Strengthening or Weakening: The Impact of an Aging Rural Workforce on Agricultural Economic Resilience in China

Hui Zhang, Jing Li and Tianshu Quan *

Abstract: Rapid population aging has serious implications for socio-economic development and poses considerable challenges to food security and agricultural economic resilience, issues that are not well understood to date. Against the background of the aging agricultural labor force in China, this paper, based on the sample data of 30 provinces in China from 2011 to 2020, constructs a spatial autoregressive model and uses the generalized moment method to measure the development level of agricultural economic resilience in China. Moreover, the GMM model and intermediary effect model are used to empirically analyze the impact of rural labor aging on agricultural economic resilience in China and its role channels. The results show that the aging of China’s rural labor force is on the rise, and the resilience level of China’s agricultural economy is on the decline. The aging of the rural labor force significantly weakened the resilience of the agricultural economy; the aging level of the rural labor force increased by 1 unit, and the resilience of the agricultural economy decreased by 1.085 units. The results of this mechanistic analysis show that the aging of the rural labor force mainly weakens the resilience of the agricultural economy by reducing rural human capital and restraining agricultural scale management and agricultural technology progress. Our heterogeneity analysis shows that the aging of the rural labor force has a stronger inhibitory effect on the resilience of the agricultural economy in western regions, non-grain-producing areas, and areas with low economic development levels. This means that the government should pay attention to the impact of the aging rural labor force on the resilience of the agricultural economy, focusing on solving problems such as low agricultural production efficiency and insufficient rural human capital.

Keywords: the aging rural labor force; agricultural economic resilience; China

1. Introduction

The phenomenon of population aging is an inevitable experience of a country in the process of development and has become a global social phenomenon [1,2]. It has been predicted that by 2050, the world’s elderly population will reach 2.1 billion, accounting for 17% of the world’s population. Aging populations pose a major challenge to the resilience of economies around the world. Population aging puts pressure on the national pension system and retirement policies, and the implementation of these policies can cause national financial difficulties and macroeconomic problems [3]. Moreover, population aging leads to a decrease in the size of the working-age population and a decline in the labor participation rate, which directly affects the future labor shortage and aging, thus affecting the economic and social development of the country [4,5]. As a labor-intensive industry, agriculture is one of the sectors most affected by population aging [6,7]. Faced with increasingly complex external risks and the inherent vulnerability of agriculture, the impact of uncertainty on the development of China’s agricultural economy has significantly intensified [8,9], and China’s agricultural economic resilience has been greatly challenged. However, so far, how aging affects the resilience of the agricultural economy has not been fully studied and deeply discussed. The agricultural industry has made great contributions to ensuring food
security and increasing farmers’ incomes and is an important part of economic growth. Exploring the above issues is of great significance for addressing the aging of the rural labor force, enhancing the resilience of the agricultural economy, and ensuring sustainable agricultural development in China.

What impact will the aging of the rural labor force have on the resilience of the agricultural economy? At present, the academic community has not reached a unanimous conclusion. The existing literature focuses on the effects of rural labor aging on agricultural output, production efficiency, food security, and agricultural modernization, which can be roughly divided into two viewpoints. One category of the literature suggests that the aging of the rural labor force may weaken the resilience of the agricultural economy. Ren et al. [10] found that rural population aging reduced farm size by 4% through a transfer of arable land ownership and land abandonment. Agricultural output and labor productivity declined by 5% and 4%, respectively, seriously inhibiting the sustainable development of agriculture. Akdemir et al. [11] and Ji et al. [12] believed that the aging of rural labor causes producers to reduce their investments in agricultural activities and completely give up production requiring more labor, which seriously restricts the future development of the agricultural sector. Guo et al. [13] found that China’s agriculture is facing the problem of an aging labor force, and agricultural producers may withdraw from agricultural operations, which is a potential threat to the future development of China’s agriculture. Li and Sicular [14] found that the aging of the rural labor force hinders farmers from adopting agricultural technology. When the average age of the family labor force reaches 45 years old, the agricultural production efficiency reaches its peak, and then the efficiency declines [15]. Another category of the literature suggests that the aging of the rural labor force may enhance the resilience of the agricultural economy. The study by Li et al. [16] found that in the long run, the aging of the rural labor force has a significant positive impact on agricultural green total factor productivity. Zou et al. [17] pointed out that elderly farmers are less likely to leave their farmland idle and are more inclined to use it, thus improving the utilization rate of agricultural land. Research by Ciutiene et al. [18] and Maxime et al. [19] suggests that in the early stages of population aging, a higher proportion of middle-aged people will provide a large number of skilled laborers for the agricultural sector and improve the agricultural production efficiency. Ren et al. [20] suggested that land transfer to agricultural enterprises or rural young people can achieve agricultural scale management; furthermore, agricultural production costs can be reduced, and “economies of scale” can be achieved. Park et al. [21] pointed out that the aging of the rural population can induce improvements in agricultural technology and promote the large-scale development of land transfer.

To sum up, the current research conclusions on the relationship between rural labor aging and agricultural economic development have not been unified, and prior studies have primarily examined this area from the perspective of agricultural production efficiency and high-quality agricultural development, ignoring the discussion on the resilience of the agricultural economy. Agricultural resilience refers to the ability of agricultural systems to resist and recover from external shocks through adaptive structural adjustments to achieve the transition to new growth paths and pursue sustainable development [22]. In the context of China’s increasingly serious aging problem, enhancing agricultural resilience has become increasingly important in agricultural modernization, which can not only ensure the stable and healthy development of agriculture but also inject a strong impetus into the formation of a new growth path for China in the new development stage. Based on this, the innovation of this study lies in exploring the impact of the aging rural labor force in China on the resilience of China’s agricultural economy for the first time. The marginal contribution of this paper is as follows: (1) it is helpful to understand the development status of China’s agricultural economic resilience by constructing a spatial autoregressive model and using the generalized moment method to estimate the resilience of China’s agricultural economy; (2) we analyze the impact of rural labor aging on the resilience of the agricultural economy, fill the research gap in this field, and provide a new perspective to further
reduce the negative impact of rural labor aging; and (3) based on the theoretical analysis framework, this paper empirically analyzes the impact of rural labor aging on the resilience of the agricultural economy from the perspectives of rural human capital, agricultural technology progress, and agricultural scale management, and we offer actionable policy recommendations for improving the resilience of China’s agricultural economy and coping with the aging of the rural labor force.

2. Theoretical Framework and Research Hypothesis

The influence of rural labor aging on the resilience of the agricultural economy is multifaceted. Due to the increasingly serious problem of population aging, there is land abandonment and farmland return and abandonment in some areas, and human capital in rural areas has decreased [23]. This results in low labor productivity [24,25], reduces farmers’ technology adoption behavior [15,26], and threatens the resilience of the agricultural economy.

First, the human capital theory points out that aging will first have a significant negative impact on the accumulation of rural human capital, and the elderly labor force will reduce human capital investment due to the lack of investment incentives. The direct result is that the number and proportion of the working-age labor force participating in agricultural production will decline. Furthermore, aging farmers are at a significant disadvantage in terms of health, physical strength, and labor intensity. The decline in the quality of the agricultural labor force will directly affect the labor input and level of intensive cultivation of grain planting, which is not conducive to agricultural production. At the same time, the education level of aging farmers is generally low, and low rural human capital often results in conservative attitudes towards new technologies and skills, which causes significant obstacles to the promotion of new agricultural technologies, the use of agricultural machinery, and the popularization and promotion of new organizational models. This, in turn, is not conducive to the improvement of technological progress and the resilience of the agricultural economy. In addition, when high-quality rural labor forces are reduced and the level of agricultural technology is low, some rural residents will abandon land far from their families. This land will return to tillng or abandonment, leading to a decrease in the amount of cultivated land. When the labor input is insufficient to support all the contracted land, land with poor agricultural resource endowments, such as low fertility, remote transportation needs, and difficult irrigation, will withdraw from agricultural production, further negatively impacting food security and agricultural resilience. The theoretical framework is shown in Figure 1. Based on this, we propose the following hypothesis:

Hypothesis 1: The aging of the rural labor force can weaken the resilience of the agricultural economy.

Hypothesis 2: Rural labor aging weakens agricultural economic resilience by reducing rural human capital, inhibiting agricultural technological progress and agricultural scale management.
3. Methodology and Data

3.1. Methodology

In this study, a two-way fixed-effect model was used to assess the impact of rural labor aging on agricultural economic resilience. Considering that the current values may be influenced by their past values and have dynamic effects, a first-order lag term was added to the model, which was set as a dynamic panel regression model and analyzed using the GMM (generalized method of moment) model. The measurement model was constructed as follows:

\[ \text{Aer}_{it} = \beta_0 + \beta_1 \text{Aging}_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \]  

where \( \text{Aer}_{it} \) is the resilience level of the agricultural economy in region \( i \) during the period \( t \), \( \text{Aging}_{it} \) is the aging level of the rural labor force in region \( i \) during the period \( t \), \( X_{it} \) represents a series of relevant control variables, \( \gamma_i \) represents the individual fixed effect of region \( i \), \( \mu_t \) represents the time fixed effect, and \( \varepsilon_{it} \) represents a random disturbance term. In order to explore the effect of rural labor aging on agricultural economic resilience through rural human capital, agricultural technology innovation, and agricultural scale management, this paper adopts the intermediary effect model to test its mechanism, as shown in Equation (1):

\[ \text{M}_{it} = \beta_0 + \beta_1 \text{Aging}_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \]  

\[ \text{Aer}_{it} = \beta_0 + \beta_1 \text{Aging}_{it} + \beta_2 \text{M}_{it} + \beta_3 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \]  

The explained variable \( \text{M}_{it} \) represents the intermediary variable of this paper, which represents rural human capital, agricultural technological innovation, and agricultural scale management. The remaining variables are the same as in the benchmark model.

3.2. Data and Variables

This study selected 30 provincial-level administrative regions in China, excluding the Tibet Autonomous Region, Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan Province, as samples. Due to the long agricultural production cycle, there is a certain time lag in the process of converting input into output. The output index lags behind the input index by one year; that is, the input index data from 2011 to 2020 correspond to the output index data from 2012 to 2021. The data are from the China Rural Statistical Yearbook, China Statistical Yearbook, China Agricultural Statistical Yearbook, Provincial Statistical Yearbook, and the Department of Trade of the Ministry of Commerce of China.

This article selected agricultural economic resilience (AER) as the dependent variable. Economic resilience refers to the ability of an economy to effectively cope with internal and external disturbances, resist shocks, and achieve sustainable economic development by adjusting its economic structure and growth mode. It is the key to determining whether an economy will “successfully recover and achieve steady economic growth again” or “enter the downward economic trajectory” after being hit by shocks [27,28]. The academic community has not yet formed a unified method system on how to measure economic resilience. Most of the existing literature uses a comprehensive index system to assess national economic resilience, but this method struggles to avoid the problem of cause–effect confusion. Martin [29] proposed that economic resilience can be measured by observing the difference between the real growth path of major economic variables (such as output, employment, etc.) and the counterfactual growth path without shocks. However, from the perspective of industry, it is difficult to fully depict the important connotation of industrial structure adjustment from the perspective of resilience by considering only the unilateral growth difference of output or employment. China’s National Bureau of Statistics has pointed out that labor productivity is a landmark indicator to determine whether a country’s economy has future growth. At the same time, the adjustment of industrial structure is accompanied by the optimal allocation of factor input, and changes in labor factor input structures will lead to changes in productivity. Therefore, labor
productivity can directly reflect the degree of structural adjustment and optimization, as well as upgrades to regional agricultural economies. Using the difference between the real growth path and the counterfactual growth path of agricultural labor productivity to measure agricultural economic resilience is more in line with the theoretical connotation of adaptive resilience.

The first step in measuring the resilience of the agricultural economy is to predict and simulate the counterfactual labor productivity of agriculture without the impact of the external environment. Referring to the research method of Doran and Fingleton [30], this paper regards the 2008 international financial crisis as a major exogenous economic shock, regards the growth rate of China’s actual agricultural output as the counterfactual output growth rate of agricultural output in different regions without the impact of the financial crisis, and predicts the counterfactual output of agricultural output in different regions. Based on the Dixon–Thirlwal circular causality model, the regression equation between agricultural output and employment was constructed by the static Vanden’s Law, and GMM (generalized method of moment) estimation was carried out. Counterfactual employment without a financial crisis was predicted according to the estimated results. Then, we further divided the counterfactual output of manufacturing by counterfactual employment to obtain the counterfactual labor productivity. Finally, agricultural economic resilience was measured by the difference between the real growth path and the counterfactual growth path of labor productivity. The specific methods are as follows.

First, Vanden’s law points out that under the assumption of increasing returns to scale, there is a positive correlation between the growth rate of agricultural labor productivity and the growth rate of the output. Therefore, the following equation can be established:

\[ p = a + by \] (4)

where \( p \) represents the growth rate of agricultural labor productivity, \( y \) is the growth rate of agricultural output, and \( a \) is a constant term. Second, on the basis of the ordinary least squares (OLS) estimation method, the agricultural labor productivity growth rate can be defined as the output growth rate \( (y) \) minus the employment growth rate \( (e) \), so Equation (4) can be rewritten as

\[ y - e = a + by \] (5)

Equation (5) can be obtained after transferring some terms, as follows:

\[ e = -a + (1 - b)y \] (6)

Since Vanden’s Law is regarded as a specification of the equation of linear technological progress, Equation (6) can be further transformed into

\[ \ln E = -a + (1 - b)y \] (7)

Equation (7) is usually defined as the static Vanden’s law, where, \( E \) represents the employment level of the manufacturing industry, and \( Y \) represents the level of manufacturing output. On this basis, considering the spatial interaction between agricultural industry employment in neighboring regions and agricultural industry employment in the local region and further introducing the lag term of agricultural industry employment in the local region, the following spatial autoregressive model can be established:

\[ \ln E_t = \alpha_1 + \rho W \ln E_t + \gamma \ln E_{t-1} + \beta \ln Y_t + \epsilon_t \] (8)

Here, \( E_t \) is the level of agricultural employment industry in period \( t \); \( Y_t \) is the agricultural output level of period \( t \). \( E_{t-1} \) is the employment level of the \( t - 1 \) manufacturing industry. \( W \ln E_t \) is a spatial lag term for manufacturing employment in neighboring areas; \( \epsilon_t \) is a random error term. Finally, taking the actual agricultural output of China in 2007 as the starting point, the growth rate of China’s actual agricultural output was regarded as
the counterfactual output growth rate of agriculture in each region, and the counterfactual output of agriculture in each region was calculated. The agricultural counterfactual employment in each region was calculated based on the agricultural counterfactual output obtained for each region. The counterfactual labor productivity was obtained by dividing the agricultural counterfactual output by the counterfactual employment in each region.

Martin and Sunley [31] pointed out that the adaptive structural adjustments of the regional economy will change the potential growth rate of output or employment. Based on this, the standard to measure the resilience of a regional economy is whether the maximum potential growth rate that an economy can achieve is higher than the counterfactual potential growth rate when it is not affected by the external environment. Therefore, this paper calculates the actual potential growth rate and counterfactual potential growth rate based on the actual growth rate and counterfactual growth rate of labor productivity in the agricultural sector by the HP filtering method and takes the gap value of the two as the resilience level of the agricultural economy. If this value is positive, it means that the actual potential growth rate of labor productivity in the agricultural sector is higher than the counterfactual potential growth rate, which means that, compared with the whole country, agriculture in the region shows better growth vitality and relatively higher resilience; that is, the agricultural economy in the region is resilient. On this basis, if the resilience value continues to increase, it indicates that the region can make timely adaptive structural adjustments according to changes in the external environment and enter a more optimized development path, thus obtaining the resilience of sustainable growth [32,33].

The independent variable of this paper is the Aging rate of the rural labor force (Aging). Considering that Chinese rural residents work for a long time, the aging rate of the rural labor force is represented by the proportion of the rural elderly population aged 65 and above in the total rural population according to the study by Ren et al. [10].

The mediating variables selected in this article are rural human capital, agricultural scale management and agricultural technological innovation. Among them, following the practice of Ahsan and Haque [34], the average years of schooling method are used to express the human capital level (Edu). The specific practice is that the rural human capital level = 2 × (illiterate and semi-literate rural population proportion) + 6 × primary school education rural population proportion + 9 × junior high school education rural population proportion + 12 × senior high school education rural population proportion + 16 × college and post-secondary education rural population proportion. According to the study by Cao et al. [35], agricultural scale management (Scale) is expressed by the ratio of the sown area of food crops to the number of agricultural employees. According to the study by Tan et al. [36], agricultural technological innovation is represented by the logarithm of the number of agricultural industry patents.

The control variables in this article mainly include Disaster, Industry, Urban, Gdp, Trade, and Funds. We measured agricultural natural disasters (Disaster) by the ratio of the affected area at the end of the year to the total sown area of crops in the year. We chose to represent the degree of industrialization (Industry) by the ratio of industrial added value to the gross regional product. We defined the urbanization level (Urban) as the proportion of the urban population to the total population. The economic development level (Gdp) was measured according to the logarithm of the per capita gdp of each province. The degree of dependence on foreign trade of agricultural products (Trade) was defined as the ratio of the total imports and exports of agricultural products to the gross agricultural product. The financial input necessary to support agriculture (Fund) was expressed by the proportion of the financial expenditure to the total financial expenditure of the sample provinces. Descriptive statistics are shown in Table 1.
Table 1. Descriptive statistics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aer</td>
<td>300</td>
<td>0.009</td>
<td>0.058</td>
<td>−0.289</td>
<td>0.230</td>
</tr>
<tr>
<td>Aging</td>
<td>300</td>
<td>0.105</td>
<td>0.024</td>
<td>0.055</td>
<td>0.176</td>
</tr>
<tr>
<td>Edu</td>
<td>300</td>
<td>7.041</td>
<td>0.473</td>
<td>0.846</td>
<td>9.559</td>
</tr>
<tr>
<td>Scale</td>
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<td>7.416</td>
<td>3.754</td>
<td>2.089</td>
<td>27.714</td>
</tr>
<tr>
<td>Innovate</td>
<td>300</td>
<td>5.212</td>
<td>0.534</td>
<td>2.747</td>
<td>8.481</td>
</tr>
<tr>
<td>Disaster</td>
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<td>0.150</td>
<td>0.116</td>
<td>0</td>
<td>0.695</td>
</tr>
<tr>
<td>Industry</td>
<td>300</td>
<td>0.355</td>
<td>0.087</td>
<td>0.097</td>
<td>0.530</td>
</tr>
<tr>
<td>Urban</td>
<td>300</td>
<td>0.590</td>
<td>0.122</td>
<td>0.350</td>
<td>0.896</td>
</tr>
<tr>
<td>Gdp</td>
<td>300</td>
<td>2.194</td>
<td>2.481</td>
<td>0.027</td>
<td>10.349</td>
</tr>
<tr>
<td>Trade</td>
<td>300</td>
<td>0.127</td>
<td>0.190</td>
<td>0.005</td>
<td>1.033</td>
</tr>
<tr>
<td>Fund</td>
<td>300</td>
<td>11.455</td>
<td>3.284</td>
<td>4.109</td>
<td>20.384</td>
</tr>
</tbody>
</table>

4. Empirical Findings

4.1. The Attributes of the Aging of Rural Labor Force and the Resilience of Agricultural Economy in China

First, the temporal and spatial trends of the aging level of China’s rural labor force from 2011 to 2020 are shown in Figure 2a–d. Figure 2a–d shows the spatial distribution of the aging level of China’s rural labor force in 2011, 2014, 2017, and 2020, respectively. It can be seen that in 2011, the level of aging of China’s rural labor force was relatively low; the age of China’s rural labor force continued to rise from 2014 to 2020, with the highest concentration in the central region and the lowest concentration in the north and south. Second, the spatial-temporal change trend of China’s agricultural resilience from 2011 to 2020 is shown in Figure 3a–d. Figure 3a–d shows the spatial distribution of rural resilience in China in 2011, 2014, 2017, and 2020, respectively. It can be seen that in 2011, China’s agricultural resilience level was relatively high; over time, the level of agricultural resilience gradually declined, and now, the distribution is low in the east and high in the middle and west. The possible reason for this is that a large amount of the young labor force from the agricultural sector has transferred to cities and towns, resulting in a large number of left-behind elderly people in the rural population, which intensifies the aging of the rural labor force.

Finally, as shown in Figure 4, which depicts the core density diagram of the aging of China’s rural labor force and agricultural resilience during 2011–2020, the peak of the aging level of China’s rural labor force in 2011 was around 10%, and with time, the peak gradually moved to the right and gradually decreased, indicating that the degree of aging in China is becoming increasingly serious. The gap in aging between regions is widening gradually. In 2011, the development level of China’s agricultural resilience was relatively concentrated, with small differences among different regions. With time, the gap between regions has gradually widened, and agricultural resilience shows a trend of first strengthening and then weakening with time. In 2020, the peak resilience of China’s agricultural economy was concentrated at −0.1, indicating that the resilience of China’s agricultural economy is under serious threat. Moreover, the development gap in agricultural resilience between regions is increasing. The aging crisis in China’s rural labor force is due to a combination of factors, including population structure adjustment, increased life expectancy, and decreased fertility rates [37].
Figure 2. Represent Spatial distribution of the aging rate of China’s rural labor force in 2011 (a), 2014 (b), 2017 (c), and 2020 (d).

Figure 3. Cont.
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Figure 3. Represent spatial distribution of agricultural resilience in China in 2011 (a), 2014 (b), 2017 (c), and 2020 (d).

Figure 4. Nuclear density map of rural labor aging and agricultural resilience in China from 2011 to 2020.

4.2. Baseline Regression Results

Since traditional regression may have endogeneity problems caused by missing variables and two-way causality, this paper included the lag period as an explanatory variable in the model and tested the robustness of the estimation results using the GMM model for the dynamic panel. AR and Hansen’s test results indicate that the system GMM estimation results in this paper are reliable. The results are shown in Table 2. Column (1) does not include any control variables, and the coefficient of the aging of the rural labor force affecting the resilience of the agricultural economy is negative; after the addition of control variables to column (6), the coefficient is −1.085 and significantly positive. This finding confirms hypothesis 1a, which predicts that the aging of rural labor significantly weakens the resilience of China’s agricultural economy. Further, by observing the coefficients of the control variables, we can find that the impact of agricultural natural disasters on the resilience of the agricultural economy is not significant. The degree of industrialization, the level of economic development, the degree of dependence on foreign trade of agricultural products, and the financial input to support agriculture all significantly contribute to improving the green development of agriculture, while the level of urbanization has significantly weakened the resilience of the agricultural economy.
Table 2. Results of baseline regression.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Aer</th>
<th>(2) Aer</th>
<th>(3) Aer</th>
<th>(4) Aer</th>
<th>(5) Aer</th>
<th>(6) Aer</th>
</tr>
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<tbody>
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<td>Aging</td>
<td>−1.753 ***</td>
<td>−1.659 ***</td>
<td>−1.481 ***</td>
<td>−1.242 **</td>
<td>−0.115 ***</td>
<td>−1.085 ***</td>
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<tr>
<td></td>
<td>(0.125)</td>
<td>(0.241)</td>
<td>(0.159)</td>
<td>(0.503)</td>
<td>(0.039)</td>
<td>(0.226)</td>
</tr>
<tr>
<td>Disaster</td>
<td>−0.301</td>
<td>−0.213 ***</td>
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<td>−0.089</td>
<td>−0.209</td>
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</tr>
<tr>
<td></td>
<td>(0.291)</td>
<td>(0.019)</td>
<td>(0.138)</td>
<td>(0.101)</td>
<td>(0.196)</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>0.163 ***</td>
<td>0.245 ***</td>
<td>0.317 ***</td>
<td>0.298 ***</td>
<td>0.200 ***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.019)</td>
<td>(0.021)</td>
<td>(0.059)</td>
<td>(0.005)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>−0.261</td>
<td>−0.237</td>
<td>−0.111 **</td>
<td>−0.365 **</td>
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<tr>
<td></td>
<td>(0.211)</td>
<td>(0.215)</td>
<td>(0.052)</td>
<td>(0.128)</td>
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<td>Gdp</td>
<td>0.143 ***</td>
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<td>0.010 ***</td>
<td>0.010 ***</td>
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<td>(0.021)</td>
<td>(0.001)</td>
<td>(0.002)</td>
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<td>(0.012)</td>
<td>(0.057)</td>
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<tr>
<td>Fund</td>
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<td>0.001</td>
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<tr>
<td>L.Aer</td>
<td>0.041 **</td>
<td>0.088 **</td>
<td>0.078 ***</td>
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<td>(0.006)</td>
<td>(0.011)</td>
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<td>AR (2)</td>
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<td>0.736</td>
<td>0.332</td>
<td>0.643</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

Note: ** and *** indicate passing the test at significance levels of 5% and 1%, respectively. The numbers in parentheses are robust standard errors.

4.3. The Underlying Mechanism

To explore whether the aging of the rural labor force weakens the resilience of agricultural economy through the reduction of rural human capital, this study further introduces the intermediary effect model, and the regression results are shown in Table 3. The results in column (1) show that the aging of the rural labor force significantly reduces the level of rural human capital, and the reduction of rural human capital directly affects the improvement of agricultural production efficiency. It is not conducive to the improvement of agricultural technological innovation and agricultural toughness. Therefore, we argue that rural labor aging weakens agricultural economic resilience by reducing rural human capital. In addition, some studies have pointed out that the shortage of an effective labor force brought about by the aging of the rural labor force will force agricultural production to adopt new production factors and new production technologies, while the reduction of the labor force will promote agricultural scale management to hedge the negative impact of aging and thus enhance the resilience of the agricultural economy. Based on this, this study further introduces the mediation effect model, takes agricultural technology innovation and agricultural scale management as the intermediary variables, and explores the mediating role of agricultural technology innovation and agricultural scale management in the influence of rural labor aging on agricultural economic resilience. The regression results are shown in columns (2) and (3). The aging of the rural labor force has a significantly negative impact on both agricultural scale management and agricultural technology innovation, indicating that the aging of the rural labor force does not reverse the progress of agricultural production technology and scale management but inhibits the progress of agricultural scale management and agricultural technology. Therefore, we believe that the aging of the rural labor force weakens the resilience of the agricultural economy by reducing rural human capital and inhibiting agricultural scale management and agricultural technological progress. The theoretical results are shown in Figure 5.
Table 3. The underlying mechanism.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Edu</th>
<th>(2) Aer</th>
<th>(3) Scale</th>
<th>(4) Aer</th>
<th>(5) Innovate</th>
<th>(6) Aer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aging</td>
<td>−0.371 ***&lt;br&gt;(0.016)</td>
<td>−1.142 **&lt;br&gt;(0.439)</td>
<td>−1.212 **&lt;br&gt;(0.582)</td>
<td>−0.103 **&lt;br&gt;(0.051)</td>
<td>−0.419 ***&lt;br&gt;(0.012)</td>
<td>−0.939 ***&lt;br&gt;(0.031)</td>
</tr>
<tr>
<td>Edu</td>
<td>0.382 ***&lt;br&gt;(0.032)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td></td>
<td>0.012 ***&lt;br&gt;(0.003)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** and *** indicate passing the test at significance levels of 5% and 1%, respectively. The numbers in parentheses are robust standard errors.

Figure 5. The underlying mechanism.

4.4. Robustness Test

(1) Considering that there may still be an endogeneity problem between the aging of the rural labor force and the resilience of the agricultural economy, the two-stage least squares test, which takes the aging of the rural labor force with a lag of one stage as an instrumental variable, was considered to investigate the endogeneity problem among the variables. First, the Durbin–Wu–Hausman test was selected, and the results show that after controlling the relevant variables, \( p = 0.000 \). This shows that the influence of rural aging on the resilience of the agricultural economy is endogenous. Secondly, in the weak instrumental variable test, an F statistic > 10 indicates that the selected instrumental variable is qualified. Finally, the test results in Table 4 show that after controlling the province-fixed effect, time-fixed effect, and relevant control variables, there is no significant difference from the original regression results, and it is significant at the significance level of 1%. This shows that after solving the endogeneity problem, the aging of the rural labor force significantly weakens the resilience of the agricultural economy. When the aging of the rural labor force increases by 1 percentage point, the resilience level of the agricultural economy decreases by 1.041%.

(2) Due to the large differences in the degree of rural labor aging and the level of agricultural economic resilience among different provinces in China, there may be some extreme values in the samples, which may cause bias in the empirical results. Therefore, the main variables involved in the model were further curtailed at the level of 1% and 99%, and the extreme values were eliminated. The regression results show that after controlling the relevant variables, the coefficient is significantly negative at the significance level of 1%, indicating that the aging of the rural labor force signifi-
sically weakens the resilience of the agricultural economy after solving the extreme value problem.

(3) Considering that the agricultural economic resilience and control variables may have reverse effects, to avoid endogenous effects, all control variables were delayed by one stage and then returned to regression. The regression results were consistent with the benchmark regression coefficient and were significant. The test results showed that the baseline regression results were robust.

(4) Since some countries or regions define an aged population as the population aged 60 years and above, this study further defined the age of rural labor aging as the population aged 60 years and above and conducted a robustness test. The regression results show that the aging of the rural labor force significantly weakens the resilience of the agricultural economy.

Table 4. Robustness test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Instrumental Variable Method</th>
<th>(2) Regression after Tail Reduction</th>
<th>(3) Lagging Control Variable of Phase 1</th>
<th>(4) Replace the Explanatory Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aging</td>
<td>−1.041 *** (0.026)</td>
<td>−1.418 *** (0.045)</td>
<td>−1.022 *** (0.024)</td>
<td>−1.319 *** (0.035)</td>
</tr>
<tr>
<td>Control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Province</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

Note: *** indicate passing the test at significance levels of 1%. The numbers in parentheses are robust standard errors.

4.5. Heterogeneity Analysis

(1) We first examined regional heterogeneity. Considering the differences in the level of agricultural economic development in eastern, central, and western China, the impact of rural labor aging on the resilience of the agricultural economy may be due to locational heterogeneity. Based on this, this paper divides the research samples into three groups: the eastern region, central region, and western region, according to their different geographical locations and natural attributes. The specific regression results are shown in Table 5. The aging of the rural labor force has a significant impact on the resilience of the agricultural economy in the eastern, central, and western regions, among which the inhibitory effect on the western region is greater. The possible reason may be because, in the western region, agricultural production is relatively backward, and thus, agricultural economic development is more fragile. The eastern region has a higher level of economic development and a more complete agricultural industrial structure system. Under the background of an aging rural labor force, agricultural production and operations in the eastern region are better at using scale management and technological innovation to improve the resilience of the agricultural economy, so the inhibitory effect there is relatively low.

(2) We next examined production structure heterogeneity. Considering that agricultural production structures in different provinces face different degrees of economic resilience, this paper conducted a sub-sample regression analysis of agricultural economic resilience according to the two major grain-producing areas designated by the Ministry of Finance in 2003 (the 13 major grain-producing areas are Heilongjiang, Henan, Shandong, Sichuan, Jiangsu, Hebei, Jilin, Anhui, Hunan, Hebei, Inner Mongolia, Jiangxi, and Liaoning provinces) and 17 non-grain-producing areas. The results show that the aging of the rural labor force has a more significant inhibitory effect on the agricultural economic resilience of non-grain-producing areas than non-grain-producing areas. The possible reason for this is that the agricultural scale management level and the degree of agricultural mechanization in the major grain-producing areas are higher, and the implementation of reform makes it easier to adopt technology in
agricultural production in the major grain-producing areas, which is conducive to improving agricultural economic resilience.

(3) We finally investigated heterogeneity at the level of economic development. Due to the large differences in the level of economic development among different regions in China, generally speaking, economically developed regions have more reasonable industrial structures and higher agricultural technology levels, and agriculture has stronger economic resilience in the face of the threat of rural aging. Therefore, this study further divided the samples equally according to their level of economic development. The samples were divided into regions with high levels of economic development and regions with low levels of economic development. The regression structure is shown in (6) and (7). The aging of the rural labor force significantly enhances the resilience of the agricultural economy in areas with high economic development levels, indicating that the aging of the rural labor force enhances the agricultural scale management and technological progress in areas with high economic development levels. The aging of the rural labor force has a more significant inhibitory effect on the resilience of the agricultural economy in areas with low economic development levels.

Table 5. Heterogeneity analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Eastern</th>
<th>(2) Central</th>
<th>(3) Western</th>
<th>Grain-Producing Area</th>
<th>(4) Major</th>
<th>(5) Non-Major</th>
<th>Economic Development</th>
<th>(6) High</th>
<th>(7) Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aging</td>
<td>−0.237 ***</td>
<td>−0.934 ***</td>
<td>−1.311 ***</td>
<td>−0.031 *</td>
<td>−1.013 ***</td>
<td>0.341 **</td>
<td>−1.491 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.015)</td>
<td>(0.010)</td>
<td>(0.019)</td>
<td>(0.008)</td>
<td>(0.148)</td>
<td>(0.038)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Province</td>
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<tr>
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<td>80</td>
<td>110</td>
<td>130</td>
<td>170</td>
<td>150</td>
<td>150</td>
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<td></td>
</tr>
</tbody>
</table>

Note: *, ** and *** indicate passing the test at significance levels of 10%, 5%, and 1%, respectively. The numbers in parentheses are robust standard errors.

4.6. Discussion

Previous scholars mainly studied the impact of rural labor aging on the agricultural sector from the perspectives of sustainable agricultural development, high-quality agricultural development, and green agricultural development. China’s agricultural sector itself is inherently vulnerable to natural disasters and other risks, and China’s increasingly aging population has greatly challenged the resilience of the agricultural economy. Therefore, this paper innovatively explored the impact of the aging rural labor force on the agricultural sector from the perspective of agricultural economic resilience. Specifically, we found that the aging of China’s rural labor force significantly weakens the resilience of the agricultural economy, and the potential mechanism by which this occurs is the reduction in the human capital of the rural labor force and the inhibition of agricultural technological innovation and scale management. Our findings are in line with those of other scholars, including Ren et al. [10], who identified a reduction in the scale of the agricultural economy due to the aging of China’s rural labor force, resulting in a 5% and 4% decrease in agricultural production output and labor productivity, respectively. Liu et al. [4] found that the aging of the agricultural population had a significant inhibitory effect on the risk resistance of labor-intensive agricultural production. Li and Sicural [14] also found that the aging of the rural labor force threatened the technical efficiency of agricultural production and further inhibited the development of agriculture. Huang et al. [15] and Szabo et al. [26] found that the aging of rural labor poses a threat to agricultural economic resilience by reducing farmers’ technology adoption behavior. In addition, different from other scholars’ research on the development trend of an aging society and economic resilience in China as a whole [16,32], we discussed the development level and spatial distribution of rural labor force aging and agricultural economic resilience from the perspective of the agricultural sector. We found that the aging of China’s rural labor force showed an increasing trend.
year by year, and the resilience of China’s agriculture showed a decreasing trend. The increasing aging and the declining resilience of the agricultural economy have seriously affected the development of China’s agricultural sector.

The main reason for our inconsistency with other scholars’ research conclusions is that our research perspectives are different. Other scholars who conducted their studies from the perspective of agricultural green development believe that aging will prompt a surplus labor force to adopt green technology to promote agricultural green development [16]. Zou et al. [17] and Ciutiene et al. [18] utilized the perspective of agricultural production efficiency and found that a higher proportion of middle-aged people will provide a large number of skilled laborers for the agricultural sector, improving agricultural production efficiency. Moreover, the data used are different. The time sample studied by Ciutiene et al. [18] and Maxime et al. [19] is the early stage of aging, so these authors concluded that a high proportion of middle-aged people in the early stage of aging would provide a large number of skilled laborers for the agricultural sector and improve the efficiency of agricultural production. However, we used the latest data to consider the aging of the rural labor force and the development status of agricultural economic resilience in China. In this way, this study fills the previous gap and completes the study on agricultural economic resilience.

5. Conclusions and Policy Recommendations

Based on the sample data from 30 provinces in China from 2011 to 2020, this paper constructs a spatial autoregressive model and uses the generalized moment method to measure the development level of agricultural economic resilience in various provinces in China from 2011 to 2020. The aging of China’s rural labor force is on the rise, and the resilience of China’s agricultural economy is on the decline. In addition, our research using the GMM model has found that the results of mechanistic analyses show that the aging of the rural labor force weakens the resilience of the agricultural economy mainly by reducing rural human capital and inhibiting agricultural scale management and agricultural technological progress. Furthermore, our heterogeneity analysis shows that the aging of the rural labor force has a stronger inhibitory effect on the resilience of the agricultural economy in the western region, non-grain-producing areas, and areas with low economic development levels.

Based on our findings, the policy recommendations are as follows.

First, moderate-scale agriculture should be developed. The government should guide the orderly transfer of rural land management rights, establish a healthy land transfer mechanism, take the lead in introducing agricultural enterprises, and encourage returnees to set up family farms and cooperatives, in which farmers participate in the form of land leases or shares. Second, we must raise the level of agricultural mechanization. When the government subsidizes the purchase of agricultural machinery, it should tilt the subsidy to large- and medium-sized agricultural machinery and equipment. In addition, the policy should be more inclined toward farmers with lower incomes, improve the ability to purchase agricultural machinery, and improve the level of rural mechanization. Third, we should cultivate a new type of professional farmers. Local governments should attract talented people. In order to build a new professional farmer team, we must encourage, guide, reward, and apply other policies to encourage outstanding talents to take the initiative to join the grassroots construction team and improve the quality and quantity of the new professional farmer team at the grassroots. Fourth, we must protect the quality of cultivated land. On the one hand, it is necessary to strengthen the training of cultivated land operators on the awareness of cultivated land protection and the scientific use of fertilizers and pesticides, and relevant government departments should arrange financial support for this. On the other hand, we must promote the use of biofertilizers. Biofertilizers have the ability to improve soil effort, promote crop growth, improve the quality of agricultural products, and maintain soil fertility to achieve sustainable land use.
However, this study also has some limitations. Firstly, in terms of data selection, this study used macro data from 30 provinces in China. Further research is needed to determine whether the aging of the rural labor force has affected micro-level agricultural economic resilience, such as farmer behavior and agricultural production. Secondly, regarding the method of measuring agricultural economic resilience, subsequent research can use a multifaceted and multi-level indicator system in order to expect better research results.

**Author Contributions:** Conceptualization, J.L., H.Z. and T.Q.; methodology, J.L. and T.Q.; software, J.L.; validation, J.L. and T.Q.; formal analysis, J.L.; resources, J.L. and T.Q.; data curation, J.L. and T.Q.; writing—original draft preparation, J.L., T.Q. and H.Z.; writing—review and editing, J.L., T.Q. and H.Z.; visualization, J.L.; supervision, T.Q.; project administration, H.Z.; funding acquisition, H.Z. All authors have read and agreed to the published version of the manuscript.

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