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Analysis of the Club Convergence and Driving Factors of China's Green Agricultural Development Levels

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Abstract: Green agricultural development opens up a feasible way for China to construct sustainable communities and promote rural revitalization strategies. However, a clear gap on the subject sets apart various regions in China, resulting in off-balance development. This paper, based on the panel data from 31 provinces (municipalities and autonomous regions) in China from 2013 to 2020, established an evaluation index system for China's green agricultural development levels, measured the green agricultural development in different regions, and applied the log(t) model, the Ordered Probit model, and the Ordered Logit model to identify convergence trends and causes of China's green agricultural development level club convergence, respectively. Our research found the following: (1) The green agricultural development levels in various regions in China are on the rise, and regional gaps are still significant. The output of green agricultural products is the focus of various regions in promoting green agricultural development. (2) The green agricultural development levels in China's 31 provinces (municipalities and autonomous regions) have converged to four clubs. China is gradually forming a convergence pattern of green agricultural development levels, with the main agricultural production areas as the core. (3) The regional gap at the level of environmental regulation for green agricultural development first narrows, then expands, and then narrows. The intensity of environmental regulation in most areas is in the first stage. This indicates that China should continue to maintain the current intensity and promote green agricultural development levels to converge towards high-level clubs. In addition, the GDP, grain production area, fiscal support for agriculture, and rural human capital can narrow the gaps in green agricultural development levels between regions.

Keywords: green agricultural development level; club convergence; environmental regulation; green agricultural transformation

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1. Introduction

Green agricultural development, a path of great significance for China to build sustainable communities, is an inevitable choice for implementing rural revitalization strategies. Traditional agricultural production that over-depends on chemical agents has led to increased pressure on the environment and the excessive consumption of resources, going against the green development of agriculture. According to the FAO database, the pesticide consumption per unit cultivated area in China in 2019 was 14.85 kg/hm^2, which was 4.93 times greater than the world average. The consumption of chemical fertilizers per unit cultivated area was 398.02 kg/hm^2, which was 2.92 times greater than the world average. Against this background, the No. 1 Central Document in 2016 proposed to strengthen resource protection and ecological restoration and promote green agricultural development. The No. 1 Central Document in 2022 proposed to promote the green development of agriculture and rural areas and strengthen the comprehensive control of agricultural non-point source pollution. Promoting resource-saving and environmentally friendly agricultural production methods has become a consensus to achieve the goal of green agricultural development. Under the guidance of a series of national policies, China's green agricultural development level (GADL) has been significantly improved, but what cannot be ignored is that there are obvious gaps in the GADLs among various regions in China, and the regional development of the GADL is uneven [1,2]. On the one hand, there are large gaps in resource endowments among various regions in China, as well as large differences in the regional agricultural development methods, resulting in uneven regional GADLs [3,4]. On the other hand, with the gradual advancement in the transformation of agricultural production methods, the GADL among regions has produced a "club effect" [5], and the gap in GADLs between regions has gradually widened. This phenomenon can be explained by the theory of "club convergence". If the regions are grouped according to the changes in the GADL for different years, the regions of the same club converge to the same steady-state level, and the "club effect" will occur. The internal members of high-level clubs have a driving role; low-level club members are often in danger of falling into a "low-level trap" [6]. If the gap between different clubs can be reduced, the lower-level areas can be positively influenced by the higher-level areas. According to the club theory, the GADL in China will be significantly improved. So, what is China's GADL? Is there any club convergence in the GADLs of various regions? What are the driving factors that form its convergence club?

There are established research studies on green agricultural development from the perspectives of index system construction, regional heterogeneity, and convergence. First and foremost, existing research has not yet formed a unified evaluation index system for GADLs. Based on the perspective of agricultural production, scholars characterize the GADL from the input of green production materials such as chemical fertilizers, pesticides, and agricultural films, as well as the intensive use of energy and water resources [7–9]. Some have constructed a green agricultural development index from the dimensions of low carbon production, economic income increases, and secure supplies [10]. With the refinement of relevant research, scholars have conducted research on GADLs from a micro-perspective [11] and regional level [12,13]. Secondly, due to different research methods, the convergence conclusions drawn from the analysis of agricultural regional heterogeneity are inconsistent. Some have explored regional differences and the convergence of the agricultural total factor productivity based on the green agricultural total factor productivity [14–16], and generally believe that China's green regional agricultural development is unbalanced, but there is no overall σ convergence or absolute β convergence [17,18]. Others found that based on measuring the green agricultural development index, there are significant differences in the green agricultural development indexes in different regions, and they show σ convergence and conditional β convergence [3]. Finally, on the basis of analyzing regional differences in green agricultural development, some scholars discussed the influencing factors of green agricultural development [19,20]. The labor force quality, crop disaster area, agricultural scientific research investment, regional agricultural development level, and regional economic development level will all have an impact on the GADL, and the driving factors are different in different regions [21,22].

In summary, to measure green agricultural development in China, the convergence and causes of different regions were analyzed. This paper refers to the ideas of Huang [21] and Qi [23] and the principles of reducing pollution and improving the efficiency of green agricultural production, building an indicator system from the input of factors in the production–output link, utilizing waste resources, and outputting green agricultural products. On this basis, this paper further uses the log(t) model to expand and analyze the club convergence of green agricultural production levels and uses the Ordered Probit model and Ordered Logit model to analyze the effects of environmental regulation, the GDP, grain planting area, financial support for agriculture, and rural human capital on the club convergence results. This paper uses the method of club convergence to analyze the regional differences in the green agricultural development level and its influencing factors, aiming to fill the gaps in related research, enrich the contents and methods of green agricultural development research, and provide a reasonable policy basis for promoting green agricultural development in different regions.

2. Measurement and Comparison of Green Agricultural Development in China

2.1. Indicator Construction and Data Sources

China's green agricultural development process mostly features resource conservation and environmental friendliness [23]. Considering the complexity of measuring the level of green agricultural development and the practical significance of indicators, this paper selects indicators from agricultural production factors such as water resources, fertilizers, pesticides, land, agricultural films, and agricultural machinery from the perspective of reducing agricultural pollution and improving the resource utilization efficiency, combined with the research on low-carbon agricultural production and green agricultural development [24]. This paper not only considers resource conservation and environmental friendliness in the production process but incorporates the quantity of green organic food into the evaluation index system as an output indicator of green agricultural development. Based on the availability and completeness of the data, this paper selects seven indicators to comprehensively evaluate the GADL in 31 provinces (municipalities and autonomous regions) in China, including the following: efficiency of chemical fertilizer use, efficiency of pesticide use, efficiency of use of agricultural film, water-saving irrigation rate, comprehensive utilization rate of livestock and poultry manure, comprehensive utilization rate of crop straw, and number of green organic food products. The data are all sourced from the China Rural Statistical Yearbook (2013–2020) [25]. The specific indicators are shown in Table 1.

Table 1. Evaluation index of green agricultural development level in China.

Indicator		Metrics Interpretation
Pre-production stage	Efficiency of chemical fertilizer use	Amount of agricultural chemical fertilizer/total agricultural output value, kg/CNY 10,000
	Efficiency of pesticide use	Amount of pesticide used/total agricultural output value, kg/CNY 10,000
	Efficiency of use of agricultural film	Amount of agricultural film used/total agricultural output value, kg/CNY 10,000
	Water-saving irrigation rate	Water-saving irrigated area/arable land irrigated area, %
Mid-production stage	Comprehensive utilization rate of livestock and poultry manure	Comprehensive utilization rate of livestock and poultry manure, %
	Comprehensive utilization rate of crop straw	Comprehensive utilization rate of crop straw, %
Output stage	Number of green organic food products	Number of green food products + number of organic food products, pcs

2.2. Determine the Index Weight

Before calculating the GADL, the data need to be weighted with indicators. The calculation results of the entropy weight method can more profoundly reflect the utility value of the index information entropy [17,26]. The weight of the evaluation index reflects the relative importance of the index. The degree of variation in the index value determines the weight, and it changes in the same direction. By calculating the obtained weights and related data, a specific value that represents the GADL is obtained. The size of this value reflects the GADL. The larger the value, the higher the GADL. The specific steps are as follows:

First, data standardization is performed. Because of the differences in each index unit and the inconsistent direction of their effects on the GADL, in order to reduce the error, the indexes are standardized in turn by range, so as to obtain dimensionless data with the same direction and comparability.

(1) Positive indicator processing:

$$X_{ij} = \frac{x_{ij} - min(x_{ij})}{max(x_{ij}) - min(x_{ij})} \tag{1}$$

(2) Negative indicator processing:

$$X_{ij} = \frac{max(x_{ij}) - x_{ij}}{max(x_{ij}) - min(x_{ij})} \tag{2}$$

Second, the degree of contribution to the indicator is determined. z_{ij} indicates the contribution of each region to the j-th indicator in year i:

$$z_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}, x_{ij} \geq 0, i = 1,2,3,\cdots,n, j = 1,2,3,\cdots,n \tag{3}$$

Third, the entropy value of the j-th indicator is calculated:

$$e_j = -k\sum_{i=1}^{n} z_{ij} \ln z_{ij} \tag{4}$$

where $e_j > 0$, $k = \frac{1}{\ln n}$, $k > 0$, and n is the number of provinces.

Fourth, the information entropy of the indicator x_{ij} is calculated:

$$g_j = 1 - e_j \tag{5}$$

where the larger the value of g_j, the greater the effect of the indicator; the smaller the value of g_j, the lesser the effect of the indicator.

Fifth, the weight of the j-th indicator x_j is calculated:

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \tag{6}$$

where w_j is the weighting coefficient of the non-dimensional indicator. The index weights of the green agricultural development levels are shown in Table 2.

Table 2. Weights of green agricultural development levels in China.

Indicator	Weight	Orientation
Efficiency of chemical fertilizer use	0.078	−
Efficiency of pesticide use	0.036	−
Efficiency of use of agricultural film	0.042	−
Water-saving irrigation rate	0.269	+
Comprehensive utilization rate of livestock and poultry manure	0.080	+
Comprehensive utilization rate of crop straw	0.031	+
Number of green organic food products	0.465	+

Sixth, the level of green agricultural development in each region is calculated. This paper uses a linear weighting method to calculate the GADL in each region:

$$G_i^k = \sum_{i=1}^{n} \left(w_j^k \times x_{ij}^k \right) \tag{7}$$

Among them, G_i^k is the level of green agricultural development. The higher the value of G_i^k, the higher the GADL in the region i; conversely, a lower value indicates that the GADL is lower.

2.3. Green Agricultural Development Level Analysis

Based on the evaluation index system in Table 1, this paper measures the GADL in 31 provinces (municipalities and autonomous regions) in China from 2013 to 2020, and then analyzes the evolution characteristics of the GADLs. The calculation results are shown in Table 3.

Table 3. Green agricultural development levels in China from 2013 to 2020.

Region	Province	2013	2015	2017	2019	2020	Average	Increasing Rate
Northeast China	Heilongjiang	0.365	0.354	0.382	0.392	0.692	0.533	89%
	Jilin	0.207	0.180	0.206	0.236	0.362	0.275	75%
	Liaoning	0.302	0.303	0.321	0.434	0.410	0.369	36%
North China	Beijing	0.424	0.396	0.382	0.431	0.522	0.485	23%
	Tianjin	0.244	0.361	0.391	0.441	0.361	0.303	48%
	Shanxi	0.212	0.214	0.237	0.287	0.386	0.270	82%
	Hebei	0.392	0.338	0.371	0.445	0.445	0.401	14%
	Inner Mongolia	0.298	0.521	0.521	0.680	0.490	0.379	64%
East China	Shandong	0.584	0.457	0.498	0.542	0.775	0.681	33%
	Jiangsu	0.453	0.286	0.303	0.323	0.728	0.562	61%
	Zhejiang	0.409	0.239	0.241	0.321	0.499	0.459	22%
	Anhui	0.271	0.337	0.351	0.405	0.669	0.439	147%
	Shanghai	0.280	0.333	0.438	0.593	0.495	0.352	77%
	Jiangxi	0.246	0.223	0.256	0.339	0.367	0.299	49%
	Fujian	0.302	0.457	0.583	0.638	0.433	0.361	43%
Central China	Hubei	0.296	0.443	0.454	0.501	0.476	0.386	61%
	Hunan	0.250	0.669	0.660	0.745	0.529	0.349	112%
	Henan	0.183	0.299	0.310	0.360	0.391	0.265	113%
South China	Guangdong	0.231	0.266	0.289	0.323	0.318	0.277	38%
	Guangxi	0.228	0.393	0.405	0.471	0.375	0.289	64%
	Hainan	0.133	0.237	0.289	0.327	0.269	0.194	103%
Southwest China	Guizhou	0.188	0.286	0.332	0.432	0.307	0.239	64%
	Sichuan	0.331	0.243	0.267	0.335	0.498	0.411	51%
	Yunnan	0.236	0.300	0.334	0.434	0.505	0.341	114%
	Chongqing	0.235	0.269	0.268	0.306	0.578	0.356	146%
	Tibet	0.188	0.257	0.296	0.331	0.245	0.209	30%
Northwest China	Gansu	0.231	0.152	0.187	0.246	0.478	0.342	107%
	Shaanxi	0.228	0.294	0.317	0.464	0.358	0.289	57%
	Qinghai	0.257	0.281	0.293	0.330	0.369	0.315	44%
	Ningxia	0.171	0.242	0.277	0.318	0.333	0.266	94%
	Xinjiang	0.209	0.275	0.322	0.457	0.359	0.279	71%

As shown in Table 3, the overall GADL in the 31 provinces (municipalities and autonomous regions) has shown a steady upward trend. The lowest value of the GADL from 2013 to 2020 increased from 0.133 (Hainan) in 2013 to 0.245 (Tibet); the highest value increased from 0.584 in 2013 to 0.584 (Shandong) and 0.775 (Shandong). Judging from the comprehensive score of the GADL from 2013 to 2020, the top 10 provinces are Shandong, Jiangsu, Heilongjiang, Beijing, Zhejiang, Anhui, Sichuan, Hebei, Hubei, and Inner Mongolia. Secondly, there are obvious regional gaps in the GADLs of various provinces (municipalities and autonomous regions). The initial range was 0.451, and the end range was 0.53. The overall regional gap shows an expanding trend. Overall, China's GADL has an obvious upward trend from 2013 to 2020, but there is a large gap in the growth rates of the GADLs among provinces (municipalities and autonomous regions). Regions with an increase of more than 100% include Anhui, Hunan, Yunnan, Chongqing, Gansu, Henan, and Hainan. However, in Hebei, Zhejiang, Beijing, and Tibet, the growth rate is relatively small, not exceeding 30%.

3. Analysis of the Causes of Convergence Clubs

This paper uses the log(t) model to analyze the club convergence of the GADLs and uses the Ordered Probit model to analyze the causes of the GADL club convergence results.

3.1. Model Building

3.1.1. Log(t) Model

To analyze the evolution process of China's GADL, this paper uses the nonlinear, time-varying factor model testing method proposed by Phillips and Sul to analyze the club convergence of China's GADL [27]. Different from the β convergence test and σ convergence test, the advantage of the club convergence test is that when there is no convergence trend in the overall sample, there is no need to divide the convergence groups, but the convergence of all individuals can be clustered through trial and error. This method can identify all local convergence situations using statistical methods and form different convergence clubs [28]. PS convergence incorporates the heterogeneity assumption into the model and can better analyze the convergence and dynamic evolution characteristics between regions. A PS convergence analysis needs to verify the overall convergence situation. If the test passes, it means that the difference in the GADLs between provinces is gradually decreasing. If the assumption of overall convergence is not established, it means that there is no overall convergence, and it is necessary to further test the club convergence [29,30]. A log(t) test can not only judge the convergence of the sample population, but also further judge whether individuals converge to different clubs if the population does not converge.

In econometrics, any panel data X_{it} can be broken down into the following form:

$$X_{it} = \delta_{it}\mu_t \quad (8)$$

Among them, δ_{it} is the load coefficient of the time change factor; μ_t is the common factor.

Furthermore, a semi-parametric equation can be used to express the load factor of the time change factor δ_{it}. The formula is as follows:

$$\delta_{it} = \delta_i + \frac{\delta_i}{L(t)t^a} \times \xi_{it} \quad (9)$$

Among them, δ_i is a fixed component that does not change with time; ξ_{it} is a distribution factor; ξ_{it} has the same independent distribution as δ_i and follows a standard normal distribution. $L(t)$ is an equation that includes time t. Its main function is to eliminate the natural increase in the variance over time, so that the panel data X_{it} become stable data. When X_{it} represents the flat panel data, for either scenario of $a \geq 0$, δ_{it} will converge over δ_i when the time $t \to +\infty$. Assuming there is such a situation where the X_{it} of all individuals i in the panel data have the same common factors, that is, $\delta_i = \delta$, a situation that has occurred previously, then when $a \geq 0$, all individuals i in the panel data X_{it} will converge to the same steady state. As a result, checking whether the panel data X_{it} have converged is converted into testing whether or not $a \geq 0$.

In specific operations, the convergence of panel data X_{it} can be tested using the equation below. The original hypothesis was that $H_0 : \delta_1 = \delta$, that is, $a \geq 0$. The test equation is structured as follows:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = c + b\log(t) + u_t \quad (10)$$

In the above equation:

$$h_{it} = \frac{X_{it}}{N^{-1}\sum_{i=1}^{N} X_{it}} \quad (11)$$

$$b_0 = -2\log L(1) + u_1 \tag{12}$$

Among them, $t = [rT], [rT+1], \cdots, T$, and $r \in (0,1)$. This article takes $r = 0.2$, and $L(t) = \log t$. If b is significantly non-negative, then there is convergence; conversely, if $t_{\hat{b}} < -1.65$, then there is no convergence.

3.1.2. Ordered Probit Model

In the analysis of factors affecting the club convergence, since the green agricultural development level converges into different levels of clubs and is an ordered variable, this paper selects the Ordered Probit model to analyze the factors influencing the GADL convergence club (y). The model is as follows:

$$y_i = \beta X_i + \varepsilon_i \tag{13}$$

In the formula, y_i represents the latent variable corresponding to the dependent variable and cannot be directly measured. X_i is an independent variable, representing the influencing factor of the club convergence group; β is the coefficient of the independent variable; ε_i is a random perturbation term.

3.2. Data Processing

On the basis of comprehensively considering the connotation of China's GADL and the characteristics of green agricultural development, this paper explores its impact on the GADL club convergence from five aspects: the intensity of environmental regulation, regional economic development level, grain production area, level of fiscal support for agriculture, and level of rural human capital.

Environmental regulation (ER): This paper selects the number of local environmental protection regulations promulgated in the current year to measure the environmental regulations. The data are obtained by adding the number of local environmental regulations promulgated in that year and the number of local environmental protection regulations promulgated in that year. According to the externality theory, ERs will improve the GADL by improving the negative externality of traditional agricultural production methods. Therefore, this paper will further discuss the influence of ERs on the club convergence results of the GADL. Considering the possible nonlinear impact of environmental regulations on the GADL [31,32], this paper introduces the secondary and tertiary items of environmental regulation to test the impact of environmental regulation on the results of GADL club convergence.

Gross domestic product (GDP): This paper selects the gross domestic product to test the impact of regional economic development levels on the club convergence results. Generally speaking, the higher the regional production level, the more reasonable the regional economic development structure and the higher the quality of regional economic development, so the difference in the regional production level may affect the regional difference in the GADL. This paper will discuss the influence of the GDP on the convergence club results of the GADL.

Grain production area (GPA): This paper selects the grain production area to test the influence of agricultural development methods on the club convergence results.

Financial support for agriculture (FSA): This paper selects the financial expenditure of agriculture, forestry, and water affairs to measure the influence of financial support for agriculture on the club convergence results. According to Zhang's [33] research results, the level of financial support for agriculture can significantly affect the level of green agricultural development. Therefore, this paper will further discuss the influence of the level of financial support for agriculture on the club convergence result of the GADL.

Rural human capital (RHC): This article selects the average years of education in rural areas to represent the rural human capital. The data are obtained by multiplying the proportion of the rural population with different educational levels and the corresponding years of education. Among them, the education level is divided into semi-illiterate and below, primary school, junior high school, high school (secondary vocational school), college, and above. And the corresponding years of education are 0, 6, 9, 12, and 15.5 years, respectively [34]; its specific formula is as follows:

$$X_{RHC} = 0a_1+6a_2+9a_3+12a_4+15.5a_5 \quad (14)$$

In the analysis of the causes of club convergence, the environmental regulation data come from the China Environmental Statistics Yearbook (2013–2020) [35], the data on the gross domestic product, level of financial support for agriculture, and rural human capital come from the China Statistical Yearbook (2013–2020) [36], and the data on the grain production area come from the China Rural Statistics Yearbook (2013–2020) [25]. The descriptive statistical results of the main variables are shown in Table 4.

Table 4. Descriptive statistical results of main variables.

Variables	Average	Min.	Max.	Std. Dev.
ER	2.871	0	26	3.473
ER2	20.190	0	676	58.381
ER3	236.359	0	17,576	1254.522
GDP	2.654	0.082	11.076	2.167
GPA	3730.282	46.5	14,438.4	3159.18
FSA	586.919	123.03	1339.36	272.392
RHC	7.719	3.807	9.825	0.826

From the descriptive statistical results of the influencing variables, it can be seen that the average intensity of environmental regulation in various regions of China from 2013 to 2020 is 2.871, the maximum value is 26, and the minimum value is 0. Thus, it can be seen that the intensity of agricultural environmental regulation in various regions of China is generally low, and the intensity of agricultural environmental regulation in different regions is quite different. In terms of the regional GDP, the regional GDPs of 31 provinces in China show a significant upward trend, but the regional GDP gap is large. In addition, the regional difference in the grain sown area is obvious; the minimum value is 46.5, and the maximum value is 14,438.4, which is caused by the difference in cultivated land resources and the difference in grain production functional zones in China. Judging from the level of financial support for agriculture, the financial expenditure levels for agriculture, forestry, and water affairs in various regions of China increased year by year from 2013 to 2020. In terms of the rural human capital, the average value of rural human capital is 7.719, and the minimum value is 3.807, which indicates that the average number of years of education in rural areas of China has improved, and that rural compulsory education is well promoted.

3.3. Empirical Analysis

3.3.1. Green Agricultural Development Level Club Convergence

This paper uses data on the GADLs from 31 provinces in China from 2013 to 2020. Under the original assumption of overall panel data convergence, the test results are shown in Table 5.

Table 5. The $\log(t)$ test of green agricultural development level in China.

Variable	Coeff	SE	T-Stat
log(t)	−1.3003	0.3797	−3.4241

In Table 4, $t_{\hat{b}} = -3.42$ is less than -1.65, so at a significance level of 0.01, it is possible to reject the original hypothesis. There was no overall convergence in the green agricultural development levels of 31 provinces in China from 2013 to 2020. Based on this, this paper tests the club convergence on the GADLs of 31 provinces in China.

Step I is to sort all provinces according to the level average. The order from highest to lowest is as follows: Shandong, Jiangsu, Heilongjiang, Anhui, Chongqing, Hunan, Beijing, Yunnan, Zhejiang, Sichuan, Shanghai, Inner Mongolia, Gansu, Hubei, Hebei, Fujian, Liaoning, Henan, Shanxi, Guangxi, Qinghai, Jiangxi, Jilin, Tianjin, Xinjiang, Shaanxi, Ningxia, Guangdong, Guizhou, Hainan, and Tibet.

Step II is to establish the first club for the region with the highest GADL $(2 \leq k < n)$, and then use the $\log(t)$ test to determine its convergence. If the original hypothesis cannot be rejected, the remaining provinces are added to the club one by one, the $\log(t)$ and other tests are carried out together, all regions that satisfy $t > -1.65$ are screened out, and the province with the highest t value is merged with the two previous provinces. Assuming that the club composed of the first and second ranked provinces does not pass the test, the second and third provinces are removed, and the second and third provinces are formed into new clubs. If the convergence conditions are still not met, the above operations are repeated; if none of the above conditions are met at the end of the calculation, there is no club convergence. If some provinces pass the club convergence test in Step II, the remaining regions will be added to the club one by one.

Step III is to regroup the regions not included in the $\log(t)$ test of Step II and continue to perform the test. If there is convergence, it forms another club. If convergence is denied, the steps above are repeated for the remaining regions. The club convergence results are shown in Table 6.

Table 6. China's green agricultural development level club convergence results.

Region	Club 1	Club 2	Club 3	Club 4
Northeast China	Heilongjiang	Liaoning	Jilin	-
North China	Beijing	Inner Mongolia, Hebei, and Shanxi	Tianjin	-
East China	Shandong, Jiangsu, Anhui, Zhejiang, and Shanghai	Fujian	Jiangxi	-
Central China	Hunan	Hubei and Henan	-	-
South China	-	Guangxi	Guangdong and Hainan	-
Southwest China	Chongqing and Sichuan	-	Guizhou	-
Northwest China	-	Gansu and Qinghai	Xinjiang, Shaanxi, and Ningxia	Tibet

As in Table 6, Convergence Club 1 includes 11 provinces (municipalities and autonomous regions): Shandong, Jiangsu, Heilongjiang, Anhui, Chongqing, Hunan, Beijing, Yunnan, Zhejiang, Sichuan, and Shanghai. The overall level of agricultural development in these areas is relatively high, and farmers with a higher income pay attention to the economic benefits of agricultural production while also taking into account the ecological benefits of agricultural production. The popularity of green production concepts is higher, and the use efficiency of various agricultural production factors is higher. Convergence Club 2 includes 10 provinces (municipalities and autonomous regions): Inner Mongolia, Gansu, Hubei, Hebei, Fujian, Liaoning, Henan, Shanxi, Guangxi, and Qinghai. The levels and development methods of green agricultural development in these areas are relatively similar. Although the agricultural production methods have changed, a change has begun to occur, with agricultural non-point source pollution decreasing, but there is still a tendency to use physical capital (machinery, fertilizers, pesticides, etc.) to replace labor and produce more agricultural pollutants. Convergence Club 3 includes nine provinces (municipalities and autonomous regions): Jiangxi, Jilin, Tianjin, Xinjiang, Shaanxi, Ningxia, Guangdong, Guizhou, and Hunan. The overall GADLs in the provinces in this club are not high, but agricultural production already exists with the trend of transformation from traditional production methods to green production methods, pollutant emissions have been reduced, and green agricultural products and organic agricultural products have been registered. Convergence Club 4 only includes Tibet. The level of green agricultural development in this region is low. The agricultural development still relies on traditional agricultural production materials. The spread of agricultural development methods is relatively slow, and the concept of green production still needs to be further popularized.

3.3.2. Analysis of the Causes of Green Agricultural Development Level Club Convergence

To thoroughly explore the causes of the GADL convergence clubs and provide policy suggestions for green agricultural development in regions with different types of convergence clubs, according to the Ordered Logit/Probit model, this paper uses four convergent clubs as ordered variables to analyze the influencing factors of club convergence. A regression analysis is performed with the convergence clubs as the dependent variable and environmental regulation (ER), GDP, grain production area (GPA), fiscal support for agriculture (FSA), and rural human capital (RHC) as the independent variables. The regression results of the Ordered Logit/Probit model are shown in Table 7.

Table 7. Ordered Logit/Probit model analysis results of influencing factors of club convergence.

Variables	Ordered Logit	Ordered Probit
ER	−0.515 (0.197) ***	−0.280 (0.115) **
ER^2	0.077 (0.035) **	0.044 (0.021) **
ER^3	−0.003 (0.002) **	−0.002 (0.001) **
GDP	−0.173 (0.095) *	−0.080 (0.050)
GPA	−0.001 (0.000) ***	−0.001 (0.000) ***
FSA	−0.002 (0.000) **	−0.001 (0.001) **
RHC	−0.412 (0.203) **	−0.263 (0.110) **
LR chi2(8)	86.92	90.12
Prob > chi2	0.000	0.000
R^2	0.1500	0.1556
Ob	240	240

***, **, * shows the level of significance at 1%, 5%, and 10%, respectively, and the standard error of each coefficient is in brackets.

Judging from the empirical results, the linear, quadratic, and cubic terms of ER passed the significance test of the Ordered Logit model. The coefficient of the linear term is negative, the coefficient of the quadratic term is positive, and the coefficient of the cubic term is negative. This shows that the impact of ERs on the convergence club results is nonlinear and has an inverted "N"-shaped relationship; that is, the impact of ERs on the convergence club results has a two-stage characteristic of first being negative, then positive, and then negative. This shows that the probability of a region converging on low-level clubs has the characteristics of first decreasing, then increasing, and then decreasing. To better describe the impact of the current stage of ER intensity on the GADL convergence clubs, the extreme points were further calculated, which were found to be 4.56 and 12.55, respectively. It can be seen that when the intensity of ER is less than 4.56, the club convergence results tend to be high-level clubs as the intensity of ER increases. When the intensity of ER is between 4.56 and 12.55, the club convergence results will tend to be low-level clubs as the intensity of ER increases. When the intensity of ER is greater than 12.55, the club convergence results will tend to be high-level clubs as the intensity of ER increases significantly.

The GDP passed the significance test of the Ordered Logit model at the 10% level, with a coefficient of −0.173, indicating that the higher the local GDP, the probability of the region converging to the high-level club increases by 0.173 units. The possible reason is that if the GDP of a certain region increases, resulting problems such as the irrational use of production means and backward production methods in rural areas will be improved, and the regional GADL will tend to converge to the high-level club. Every unit increase in the GPA increases the probability that the region converges to the high-level club, and the result is significant at the 1% level. The higher the level of FSA, the greater the probability that the region's GADL will enter the high-level club. The results passed the significance test of the two models at the 5% level. On the one hand, an improvement in the FSA is conducive to the construction of relevant facilities and investment in scientific and technological innovation for green agricultural development. On the other hand, an improvement in the FSA is also conducive to the transformation of agricultural production from traditional production methods to green production methods, improving the regional agricultural greenness and converging to high-level clubs. For every unit increase in the RHC, the probability of a region converging into the high-level club increases by 0.263 units. An improvement in the RHC is not only conducive to the popularization and dissemination of green agricultural production methods, but also promotes the research, development, and promotion of regional agricultural scientific and technological innovation, thus increasing the probability of converging to high-level clubs.

To further analyze the specific impact, this article decomposes the marginal effect, as shown in Table 8. Columns (1)–(4) are the marginal effect decomposition of the Ordered Logit model, and columns (5)–(8) are the marginal effect decomposition of the Ordered Probit model. The marginal effect decomposition results show that for every unit increase in the GPA and FSA in the Ordered Logit model, the probability of each province's GADL entering Club 1 increases, and the probabilities of entering Club 2 and Club 4 decrease, indicating that the increase in the GPA and FSA can significantly increase the probability of each region entering a high-level club.

Table 8. Ordered Logit/Probit model marginal effect decomposition.

Variables	Ordered Logit				Ordered Probit			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ER	0.086 *** (0.032)	0.002 (0.006)	−0.073 *** (0.027)	−0.016 ** (0.007)	0.081 ** (0.033)	0.001 (0.005)	−0.067 ** (0.027)	−0.014 ** (0.007)
ER^2	−0.013 ** (0.006)	−0.001 (0.001)	0.011 ** (0.005)	0.002 * (0.001)	−0.013 ** (0.006)	−0.001 (0.000)	0.011 ** (0.005)	0.002 * (0.001)
ER^3	0.001 ** (0.000)	0.001 (0.000)	−0.001 ** (0.000)	−0.001 * (0.000)	0.001 ** (0.000)	0.000 (0.000)	−0.001 ** (0.000)	−0.001 * (0.000)
GDP	0.029 * (0.015)	0.001 (0.002)	−0.024 * (0.013)	−0.005 (0.003)	0.023 (0.014)	0.001 (0.001)	−0.019 (0.012)	−0.004 (0.003)
GPA	0.001 ** (0.000)	0.000 (0.000)	−0.001 ** (0.000)	−0.000 ** (0.000)	0.001 *** (0.000)	0.000 (0.000)	−0.001 *** (0.000)	−0.000 (0.000)
FSA	0.001 ** (0.000)	0.000 (0.000)	−0.001 ** (0.000)	−0.001 * (0.000)	0.001 * (0.000)	0.000 (0.000)	−0.001 ** (0.000)	−0.001 * (0.000)
RHC	0.069 ** (0.035)	0.002 (0.004)	−0.058 ** (0.029)	−0.013 * (0.007)	0.077 ** (0.033)	0.001 (0.004)	−0.063 ** (0.027)	−0.013 ** (0.006)

***, **, * shows the level of significance at 1%, 5%, and 10%, respectively, and the standard error of each coefficient is in brackets.

In the model, the coefficients of RHC in Club 1, Club 3, and Club 4 are 0.069, −0.058, and −0.013, respectively and are significant at the 5% and 10% statistical levels. This means that when the level of RHC increases by one additional unit, the probability of each region's GADL entering Club 1 increases by 6.9%, the probability of entering Club 3 decreases by 5.8%, and the probability of entering Club 4 decreases by 1.3%, indicating that an improvement in the RHC has a positive impact on the region entering a high-level club. For the improvement in the GADL and the narrowing of regional gaps, the level of RHC has a more obvious promoting effect than the GPA and the level of FSA. This conclusion is basically consistent with the conclusion of the Ordered Probit model.

4. Discussion

This paper addresses the issues raised in the Introduction, such as measuring the level and evolution of China's green agricultural development and analyzing the convergence trends and causes of China's GADL. First, the study found that from 2013 to 2020, the GADL in China's provinces showed an upward trend [37], and each region paid more attention to the output of green agricultural products in the process of promoting the GADL. Second, this article confirms Hu J's view [38] and finds that the GADL in China can be divided into four convergence clubs, and that regional development is not coordinated. At the same time, around major agricultural production areas, China is gradually forming a relatively clear pattern of convergence in the GADL, and there is still plenty of room for development in the GADL. Third, the trend of ER converging on China's GADL convergence clubs is an inverted "N". There are two inflection points of 4.56 and 12.55. Currently, most regions of China are before the first inflection point. This also shows that China should continue to maintain the intensity of existing environmental regulations and push the GADL to the high-level club (Club 1).

Based on the empirical research, this paper believes that, firstly, China should pay more attention to the output of green products and promote the green development of agriculture from the supply side on the basis of adhering to "one control, two reductions and three basics". Pre-production links such as the water-saving irrigation rate, pesticide use efficiency, and agricultural chemical fertilizer application have a higher weight on the GADL. This also shows that China is reducing the total application of chemical fertilizers and pesticides in the region and increasing the use of biopesticides and organic fertilizers. Regarding the usage rate, significant results have been achieved in reducing the impact of chemical agents on agricultural ecology [39,40]; the output link has the highest weight, which further illustrates that in the future, we should start from the supply side of green agricultural products to drive the green transformation of local agriculture [41,42]. Secondly, China should strengthen regional cooperation to promote green agricultural production. The research results show that there are not many regions in high-level clubs, and most of them are concentrated in the main agricultural production areas or areas with advantages in economic development [43,44]. This phenomenon will have a negative impact on the short-term improvement of agricultural production ecology, the long-term green transformation of agricultural development, and the sustainable development of agriculture. Therefore, based on the heterogeneity of agricultural development functional zones and GADLs in various regions, local governments must explore regional resources and environmental advantages and find a green agricultural development path suitable for their region [45]. Thirdly, when introducing and improving relevant environmental protection policies, laws, and regulations at the government level, we should fully consider the economic development and rural development in various places, clarify the institutional standards for farmers to participate in green production, and also provide guidance for relevant departments to take compulsory measures. It has been found that the combination of incentives, guidance, and constraints on environmental regulation policies is more conducive to enhancing the green production awareness of agricultural producers, improving the level of green agricultural development and narrowing the regional differences in green agricultural development [46,47]. Finally, it is necessary to strengthen regional exchanges and collaboration, achieve the effective diffusion of high-level clubs to low-level clubs, and narrow the gap in regional green agricultural development [48,49].

5. Conclusions

Referring to the relevant literature, this paper constructs an GADL evaluation system based on panel data from 31 provinces (municipalities and autonomous regions) from 2013 to 2020, calculates the GADL in each province, and performs overall convergence tests and club convergence tests to analyze the convergence situation of clubs using the green agricultural development levels in each region. Finally, it presents the influencing factors of the clubs based on the Ordered Probit/Logic model and draws the following conclusions:

(1) The results of the calculation of the GADLshow that the GADLs in various regions of China are on the rise, but the overall level is not high, and regional gaps are obvious. From the weighting results of the GADL indicators, it can be seen that the number of green organic food products at the output end has the largest weight.

(2) From the club convergence grouping results, the GADLs of China's 31 provinces (municipalities and autonomous regions) converge to four clubs. Club 1 includes Shandong, Jiangsu, Heilongjiang, Anhui, Chongqing, Hunan, Beijing, Yunnan, Zhejiang, Sichuan, and Shanghai, involving most of China's main agricultural producing areas. Club 2 includes Inner Mongolia, Gansu, Hubei, Hebei, Fujian, Liaoning, Henan, Shanxi, Guangxi, and Qinghai; Club 3 includes Jiangxi, Jilin, Tianjin, Xinjiang, Shaanxi, Ningxia, Guangdong, Guizhou, and Hainan; Club 4 only includes Tibet.

(3) By analyzing the causes of the club convergence results, it is found that the convergence trend of ERs on the GADL has the characteristics of first narrowing, then expanding, and then narrowing; the regional gross product (GDP), grain production area (GPA), fiscal expenditure for agricultural (FSA), and rural human capital (RHC) will promote the GADL to converge towards high-level clubs, and the possibility of entering Club 1 will increase by 2.9%, 1%, 1%, and 6.9%, respectively.

The possible contribution of this paper lies in the following conclusions: This paper solves the problems raised in the Introduction, analyzes the GADLs in China and their club convergence, and discusses their influencing factors. This paper uses the method of club convergence to analyze the regional differences in the GADL and its influencing factors, which enriches the contents and methods of green agricultural development research, provides new research ideas and methods for China's green agricultural development research, and provides a reasonable theoretical basis for promoting green agricultural development in different regions.

There are still some limitations in this paper, specifically as follows: Due to the current level of completeness and availability of data, the calculation of the green agricultural development level in this article is only updated to 2020 and does not take into account the impact of the COVID-19 pandemic on China's green agricultural development. At the end of 2019, the COVID-19 pandemic swept across China and had a serious impact on the development of the agricultural industry. The measurement results of the green agricultural development level show that there are no outliers in the GADL in 2020. The COVID-19 pandemic caused a lag in the GADL. Therefore, this paper does not explore the impact of the COVID-19 pandemic on China's GADL. In addition, in order to make the article focus more on the development trend of green agriculture in different regions of China, there is no comparative study on the level of green agricultural development between China and other countries or regions, which is also a direction that this study will further explore in the future. In the future, this study will focus on the measurement and comparative study of the green agricultural development levels in various countries, providing a broader perspective for green agricultural development research and theoretical support for international sustainable agricultural development.

Based on the conclusions of this paper, this paper puts forward the following policy suggestions: First, it encourages the application and establishment of green agricultural production bases and suggests improving the GADL, with the production of green organic agricultural products as the guide. Secondly, according to the difference in the GADL and the local agricultural development level, the green agricultural development plan should be formulated according to local conditions. Third, it encourages increasing policy support and financial support for green agricultural development, and suggests developing green agriculture on a moderate scale, improving the education level of agricultural producers, and strengthening their understanding of green agricultural development.

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Abbreviations

GADL	green agricultural development level
GDP	gross domestic product
GPA	grain production area
FSA	financial support for agriculture
RHC	rural human capital
ER	environmental regulation

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