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# The Agricultural Economic Value of Weather Forecasting in China

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**Abstract:** Agriculture is one of the areas most sensitive to climate change. Extreme climate events can directly affect agricultural production and development. Based on the data from the statistical yearbooks of 30 provinces in China from 2009 to 2019 and the survey data of meteorological forecasting, this paper uses the fixed-effect model to empirically test the impact of meteorological forecasting on agricultural economic value. The results show that meteorological forecasting has a significant promoting effect on agricultural economic value, in that an increase in the accuracy of the meteorological forecast by one percentage point will increase agricultural economic value by 0.500 percentage points, and the results still hold after a series of robustness tests. Further study showed that there were some regional differences in the agricultural economic value of the meteorological forecasting, and the meteorological forecasting had the strongest promoting effect on the agricultural economic value of the western region, followed by the eastern region and the central region.

**Keywords:** weather forecasting services; agricultural economic value; climate change



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## 1. Introduction

The climate determines human survival and is an important factor affecting the sustainable and stable development of agriculture. Due to the change in the climate from natural conditions and the combined effect of human factors caused by industrialization, the global temperature presents a significant rising trend, and the frequency and intensity of extreme climate events have also significantly increased [1]. As one of the areas most sensitive to and strongly affected by global climate change, China's weather situation is complex, meteorological anomalies are prominent, and extreme events are increasing with time. From the continuous low temperature, rain, snow, and freezing weather in southern China in 2008 and the severe summer drought in North China and Northeast China in 2014, to the "720" rainstorm in Henan Province in 2021 and the severe summer and autumn drought in the Yangtze River Basin caused by continuously high temperatures for several days in 2022, this has not only brought about severe challenges to peoples' lives and property and the stability of the social order, but it has also made agricultural production more unstable and has even endangered food security and the sustainable development of agriculture. The negative impact of climate change on agriculture cannot be ignored. It has become an important issue to be urgently studied and solved by the Chinese government and academia.

Weather forecasting is a way for agriculture to cope with climate change. To mitigate the impact of climate change on agricultural production and food security, agricultural production planning must take current and future climate change into consideration. *Outline of the 14th Five-Year Plan* clearly states, for the first time, that China will enhance the capacity of agricultural production to adapt to climate change, improve the level of modern agricultural meteorological services, help agricultural production prevent and reduce disasters, and increase output and income. To this end, the state has accelerated the research and analysis of meteorological data to meet the needs of the new era and guide agricultural production. The weather forecast is no longer just a reminder of the weather, but uses a new generation of information technologies such as artificial intelligence, mobile communications, the Internet, and so on, to obtain meteorological data, monitor, forecast, and warn people, so as to provide more refined, specialized, and diversified information services and consulting services for agriculture to reduce the uncertainty and risk of agricultural production activity [2]. Therefore, whether weather forecasting can help agricultural production to actively respond to climate change, prevent and reduce disaster, and increase the economic benefits of agricultural production is an important issue that needs to be verified.

The impact of a meteorological forecast is mainly manifested in two aspects: one is to reduce or prevent the damage caused by meteorological events; second, it brings significant economic and social benefits. With the in-depth study of meteorological science by scholars, meteorological forecasting has evolved into a multidisciplinary comprehensive research field, covering economic sectors as agriculture, hydrology, national defense and transportation, the retail industry, public service, and the construction industry [3]. For example, Zavala (2009) et al. [4] explored the impact of meteorological forecast information on commercial sectors, such as architecture, landscaping, film and television, and agriculture, based on the willingness to pay of those who use weather forecasts. Given the sensitivity of agriculture to climate and the availability of data, scholars have mostly focused their research on agriculture. Bendre et al. (2015) [5] studied weather-based agricultural prediction and decision support, and concluded that weather forecasting was of great significance for improving agricultural decision-making and production in dry zones in India. Tesfaye (2019) et al. [6] studied the economic impact of meteorological services on farmers in Ethiopia, and found that meteorological services enhanced farmers' resilience to climate variability and risk resilience.

Compared with international research progress, China's research on the impact of meteorological forecasting started late and has developed. Methods have mainly focused on qualitative analysis, and the research direction has mostly been aimed toward the construction of an accurate meteorological forecasting system. Few scholars have used econometric methods to discuss and verify the relationship between meteorological forecasting and economic benefits. Huang (2009) et al. [7] pointed out that a regular weather forecast can directly affect the change in certain in the financial market by predicting the change in a certain crop yield at a certain time in the future. Wang (2019) [8] found that weather forecasting plays an important role in agricultural production, which is specifically reflected in helping to establish an early warning mechanism for agricultural production, reducing meteorological disaster losses and improving the scientific level of agricultural production management. Guo (2020) [9] pointed out that meteorological services could help Tuquan County to emerge from poverty; for example, meteorological services can reduce the risk of falling back into poverty caused by meteorological disasters and improve the prevention capacity of agriculture. China's existing research results do not meet the requirements of a scientific understanding of the economic benefits of meteorological forecasting. In view of this, this paper begins from the agricultural field, to construct an index system and design a model, using econometrics analysis, and to carry out an empirical study of the relationship between meteorological forecasting and the agricultural economy. On the one hand, the dynamic correlation characteristics between the two are explained and empirical evidence on the impact of meteorological forecasting on the agricultural field is provided. On the other hand, the research provides a scientific basis for agricultural disaster prevention and reduction, mitigation of the economic losses caused by extreme weather, and realization of the sustainable and stable development of the agricultural economy.

## 2. The Theoretical Analysis

Climate is the most fundamental element affecting agricultural production. Weather forecasting services have many benefits for agriculture, from extreme weather warnings to agricultural planning. The application of meteorological forecasting in agricultural production can enhance the ability of agriculture to cope with meteorological disasters from three aspects: reducing meteorological disaster losses, guiding scientific agricultural production, and optimizing the agricultural production layout, so as to achieve stable and increased yields and promote the high-quality development of agriculture.

First of all, a meteorological forecast is helpful to reduce the losses caused by meteorological disasters, and it plays a role in disaster prevention and reduction for agricultural production. In the process of crop growth, once natural disasters such as flood and drought occur, the yield of wheat, rice, corn, and other crops will decline and can even result in crop failure in severe cases [10]. The weather forecast provided by the meteorological department can encourage agricultural producers to adopt scientific and effective methods to reduce the damage of extreme weather to agricultural production. Specifically, meteorological departments use information technology and tools to monitor weather conditions in real time and forecast the probability of related disasters by analyzing the collected meteorological data analysis, so as to timely transmit early warning information to agricultural production departments and producers before disasters occur and assist them in formulating corresponding disaster prevention and mitigation measures in advance to achieve the healthy and stable development of agricultural production [11].

Secondly, meteorological forecasting is conducive to realizing scientific agricultural production and improving agricultural production efficiency. In the past, agricultural production mainly relied on the production experience and environmental information of agricultural producers. There were problems such as the inability to accurately measure the agricultural environment and the difficulty in obtaining an adaptive environment for crop production, which could not effectively ensure an increase in crop production and income. The development of weather forecasting has promoted the development of agriculture from the traditional mode of agricultural production to the direction of modernization. It can not only deepen the scientific understanding of agricultural production by agricultural producers but also realize refined operation management and finally achieve the effect of increasing the production, quality, and income of agriculture.

Finally, weather forecasting helps to optimize the agricultural production layout and achieve sustainable agricultural development. The healthy growth of crops cannot be achieved without the appropriate temperature, humidity, light, and water [12]. As an important part of agricultural production, meteorological forecasting can provide an important reference basis for agricultural planning and the rational distribution of crops and guide agricultural producers according to the meteorological information and consulting services provided by meteorological departments to determine the structure of agricultural production, planting systems, crop varieties, and management measures [13], so that crops can make full use of meteorological conditions, such as sunlight, temperature, and precipitation, promote the rational utilization of resources, optimize the allocation of resources, and achieve the sustainable and stable development of agricultural production. The analysis idea is shown in Figure 1. Based on this, this paper proposes the following hypothesis:

Hypothesis: The meteorological forecasting service helps to reduce the loss from meteorological disasters, guide agricultural scientific production, optimize agricultural production layout, and promote the improvement in agricultural economic benefits.

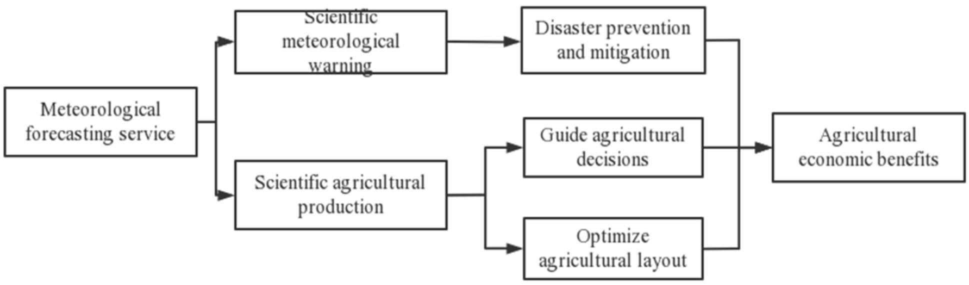


**Figure 1.** Framework diagram of the analysis of the economic benefits of meteorological forecasting services on agriculture.

## 3. Materials and Methods

### 3.1. Empirical Model

Based on the above theoretical analysis, in order to explore the relationship between meteorological forecasting and its agricultural economic effects, the following model was constructed for analysis:

$$lnfirstland_{it} = \beta_0 + \beta_1 lnaccurate_{it} + \beta_2 control_{it} + \delta_i + \mu_t + \varepsilon_{it} \quad (1)$$

where $lnfirstland$ represents the agricultural economic benefits, $lnaccurate$ represents the accuracy of the meteorological forecast, and $control$ is the control variable. $\beta_0$ is a constant term, $\beta_1$ and $\beta_2$ are the regression coefficients, $\varepsilon$ is a random error term, $I$ is the province, and $t$ is the time. On this basis, we also introduced the industry fixed effect $\delta_i$ and time fixed effect $\mu_t$ into the model to control the influence of industry and time.

### 3.2. Variables and Data Selection

#### 3.2.1. Explained Variable

Weather forecasting (Inaccurate). In this research, the accuracy rate of the meteorological forecast was chosen to measure the weather forecast. Due to the timeliness, accuracy, and other characteristics of a meteorological forecast, along with the control of many factors, the accuracy of a weather forecast cannot be described by a simple parameter. In previous studies, entropy [14], probability score [15], neural network [16], and prediction error [17] have been used to quantitatively measure the forecast accuracy or information content from rainfall, cloud cover, temperature, and other aspects. Considering the availability of data, this research used four specific indicators, namely the accuracy of 1–5 days of the sunny and rainy forecast, the accuracy of 1–5 days of the maximum and minimum temperature forecast, the accuracy of the monthly precipitation forecast, and the accuracy of the monthly average temperature forecast, as the measurement indicators for the accuracy of the meteorological forecast. For the specific formula, please refer to the "Compilation of Meteorological Forecasting and Information Business Management Documents" published by the China Meteorological Administration. Then, 314 farmers and experts in the field of agriculture were used as the survey subjects, and the weights of the four indicators were calculated using the expert scoring method. Since there was not much difference between the weight of each index, the equal-weight method was finally used to obtain the comprehensive score of the weather forecast prediction accuracy. The higher the value of this variable, the higher the accuracy of the weather forecast. It was assumed that the change in agricultural output caused by the improvement in the accuracy of weather forecast was calculated under the condition that the early warning service capacity remained unchanged, and the application of chemical fertilizer, agricultural investment, and the education level of farmers, which affect agricultural production, were unchanged.

#### 3.2.2. Explanatory Variable

Economic Benefits in Agriculture (lnfirstind). According to the existing literature, scholars mostly measure the development level of the Chinese agricultural economy by the gross product or the added value of the primary industry [18]. Since the added value of the primary industry is more inclusive and not affected by regional factors, this research used the added value of the primary industry to represent the agricultural economic benefits. Taking the effect of inflation into account, the constant price in 2008 was taken as the base period for deflator calculation.

#### 3.2.3. Control Variables

Referring to the existing relevant studies, this research selected the factors related to agricultural production and user decision as the control variables. These included: (1) the growth of agricultural products (lnfertile), expressed by the amount of chemical fertilizer applied in a province; (2) the agricultural investment scale (lnpgdp), represented by per capita GDP; (3) the farmers' education level (edu), which was expressed by the years of schooling of the local farmers; (4) the meteorological factors (lnprecipitation), which were demonstrated by the annual precipitation of various provinces; (5) the public service satisfaction, shown by the index of public service satisfaction carried out by the China Meteorological Administration every year; (6) the policy decision basis (lndecision_making_service), which was represented by the meteorological decision materials submitted by the local meteorological bureau to the local government. Descriptive statistics of the specific variables are shown in Table 1.

**Table 1.** Descriptive statistics of the Variables.

| Variables | Variable Symbol | Samples | Mean Value | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Output Value of Primary Industry | Infirstind | 330 | 1459.929 | 974.795 | 120.824 | 3890.723 |
| Weather Forecast | lnaccurate | 330 | 84.403 | 3.340 | 74.970 | 92.129 |
| Agricultural Products' Growth | lnfertile | 330 | 192.942 | 146.459 | 6.173 | 716.090 |
| Agricultural Investment Scale | lnpgdp | 330 | 26,479 | 15,206.570 | 9234.997 | 86,558.750 |
| Education Level of Farmers | edu | 330 | 9.103 | 0.537 | 7.987 | 10.629 |
| Meteorological Factors | lnprecipitation | 330 | 953.726 | 523.384 | 150.288 | 2264.985 |
| Public Service Satisfaction | lnsatisfication | 330 | 87.162 | 4.103 | 73.700 | 98.100 |
| Basis for Policy Decision | lndecision_ making_service | 330 | 22,351.160 | 43,872.520 | 113 | 431,388 |

### *3.3. The Data Source*

Based on the availability of the data, this paper conducted an empirical analysis of the statistical data and meteorological forecast survey data of 30 provinces from 2009 to 2019. Among them, the weather forecast data were mainly based on a questionnaire survey at the provincial level. With farmers and experts in the field of agriculture as the survey objects, 19 questions were designed through the questionnaire to collect the prediction accuracy of sun and rain, the maximum high temperature and minimum low temperature for 24 h, 48 h, 72 h, 96 h, and 120 h, as well as the importance rating of the prediction accuracy of the monthly precipitation and monthly temperature for agricultural production. The specific questions are not listed here due to the length of the paper. The year of the survey was 2022, and 319 valid samples were obtained. The data of the explained variables and control variables were derived from the *Meteorological Disaster Statistical Yearbook*, *Meteorological Statistical Yearbook*, *the Statistical Yearbook of China*, the decision-making service information sharing platforms, and the National Meteorological Service Intranet. On the basis of the initial samples, this research made the following decisions: first, due to a large number of omissions in the data of Tibet, Tibet was removed; secondly, some missing values were processed by interpolation; thirdly, all continuous variables were reduced to eliminate the influence of extreme outliers on the regression results; fourthly, the logarithmic method was adopted to process the variables, such as the output value of the primary industry and the weather forecast, so as to eliminate the dimensional influence; finally, 330 annual observations were obtained.

## 4. Empirical Results and Analysis

### *4.1. Baseline Regression Results*

In order to empirically test the direct influence of the meteorological forecasting on the agricultural economic benefits, the Hausman test was conducted, and the results showed that the fixed-effects model should be selected. In addition, in order to analyze and compare the estimation results more objectively, this research adopted the itemized regression method. The regression results are shown in Table 2. Before adding the control variables, the regression coefficient of the weather forecasting was 0.832, which passed the 1% significance test; from the regression results, adding the control variables one by one, the meteorological forecasting still retained a significant positive impact on the agricultural economic efficiency. From the regression results of column (7), it can be seen that for every one percentage point increase in the accuracy of the weather forecasting, the economic efficiency of agriculture increased by 0.500 percentage points. Therefore, the empirical results verified the promotion effect of accurate weather forecasting on the agricultural economic benefits. In terms of the control variables, from the regression coefficients of column (7), all control variables had regression coefficients greater than 0, which was consistent with the actual situation, but there was a difference in the regression coefficients.

**Table 2.** Effect of Meteorological Forecast on Agricultural Economic Benefit.

| | **Column (1)** | **Column (2)** | **Column (3)** | **Column (4)** | **Column (5)** | **Column (6)** | **Column (7)** |
|---|---|---|---|---|---|---|---|
| lnaccurate | 0.832 ***<br>(4.62) | 0.866 ***<br>(4.76) | 0981 ***<br>(6.40) | 0.939 ***<br>(6.52) | 0.966 ***<br>(6.76) | 0.536 ***<br>(3.17) | 0.500 ***<br>(2.90) |
| lnfertile | | 0.079<br>(1.21) | 0.168 ***<br>(3.04) | 0.019<br>(0.33) | 0.025<br>(0.44) | 0.090<br>(1.59) | 0.091<br>(1.59) |
| lnpgdp | | | 0.759 ***<br>(10.64) | 0.765 ***<br>(11.44) | 0.764 ***<br>(11.54) | 0.628 ***<br>(8.84) | 0.627 ***<br>(8.84) |
| edu | | | | 0.242 ***<br>(6.11) | 0.231 ***<br>(5.87) | 0.172 ***<br>(4.25) | 0.172 ***<br>(4.25) |
| lnprecipitation | | | | | 0.075 ***<br>(−7.22) | 0.070 ***<br>(2.52) | 0.071 ***<br>(2.56) |
| lnsatisfication | | | | | | 0.645 ***<br>(4.42) | 0.630 ***<br>(4.29) |
| lndecision_<br>making_service | | | | | | | 0.107<br>(1.07) |
| constant | 3.273 ***<br>(4.14) | 2.741 ***<br>(3.03) | −5.829 ***<br>(−5.27) | −7.189 ***<br>(−6.77) | −7.462 ***<br>(−7.22) | −7.094 ***<br>(−6.79) | −6.978 ***<br>(−6.65) |
| Fixed Time | Y | Y | Y | Y | Y | Y | Y |
| Fixed Industry | Y | Y | Y | Y | Y | Y | Y |
| N | 330 | 330 | 330 | 330 | 330 | 330 | 330 |
| $R^2$ | 0.074 | 0.079 | 0.353 | 0.435 | 0.447 | 0.485 | 0.487 |

Note: ***, **, * are significant at the level of 1%, 5% and 10%, respectively, and the *t* value is in brackets.

### *4.2. Robustness Test*

#### 4.2.1. Replace the Measure of the Explained Variables

In the previous section, the added value of the primary industry was used to measure the agricultural economic benefits. In order to verify the robustness of the regression results, the quantitative method of the explained variables was replaced. Considering that the most obvious impact of meteorological change on agriculture is crop yield, and grain yield accounts for the majority of China's agricultural production structure [19], this section used the total grain production (grain) index to replace the added value of the first output, and performed logarithmic processing, keeping the other variables unchanged. In addition, the impact of the meteorological forecasting on the agricultural economic benefits was regressed. The regression results are shown in Column (1) in Table 3. The regression coefficient of the meteorological forecasting was 0.339, which was significant at the 1%

level, indicating that the meteorological forecasting had a positive effect on the total grain production; namely, meteorological forecasting can indeed promote production.

**Table 3.** Robustness Test of the Influence of the Weather Forecasting on the Agricultural Economic Benefits.

| | **Column (1)** | **Column (2)** | **Column (3)** |
|---|---|---|---|
| lnaccurate | 0.339 ***<br>(0.15) | 1.182 ***<br>(7.34) | 0.446 *<br>(0.85) |
| lnfertile | 0.700 **<br>(0.34) | 0.091<br>(1.48) | 0.018 **<br>(0.17) |
| lnpgdp | −0.616 ***<br>(−0.20) | 0.653 ***<br>(9.52) | 0.133<br>(1.31) |
| edu | 0.154 *<br>(0.09) | 0.185 ***<br>(4.41) | 0.305 ***<br>(3.27) |
| lnprecipitation | 0.033<br>(0.04) | 0.075 **<br>(2.60) | 0.052<br>(1.22) |
| lnsatisfication | −0.306<br>(−0.31) | | −0.184<br>(−0.51) |
| lndecision_making_service | −0.017<br>(−0.01) | 0.010<br>(0.84) | 0.002<br>(0.09) |

Note: ***, **, * are significant at the level of 1%, 5% and 10%, respectively, and the *t* value is in brackets.

4.2.2. Replace the Measure of the Explanatory Variables

Weather forecasting not only provides agricultural producers with weather forecast information, but also includes a meteorological disaster warning service and a meteorological advisory service. Therefore, when measuring the weather forecast, in addition to the weather forecasting accuracy, it is essential to consider the users' factors. In this section, the public service satisfaction index was added to the variable measurement of the weather forecast. According to the expert investigation method, the weight of the accuracy of the meteorological forecast was 65.6% and the public service satisfaction weight was 36.4%. Finally, the weather forecast variables were calculated under the condition of the regression method, and the control variables remained basically unchanged. The regression results in column (2) showed that there was a significant positive correlation between the meteorological forecasting and the agricultural economic benefits. The regression results obtained by this method were consistent with the above regression results, indicating that the baseline regression results had good robustness.

4.2.3. Narrow the Sample Interval

In this research, the robustness test was conducted by shortening the sample interval. Since 2015, with the rapid development of digital technology and the application of digital technology in the meteorological field, meteorological forecasting has gradually developed in the direction of digitalization, intelligence, and smartness, which may improve the economic benefits of meteorological forecasting to a certain extent [20]. Hence, the sample interval was adjusted for the period 2015–2019 to retest the above result. The regression results are shown in Column (3). The results show that the regression coefficient of the meteorological forecasting was still positive and relatively significant, which was basically consistent with the theoretical hypothesis of this paper, and further strengthened the research conclusions of this paper.

### *4.3. Regional Heterogeneity Test*

Considering the obvious differences in the industrial structure and agricultural production conditions among the eastern, central, and western regions, this research divided the data into the eastern, central, and western regions and analyzed the regional heterogeneity of the effects of meteorological forecasting on the agricultural economic benefits.

Table 4 reports the regression results for the regional heterogeneity. Column (1) reports the regression results for the western region. The regression coefficient of the weather forecasting was significantly positive, which indicated that the weather forecasting significantly improved the agricultural economic benefits of the western region. This could be due to the fact that more than 70% of the meteorological disasters in China occur in the western rural areas [21]; hence, the role of weather forecasting in this region was more obvious, and agricultural producers were told in time to pursue coping strategies to minimize the damage and mitigate the losses caused by meteorological disasters. Column (2) reports the regression results for the central region, which showed that the regression coefficient of the weather forecast was positive but not that significant. Column (3) showed the regression results for the eastern region. The results showed that the regression coefficient of the meteorological forecast was positive at the significance level of 10%, but the regression coefficient of 0.758 was significantly lower than that of the western region (1.321), which may be closely related to the industrial structure of the eastern region. Compared with the western region, the eastern region mainly depends on high-tech manufacturing, the financial industry, and other industries, and agriculture accounts for a relatively small proportion, so the impact of the weather forecasting on the agricultural economic benefits was not as strong as that of the western region. However, from the perspective of the weather forecast quality, compared with the central region, the eastern region showed a more obvious effect on the agricultural economic benefits due to its complete meteorological infrastructure, effective system, and comprehensive meteorological services.

**Table 4.** Regional Heterogeneity Test of the Influence of the Weather Forecasting on the Agricultural Economic Benefits.

| | **Column (1)** | **Column (2)** | **Column (3)** |
|---|---|---|---|
| Lnaccurate | 1.321 ***<br>(2.79) | 0.428<br>(0.56) | 0.758 **<br>(2.41) |
| Lnfertile | −0.169 **<br>(−2.06) | 0.331 *<br>(1.95) | 0.276 **<br>(4.01) |
| Lnpgdp | 1.026 ***<br>(6.07) | 0.371 **<br>(2.41) | 0.557 ***<br>(6.74) |
| Edu | 0.419 ***<br>(6.39) | 0.124<br>(0.95) | −0.048<br>(−0.76) |
| lnprecipitation | 0.010<br>(0.22) | 0.066<br>(0.99) | 0.0537<br>(1.16) |
| lnsatisfication | −0.371<br>(−1.15) | 0.845<br>(1.50) | 0.517<br>(2.05) |
| lndecision_making_service | −0.017<br>(−0.90) | −0.038<br>(−0.55) | 0.007<br>(0.81) |

Note: ***, **, * are significant at the level of 1%, 5% and 10%, respectively, and the *t* value is in brackets.

## 5. Discussion

China is a country dominated by agriculture; its agricultural development is inseparable from the influence of weather, and meteorological forecasting services play a pivotal role in agricultural development. This paper used data from 30 provinces in China to verify whether weather forecasting had an impact on agricultural economic performance. Based on the test results, we found that weather forecasting services had a significant positive impact on agricultural economic efficiency. The research results in this paper enrich the research into the effect of meteorological forecasting in the field of agriculture in the context of China and have important theoretical and practical significance.

On the one hand, a review of the existing research showed that Chinese scholars' research into meteorology in the field of agriculture was qualitative research, and there was a need for the rigorous demonstration of the relationship between the two. This paper referred to the method of accounting for the accuracy of meteorological forecasting and forecasting by the China Meteorological Administration, which effectively and accurately calculated the indicators of the meteorological forecasting service, to provide direct evidence of the effect of the meteorological forecasting service on improving the economic efficiency of agriculture at the macro level and make up for the shortcomings of the existing research. On the other hand, it provides an important reference for the Chinese government's scientific decision-making and can strengthen the ability of government departments to cope with the agricultural effects of climate change and the construction of the public service system of agricultural meteorological services. This study prompts China's government departments to actively improve the quality of meteorological services, quantitatively assess the impact of climate change on China's agricultural production, scientifically respond to the long-term climate risks of agricultural production, provide scientific guidance for agricultural development and food production disaster prevention and mitigation, seek benefits, and avoid harms.

## 6. Conclusions and Suggestions

### *6.1. Research Conclusions*

Agriculture is the sector of industry most closely related to the natural environment. Climate change will directly affect the output, results, and industrial layout of crops. Taking 30 provinces in China from 2009 to 2019 as research samples, this paper empirically tested the influence of meteorological forecasting on the agricultural economic benefits by using the fixed-effects model. The results showed that the meteorological forecasting had a significant positive promoting effect on the agricultural economic benefits; specifically, agricultural economic benefits increased 0.500 percentage points for every one percentage point increase in the accuracy of the meteorological forecast. After replacing the explained variables, the measuring methods of the explanatory variables, and the robustness test of reducing the sample interval, the conclusions remained consistent. Further research showed that the economic benefits of the agricultural weather forecasting were different for different regions. The promotion effect of the meteorological forecasting on the agricultural economic benefits in the western region was the strongest, followed by that in the eastern region, and it was the weakest in the central region.

### *6.2. Policy Suggestions*

Based on the research conclusions, this paper puts forward the following policy suggestions to effectively improve the economic benefits of agricultural weather forecasting:

Firstly, China should establish a precise weather forecasting system to enhance the ability of agricultural producers to cope with extreme weather risks. To meet the requirements of agricultural meteorological services and disaster prevention and mitigation, meteorological departments should develop a customized comprehensive observation and early warning system for severe weather to realize automatic, all-directional, and all-weather meteorological environment monitoring and timely and effective release of meteorological early warning information, so as to provide strong data support for crop growth and, most importantly, help agricultural producers to formulate scientific plans for the prevention and control of meteorological and environmental disasters to minimize losses.

Secondly, China should expand the distribution channels of meteorological forecast information and enhance the dissemination of the early warning information of meteorological disasters in rural and agricultural areas to effectively solve the problem of meteorological information dissemination in the "last kilometer", make full use of large LED screens, televisions, and existing power amplifiers and speakers in rural areas, schools, and communities, and timely and accurately release meteorological forecast information to the public through text, voice, and video. In addition, the advantages of APP, WeChat, Weibo and other network new media platforms can also be used to form the synergistic benefits of multisubject communication. With information technology as the core, an intelligent push can be realized, and the coverage of meteorological information can grow geometrically grow, so as to maximize the information to users.

Finally, China should improve the ability to prevent agricultural meteorological disasters. Significant global warming will have a far-reaching impact on agricultural production, which calls for pursuing advantages while avoiding disadvantages.

China should accelerate efforts to expand the coverage of high-risk agricultural meteorological disasters with full agricultural insurance coverage and provide traditional agriculture with accurate insurance coverage and rapid services such as survey, loss determination, and claim settlement, so that agricultural producers can resume production as soon as possible after disasters. In order to enhance the ability and consciousness of agricultural producers to cope with agrometeorological disasters, weather index insurance should be vigorously promoted. Meanwhile, China should increase efforts to promote self-reliance in high-level agricultural science and technology, encourage innovation and development in agricultural science and technology, and strengthen the ability of agricultural products to resist disasters through modern seed production techniques and mechanized farming and other methods to finally achieve steady growth in agricultural output.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

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