market integration on economic development. Drawing on the theories of specialization and comparative advantage, different regions within the country and other nations will focus on producing specific types of agricultural products to improve overall production efficiency in the agricultural industry. If certain agricultural products on the international market possess technological and cost advantages, they will partially substitute for domestic agricultural product markets based on the fundamental principles of a market economy.

In order to balance production efficiency and ensure a stable market supply, it is necessary to encourage different regions to specialize in agricultural production, while also meeting the diverse demands for various agricultural products across regions [130]. This necessitates an increase in the level of domestic agricultural product market integration. Moreover, when a particular region engages in the import and export trade of agricultural products, it will no longer solely rely on the production and sales of agricultural products from other domestic regions. This shift implies that the economic development of the local region is no longer solely dependent on interregional trade of agricultural products within the country; in fact, to some extent, the international market is "diluting" the promoting effect of domestic agricultural product market integration on regional economic development. Some studies suggest that during the COVID-19 pandemic, difficulties in cross-regional domestic agricultural product supply were encountered, and the international agricultural product market played a positive role in ensuring a stable food supply in certain domestic regions [131]. Therefore, it is evident that in the post-pandemic era, along with the vigorous restoration of domestic agricultural product market integration and economic development in various regions, there is a need to enhance the level of openness to the outside world, promoting the sustained development of international agricultural product trade.

7.3. Analysis of Heterogeneity Based on Different Theories

In an open economy context, this analysis examines the variations in the role of agricultural product market integration in promoting regional economic development across different regions in China. The regression coefficients for agricultural product market integration in the eastern and western regions are 0.01804 and 0.02354, respectively, indicating a stronger impact in the western region, consistent with previous research findings [104]. The theory of economies of scale suggests that agricultural product market integration incentivizes farmers and other producers to achieve economies of scale in production and engage in cross-regional or international trade. As the first region in China to embrace international trade, the eastern region, situated near economically vibrant areas like Japan, South Korea, and ASEAN countries, enjoys convenient shipping and inherent advantages for fostering international agricultural trade [132]. Over time, the agricultural product markets in these East and Southeast Asian countries have become intricately linked with the sale of agricultural products in the eastern region of China. For instance, in 2019, agricultural product exports from Shandong province to Japan and ASEAN countries constituted 42.3% of the total agricultural product exports. Conversely, the western region, being relatively closed, primarily sells its agricultural products to other provinces and cities within the country. The economic development in the western region is more significantly influenced by domestic agricultural product market integration than in the eastern region.

In-depth analysis reveals that the international agricultural product market can substitute for a portion of the domestic market, but the strength of this substitution effect varies regionally. The research findings in this paper indicate that the substitution effect coefficients in the eastern and western regions are -0.00099 and -0.00217, respectively. This further confirms that, in the less open western region, developing foreign agricultural product trade holds significant potential for promoting regional economic development.

However, the impact of the COVID-19 pandemic, leading to disruptions in global supply chains and transportation difficulties, has resulted in increased production and sales costs for agricultural products [133], reversing the effects of economies of scale. Faced with uncertainty and risks, risk theory suggests that farmers and businesses tend to adopt conservative strategies. Governments and enterprises worldwide are more inclined to produce and supply agricultural products locally to reduce dependence on international trade. This, in turn, results in a reduction in trade volume, which is detrimental to global economic development [134]. Addressing concerns about global agricultural supply chain stability and preventing further deglobalization in agricultural trade is crucial in the post-pandemic era.

8. Conclusions

8.1. Key Findings

This paper employs a dynamic spatial Durbin model to analyze the impact of agricultural market integration on regional economic development across 31 provinces in China during the ten years preceding the onset of the COVID-19 pandemic. The research findings indicate the following: firstly, under closed economic conditions, agricultural market integration effectively promotes the development of the domestic economy in various regions. Secondly, under open economic conditions, domestic agricultural market integration continues to foster regional economic development, although this promoting effect is somewhat diminished. Thirdly, the role of agricultural market integration in promoting economic development is greater in the western region compared to the eastern region. Lastly, there are significant regional variations in the strength and weakness of the substitutive effect of agricultural import and export trade on domestic agricultural market integration.

8.2. Policy Recommendations

In the post-pandemic era, countries worldwide are keenly focused on issues such as fluctuations in agricultural import and export prices and the vulnerability of single-supplier supply chains. There is a heightened emphasis on the localization of agricultural production and supply. This has resulted in two prominent features in the international agricultural market: a weakening of complementary capabilities and an increase in trade restrictive measures. Against this backdrop, China, in order to better address global challenges like pandemics, should underscore the integrated development of regional agricultural markets while leveraging the strengths of various domestic regions. To achieve this, the following three policy measures are proposed.

Firstly, strengthening connections in the domestic agricultural market. Attention should be given to eliminating policy and regulatory barriers to market access between regions. Further efforts should be made to plan a rational layout of transportation infrastructure connecting the entire nation, and the construction of an efficient agricultural cold chain transportation network and storage facilities. Secondly, encouraging international trade of agricultural products. In alignment with WTO rules and regulations of other economic cooperation organizations, tariffs should be reduced, and efforts should be intensified to strengthen trade connections with countries worldwide in the agricultural sector. Thirdly, emphasizing the development of the agricultural market in the western region. Promoting the development of internet-based smart agriculture in the western region will help overcome the geographical constraints of this area.

8.3. Limitations of this Research

This paper has contributed novel findings to the field of agricultural market research, yet certain limitations persist. Firstly, while the level of agricultural market integration influences regional economic development, the specific pathways through which it affects regional economic development require meticulous examination through the acquisition of substantial real-world data and empirical validation. Secondly, constrained by the difficulty in systematically obtaining micro-level agricultural market data, the authors were unable to investigate the specific impacts of agricultural market integration on the income and costs of farmers, agricultural enterprises, and other producers at the level of individual cities or more granular entities.

8.4. Future Research Prospects

The elevation of the level of agricultural market integration may also be accompanied by adverse effects. Subsequent research should focus on two aspects: firstly, in conjunction with policy incentive mechanisms, efforts should be made to prevent agricultural enterprises and individuals from pursuing profit as the sole objective, prioritizing the supply of high-quality agricultural products to the most economically developed regions. This practice may impact the food and nutritional health of the population in less developed regions. Secondly, considering the productivity differences between the less developed western regions and the developed eastern regions, differentiated subsidy measures should be introduced. This aims to encourage agricultural enterprises in less developed regions to adopt clean energy and low-carbon production methods, preventing environmental damage and safeguarding public health. In conclusion, in the post-pandemic era, research on the relationship between agricultural market integration, international trade of agricultural products, and economic development should place greater emphasis on a micro-level analysis, considering production efficiency, environmental factors, social aspects, and economic development concurrently.

Author Contributions: Conceptualization, X.M. and S.W.; methodology, J.H.; writing—original draft preparation, X.M.; writing—review and editing, Z.R., T.M. and H.X. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the Postgraduate Research & Practice Innovation Program of Jiangsu Province (Funder: Jiangsu Education Department; Funding number: KYCX21_0554).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

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