Research on the path of agricultural disaster reduction based on the perspective of water conservancy facilities

Li Junpeng; Zhang Yancai; Meng Xianghai
School of Economics and Management, Huaiyin Normal University, Huai'an 223300, Jiangsu

Abstract: The flood and drought disasters have seriously restricted the grain planting in China, and the threat to food security cannot be ignored. Water conservancy facilities can reduce agricultural natural disasters because they can allocate water resources. Therefore, it is of great significance to explore a feasible way to reduce agricultural floods and droughts from the perspective of water conservancy facilities to ensure China's food security. Based on the improvement of capital depreciation rate, capital stock in the base period and investment flow, this paper estimates the capital stock of provincial water conservancy facilities using the Perpetual Inventory Method (PIM), and empirically analyzes the impact of water conservancy facilities on the area affected by agricultural drought and flood disasters using the Spatial Dubin Model (SDM). The research found that: (1) Water conservancy facilities have significantly negative direct impact and spillover effect on the drought affected area and flood affected area, indicating that water conservancy facilities can reduce agricultural flood and drought disasters in this region, and reduce the occurrence of related disasters in other regions. (2) On the time dimension, the direct impact of water conservancy facilities on the affected areas of drought and flood disasters is consistent, and with the increase of supply, its negative spillover effect on the two natural disasters is gradually significant. Based on the research conclusions and the actual situation of China's infrastructure construction and agricultural development, the following policy recommendations are put forward: (1) On the basis of optimizing the investment and construction content, continue to strengthen the supply of water conservancy facilities and enhance the grain production's resistance to floods and droughts; (2) The investment and construction of water conservancy facilities need to achieve coordination and cooperation among regions to improve investment efficiency and utilization rate of water conservancy facilities. (3) Promote the promotion and application of agricultural human capital, water-saving irrigation technology, and improve the disaster reduction effect of water conservancy facilities.

Keywords: water conservancy facilities; Capital stock; Drought; Flood disaster; Spatial Dubin model

Stable and appropriate irrigation water supply is an important guarantee for grain planting. Due to the uneven distribution of water resources in time and space, floods and droughts occur frequently in China, and food production is severely restricted. According to statistics, the yield reduction of food crops caused by drought and flood in 2011-2017 was 122.472 billion kg and 128.856 billion kg respectively. What's more, with the global warming, the frequency and impact of agricultural floods and droughts are increasing. Therefore, it is of great significance to explore ways to deal with agricultural flood and drought disasters and enhance the resistance of grain planting to disasters.

Water conservancy facilities can optimize the temporal and spatial allocation of water resources, improve the timeliness of agricultural water supply and drainage, and reduce agricultural floods and droughts, and many studies have preliminarily proved this:. Chen Huang et al.] evaluated the drought resistance effect of different water conservancy facilities from a more detailed perspective, and pointed out that the drought resistance effect of different water conservancy facilities is significantly different, which indicates that optimizing the supply structure of water conservancy facilities can effectively improve its disaster resistance effect. This view was supported by Sun Liangshun, Zan Mengying and Wang Shuwen. From the perspective of agricultural production, Sun Liangshun and Zan Mengying evaluated the disaster reduction effect of different farmland water conservancy facilities, and found that the disaster reduction effect of large reservoirs on flood and drought disasters was obvious. Wang Shuwen and others proved that the Three Gorges Water Conservancy and Hydropower Project can effectively reduce flood, waterlogging, drought and other flood and drought disasters. (2) At the micro level, Yang Yu and others found that the perfect farmland water conservancy facilities improved the availability of irrigation water for farmers and reduced the drought losses of farmers' wheat. Tang et al., Foudi and Erdlenbruch also found that perfect farmland water conservancy facilities can effectively reduce the disaster losses of farmers through their analysis of farmers in Guanzhong area of China and French farmers. It can be seen from the literature that water conservancy facilities are the key to improve the resistance to agricultural disasters and reduce the adverse effects of floods and droughts on agricultural production.

The above studies verify the inhibition of water conservancy facilities on agricultural flood and drought disasters from different levels, and clarify the necessity of strengthening the construction of water conservancy facilities. However, due to the availability of research indicators and research methods, the existing literature has left the following room for improvement for this study: (1) The above studies did not consider the spatial correlation of water conservancy facilities in disaster reduction. Due to the fluidity of water resources and the relative stability of the quantity in the short term, there may be a spatial spillover effect on the disaster reduction effect of water conservancy facilities. If the spatial correlation of variables is ignored in the econometric model, it may lead to overestimation of variable coefficients, which makes it difficult to accurately estimate the disaster reduction effect of water conservancy facilities; (2) The above studies attribute the disaster reduction effect to a specific water conservancy facility (such as reservoir, ditch, pump well, etc.). However, the water conservancy facilities are a complex system composed of a variety of specific infrastructures, and their normal functioning depends on the integrity of their composition and the coordination and cooperation of specific water conservancy facilities. Therefore, it is difficult to attribute the role of disaster reduction to a specific water conservancy facility. This requires a comprehensive and accurate measurement of the supply level of water conservancy facilities. The capital stock index can effectively aggregate the supply level of specific infrastructure, making it possible to accurately measure water conservancy facilities. At the same time, the spatial econometric model fully considers the spatial correlation of variable impacts, which provides a scientific method for assessing the disaster reduction effect of water conservancy facilities. Therefore, in view of the shortage of existing literature, this paper plans to use capital stock as the proxy indicator of water conservancy facilities to measure the supply level of water conservancy facilities. At the same time, the spatial econometric model is used as an empirical analysis tool to consider the spatial correlation of the impact of water conservancy facilities and analyze the agricultural disaster reduction effect of water conservancy facilities. Based on the above improvements, this study, through quantitative analysis of the important role of water conservancy facilities in agricultural disaster reduction, provides specific and feasible solutions for reducing agricultural flood and drought disasters and enhancing agricultural disaster resistance; By analyzing the impact mechanism of water conservancy facilities and other variables on agricultural flood and drought disasters, they provide a basis for the subsequent construction of water conservancy facilities; Furthermore, this paper introduces the spatial econometric model and corresponding research paradigm into the analysis of the effects of water conservancy facilities on disaster reduction, which can also provide some reference for subsequent related research.

1. Theoretical analysis

The uneven distribution of water resources in time and space has led to an increase in the probability of agricultural floods and droughts. Water conservancy facilities allocate the temporal and spatial distribution of water resources through water supply and drainage, improve the allocation efficiency of water resources, and reduce agricultural floods and droughts. The relevant theories of spatial economics show that the economic phenomena between spatial units do not occur in isolation, but are the results of the interaction between spatial units. Therefore, based on the theory of space economy, the impact of water conservancy facilities on agricultural flood and drought disasters can be subdivided into: (1) the impact of water conservancy facilities on agricultural flood and drought disasters in this region, that is, direct impact; (2) The impact of water conservancy facilities in this region on agricultural flood and drought disasters in other regions, namely spillover effect.

2. Research methods, variable selection and data sources

2.1 Research methods

In view of the fact that the spatial econometric model can fully consider the spatial correlation of variable effects and avoid the overestimation of the coefficients of traditional econometric models, this paper intends to use the spatial econometric model as an empirical analysis tool. Spatial econometric models can be divided into spatial lag model (SLM) and spatial error model (SEM). For specific research, it is necessary to use Lagrange Multiplier (LM) test and robust Lagrange multiplier test to determine which model is applicable to the research object. If at least one of the above two inspections determines that SLM or SEM is applicable, Wald inspection is needed to further determine the applicability of the more inclusive Spatial Durbin Model (SDM)

2.2 Variable selection

According to theoretical analysis and relevant research, the following dependent variables, core independent variables and control variables are selected:

2.3 Dependent variable

This paper focuses on the impact of water conservancy facilities on agricultural drought and flood disasters. According to the availability of data, the affected areas of drought and flood disasters in each province (city/district) are selected as the dependent variables of the model.

2.4 Core arguments

The core independent variable of this study is the supply level of water conservancy facilities in each province (city/district). At present, the commonly used indicators to measure the supply level of infrastructure mainly include physical indicators and stock indicators. As for water conservancy facilities, there are many kinds and different statistical indicators. Specific objects (such as reservoirs, ditches, motor wells, etc.) cannot be directly aggregated, so it is difficult for physical indicators to comprehensively and accurately depict their supply levels. Compared with physical indicators, stock indicators can reflect the supply level of water conservancy facilities more comprehensively and accurately because of their unified measurement standards, wide coverage of information, and the ability to reflect the depreciation of facilities. Therefore, the capital stock of water conservancy facilities in each province (city/district) is used as the proxy indicator of the supply level of water conservancy facilities. In order to enhance the comparability among regions, the capital stock of water conservancy facilities and the area of administrative regions of each province (city/district) are used for reference.

The Perpetual Inventory Method (PIM) is widely used to measure the capital stock due to its simple form and loose requirements on the attributes of accounting data

3. Control variables

The control variables are as follows: (1) planting structure. The water demand of different crops is significantly different during the growth process. The regional crop structure determines its agricultural water supply and demand, and to a certain extent, affects the occurrence of floods and droughts in the region. On the whole, the water demand of economic crops is higher than that of grain crops. This paper specifically uses the proportion of sown area of regional economic crops as the measurement standard [28]. (2) Human capital level. Human capital determines the ability of agricultural labor force allocation and utilization of agricultural production factors, so the improvement of human capital level can enhance agricultural disaster resistance and reduce the probability of agricultural floods and droughts. Referring to the research of Hall, Jones and Li Gucheng, this study uses the Human Capital Augmented labor measurement model to estimate the provincial human capital stock and introduce an empirical model. (3) Environmental protection efforts. Regional environmental protection measures, such as “returning farmland to forests” and “returning farmland to grassland”, can effectively improve the soil water conservation capacity and reduce the occurrence of floods and droughts. Therefore, this paper introduces the strength of regional environmental protection as the control variable, which is expressed by the ratio of the area of regional environmental protection zone to the area of administrative region. (4) Water saving irrigation technology. Water saving irrigation technology can improve the utilization efficiency of water resources, reduce the constraints of water shortage on agricultural production, and reduce the occurrence of agricultural floods and droughts. The research is expressed by the area proportion of water-saving irrigation technology in crop planting area. (5) Agricultural inputs. The increase of agricultural input can promote the input of water supply and drainage elements (such as machinery and labor) and varieties resistant to floods and droughts, and reduce the actual impact of regional agricultural floods and droughts. In order to fully reflect the actual agricultural input, the average agricultural production intermediate consumption per mu is used for expression, and the price index of agricultural means of production is used for reduction. (6) Natural factors. The change of precipitation and temperature is directly related to the regional water conservation, which determines the occurrence of flood and drought disasters to a certain extent. Here, the annual precipitation and annual accumulated temperature of each province (city/district) are used as agents.

In addition, it is necessary to determine the appropriate spatial weight matrix when using spatial econometric model for analysis. In general, the spatial weight matrix is mainly divided into socio-economic feature weight matrix, socio-economic geographic feature weight matrix, and geographic feature weight matrix. The first two matrix elements include the average value of the proportion of a certain socio-economic indicator in a spatial unit in a specific period of time (such as the average GDP proportion and the average population proportion). However, economic characteristics often change over time, and the adoption of its average proportion will lead to serious information loss. Therefore, this paper uses the spatial weight matrix of geographical features. At present, the widely used spatial weight matrix of geographical features mainly includes: spatial adjacent matrix (i.e. 0-1 matrix, adjacent is 1, otherwise it is 0) and spatial distance matrix. Because the spatial adjacent matrix cannot reflect the feature that the spillover effect gradually decreases with the increase of spatial distance, and considering that the spatial distance matrix is more robust to the regression error, this paper specifically uses the spatial distance matrix with the reciprocal square of the distance between spatial elements as the element, and uses the regression results of the spatial adjacent matrix as the robustness test.

4. Conclusion

Avoiding the restriction of flood and drought on grain planting is related to China’s food security. To solve this problem, this study uses the improved perpetual inventory method (PIM) to estimate the capital stock of provincial water conservancy facilities, and uses the spatial Dubin model (SDM) to empirically analyze the impact of water conservancy facilities on the area affected by agricultural drought and flood disasters. The results show that: (1) water conservancy facilities have a significant negative direct impact and spillover effect on drought affected areas, indicating that local water conservancy facilities have a significant inhibitory effect on drought in this region and other regions; (2) Water conservancy facilities have a significant negative impact on the area affected by flood disasters in this region and other regions, indicating that water conservancy facilities can reduce the occurrence of flood disasters through direct impact and spillover effects. The above two findings indicate that water conservancy facilities have significant effects on agricultural disaster reduction; (3) The analysis of time dimension shows that the significant negative direct impact of water conservancy facilities on the affected areas of drought and flood disasters is consistent in time; At the same time, thanks to the improvement of the supply level of water conservancy facilities in China, its impact on the two natural disasters gradually shows a significant negative spillover effect.

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About the author:

Li Junpeng, doctor, lecturer, main research direction is agricultural economic theory and policy

Corresponding author: Meng Xianghai (1983 -), male, doctor, associate professor, master's supervisor, mainly engaged in agricultural economic theory and policy research

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