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# Agricultural Economic Resilience in the Context of International Food Price Fluctuation—An Empirical Analysis on the Main Grain–Producing Areas in Northeast China

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**Abstract:** In the context of international food price fluctuations, agricultural economic development is usually subject to large shocks, which also leads to clear spatial–temporal differentiation in regional agricultural economic resilience. However, there is a paucity of retrievable studies on the evolutionary process of agricultural economic resilience and its impact mechanisms. Taking the impact of and disturbance caused by international food price fluctuations on the agricultural economy from 2005 to 2021 as the research background, this paper adopts the economic resilience analysis framework and selects gross agricultural output value indicators to measure the agricultural economic resilience of 12 cities in the main grain-producing areas in Northeast China–Sanjiang Plain and Songnen Plain. At the same time, the regression model is used to further analyze the spatial and temporal changes of agricultural economic resilience and the main influencing factors. Based on the results of the research, it can be concluded that: ① international food prices exert different degrees of influence on agricultural economic resilience at different stages. From 2005 to 2013, the agricultural economic resilience of the two plains changed less, and the resilience capacity performed better in both the period of falling and rising international food prices, while from 2014 to 2021, the agricultural economic resilience of the two plains changed more due to the great impact of international food price fluctuations, with a steep decline in resilience capacity in the period of falling international food prices from 2014 to 2017, followed by a rapid rebound between 2018 and 2021. ② There are differences in the resilience capacity of the agricultural economy in the main maize- and rice-producing areas. Although it is a fact that agricultural economic development in the two major plains is faster than the national average in most periods, the comparison reveals that the main corn-producing area (Songnen Plain) is more volatile and its resilience capacity is relatively weak in both periods of falling and rising food prices, while the main rice-producing area (Sanjiang Plain) is less volatile, indicating its relatively strong agricultural economic resilience capacity. ③ Factors affecting agricultural economic resilience behave differently over the three cycles. During the period of rising international food prices, indicators reflecting agricultural production capacity have a greater impact on agricultural economic resilience, while during the period of falling international food prices, indicators reflecting agricultural input intensity and agricultural support capacity have a greater impact on agricultural economic resilience.

**Keywords:** agricultural economic resilience; international food price fluctuation; spatial–temporal differentiation; impact mechanism; Songnen Plain; Sanjiang Plain

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## 1. Introduction

The agricultural economy, as the basis of the national economy [1,2], is not only directly related to the income growth of farmers and to rural development [3], but also plays an important role in national food security and social stability [4]. The agricultural

economy can reflect the capacity and level of agricultural production on the one hand, and the configuration of agricultural structure and market supply and demand on the other [5]. Since China's accession to the WTO in 2001, the internationalization of China's grain market has gradually increased. The year 2021 saw China's grain imports reach up to 165 million tons, with imports close to a quarter of production, and the impact of international grain price fluctuations on China's grain market is gradually deepening. The increased internationalization of China's grain market has brought about a gradual accentuation of the impact of international grain price fluctuations on the domestic grain market. There are asymmetric effects and stage differences in the transmission of international food prices to domestic food prices, in which 45.1% of international rice price changes and 52.8% of international corn price changes will be transmitted to the domestic market [6]. Therefore, the fluctuation of international food prices increases the instability and vulnerability of agricultural economic development. In brief, rising international food prices tend to increase regional food production stimulated by high food prices, which in turn promotes regional agricultural economic development to a certain extent, but the negative impact is that it may lead to sluggish agricultural economic growth due to the simultaneous rise in planting and transportation costs [7], while falling international food prices tend to reduce the incentive to grow food, leading to a decrease in the growth rate of food production or even a reduction in production, which in turn leads to a reduction in farmers' income and stagnation or regression of agricultural economic development [8]. It can be concluded that international food price fluctuations usually lead to negative growth in the agricultural economy of some regions due to the impact of low food prices or weak growth in the agricultural economy during high food prices. However, there are also regions where the agricultural economy can actively manage the impact and disturbance brought by international food price fluctuations, and thus the agricultural economy can effectively endure, quickly recover and maintain development during food price fluctuations [9].

On the premise that regional agricultural economic development in the context of international food price fluctuation presents differences, agricultural economic resilience, which is considered to be an important factor in explaining such differences, is considered to be the key to the response of agricultural economic systems to uncertain shocks and perturbations [10,11], as well as the ability of agricultural economic systems to identify risks, mitigate shocks and recover from development [12]. Therefore, it is necessary to improve the resilience of the agricultural economy to cope with shocks and perturbations from international food price fluctuations and thus achieve sustainable development of the agricultural economy [13]. According to evolutionary resilience theory, since resilience views an unbalanced or unstable regional economic system as a complex adaptive cyclic system that places importance on strengthening the resistance, adaptability, and changeability of the regional economy within the system [14], it provides a new perspective for research into agricultural economic resilience. The meaning of agricultural economic resilience involves the ability of an agricultural economic system to withstand shocks and perturbations during various natural disasters or economic and social events (e.g., natural disasters, food price fluctuations, changes in agricultural subsidy policies, etc.) and to adapt rapidly to new development environments in order to guarantee the sustainable development of its system functions. [15]. The improvement of agricultural economic resilience is not only conducive to enhancing the competitiveness of regional agricultural products and promoting the modernization of regional agriculture, but also to maintaining the continuity and stability of regional economic growth [16].

The Sanjiang Plain and Songnen Plain, located in northeastern China, have become one of the important food growing bases in China by virtue of their water and soil resources and ecology [17,18]. The main crops grown in these two plains are corn, rice, soybeans and other crops, of which rice production in the two plains accounted for 14.71% and corn production accounted for 20.40% of national production in 2020. Thus, they play an important role in ensuring China's food security and stabilizing the agricultural economy. In this paper, the changes in the agricultural economic resilience of the Sanjiang and

Songnen Plains and the main influencing factors are analyzed against the background of international food price fluctuations from 2005 to 2021, in an attempt to answer the following three questions: ① What is the degree of influence of international food price fluctuations at different stages on the agricultural economic resilience of the Sanjiang and Songnen Plains? What are the trends in the spatial and temporal patterns? ② What are the differences between the changes in agricultural economic resilience in the main maize- and rice-producing areas? What are the main reasons behind them? ③ Which factors or combinations of factors shape higher agricultural economic resilience at different stages? The research is organized as follows: the "Introduction" defines agricultural economic resilience and provides an overview of the research area. Section 2 constructs a research framework on agricultural economic resilience and reviews the impact of international food price changes on agricultural economic development, and provides an overview of the theoretical lineage of agricultural resilience research. Section 3 introduces the research region, data sources, and research methods of the article. Section 4 analyzes the evolution of the spatio–temporal evolution pattern of agricultural economic resilience and the main influencing factors. Section 5 provides a summary and discussion of the whole paper.

## 2. Research Framework and Literature Review

Resilience refers to the resistance ability of regional economic–social–ecological systems in the face of market and environmental shocks and perturbations, or the sustainable development ability to quickly restore the operation of the main functions of the system, or even move to a better development path by adjusting to the transformation [19]. As for the relevant research aspects of resilience theory applied to the field of agriculture, it mainly takes ecological resilience [20,21] and engineering resilience [22,23] as the entry point, focusing on the ability of agricultural systems to recover their original development paths under the shocks of climate change, extreme weather and other catastrophic events. However, according to evolutionary resilience, agricultural systems after shocks or perturbations often give rise to new development environments and production conditions, and in such new environments agricultural systems need not return to their previous states or enter a new equilibrium state again, and such changes are more obvious in agricultural economic systems [24,25]. Compared with ecological resilience and engineering resilience, evolutionary resilience focuses more on the resistance, adaptation and change ability of agricultural economic systems to shocks and perturbations, and thus explains more fully the operation mechanism of agricultural economic systems under the influence of market changes, structural adjustments and other factors [26,27]. The existing research on agricultural economic resilience basically regards agricultural market risk [28], agricultural policy adjustment [29], the lag in rural development [30] and the adjustment of key agricultural functions [31] as shocks and disturbances. Some scholars measure the resilience of Chinese agriculture from the point of view of maintaining the original main characteristics and key functions of agriculture, and conclude that the growth of financial input to support agriculture helps to improve the resilience of the local agricultural economy [32], while other scholars, by analyzing the resilience of agricultural value chain in developing countries, conclude that improving the agricultural risk prediction ability and the agricultural specialized production capacity are the key elements to enhancing agricultural economic resilience [33]. Simultaneously, agricultural policy is traditionally regarded as a vital guarantee in the agricultural economic system [34]. Through the analysis of the agricultural system resilience of European countries against the background of EU Common Agricultural Policy (CAP) adjustment, some scholars determine that the adjustment and development direction of agricultural policy have a great impact on agricultural resilience, and emphasize that the function closely related to food production, agricultural economy and ecological environment in the agricultural system is an important link to improving agricultural economic resilience [35]. Obviously, most studies mainly focus on the risk challenges of the regional agricultural economic system within the region or countries, and lack an analysis of the impact of the risk challenges in the operation of the international agricultural economy

on the regional agricultural economy from an international perspective. Therefore, the fluctuation of international grain prices is regarded as a type of shock and disturbance, and the change of agricultural economic resilience in China's main grain-producing areas has been explored with respect to this risk challenge. On the one hand, this paper measures and analyzes the influencing factors of regional agricultural sustainable development from the perspective of evolutionary resilience theory, which expands the scope of application of resilience theory and provides a new research perspective for agricultural sustainable development; on the other hand, it can also provide points of reference for some countries and regions to resist the fluctuation of international food prices and improve the ability of agricultural sustainable development.

The nature of risks in agricultural economic systems is considered a key factor affecting resilience [36]. For example, the source, or type, of crisis (man–made or natural) will relate the resilience capacity to a specific problem; the object of the shock will relate the resilience capacity to a specific subject [37]; and the duration of the risk (one–off or short–term shock or slow–burning crisis) will determine the purpose of resilience (the core function of the agricultural system) [38]. In fact, the lack of resources, technology, and market advantages in agriculture of developed countries characterize the agricultural economies of developing and low– and middle–income countries as more responsive to international food price fluctuation [39]. In the context of economic globalization, international food price fluctuation, as a source of crisis, directly or indirectly affects agricultural production and farmers' income in agricultural production areas, which in turn affects regional agricultural economic performance and national or regional agricultural policy adjustment [40,41].

In China, the transmission mechanism of international grain price fluctuations to domestic prices varies for different grain crops [42]. China has a long–term minimum purchase price policy for wheat and rice (the government sets the minimum purchase price and state–owned grain enterprises purchase at the minimum price when the market price is below a certain level), and the self–sufficiency rate for rice and wheat is close to 100%, so international grain price fluctuations for rice and wheat mainly affect the regional agricultural economic development situation by influencing the minimum purchase price set by the government [43]. In contrast, the transmission mechanism of international corn prices to the domestic sector is more complex. In addition to consumption, China's demand for corn in the livestock, industrial, and energy sectors is also high (feed consumption accounts for more than 60% of total corn consumption and industrial consumption accounts for about 26.7%), which leads to a shortfall of about 10% in corn self–sufficiency; at the same time, the policy adopted by the Chinese government to implement a market–based purchase of corn after 2016 and no longer set a government minimum purchase price also makes the agricultural economic conditions of the main domestic corn–producing regions more sensitive to international maize price fluctuations [44].

Therefore, the evolutionary process of agricultural economic resilience described in this paper includes two key processes: crisis resistance to falling international food prices and adaptive resilience to rising international food prices [45]. Among them, crisis resistance, which mainly refers to the extent to which regional agricultural economies are affected by shocks of falling food prices, and the economies of regions with high resistance are less affected by shocks [46] and are mainly influenced by regional pre–shock development paths, including the main functions of agriculture, agricultural cropping structure, agricultural production methods, and agricultural policies. At the same time, adaptive resilience refers to the ability of the agricultural system to respond to shocks or aftershocks, and the system internal adjustment ability of the agricultural system to adapt to the shock [47], which is mainly expressed in the ability of the regional agricultural economic system to adapt to low food price shocks or to achieve rapid development of the agricultural economy and maintain sustainable regional development during the period of rising international food prices by adjusting the industrial structure, agricultural technology, and agricultural policies. In general, agricultural economic development is more affected by international food price fluctuations in regional markets with lower food

self–sufficiency, higher food marketization, and tighter food supply–demand relationships [48,49]. Shocks of low intensity and a short time frame may lead to a rebound of the regional agricultural economy, while high–intensity and prolonged disturbances may lead more to transformation [50,51]. In conclusion, agricultural economic resilience, as a process of the co–evolution of agricultural structures, food supply and demand markets, and agricultural policies amidst international food price fluctuations and phase effects, is constantly shaped by development paths, development environments, and regional contexts. The two processes of crisis resistance and adaptation resilience in this process coexist, and both influence each other.

## 3. Methodology

### *3.1. Research Area*

The Sanjiang Plain and Songnen Plain represent one of the most important grain-producing areas in China, where Sanjiang Plain is formed by the alluvial deposits of the Heilongjiang River, the Wusuli River, is located in the northeastern part of Heilongjiang Province and covers an area of 108,900 km$^2$, including the cities of Hegang, Shuangyashan, Jiamusi and Jixi. The Songnen Plain, which is mainly formed by the Songhua River and the Nen River alluvium, runs through the central part of Heilongjiang Province and Jilin Province, with an area of about 103,200 km$^2$, mainly including the cities of Heihe, Suihua, Daqing, Qiqihar, Harbin, Changchun, Songyuan, and Baicheng. Among the two major plains, Songnen Plain has long been dominated by maize crops, with maize cultivation accounting for about 65% or more of the grain cultivation area, while Sanjiang Plain has long been dominated by rice crops, with rice cultivation accounting for about 60% or more of the grain cultivation area. The spatial location of the two plains is shown in Figure 1.




**Figure 1.** Spatial location of Sanjiang Plain and Songnen Plain.

### *3.2. Data Sources*

All raw data were obtained from the Heilongjiang Statistical Yearbook, Jilin Statistical Yearbook, and Heilongjiang Agricultural Reclamation Statistical Yearbook, statistical yearbooks of cities and statistical bulletins of national economic and social development from 2006 to 2021. International food price data were obtained from the FPMA tool of the Food and Agriculture Organization of the United Nations (FAO) (https:

//www.fao.org/giews/food-prices/tool); geographic information vector data were obtained from the National Geomatics of China (http://bzdt.ch.mnr.gov.cn/).

### *3.3. Research Methodology*

Regarding the assessment methods of economic resilience, most studies were centered on the case research method, the resilience index method, the time series model, and the causal structure model, although many scholars have not yet developed a unified measure. Limited by the complexity of the problem and the availability of data, current studies mainly use the core variable method (e.g., GDP, industrial value added, etc.) [52] or the indicator system method [53] to measure the economic resilience and spatial heterogeneity of regions and industries. In the research of agricultural resilience, even though the indicator system approach can reveal the degree of influence of different factors on resilience in a more comprehensive way, it cannot be ignored that the indicator system approach is more subjective in the process of selecting indicators and assigning weights; at the same time, the importance of some indicators may diminish with increasing time scales because the agricultural system is in constant change. In contrast, the core variable method can better reflect the key functions of the agricultural system and can focus more on the changes of the key functions compared with the indicator system method [54]. Therefore, this research adopts the core variable method to analyze the agricultural economic resilience of 12 cities in the Three River Plain and Songnen Plain. By using the agricultural output value as the core variable for measuring agricultural economic resilience, this paper attempts to comprehensively analyze the operation of the agricultural economy in 12 cities in the face of international food price fluctuations, while using multiple regressions to analyze the factors influencing changes in agricultural resilience. It is important to emphasize that agriculture in this research is agriculture in a narrow sense, i.e., farming, including the production of food crops, cash crops, fodder crops, green manure, and other crops. The agricultural output value in the text, i.e., the output value of the products obtained by engaging in crop cultivation, is calculated by multiplying the output of the agricultural products obtained by crop cultivation by the respective unit product price, which is analyzed as follows:

(1) Measure of regional economic resilience

This research draws on the widely used regional economic resilience measure of Martin et al. with the following equations:

$$\mathrm{R}_i^t = (\Delta Y_i - \Delta \mathrm{E})/|\Delta \mathrm{E}| \tag{1}$$

In equation (1), $\mathrm{R}_i^t$ is the relative agricultural economic resilience level of city $i$ in year $t$; $\Delta Y_i$ is the actual agricultural development performance of city $i$ (see Equation (2)); $\Delta$E is the predicted agricultural development performance of the city based on the overall agricultural economic performance of the region in which the city is located (see Equation (3)).

$$\Delta Y_i = Y_i^t - Y_i^{t-k} \tag{2}$$

$$\Delta \mathrm{E} = (\ (Y_r^t - Y_r^{t-k})/Y_r^{t-k})Y_i^{t-k} \tag{3}$$

where $Y_i^t$ and $Y_i^{t-k}$ are the quantity indicators of city $i$ at time $t$ and $t-k$; $Y_r^t$ and $Y_r^{t-k}$ are the quantity indicators of the region (economic region or country as a whole) where the city is located at time $t$ and $t-k$.

Equations (1)–(3) can be combined as follows:

$$\mathrm{R}_i^t = \frac{(Y_i^t - Y_i^{t-k})/Y_i^{t-k} - (Y_r^t - Y_r^{t-k})/Y_r^{t-k}}{\left|\ (Y_r^t - Y_r^{t-k})/Y_r^{t-k}\right|} \tag{4}$$

$R_i$ is the relative economic resilience that indicates the level of agricultural economic resilience of each city. When $R_i > 0$, the agricultural economic resilience of city $i$ is higher than the average level of agricultural economic development of each city, and the higher

the value, the better the overall performance of the city's agricultural economic resilience level in the region; when $R_i < 0$, the agricultural economic resilience of city $i$ is lower than the average level of agricultural economic operation of each city, and the lower the value, the worse the overall performance of the city's agricultural economic resilience level in the region.

(2) Multiple regression model

This research used a multiple regression model to identify and analyze the main influencing factors of agricultural economic resilience under international food price fluctuations, with the dependent variable being agricultural economic resilience. In addition, it is believed that agricultural economic resilience is influenced by factors such as government support, agricultural input level, agricultural output level, and social consumption capacity. The calculation equation is:

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_n * X_n + e \quad (5)$$

where $\beta_0$ is a constant, which is the estimated value of the dependent variable when the respective variables are equal to 0. $\beta_1, \beta_2 \cdots \beta_n$ is the partial regression coefficient, and its detailed variable selection will be discussed in Section 4.4. If $\beta_0 > 0$, it means the independent variable $X_n$ has a positive effect on the agricultural economic resilience. $e$ is a residual.

(3) Relative development rate index

The relative development rate can accurately measure the development rate of each sub-region relative to the whole country or large region during a certain study period, and the calculation formula is as follows:

$$NICH_{abc} = \frac{x^t_{abci} - x^{t-k}_{abci}}{\left| x^t_{abc} - x^{t-k}_{abc} \right|} \quad (6)$$

where $x^t_{abci}$ and $x^{t-k}_{abci}$ represent the development level of agricultural input in tensity, agricultural production capacity and agricultural supporting capacity of the two plains at time $t$ and $t-k$, while $x^t_{abc}$ and $x^{t-k}_{abc}$ represent the development level of agricultural input intensity, agricultural production capacity and agricultural supporting capacity of China at time $t$ and $t-k$. $NICH_{abc} > 1$ (less than 1) indicates that the development rate of agricultural input intensity, agricultural production capacity and agricultural supporting capacity in the two plains is higher (lower) than the national average development rate.

## 4. Results

### *4.1. Volatility Cycles of International Food Price*

International food prices have experienced phase fluctuations since 2005 due to shocks brought about by changes in financial and futures markets, reduced food production due to extreme weather, rising energy prices, trade frictions, and increased demand for food due to population growth [55]. Among them, international food prices experienced three peaks in 2008, 2013 and since the outbreak of the epidemic. Given that the main crops grown in the Sanjiang and Songnen Plains are rice and maize, this paper focuses on the international price fluctuations of rice and maize. Figure 2 shows that the international price trends of rice and maize have remained basically consistent with the upward intervals of international food prices from 2005 to 2008, from 2011 to 2013, and from 2018 to 2021, and the downward intervals of international food prices from 2009 to 2010 and from 2014 to 2017. As international food prices rise and fall, there are transmission effects in the regional agricultural economy. In general, higher food prices tend to increase farmers' motivation to grow food, which in turn drives food production up and agricultural output is generally higher (agricultural output = production * price), while the opposite is true for lower food prices [56]. On the basis of the resilience theory, this paper considers the downward phase of international food prices as the recession period of the agricultural economy, because

the resilience of the agricultural economy in this phase mainly reflects the resistance of regional agricultural economy to the international food price decline, while the upward phase of international food prices is considered to be the recovery period of the agricultural economy, because the resilience of the agricultural economy in this phase mainly reflects the recovery ability of regional agricultural economy. Therefore, the international food price changes since 2005 are divided into two recession periods and three recovery periods, and the changes in the resilience and recovery capacity of the agricultural economy of 12 cities in the Songnen and Sanjiang Plains are analyzed in these five periods.

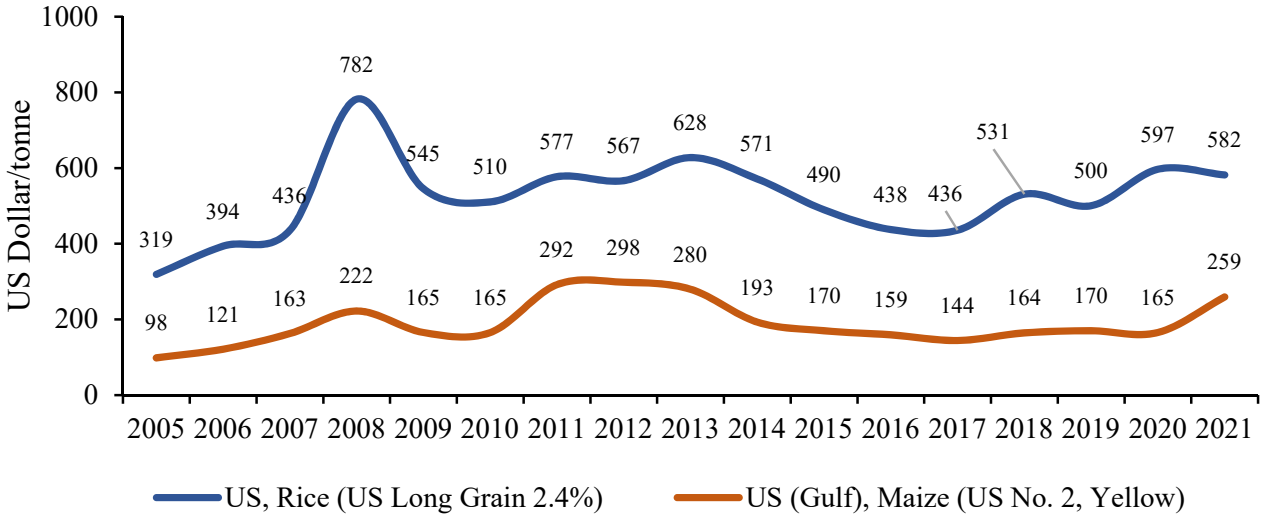



**Figure 2.** Changes in international rice and corn prices from 2005–2021.

### *4.2. Resilience and Recovery Capacity of the Songnen and Sanjiang Plains to International Food Price Fluctuations*

In this paper, agricultural economic resilience was calculated for three cycles with a total of five stages. During the first fluctuation cycle of international food prices (2005–2010, Figure 3), the overall agricultural economic resilience of the 12 cities performed well, with most cities having better agricultural economic development than the national average. From 2005 to 2008, that is, during the period of rising international food prices, the average value of the resilience water of the 12 cities was 0.36. Except for Changchun, Harbin and Hegang, where the resilience level was negative, the agricultural economic development of the other cities was better than the national average. The difference between the agricultural economic resilience of the Three River Plain and Songnen Plain was not great during this period. From 2009 to 2010, that is, during the period of falling international food prices, the average value of the resilience of the 12 cities was 0.39; of these, Changchun and Qiqihar had negative resilience levels, while the other cities had positive values. The resistance of the agricultural economy of Sanjiang Plain was better, with an average value of 0.71. During this period, the Chinese government introduced a temporary corn storage policy in 2008 to provide government purchase of corn in the northeastern region in a price–repayment approach (the government sets the purchase price of corn in the northeast and entrusts CFS to make purchases in the northeast) although affected by the decline in international grain prices. The implementation of this policy has largely stabilized corn prices and improved the economic resilience of agriculture in Songnen Plain. Meanwhile, the Chinese government has raised the minimum purchase price of japonica rice (the main varieties of rice in China are indica and japonica rice, of which the northeast is the main japonica rice-producing area) for several years, from 0.82 yuan/catty in 2008 to 1.05 yuan/catty in 2010. The high agricultural economic resilience of the main rice-producing areas in Sanjiang Plain affected by this policy indicates a strong resistance to the decline in international food prices.

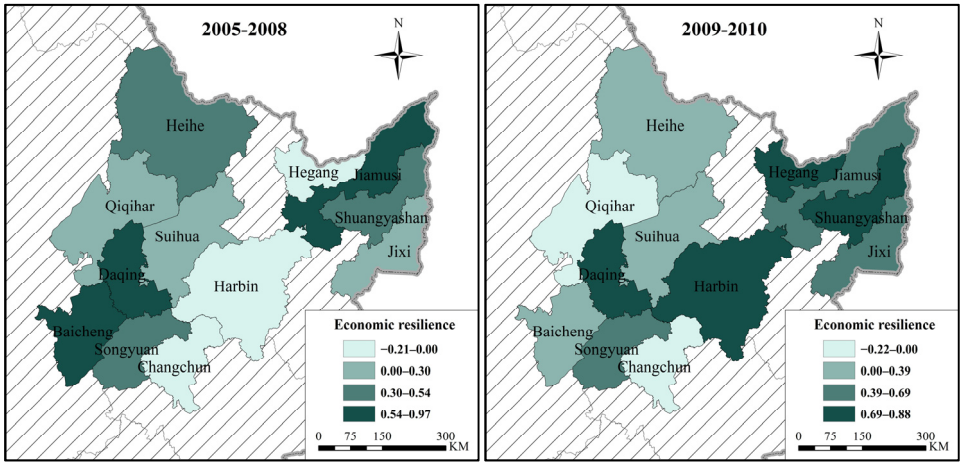



**Figure 3.** Agricultural economic resilience of 12 cities in Sanjiang Plain and Songnen Plain from 2005 to 2010.

During the second fluctuation cycle of international food prices (2011–2017, Figure 4), the difference in agricultural economic resilience between cities and regions is more obvious. In particular, during the period from 2011 to 2013, when international food prices rose, the average value of resilience water for 12 cities was 0.30. All cities had positive values, except for Shuangyashan, where the value of resilience was negative. The agricultural economic resilience of Songnen Plain performed relatively well at this stage. In fact, since the Chinese government implemented the temporary corn storage policy in the northeastern region in 2008, both the corn purchase price and the purchase volume have increased year by year, and the effect of the policy to support the market has gradually increased. Although the negative impact of this policy was a great increase in the financial burden and distortion of the market mechanism, it served to stabilize corn prices for a short period of time. The agricultural economic resilience of Songnen Plain, the main corn–producing region, was somewhat enhanced during this period. From 2014 to 2017, the period of falling international food prices, all 12 cities had negative levels of agricultural economic resilience with a mean value of −1.17, showing a poor resistance capacity. The lowest level of agricultural economic resilience was found in the southern cities of Songnen Plain, while the northern cities and Sanjiang Plain were relatively better. At this stage, the cancellation of the temporary corn storage policy made corn prices in the northeast directly face the impact of falling international corn prices; at the same time, the large backlog of corn in stock during the implementation of the policy led to a greater supply than demand in the corn market, and corn prices continued to fall for three consecutive years from 2015 to 2017. As the corn-planting area in the southern cities of Songnen Plain accounted for more than 70% of the grain-sown area, its impact from this round was more obvious, with 2016 corn prices only 60% of 2015. The minimum purchase price of rice also showed a low trend after 2014, but the rate of decline was relatively low, and the Three River Plain rice-planting areas affected by this impact on the agricultural economic resilience is also relatively poor.

During the third period of international food price increase (2018–2021, Figure 5), the overall agricultural economy of the 12 cities is better than the national average, with a mean value of the resilience index of 3.40. Among them, the agricultural economy of Sanjiang Plain shows a high resilience, while the resilience index of Suihua and Harbin in Songnen Plain is negative, indicating a weak resilience. In fact, the period of rising international food prices from 2018 to 2021 can be roughly divided into two phases, namely the 2018–2020 rice price rise period and the 2020–2021 corn price rise period. During the period of rising rice prices, the agricultural economic development in Sanjiang Plain was much higher than the national average, for the following reasons. On the one hand, this is due to the agricultural restructuring in 2018–2019 in the main paddy–producing regions of southern China that reduced the paddy planting area in some areas, while the practice of switching

double–season rice to single–season rice (single–season rice with higher yields and better quality) led to a reduction in paddy production for two consecutive years. As a result, the rice purchase enterprises in 2018 to 2019 gradually increased the purchase of rice in the northeast, driving the purchase price of rice in Sanjiang Plain to continue to be higher and the agricultural economy to be in a better position. On the other hand, the global spread of the epidemic from 2020 to 2021 also made the international market demand for ethanol sterilization products soar, leading to a significant increase in corn prices; at the same time, some major food exporting countries in the world under the influence of the epidemic introduced food export restrictions, resulting in further increases in international food prices. In this context, corn prices in the northeast rose rapidly. The agricultural economy of Songnen Plain, as the main corn producing area, is better developed, with most cities having a positive agricultural economic resilience index.

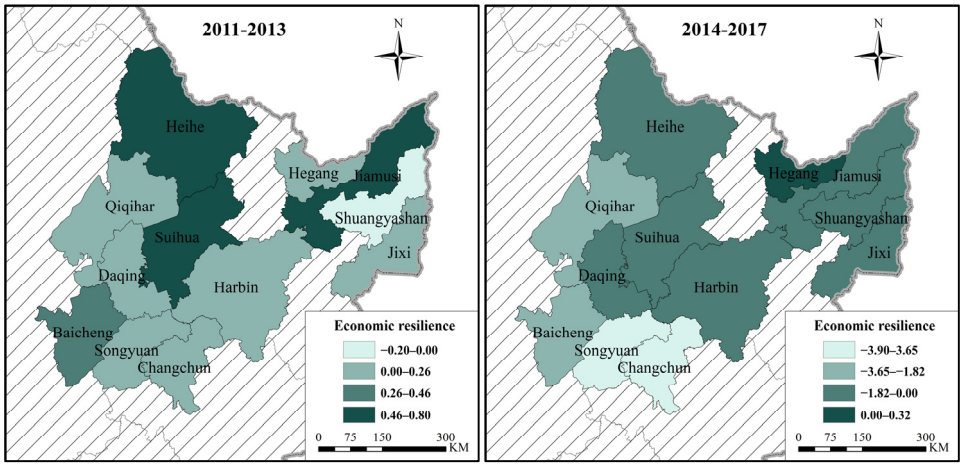



**Figure 4.** Agricultural economic resilience of 12 cities in Sanjiang Plain and Songnen Plain from 2011 to 2017.

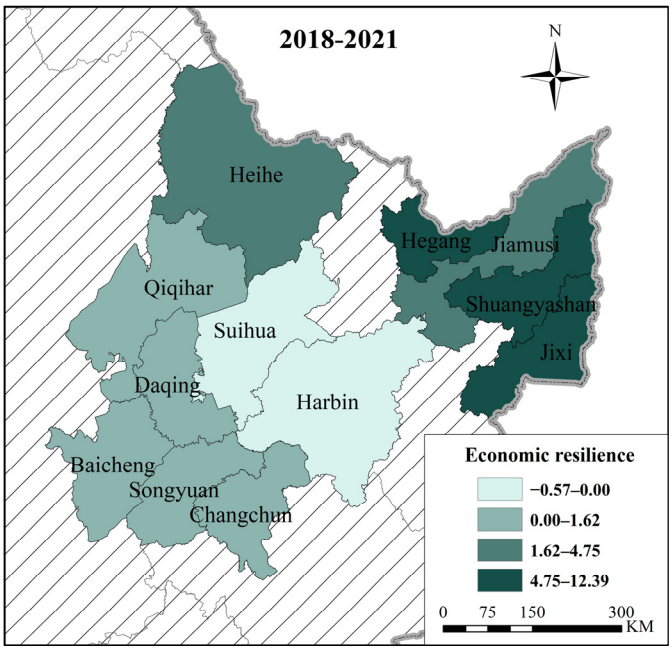



**Figure 5.** Agricultural economic resilience of 12 cities in Sanjiang Plain and Songnen Plain from 2018 to 2021.

### *4.3. Different Types of Agricultural Economic Resilience*

The main crop grown in Songnen Plain is corn, while the main crop grown in Sanjiang Plain is rice (japonica rice). It is calculated that the overall performance of the agricultural economic resilience of Sanjiang Plain is better than that of Songnen Plain; while Sanjiang Plain showed relatively high resistance during the two declines in international food prices from 2009–2010 and 2014–2017, the agricultural economic resilience index of Sanjiang Plain was much higher than that of Songnen Plain during the rise in international food prices from 2018–2021 (Table 1). There are three main reasons why the agricultural economy of Sanjiang Plain is functioning relatively well. Firstly, the variety of rice grown in Sanjiang Plain is japonica rice (the main varieties of rice in China are japonica rice and indica rice, with japonica rice production accounting for about 30% and indica rice production accounting for about 70%; japonica rice production in the northeast accounts for about 50% of total japonica rice production). Because of the lower yield and better taste of japonica rice in Sanjiang Plain compared to the national japonica rice, the price is relatively high, and its rice purchase price is about 10% higher compared to other major rice producing areas in China, which makes the economic benefits relatively good. Secondly, Sanjiang Plain is characterized by a high level of agricultural modernization, a high proportion of standardized farmland, and good conditions for mechanized farming. At the same time, more than 60% of the state farms under Heilongjiang Province Farms & Land Reclamation Administration are located in Sanjiang Plain, which makes the agricultural production in Sanjiang Plain more scalable and specialized, and the cost of arable land use and opportunity cost are both lower. Thirdly, the national policy support for Sanjiang Plain region is relatively sufficient. Since 2010, the Ministry of Agriculture in China and the Heilongjiang provincial government have successively issued a number of guiding policies committed to promoting the construction of modern agriculture in Sanjiang Plain and realizing the rapid improvement of agricultural infrastructure and a large–scale production capacity.

**Table 1.** Agricultural economic resilience of different main production areas by stages.

| Type | 2005–2008 | 2009–2010 | 2011–2013 | 2014–2017 | 2018–2021 |
|---|---|---|---|---|---|
| Songnen Plain (Main maize-producing areas) | 0.36 | 0.32 | 0.34 | −1.62 | 0.68 |
| Sanjiang Plain (Main rice-producing areas) | 0.35 | 0.54 | 0.22 | −1.17 | 8.83 |

In contrast, the applicability of the maize crop to a wider range of sectors other than rice (e.g., maize is also in greater demand in industry, clean energy, biomedicine, and animal husbandry) means its price is more influenced by oil prices, energy, feed, and international futures markets [57]. In 2016, the Chinese government implemented decoupling subsidies for corn, as well as the gradual reduction of corn acreage in non–dominant areas, which led to a reduction in corn production and an increase in market–based corn prices. This brought about greater fluctuation in domestic maize purchase prices. At the same time, according to scholars, it was found that the transmission of international rice and corn prices to domestic prices was asymmetric, in which domestic corn prices were more sensitive to the international market, and affected by it for a longer period, while rice was affected to a lesser extent and for a shorter period of time. As China is basically completely self–sufficient in rice, corn is still about 10% of the supply gap, which leads to a more complex supply-and-demand situation in the domestic corn market. The relatively large fluctuations in maize prices have brought about greater fluctuations in the economic resilience of agriculture in Songnen Plain.

### *4.4. Influencing Factors*

In this study, the analysis of agricultural economic resilience takes agricultural output as the core variable, while agricultural output reflects the sum of commodity values pro-

duced by the farming industry over time, i.e., food production * food prices. Therefore, for this study, ten indicators were selected from three dimensions, namely, agricultural input intensity, agricultural production capacity and agricultural support capacity, as factors affecting food production and food prices. Among them, agricultural input intensity is related to the strength of regional agricultural subsidies or the effect of the implementation of relevant agricultural policies, which has an important impact on food production and agricultural structure; agricultural production capacity is related to the scale of agricultural production and agricultural production efficiency, which has a greater impact on food production and food prices; and agricultural support capacity is related to regional industrial structure, agricultural processing capacity and market conditions, which has a higher degree of impact on food prices.

#### 4.4.1. Degree of Influence of Different Factors on Agricultural Economic Resilience

Based on the analysis of data accessibility, this study selected the proportion of agricultural expenditure in government finance, per capita investment in agricultural fixed assets, and the proportion of rural labor force as important indicators for measuring the agricultural inputs intensity. It selected the output per unit area of grain, the degree of mechanization and scale of agricultural production, and agricultural labor productivity as important indicators for measuring agricultural production capacity. In addition, industry structure level, per capita disposable income of rural residents, and the processing capacity of agricultural products were also selected as important indicators for measuring the agricultural support capacity. The indicators are shown in Table 2.

**Table 2.** Indicators of factors influencing agricultural economic resilience.

| Classification | Influencing Factors | Calculation Method | Weighting |
|---|---|---|---|
| Agricultural Input Intensity | Share of agricultural expenditure X1 | Agriculture, forestry and water affairs expenditure/total government financial expenditure | 0.33 |
| | Investment in agricultural fixed assets per capita X2 | Investment in agricultural fixed assets/total agricultural population | 0.33 |
| | Share of rural agricultural labor force X3 | Rural agricultural workforce/total rural population | 0.33 |
| Agricultural Production Capacity | Food production per unit area X4 | Total food production/year-end area under cultivation | 0.25 |
| | Degree of mechanization of agricultural production X5 | Total power of agricultural machinery/year-end area under cultivation | 0.25 |
| | Degree of scale of agricultural industry X6 | Crop sowing area/total agricultural population | 0.25 |
| | Agricultural labor productivity X7 | Total agricultural output value/total agricultural population | 0.25 |
| Agricultural Support Capacity | Industry structure level X8 | Total agricultural output value/regional total output value of primary, secondary and tertiary production | 0.33 |
| | Disposable income of rural residents X9 | Disposable income of rural residents | 0.33 |
| | Processing and transformation capacity of agricultural products X10 | Total output value of agricultural and sideline products processing industry/total agricultural output value | 0.33 |

With the help of multiple linear regressions, the factors affecting the agricultural economic resilience of the Songnen and Sanjiang Plains were analyzed. The regression results of agricultural economic resilience are presented in Table 3. In this study, the fitted results were tested by analysis of variance (F–test) and the accuracy was assessed based on the coefficient of determination (R2). The analysis revealed an interesting phenomenon: agricultural production capacity provided a significant positive boost to agricultural economic

resilience within the three periods of international food price increases, and agricultural input intensity and agricultural support capacity tended to exert a greater positive influence on agricultural economic resilience during the two periods of international food price decreases.

**Table 3.** Multiple linear regression results of factors influencing agricultural economic resilience.

| Influencing Factors | First Cycle | | Second Cycle | | Third Cycle |
|---|---|---|---|---|---|
| | 2005–2008 | 2009–2010 | 2011–2013 | 2014–2017 | 2018–2021 |
| X1 | 0.038 (0.034) | 0.646 (0.062) * | 0.058 (0.043) | 0.305 (0.151) * | 0.305 (0.364) * |
| X2 | 0.159 (0.038) | −0.254 (0.058) | 0.247 (0.028) | 0.533 (0.095) *** | −0.089 (0.453) |
| X3 | −0.266 (0.038) | −0.108 (0.085) | 0.012 (0.043) | −0.188 (0.155) | 0.121 (0.333) |
| X4 | 0.346 (0.040) * | −0.135 (0.083) | −0.221 (0.053) | 0.073 (0.105) | 0.380 (0.390) ** |
| X5 | 0.079 (0.043) | 0.002 (0.072) | 0.334 (0.040) * | −0.045 (0.103) | −0.284 (0.491) |
| X6 | −0.259 (0.037) | −0.328 (0.078) | 0.389 (0.039) * | 0.022 (0.105) | 0.328 (0.384) * |
| X7 | 0.235 (0.038) | 0.120 (0.121) | 0.405 (0.045) * | −0.086 (0.104) | 0.086 (0.345) |
| X8 | −0.197 (0.044) | −0.063 (0.082) | −0.174 (0.044) | −0.205 (0.112) | −0.325 (0.349) * |
| X9 | −0.261 (0.046) | 0.634 (0.097) * | 0.017 (0.031) | 0.300 (0.085) * | 0.340 (0.329) * |
| X10 | −0.082 (0.038) | −0.337 (0.075) | 0.121 (0.046) | 0.323 (0.099) * | 0.147 (0.344) |
| $R^2$ | 0.439 | 0.602 | 0.55 | 0.578 | 0.546 |
| $F$ | 2.901 ** | 1.963 | 3.050 * | 5.068 *** | 4.443 *** |

(*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; Standard errors are in brackets.).

Indicators reflecting agricultural production capacity and agricultural input intensity in the first fluctuation cycle (2005–2010) had a high degree of impact on agricultural economic resilience. The period from 2005 to 2008 was characterized by tight international food supply and demand year by year; with the rise in crude oil prices, food production costs and transportation prices increased, while the rapid development of the biofuel industry increased demand for food, and international food prices rose rapidly for a short period of time due to various influences such as increased speculative power in the futures market. The increase in food production per unit area (X4) within the phase of rising international food prices had a more significant impact on the resilience of the agricultural economy. During this phase, domestic food prices also showed an increase due to the impact of the transmission of international food prices to the domestic market and the rising demand for food in the international market. In this context, the increase in regional food production could improve the resilience of the agricultural economy by virtue of high prices, and the resilience of the agricultural economy was enhanced. During the period from 2009 to 2010, the financial crisis triggered a narrowing of global trade volume, leading to a decrease in food market demand; at the same time, the food market was forced to operate weakly under a more generous global food supply and demand, leading to a significant drop in international food prices during this period. Within this period, the higher share of government financial expenditure on agriculture (X1) and disposable income of rural residents (X9) had a significant positive effect on the improvement of agricultural economic resilience. During this period, national and local governments introduced a series of policies related to the stabilization of agricultural production, aiming to safeguard farmers' production incentives to a large extent through agricultural subsidies and other means [43]. Through initiatives such as investing special financial funds to stabilize purchase prices and expanding the volume of bailout purchases, some local governments were committed to ensuring more stable local food prices, allowing grain production to still maintain its growth momentum and the agricultural economy to be more resilient to falling international food prices.

During the second international food price fluctuation cycle (2011–2017), indicators reflecting the three dimensions of agricultural production capacity, agricultural input intensity and agricultural support capacity all exerted a significant influence on agricultural economic resilience. Among them, from 2011 to 2013, multiple factors such as extreme

weather, future markets and biofuels influenced the shortage of supply in the international food market, leading to another increase in international food prices. During this period, indicators reflecting the modernized production capacity of agriculture, such as the degree of mechanization of agricultural production (X5) and the degree of scale of agricultural industry (X6) and agricultural labor productivity (X7), had a significant positive contribution to the economic resilience of agriculture. In fact, after 2010, national and regional policies accelerated the pace of modern agricultural construction in the northern part of Songnen Plain and Sanjiang Plain [58]. In this context, both Heilongjiang and Jilin provinces proposed the goal of "taking the lead in the basic realization of agricultural modernization", and the level of agricultural modernization gradually became the key to enhancing the economic resilience of agriculture in the Sanjiang and Songnen Plain. From 2014 to 2017, the consequence of lower international oil prices and global food supply outstripping demand was a sustained low international food price. During this period, there was a positive impact on the economic resilience of agriculture if the share of agricultural expenditure (X1), the investment in agricultural fixed assets per capita (X2), disposable income of rural residents (X9) and the consumption rate of residents (X10) increased. This phase of falling international grain prices also witnessed the situation where, in China's domestic grain production, supply exceeded demand. Stimulated by successive years of rising corn and rice purchase prices, grain production in the Songnen and Sanjiang Plains climbed rapidly. Excessive pressure on grain stocks has made it difficult to achieve smooth sales. Faced with the continuous downward trend of international grain prices and the pressure on domestic grain stocks, the Chinese government canceled the temporary corn storage policy in 2016 and lowered the purchase price of rice for the first time in the same year. Among them, with the cancellation of the temporary corn storage policy, corn prices in the northeast directly faced the impact of falling international grain prices, with corn purchase prices in some areas dropping by even more than 50%. Therefore, agricultural subsidies played an important role in counteracting price shocks at this stage [29]. For the main maize producing regions, although the government abolished the maize price subsidy policy, the differences in agricultural producer subsidies across regions had a large impact on agricultural economic resilience. Agricultural producer subsidies are reflected not only in the input intensity of agricultural fiscal expenditures, but also in the level of disposable income of farmers. In regions with higher agricultural subsidies, farmers' incentive to plant was increased to some extent, and the area under grain cultivation and grain production was stabilized, and thus the ability of the agricultural economy to withstand price shocks was improved. It is necessary for the main grain–producing regions to improve the grain-processing capacity, because this is an important initiative for digesting grain stocks at this stage. Regions with a better grain-processing capacity generally have larger consumer markets and more complete agricultural processing strength, and thus food prices tend to be relatively high and more resistant to the fall in food prices due to supply exceeding demand.

During the third international food price increase cycle (2018–2021), the share of agricultural expenditure (X1), grain unit area production (X4), degree of scale of agricultural industry (X6), disposable income of rural residents (X9) had a significant positive driving effect on agricultural economic resilience. Along with COVID–19, the Russia–Ukraine conflict and the impact of extreme weather in some of the world's major grain–producing regions, international grain prices showed fluctuations in 2018–2021, while the fluctuation dynamics of corn and rice differed greatly. During this period, China's domestic corn purchase prices and rice purchase prices showed an upward trend, with corn prices climbing rapidly in 2020 and prices still remaining high to date, while rice purchase prices are relatively stable. There are two reasons behind the rise in corn purchase prices, one of which is due to the fact that the Chinese government started to reduce the corn-planting area in non–dominant areas for many years in a row in 2016, resulting in a cessation of the high growth in corn production, while corn stocks were digested in large quantities after 2016 and the supply-exceeds-demand situation in the corn market improved; on the

other hand, the outbreak of the epidemic led to a surge in demand for ethanol sterilization supplies, while corn, as a raw material for ethanol, was in great demand and its prices rose. The phenomenon of rising domestic rice prices emerged for two reasons, one being influenced by the decrease in rice production and the rapid rise in corn prices, and the other being the government's policy adjustment to alleviating the planting pressure on farmers caused by rising planting costs. Therefore, with the growing demand for corn and small fluctuations in rice production, indicators reflecting food production capacity such as food production per unit area (X4), the degree of scale of agricultural production (X6) became important factors for enhancing regional agricultural economic resilience during this period. At the same time, the impact of the spreading domestic epidemic led to a greater resistance to economic development in some regions, which in turn brought about a more subdued consumer market. Therefore, there is a more significant contribution to agricultural economic resilience by increasing the disposable income of rural residents (X9).

Based on the above, it can be concluded that the performance of the factors affecting the resilience of the agricultural economy is different within the two phases of the international food price increase and decrease periods. Specifically, the impact of factors reflecting agricultural production capacity during the period of rising international food prices usually has a greater impact on agricultural economic resilience. This is consistent with the research conclusion of agricultural resilience in some developing countries [30,33]; the impact of factors reflecting the agricultural input intensity and agricultural support capacity during the period of falling international food prices usually has a greater impact on agricultural economic resilience, while agricultural support capacity and the intensity of agricultural inputs are concentrated in the regulatory effects of agricultural policies. The achievements of EU common agricultural policy and China's minimum grain purchase price policy have proved that scientific and steady agricultural policy can effectively resist the impact of market and prices, and can protect the sustainable development of agricultural economy in this region to a certain extent [35,36,43]. It should be noted that the relationship between industry structure level (X8) and agricultural economic resilience is negative during the study period. In other words, the greater the share of agricultural economy in regional economic development, the weaker the regional agricultural economic resilience, and this is significant in the third cycle. According to the relevant evidence, with the gradual improvement of agricultural modernization, agricultural industrialization and the rapid development of industry and service industry, the share of agricultural workers in the total social labor force will gradually decrease, making the share of agricultural economy in the national economy show a decreasing trend. This trend has been confirmed in the European Union [59], and the same pattern has been observed in the agricultural development process in the major grain-producing regions of the Northeast. At the same time, the gradual acceleration of agricultural modernization and the gradual diversification of rural grain purchase market players make the factors reflecting the production capacity of agricultural modernization, such as the scale of agricultural production and mechanization, and the factors reflecting the regional consumption potential and grain processing capacity, such as farmers' income, rural consumption and agricultural by-product processing industry, have an increasingly significant impact on the regional agricultural economic resilience.

#### 4.4.2. The Characteristics of the Changes of Agricultural Input Intensity, Production Capacity and Supporting Capacity during the Fluctuation Cycle of International Food Prices

The multiple regression model reveals the degree of influence of different influencing factors on agricultural economic toughness in different stages, but it does not fully explain the changes of influencing factors on the time scale. For this reason, the relative development rate is introduced. Formula (6) was used to calculate the relative development rate of agricultural input intensity, agricultural production capacity and agricultural supporting capacity in the fluctuation cycle of international food prices. The standardized values and the corresponding weights of the influencing factors in 12 cities of Songnen Plain and Sanjiang Plain were multiplied and summed to give the mean value. Compared with the

same index in China, the development status of the above three capabilities in Songnen Plain and Sanjiang Plain is analyzed on the time scale relative to the whole country. In order to eliminate the influence of different dimensional data on the comprehensive evaluation of agricultural modernization, it is necessary to standardize the data. The extreme value method was used to quantify the data. The specific methods are as follows:

$$\text{Forward standardization}: \ Z_{ij} = \frac{x_{ij} - x_{i,min}}{x_{i,max} - x_{i,min}} \tag{7}$$

$$\text{Negative standardization}: \ Z_{ij} = \frac{x_{i,max} - x_{ij}}{x_{i,max} - x_{i,min}} \tag{8}$$

where $Z_{ij}$ represents the dimensionless value of each index, $x_{ij}$ represents the pre-dimensionless index value, and $x_{i,max}$ and $x_{i,min}$ represent the maximum and minimum value of the index, respectively.

According to Table 4, from 2005 to 2021 the development speed of agricultural input intensity and agricultural production capacity in Songnen Plain and Sanjiang Plain was higher than the national average level, while the agricultural supporting capacity was relatively backward. Among them, the agricultural production capacity developed rapidly during the rising period of international food prices, but was affected by policy changes and falling food prices from 2014 to 2017, while the speed of development declined greatly. The development speed of agricultural supporting capacity showed a fluctuating upward trend in the research stage. Combined with the previous analysis, it is obvious that the three stages of rising international food prices raised regional grain market prices and grain purchase prices, which enabled agricultural production capacity to increase rapidly during this period. As a result, grain production was increased and the resilience of the agricultural economy was improved. In different stages of the decline of international food prices, the causes of changes in agricultural economic resilience were different. During the first period of decline in international food prices from 2009 to 2010, the minimum grain price purchase policy implemented by the government increased farmers' income through a series of subsidies, resulting in a rapid increase in agricultural input intensity and agricultural supporting capacity. To a certain extent, the government's macro-control agricultural policy resisted the decline in international grain prices [44], which ensured the enthusiasm of farmers to grow grain, and then stabilized grain production. As a result, the agricultural economy was more resilient at this stage. During the second period of decline in international food prices, from 2014 to 2017, the agricultural regulation and control policy failed for a short time with the cancellation of the minimum purchase price for corn and the reduction of the minimum purchase price for rice, which led to the deepening of the transmission of international food prices to domestic food prices. Regional grain prices fell rapidly, and farmers' incomes declined, followed by a reduction in grain production. With the great changes in agricultural policy, the agricultural input intensity, agricultural production capacity and agricultural supporting capacity were affected to a great extent, and the speed of development was lower than the national average, resulting in the fragility of agricultural economy in this period. Therefore, the influence of international grain price fluctuation on agricultural economic resilience was mainly through the transmission of international food prices to regional food prices, which then affected grain production capacity, which is finally reflected in agricultural economic resilience. In this process, the regional food supply and demand situation and the regulation and control role of agricultural policy are very important [29]. The evidence of Sanjiang Plain and Songnen Plain indicates that when there is a relative balance of regional food supply and demand and a stable implementation of agricultural regulation policy, the fluctuation of international grain prices has little influence on the resilience of the agricultural economy, while when there is a large contradiction between supply and demand in the regional grain market or the failure of agricultural regulation and control policy, the fluctuation of international grain

prices has a great impact on the resilience of the agricultural economy, which may increase the fragility of agricultural economy in the stage of international grain price decline.

**Table 4.** Relative development rate of agricultural input intensity, agricultural production capacity and agricultural supporting capacity.

| Cycle | Time Range | Agricultural Input Intensity | Agricultural Production Capacity | Agricultural Supporting Capacity |
|---|---|---|---|---|
| Cycle I | 2005–2008 | 0.83 | 1.31 | 0.74 |
| | 2009–2010 | 1.36 | 1.10 | 1.08 |
| Cycle II | 2011–2013 | 1.11 | 1.63 | 0.81 |
| | 2014–2017 | 0.84 | 0.58 | 0.79 |
| Cycle III | 2018–2021 | 1.28 | 1.73 | 1.07 |
| Overall change | 2005–2021 | 1.08 | 1.23 | 0.81 |

## 5. Discussion

The results of the analysis reveal that the agricultural economy of the Sanjiang and Songnen Plains from 2005 to 2013 developed for many years above the national average and had a relatively stable resilience. The analysis suggests that an important reason for this is that the Chinese government implemented a relatively stable grain purchase policy. The minimum purchase price for rice and corn was set and the purchase price rose steadily, which to a certain extent improved the resilience of the agricultural economy in the face of falling international grain prices. Evidence from countries such as China and the United States similarly shows the importance of agricultural subsidy policies in raising farmers' incomes and agricultural economies [31,34,43]. With the cancellation of the government's corn purchase policy in 2016 and the beginning of a multi-year reduction in corn acreage in non-dominant areas, the corn market experienced significant fluctuation. Maize prices directly faced the impact of falling international grain prices, leading to a significant decline in maize prices in 2016–2017 and a plunge in the resilience of the main maize-producing areas. In contrast, the minimum purchase price policy for rice, which has been in place since 2004, has been implemented consistently and steadily since then, although it has experienced several price adjustments but has basically guaranteed the price stability of rice. This has undoubtedly made the agricultural economy in the main rice-producing areas function relatively well and have a relatively strong ability to cope with the impact of falling international food prices. Thus, China, as a country with a large population, implements agricultural policies that can have a large impact on food production, farmers' income and agricultural structure in major grain-producing regions. The stability, continuity and science of agricultural policies must be guaranteed if the resilience of the agricultural economy to international food price fluctuations is to be improved [45]. In the future, it is necessary for the government to continue to increase investment in the agricultural sector in the Songnen and Sanjiang Plains, optimize the planting structure according to local conditions, and thus achieve the goal of improving the modern production of grain and the processing capacity of agricultural products. At the same time, drawing on the successful experiences of countries such as the United States and Europe, the identification and prediction of the risk of international food price fluctuations can be strengthened through the continuous improvement of food subsidy policy, which has a positive significance in terms of improving food marketability and avoiding large agricultural policy changes under the premise of stabilizing food prices [16,28].

## 6. Conclusions

In this paper, the agricultural economic resilience of the Sanjiang and Songnen Plains under the influence of international food price fluctuations from 2005 to 2021 was analyzed, and the main influencing factors of agricultural economic resilience were also described, resulting in the following three main conclusions. The first point is that international

food price fluctuations have different degrees of impact on regional agricultural economic resilience at different stages, as evidenced by the fact that overall, the agricultural economic resilience of the Three River Plain is higher than that of Songnen Plain. From 2005 to 2013, the agricultural economic resilience of the two plains changed less and the level of resilience was higher than the national average, while from 2014 to 2021, the impact of international food price fluctuations was greater. The rising international grain prices saw both plains show good resilience, with the agricultural economic resilience of Sanjiang Plain becoming gradually higher than that of Songnen Plain after 2012, while during the first decline in international grain prices (2009–2010), both plains showed strong resilience due to the continuous upward adjustment of the national purchase prices of corn and rice. Within the second decline phase (2014–2017), various factors such as the elimination of the maize provisional storage policy, the gradual reduction of the national purchase price of rice and the gradual increase of grain marketization made the agricultural economic resilience of both major plains show a stronger vulnerability, of which the vulnerability of Songnen Plain is stronger. The second point is the difference in agricultural economic resilience between the main corn- and rice-producing areas. Although the agricultural economic development in the two major plains was higher than the national average for most of the period, the agricultural economic resilience in the main corn-producing areas (mainly in Songnen Plain) was more volatile and had a relatively low resilience index in comparison, mainly due to the more complex supply and demand situation in the corn market as a result of the multipurpose attributes of the corn crop. The massive adjustment of maize acquisition policies in 2016 and the massive reduction of maize acreage in non-dominant areas led to fluctuations in maize production. In contrast, the agricultural economic resilience in the main rice-producing regions (mainly in Sanjiang Plain) is less volatile and has a relatively high resilience index, which is mainly due to the relatively high domestic rice self-sufficiency rate. The stable production capacity of rice is guaranteed due to the relatively single application of rice compared to corn, the stable government acquisition policy for rice and the high agricultural modernization in Sanjiang Plain. The third point is that the factors affecting agricultural economic resilience vary across the three cycles, as evidenced by the fact that indicators reflecting agricultural production capacity have a greater impact on agricultural economic resilience during the phase of rising international food prices, while indicators reflecting agricultural input intensity and agricultural support capacity have a greater impact on agricultural economic resilience during the phase of falling international food prices. In addition, during the study period it was found that the characteristics of a greater share of the regional agricultural economy and a weaker resilience of the regional agricultural economy were also presented in the main grain-producing regions of the Northeast, a phenomenon similar to the process of agricultural economic development in developed countries.

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## References


1. Arjun, K.M. Indian agriculture-status, importance and role in Indian economy. *Int. J. Agric. Food Sci. Technol.* **2013**, *4*, 343–346.
2. Stanciu, S.; Virlanuta, F.O.; Dinu, V.; Zungan, D.; Antohi, V.M. The perception of the social economy by agricultural producers in the north-east development region of romania. *Transform. Bus. Econ.* **2019**, *18*, 879–899.
3. Marinov, P. Index of localization of agricultural holdings and employees in the rural areas of the South Central Region for Bulgaria. *Bulg. J. Agric.* **2019**, *25*, 464–467.
4. Thurlow, J.; Dorosh, P.; Davis, B. Demographic change, agriculture, and rural poverty. *Sustain. Food Agric.* **2019**, 31–53. [CrossRef]
5. Shabanov, V.L.; Vasilchenko, M.Y.; Derunova, E.A.; Potapov, A.P. Formation of an export-oriented agricultural economy and regional open innovations. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 32. [CrossRef]
6. Han, L. Asymmetric Transmission of World Grain Price to Domestic Market in China—A Study Based on Threshold Auto—Regression Model. *Mod. Econ. Sci.* **2018**, *40*, 78–84+127.
7. Ceballos, F.; Hernandez, M.A.; Minot, N.; Robles, M. Grain price and volatility transmission from international to domestic markets in developing countries. *World Dev.* **2017**, *94*, 305–320. [CrossRef]
8. Dawe, D.; Timmer C, P. Why stable food prices are a good thing: Lessons from stabilizing rice prices in Asia. *Glob. Food Secur.* **2012**, *1*, 127–133. [CrossRef]
9. Yan, S.; Kameyama, H.; Isoda, H.; Qian, J.; Ito, S. Effects of international grain prices on volatility of domestic grain prices in 24 developing countries. *J. Fac. Agric. Kyushu Univ.* **2016**, *61*, 225–232. [CrossRef]
10. Folke, C. Resilience (republished). *Ecol. Soc.* **2016**, *21*, 44. [CrossRef]
11. Bullock, J.M.; Dhanjal-Adams, K.L.; Milne, A.; Oliver, T.H.; Todman, L.C.; Whitmore, A.P.; Pywell, R.F. Resilience and food security: Rethinking an ecological concept. *J. Ecol.* **2017**, *105*, 880–884. [CrossRef]
12. Volkov, A.; Žičkienė, A.; Morkunas, M.; Baležentis, T.; Ribašauskienė, E.; Streimikiene, D. A Multi-Criteria Approach for Assessing the Agricultural economic resilience: The Case of Lithuania. *Sustainability* **2021**, *13*, 2370. [CrossRef]
13. Volkov, A.; Morkunas, M.; Balezentis, T.; Streimikiene, D. Are agricultural sustainability and resilience complementary notions? Evidence from the North European agriculture. *Land Use Policy* **2022**, *112*, 105791. [CrossRef]
14. Holling, C.S.; Gunderson, L.H. *Panarchy: Understanding Transformations in Human and Natural Systems*; Island Press: Washington, DC, USA, 2002.
15. Meuwissen, M.P.M.; Paas, W.H.; Slijper, T.; Coopmans, I.; Ciechomska, A.; Lievens, E.; Deckers, J.; Vroege, W.; Mathijs, E.; Kopainsky, B. Report on Resilience Framework for EU Agriculture: Sustainable and Resilient EU Farming Systems (SureFarm) Project Report, Work Package D1. 1. Wageningen University & Research. 2018. Available online: https://library.wur.nl/WebQuery/wurpubs/534605 (accessed on 3 October 2022).
16. Quendler, E.; Morkūnas, M. The economic resilience of the Austrian Agriculture since the EU accession. *J. Risk Financ. Manag.* **2020**, *13*, 236. [CrossRef]
17. Xue, T.; Zhang, Y.; Wang, X.; Zhao, C.; Li, L. Research on Coordinated Development of Ecological Resources, Environment and Economy and Society in Sanjiang Region. In IOP Conference Series: Earth and Environmental Science. *IOP Publ.* **2020**, *508*, 012074.
18. Yang, Y.; Zhang, Y.; Yang, Q.; Liu, J.; Huang, F. Coupling relationship between agricultural labor and agricultural production against the background of rural shrinkage: A case study of Songnen Plain, China. *Sustainability* **2019**, *11*, 5804. [CrossRef]
19. Martin, R.; Sunley, P.; Gardiner, B.; Tyler, P. How regions react to recessions: Resilience and the role of economic structure. *Reg. Stud.* **2016**, *50*, 561–585. [CrossRef]
20. Li, L.; Zhang, P.; Tan, J.; Guan, H. Review on The Evolution of Resilience Concept and Research Progress on Regional Economic Resilience. *Hum. Geogr.* **2019**, *34*, 1–7+151. [CrossRef]
21. Holling, C.S. Resilience and stability of ecological systems. *Annu. Rev. Ecol. Syst.* **1973**, *4*, 1–23. [CrossRef]
22. Martin, R. Regional economic resilience, hysteresis and recessionary shocks. *J. Econ. Geogr.* **2012**, *12*, 1–32. [CrossRef]
23. Fagiolo, G. The empirics of macroeconomic networks: A critical review. In *Complex Networks and Dynamics*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 173–193.
24. Angulo, A.M.; Mur, J.; Trívez, F.J. Measuring resilience to economic shocks: An application to Spain. *Ann. Reg. Sci.* **2018**, *60*, 349–373. [CrossRef]
25. Davies, S. Regional resilience in the 2008–2010 downturn: Comparative evidence from European countries. *Camb. J. Reg. Econ. Soc.* **2011**, *4*, 369–382. [CrossRef]
26. Simmie, J.; Martin, R. The economic resilience of regions: Towards an evolutionary approach. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 27–43. [CrossRef]
27. Martin, R.; Sunley, P. Regional economic resilience: Evolution and evaluation//Handbook on regional economic resilience. *Edw. Elgar Publ.* **2020**.
28. Hammond, B.; Berardi, G.; Green, R. Resilience in Agriculture: Small-and medium-sized farms in Northwest Washington State. *Agroecol. Sustain. Food Syst.* **2013**, *37*, 316–339. [CrossRef]
29. Buitenhuis, Y.; Candel, J.J.L.; Termeer, K.J.A.M.; Feindt, P.H. Does the Common Agricultural Policy enhance farming systems' resilience? Applying the Resilience Assessment Tool (ResAT) to a farming system case study in the Netherlands. *J. Rural. Stud.* **2020**, *80*, 314–327. [CrossRef]

30. Sánchez-Zamora, P.; Gallardo-Cobos, R.; Cea-Delgado, F. Analyzing resilience factors in rural territories of Andalusia through techniques of Analytical Network Process (ANP). *Inf. Tech. Econ. Agrar.* **2017**, *113*, 68–89.
31. Berardi, G.; Green, R.; Hammond, B. Stability, sustainability, and catastrophe: Applying resilience thinking to U. S. agriculture. *Hum. Ecol. Rev.* **2011**, *18*, 115–125.
32. Yu, W.; Zhang, P. Study on the Spatial-Temporal Differentiation Characteristic and Influencing Factors of Agricultural Development Resilience in China. *Geogr. Geo-Inf. Sci.* **2019**, *35*, 102–108.
33. Vroegindewey, R.; Hodbod, J. Resilience of agricultural value chains in developing country contexts: A framework and assessment approach. *Sustainability* **2018**, *10*, 916. [CrossRef]
34. Minviel, J.J.; Latruffe, L. Effect of public subsidies on farm technical efficiency: A meta-analysis of empirical results. *Appl. Econ.* **2017**, *49*, 213–226. [CrossRef]
35. Rizov, M.; Pokrivcak, J.; Ciaian, P. CAP subsidies and productivity of the EU farms. *J. Agric. Econ.* **2013**, *64*, 537–557. [CrossRef]
36. Meuwissen, M.P.M.; Feindt, P.H.; Spiegel, A.; Termeer, C.J.A.M.; Mathijs, E.; de Mey, Y.; Finger, R.; Balmann, A.; Wauters, E.; Urquhart, J.; et al. A framework to assess the resilience of farming systems. *Agric. Syst.* **2019**, *176*, 102656. [CrossRef]
37. Martin, R.L. Shocking aspects of regional development: Towards an economic geography of resilience. In *The New Oxford Handbook of Economic Geography*; Oxford University Press: Oxford, UK, 2018; pp. 839–864.
38. Li, L.; Liu, S.; Li, C.; Zhang, P.; Lo, K. What Matters for Regional Economic Resilience Amid Multi Shock Situations: Structural or Agency? Evidence from Resource-Based Cities in China. *Sustainability* **2022**, *14*, 5701. [CrossRef]
39. Elleby, C.; Jensen, F. Food price transmission and economic development. *J. Dev. Stud.* **2019**, *55*, 1708–1725. [CrossRef]
40. Brown, M.E.; Tondel, F.; Essam, T.; Thorne, J.A.; Mann, B.F.; Leonard, K.; Stabler, B.; Eilerts, G. Country and regional staple food price indices for improved identification of food insecurity. *Glob. Environ. Change* **2012**, *22*, 784–794. [CrossRef]
41. Clapp, J. Food Price Volatility and Vulnerability in the Global South: Considering the global economic context. *Third World Q.* **2009**, *30*, 1183–1196. [CrossRef]
42. Peng, J.Y.; Xie, R.; Lai, M.Y. A study on the asymmetric impacts of international grain prices on domestic grain prices in China. *Resour. Sci.* **2016**, *38*, 847–857.
43. Wang, L.; Sun, L. Did the Minimum Purchase Price Policy Stabilize Grain Price Fluctuation. *J. Agrotech. Econ.* **2019**, 111–121. [CrossRef]
44. Zhang, X.; Liu, Y. The dynamic impact of international agricultural commodity price fluctuation on Chinese agricultural commodity prices. *Int. Food Agribus. Manag. Rev.* **2020**, *23*, 391–409. [CrossRef]
45. Knickel, K.; Redman, M.; Darnhofer, I.; Ashkenazy, A.; Chebach, T.C.; Šūmane, S.; Tisenkopfs, T.; Zemeckis, R.; Atkociuniene, V.; Rivera, M.; et al. Between aspirations and reality: Making farming, food systems and rural areas more resilient, sustainable and equitable. *J. Rural. Stud.* **2018**, *59*, 197–210. [CrossRef]
46. Folke, C.; Carpenter, S.R.; Walker, B.; Scheffer, M.; Chapin, T.; Rockström, J. Resilience thinking: Integrating resilience, adaptability and transformability. *Ecol. Soc.* **2010**, *15*, 1–9. [CrossRef]
47. Anderies, J.M.; Folke, C.; Walker, B.; Ostrom, E. Aligning key concepts for global change policy: Robustness, resilience, and sustainability. *Ecol. Soc.* **2013**, *18*, 1–16. [CrossRef]
48. Arezki, R.; Brueckner, M. Effects of international food price shocks on political institutions in low-income countries: Evidence from an international food net-export price index. *World Dev.* **2014**, *61*, 142–153. [CrossRef]
49. Tanaka, T.; Guo, J. How does the self-sufficiency rate affect international price volatility transmissions in the wheat sector? Evidence from wheat-exporting countries. *Humanit. Soc. Sci. Commun.* **2020**, *7*, 1–13. [CrossRef]
50. Manca, A.R.; Benczur, P.; Giovannini, E. Building a scientific narrative towards a more resilient EU society. *JRC Sci. Policy Rep.* **2017**, 137.
51. Walker, B.; Holling, C.S.; Carpenter, S.R.; Kinzig, A.P. Resilience, adaptability and transformability in social–ecological systems. *Ecol. Soc.* **2004**, *9*, 9. [CrossRef]
52. Hu, X.; Li, L.; Dong, K. What matters for regional economic resilience amid COVID-19? Evidence from cities in Northeast China. *Cities* **2022**, *120*, 103440. [CrossRef]
53. Angeon, V.; Bates, S. Reviewing composite vulnerability and resilience indexes: A sustainable approach and application. *World Dev.* **2015**, *72*, 140–162. [CrossRef]
54. Kitsos, T. Economic resilience in Great Britain: An empirical analysis at the local authority district level. In *Handbook on Regional Economic Resilience*; Edward Elgar Publishing: Cheltenham, UK, 2020; pp. 190–207.
55. Saman, C.; Alexandri, C. The impact of the world food price index on some East-European economies. *J. Bus. Econ. Manag.* **2018**, *19*, 268–287. [CrossRef]
56. Pop, L.N.; Rovinaru, M.; Rovinaru, F. Managing. The Agricultural Price Volatility A Governmental Approach from A Global And European Perspective. *Under Auspices Pres. Repub. Croat.* **2016**, 531.
57. Lv, J.; Lin, Y. Characteristics of international corn price volatility and its impact on China's food security. *J. Manag. World* **2013**, 76–87. [CrossRef]
58. Yang, Q.; Zhang, P.; Li, J.; Liu, W.; He, X. Development Level and Spatio-temporal Evolution of Agricultural Modernization in Northeast China. *Sci. Geogr. Sin.* **2022**, *42*, 1588–1599. [CrossRef]
59. Cristóbal, J.R.S. Is agriculture a key sector in the European economies? *Outlook Agric.* **2008**, *37*, 31–35. [CrossRef]