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Analysis on the Development Mode of Leisure Agriculture Industrialization Based on General Equilibrium Model

Binbin Li [1] and Kai Du [2,*]

[1] Guanghua School of Management, Peking University, Beijing 100080, China
[2] Administration and Management Institute, Ministry of Agriculture and Rural Affairs, Beijing 102208, China
* Correspondence: dkphd@cau.edu.cn

Abstract: In recent years, leisure agriculture has been developing rapidly. Leisure agriculture has gradually become an important way to promote economic growth in rural areas and improve farmers' income. By building a two-department general equilibrium model, this paper finds that the simple pursuit of leisure agriculture development may have a certain negative impact on the development of traditional industries in rural areas, so as to put forward the development idea of leisure agriculture industrialization. Combined with the general equilibrium model, it proves that the industrialization of leisure agriculture can promote the development of rural economy and improve the economic competitiveness of rural areas. The research of this paper enriches the research direction of leisure agriculture and provides theoretical support for the industrialization development of leisure agriculture.

Keywords: leisure agriculture; general equilibrium model; industrialization

1. Introduction

The report to the 19th National Congress pointed out that China's economic development has entered a new period, shifting from emphasis on production and quantity to emphasis on consumption and quality. The principal contradiction in Chinese society has been transformed into one between unbalanced and inadequate development and the people's ever-growing needs for a better life. Local governments will pay more attention to the unbalanced development between urban and rural areas, accelerate the transformation of the pattern of agricultural development, adjust and optimize the rural industrial structure, and achieve rapid and stable economic development in rural areas. In 2006, "the Guidance on Promoting the development of Rural Tourism" officially put forward that rural tourism has become one of the effective ways to promote the construction of new rural areas. In 2007, the Ministry of Agriculture and the National Tourism Administration jointly issued the Notice on Vigorously Promoting the Development of National Leisure Agriculture and Rural Tourism, which clarified the guiding ideology and work requirements for the development of leisure agriculture, signed a cooperation framework agreement, and put forward the plan of establishing demonstration counties and villages of leisure agriculture. By 2009, there were 47,524 leisure agriculture enterprises (parks) in China, with a comprehensive business income of about 87.7 billion yuan (about 12.56 billion dollars), among which the income of farmers was nearly 27 billion yuan (about 3.87 billion dollars), and the sales income of agricultural products was about 38 billion yuan (about 5.4 billion dollars). After five years of development, in 2015 leisure agriculture and rural tourism in China received more than 2.2 billion tourists and generated revenue of more than 440 billion yuan (about 63 billion dollars). It employed 7.9 million people, including 6.3 million farmers, benefiting 5.5 million rural households. During the 12th Five-Year Plan period, the annual growth rate of the comprehensive revenue of leisure agriculture is about 29.7%, and the annual growth rate of tourist arrivals is about 40.6%. According to China's Ministry of Agriculture

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and Rural Affairs, in 2020, the national revenue of leisure agriculture reached 604.9 billion yuan (about 86.6 billion dollars). Due to the impact of COVID-19, the income of leisure agriculture in 2020 is only about 70% of that in 2019.

Leisure agriculture is the specific expression of agricultural multifunction, and there are many similar expressions, commonly used similar expressions are the following: Agriculture Tourism, Agro-tourism, Rural Tourism, Farm Tourism, Sightseeing Agriculture, Farm Tourism, Village Tourism, etc. There are some commonalities and intersections among these ideas, but there are some differences in the scope covered and the angle of analysis. Among them, agricultural tourism is the closest concept to leisure agriculture. Agricultural tourism is a concept used in the early development of leisure agriculture. Leisure agriculture includes all the contents of agricultural tourism. Leisure agriculture is a concrete manifestation of agricultural versatility. It is a new agricultural production and management mode with characteristics of primary, secondary, and tertiary industries, which is produced in the process of extension and integration of agriculture to tertiary industry on the basis of agriculture. The concept and connotation of leisure agriculture include the following aspects: (1) In terms of industry attribution, leisure agriculture is a new agricultural production and management mode with characteristics of primary, secondary, and tertiary industries, which is generated in the process of extension and integration of agriculture to the tertiary industry based on agriculture. (2) In terms of content, leisure agriculture is a production and management activity based on agricultural production and farmers' life with agricultural resources, rural environment, farming culture. and folk culture as the background. (3) In terms of development impetus, leisure agriculture is a production and operation activity based on agricultural resources, with agricultural resources and rural tourism resources as the core attractions. It is promoted by residents' leisure consumption and actively guided by government policies.

In recent years, leisure agriculture develops rapidly in developing counties such as China, and makes some achievements. However, scholars hold different attitudes towards the relationship between leisure agriculture and rural regional economic development. On the positive side, studies by scholars such as Sharpley [1], McGehee [2], and Torres [3] believed that developing leisure agriculture is an effective way to increase farmers' income and improve the employment rate in rural areas. Su [4] and Li [5] believed that the development of leisure agriculture in China has diversified the rural economy and reduced the poverty level in rural areas. Nickerson [6] and McGehee [7] also confirmed that although the development modes of leisure agriculture in different regions are different, they all provide new economic growth points for regional economy, especially in terms of increasing farmers' income and employment. Luo [8] believed that the development of leisure agriculture improves the housing conditions of farmers, beautifies the rural environment, and enhances the degree of civilization and spirit of solidarity among farmers. In addition, Valdivia [9] and Wilson [10] also found that leisure agriculture not only achieves economic benefits and improves farmers' income, but also affects the agricultural industry structure to a certain extent. It can be said that traditional agriculture in the function of extension and expansion has driven the development of agriculture-related industries so that the development of traditional agriculture ushered in a new opportunity. On the other hand, many scholars believe that the development of leisure agriculture will have a negative impact on traditional agricultural production and increase the imbalance of regional development. For example, Forsyth [11] found in his investigation of villages in northern Thailand that the opening area of leisure agriculture depends on local natural resources and traditional culture, which will inevitably lead to the unbalanced development of various villages, and may lead to the social phenomenon of further polarization of the rich and poor in rural society. Macbeth [12] also found that due to the imbalance in the distribution of agricultural resources and natural resources, the development of leisure agriculture will intensify regional differentiation and estrangement. Cui [13] believed that with the continuous expansion of the agricultural development scale, commercial business models will have a negative impact on the traditional agricultural production mode, which

will weaken the rurality of the region, and the traditional farming culture will gradually disappear under the impact of the market economy.

Existing studies have verified the effect of leisure agriculture on the development of rural economy by case or empirical analysis, but there is a lack of theoretical explanations.

This paper uses the theoretical derivation of the general equilibrium model to verify the effect of the industrialization of leisure agriculture on the rural economy in order to explain the influence of leisure agriculture on the rural economy from the theoretical level. Based on this, this paper constructs a two-part general equilibrium model, including the production sector and the trade sector, to analyze the impact of the development of leisure agriculture on traditional agricultural production, agricultural processing industry and infrastructure construction. According to the results of the theoretical derivation and the actual situation of the development of leisure agriculture, the ideas of the industrialization of leisure agriculture are put forward. By combining the general equilibrium model, it is proved that the industrialization of leisure agriculture can promote the development of rural economy and improve the competitiveness of rural regional economy. Finally, according to the present situation of leisure agriculture development, the issues that need attention in the process of leisure agriculture industrialization are proposed.

2. Materials and Methods

2.1. General Equilibrium Model Overview

The general equilibrium theory, which originated in Walras' Essentials of Pure Economics published in 1874, features a comprehensive examination of the supply and demand relationships between various goods and factors of production in an economic system. Walras first gave the method of building the general equilibrium model, which is still the basis of building the general equilibrium model. The equation of supply and demand equilibrium for n products can be expressed as the following:

$$D_n(p_1, \cdots, p_n) = S_n(p_1, \cdots, p_n) \quad (1)$$

Among them, the quantity supplied $S_n(p_1, \cdots, p_n)$ and quantity demanded $D_n(p_1, \cdots, p_n)$ is the product or elements $p_1, \cdots, p_n$ function. The product demand function and factor supply function are obtained by using the consumer utility maximum rule, and the product supply function and factor demand function are obtained by using the producer profit maximum rule, and then the supply is equal to the demand.

Arrow and Debreu formed the general equilibrium theory into a complete system in the 1950s [14]. The existence, stability, and uniqueness of general equilibrium points are proved by Brouwer fixed point theorem and Kakugu fixed point theorem. In recent years, general equilibrium theory has been further developed on the basis of Arrow-Debreu system, introducing information theory, transaction cost, location choice, etc., or making general equilibrium concept more abstract, introducing distribution mechanism and incentive mechanism [15].

According to the general equilibrium model developed by the general equilibrium theory, the economic subject generally includes producers, consumers, and government [16–18]. Accordingly, the model structure consists of three sets of equations representing the supply side, the demand side, and the supply and demand relationship, respectively. These three sets of equations all contain corresponding optimization equations, that is, although the general equilibrium also has a total objective function, its optimization process is completed in various departments.

2.2. Construction of Two-Part General Equilibrium Model

The industries related to the development of leisure agriculture in rural areas are mainly agricultural production (traditional agricultural products), agricultural processing industry (primary agricultural products), and rural infrastructure construction. Among them, agricultural production and agricultural processing industry belong to the trade commodity sector, that is, products are mainly sold through trade. The infrastructure sector

is an auxiliary sector for the development of leisure agriculture, and leisure agriculture products (mainly referred to as rural tourism and farming culture experience and other activities in this paper) are non-trade sectors, that is, products that cannot be sold through trade and need to be consumed locally in rural areas. The influences brought by the development of leisure agriculture on the trade commodity sector and the non-trade sector are obviously different, so the discussion should be treated differently.

2.2.1. Household Lifetime Utility Function and Production Function

Suppose an economy consists of a single household with infinite life (the local community household), and it only carries out three types of consumption: leisure agricultural commodity C^{X_1}, infrastructure C^{X_2}, and trade commodity C^Y. Trade commodities include commodities produced by agriculture and agricultural processing industry, while leisure agricultural commodities are non-trade sector commodities. The lifetime utility function of the household is the following:

$$U = \int_0^\infty \frac{\left[\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^Y\right)^{1-\varepsilon_1-\varepsilon_2}\right]^{1-\sigma} - 1}{1-\sigma} e^{-\beta t} dt,\ \sigma > 0,\ 1 > \beta > 0 \tag{2}$$

The utility weights of leisure agricultural products, infrastructure, and traded commodities are ε_1, ε_2 and $1-\varepsilon_1-\varepsilon_2$, $\sigma > 0$ is the reciprocal of the intertemporal elasticity of substitution in the consumption bundle, and β is the constant time preference rate.

Suppose a household is given a unit of labor, and the portion of it allocated to the production of leisure agricultural products. X_1 is $u_1(0 < u_1 < 1)$ the part assigned to infrastructure construction. X_2 is $u_2(0 < u_2 < 1-u_1)$, which is assigned to the production of trade goods. Y is $1-u_1-u_2$. At the same time, households also accumulated physical capital K and decided to allocate the existing capital stock to the production of leisure agricultural commodities $s_1K(0 < s_1 < 1)$, the part allocated to infrastructure construction is $s_2K(0 < s_2 < 1-s_1)$, and the portion allocated to traded goods is $(1-s_1-s_2)K$. The production techniques of the three commodities $X_1(u_1, s_1K)$, $X_2(u_2, s_2K)$ and $Y((1-u_1-u_2),(1-s_1-s_2)K)$ are assumed to conform to the law of marginal production decline, the inputs are homogeneous and linear, and the returns to scale are constant. Therefore, the production function is modified to the following:

$$X_1 = u_1 f\left(k^{X_1}\right) \tag{3}$$

$$X_2 = u_2 g\left(k^{X_2}\right) \tag{4}$$

$$Y = (1-u_1-u_2) j\left(k^Y\right) \tag{5}$$

Here $k^{X_1} \equiv \frac{s_1K}{u_1L}$ and $k^{X_2} \equiv \frac{s_2K}{u_2L}$ on behalf of leisure agriculture and infrastructure department of capital/labor ratio, $k^Y \equiv \frac{(1-s_1-s_2)K}{(1-u_1-u_2)L}$ represents the capital/labor ratio in the trade goods sector. We assume that the leisure agriculture sector and the infrastructure sector have the same factor intensity. $k^{X_1} > k^Y$ and $k^{X_2} > k^Y$, non-tradable goods industries, are (relatively) capital intensive, while tradable goods industries are labor intensive. If it is $k^{X_1} < k^Y$ and $k^{X_2} < k^Y$, then it is the other way around.

2.2.2. Demand Function and Market Clearing

Suppose there are tourists in the economy in addition to local household consumption. Since trade commodities such as agricultural products and agro-processed products can be purchased in cities, we assume that external tourists only have demand for non-traded commodities (mainly refers to tourists' consumption of leisure agricultural products and incidental consumption of local infrastructure construction), the demand functions of external tourists for non-traded commodities are as follows:

$$D_1 = D_1(p_1, T),\ \ D_{1p_1} < 0,\ \ D_{1T} > 0 \tag{6}$$

$$D_2 = D_2(p_2, T),\ D_{2p_2} < 0,\ \ D_{2T} > 0 \tag{7}$$

The subscript is the partial derivative. p_1, p_2 are the relative prices of leisure agricultural products and infrastructure with respect to trade commodities, respectively, while T is the exogenous parameters of leisure agricultural activities. Then the market clearance conditions of non-traded commodities are as follows:

$$X_1 = C^{X_1} + D_1 \tag{8}$$

$$X_2 = C^{X_2} + D_2 \tag{9}$$

Suppose that traded goods Y are used for consumption or investment, while non-traded goods X_1, X_2 are used only for consumption. Therefore, the household's instantaneous budget constraint can be written as follows:

$$\dot{A} = p_1 X_1 + p_2 X_2 + Y + rA - rK - p_1 C^{X_1} - p_2 C^{X_2} - C^Y \tag{10}$$

Here $A \equiv K - B$ is the net assets, B is the stock of loans, and r is the interest rate. When external funds (social capital) are allowed in, $B > 0$, when the economy is closed, $B = 0$.

In the following analysis, we first investigated the influence of the intensity of leisure agriculture factors on farmers' welfare and related industries in the process of the development of leisure agriculture when farmers could not obtain loans, and then considered the effect of leisure agriculture development on farmers' welfare and related industries when farmers could obtain loans. Finally, the particularity and influence of the current "agriculture, rural areas, and farmers" and leisure agriculture policy are analyzed.

2.3. The Influence of Leisure Agriculture Development on Capital Accumulation and Related Industries in Closed Economy

2.3.1. Construction of Hamilton Function in Closed Economy

When you ignore the possibility that social capital is readily available, $B = 0$ and $A = K$. When the economy is not connected to the external financial market, the relative factor intensity will have a Dutch disease effect on the regional economy. It should be pointed out that the Dutch disease effect refers to an economic phenomenon in which abundant natural resources drag down economic development. Because the development of leisure agriculture has a positive impact on the infrastructure construction sector, and the factor intensity is higher than that of agriculture and agricultural processing industry, the leisure agriculture sector and infrastructure sector are integrated into the non-tradable commodity sector for comprehensive consideration, and the agricultural sector and agricultural processing industry are integrated into the tradable commodity sector for comprehensive consideration. That is, household consumption is divided into two types: non-tradable commodity C^X and tradable commodity C^Y, and $u = u_1 + u_2$, $s = s_1 + s_2$. The Hamiltonian function itself is derived from the extension of the classical variational method, and its conclusion can be reduced to Euler's equation. Hamilton, a British mathematician in the 19th century, derived the Hamiltonian regular equation with the variational principle. This equation is a first-order system of equations expressed by the Hamiltonian function with generalized coordinates and momentum as variables, and its form is symmetric. The introduction of Hamilton function makes Euler-Lagrange equations of unconstrained optimal control can be described by first order ordinary differential equations. The Hamiltonian function can be defined using any smooth, real-valued function H of symplectic manifold. By assuming $B = 0$ and defining lambda as the utility value of capital in terms of utility, the present value of the Hamilton function can be written as follows:

$$H = \frac{\left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{1-\sigma} - 1}{1-\sigma} + \lambda\left[upf\left(k^X\right) + (1-u)j\left(k^Y\right) - pC^X - C^Y\right], \tag{11}$$

For the specified variable, the necessary conditions for the optimal solution are the following:

$$C^X : \left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{-\sigma}\varepsilon\left(C^X\right)^{\varepsilon-1}\left(C^Y\right)^{1-\varepsilon} = p\lambda, \tag{12}$$

$$C^Y : \left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{-\sigma}(1-\varepsilon)\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{-\varepsilon} = \lambda, \tag{13}$$

$$s : pf'\left(k^X\right) = j'\left(k^Y\right), \tag{14}$$

$$u : p\left[f\left(k^X\right) - k^X f'\left(k^X\right)\right] = j\left(k^Y\right) - k^Y j'\left(k^Y\right), \tag{15}$$

$$K : \lambda\left[psf'\left(k^X\right) + (1-s)j'\left(k^Y\right)\right] = -\dot{\lambda} + \beta\lambda, \tag{16}$$

$$\lambda : \dot{K} = puf\left(k^X\right) + (1-u)j\left(k^Y\right) - pC^X - C^Y, \tag{17}$$

By transversality conditions $\lim_{t\to\infty}\lambda Ke^{-\beta t} = 0$ and the Equations (12)–(17), capital investment balance condition of $uk^X + (1-u)k^Y = K$ and equilibrium conditions of non-traded goods $f\left(k^X\right) = C^X + D(p,T)$ jointly set eight unknown parameters, $C^X, C^Y, p, k^X, k^Y, u, \lambda, K$.

2.3.2. The Influence of Leisure Agriculture on Total Household Capital under Closed Economy

From the Equations (14), (16) and (17), we can derive the dynamic changes of λ and K:

$$\dot{\lambda} = \lambda\left[\beta - j'\left(k^Y(p)\right)\right], \tag{18}$$

$$\dot{K} = (1-u(K,p))j\left(k^Y(p)\right) - C^Y(p,\lambda) + pD(p,T). \tag{19}$$

Then, consider the influence of the steady state (that is, all variables remained unchanged), based on the Equation (17) and $\dot{\lambda} = 0$, and we have $j'\left(k^Y(p)\right) = \beta$. This shows that at steady state, relative prices can be obtained by solving the time preference equation:

$$\widetilde{p} = \theta(\beta) \tag{20}$$

Where the tilde represents the steady-state value of any variable. Equations (6) and (7) indicate that the development of leisure agriculture in relative prices have no long-term effects, namely $\widetilde{p}_T = 0$. In the short term, the development of leisure agriculture increases the demand for non-traded goods and shifts the demand curve of non-traded goods to the right, which leads to the rise of the relative price between non-traded goods and traded goods.

In the long run, as prices of non-tradable goods rise, so do inputs, which in turn shifts the supply curve of non-tradable goods to the right. Because of the free flow of inputs (labor and physical capital) between the two sectors, the effect of a rightward shift in the demand curve is precisely offset by a rightward shift in the supply curve.

In order to test the long-term impact of the development of leisure agriculture, we conducted full differentiation of Equations (18) and (19) to obtain the following:

$$\begin{bmatrix} p_\lambda & p_K \\ -C^Y_\lambda & (1-u_K)j \end{bmatrix}\begin{bmatrix} \widetilde{\lambda}_T \\ \widetilde{K}_T \end{bmatrix} = \begin{bmatrix} -p_T \\ -pD_T \end{bmatrix}, \tag{21}$$

Therefore, the following is the case:

$$\widetilde{\lambda}_T = \frac{\left(k^X - k^Y\right)\varepsilon f' p D_T}{[\varepsilon j + (1-\varepsilon) pf] C_\lambda^X} \underset{<}{\geq} 0 \ \ if \ \ k^X \underset{<}{\geq} k^Y, \tag{22}$$

$$\widetilde{K}_T = \frac{\left(k^X - k^Y\right) p D_T}{\varepsilon j + (1-\varepsilon) pf} \underset{<}{\geq} 0 \ \ if \ \ k^X \underset{<}{\geq} k^Y. \tag{23}$$

Conclusion 1: The steady-state level of physical capital increases during the development of leisure agriculture. The reason for Conclusion 1 is relatively easy to understand. The development of leisure agriculture makes the capital flow from the trade commodity sector to the leisure agricultural product sector. As the development of leisure agriculture landscape and the construction of agricultural culture experience museum are capital intensive industries, compared with traditional agriculture and agricultural product processing industry, leisure agriculture requires relatively intensive capital, so the production of leisure agriculture is mostly capital intensive. The flow of capital from the tradable goods sector to the leisure agricultural goods sector implies more capital accumulation (relative to labor), thus increasing the steady-state level of capital.

2.3.3. The Influence of Leisure Agriculture on Related Industries under Closed Economy

Next, we analyze whether the development of leisure agriculture will have a negative impact on related industries.

$$\widetilde{X}_T = \frac{f}{(1-\varepsilon) pf + \varepsilon j} p D_T > 0, \tag{24}$$

$$\widetilde{Y}_T = -\frac{j}{(1-\varepsilon) pf + \varepsilon j} p D_T < 0, \tag{25}$$

It is clear that the growth of leisure agriculture has brought with it the growth of the non-tradable goods (leisure agricultural goods) sector and the shrinkage of the tradable goods sector, indicating that the Dutch disease phenomenon exists. Through the above analysis, we know that the development of leisure agriculture makes the capital flow from the trade commodity sector to the leisure agricultural commodity sector. This gives us the following:

Conclusion 2: In the case of closed economy, the development of leisure agriculture reduces the investment of traditional agricultural production and agricultural processing industry and increases the construction of infrastructure. Under the condition of constant production efficiency, it must have a certain negative impact on traditional agricultural production and agricultural processing industry, but has a certain positive impact on the infrastructure construction sector.

2.4. The Influence of Leisure Agriculture Development on Capital Accumulation and Related Industries in Open Economy

2.4.1. Construction of Hamilton Function under Open Economy

When leisure farming grows in an open economy, households can borrow freely. In the case of household utility maximization, the Hamilton function of the present value of a household can be obtained by substituting the household instantaneous budget constraint into the household maximum utility function:

$$H = \frac{\left[\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^Y\right)^{1-\varepsilon_1-\varepsilon_2}\right]^{1-\sigma} - 1}{1-\sigma} + \varphi\left[p_1 u_1 f\left(k^{X_1}\right) + p_2 u_2 g\left(k^{X_2}\right) + (1-u_1-u_2) j\left(k^Y\right) + rA - rK - p_1 C^{X_1} - p_2 C^{X_2} - C^Y\right] \tag{26}$$

φ is A net worth of utility, the interest rate r, assume that the interest rate for the open economy is determined by the interest rate $\bar{r}$, $r = \bar{r}$. The necessary conditions for the optimality of explanatory variables are the following:

$$C^{X_1}: \left[\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^{Y}\right)^{1-\varepsilon_1-\varepsilon_2}\right]^{-\sigma}\varepsilon_1\left(C^{X_1}\right)^{\varepsilon_1-1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^{Y}\right)^{1-\varepsilon_1-\varepsilon_2} = p_1\varphi, \quad (27)$$

$$C^{X_2}: \left[\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^{Y}\right)^{1-\varepsilon_1-\varepsilon_2}\right]^{-\sigma}\left(C^{X_1}\right)^{\varepsilon_1}\varepsilon_2\left(C^{X_2}\right)^{\varepsilon_2-1}\left(C^{Y}\right)^{1-\varepsilon_1-\varepsilon_2} = p_2\varphi, \quad (28)$$

$$C^{Y}: \left[\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^{Y}\right)^{1-\varepsilon_1-\varepsilon_2}\right]^{-\sigma}(1-\varepsilon_1-\varepsilon_2)\left(C^{X_1}\right)^{\varepsilon_1}\left(C^{X_2}\right)^{\varepsilon_2}\left(C^{Y}\right)^{-\varepsilon_1-\varepsilon_2} = \varphi, \quad (29)$$

$$s_1: p_1 f'\left(k^{X_1}\right) = j'\left(k^{Y}\right), \quad (30)$$

$$s_2: p_2 g'\left(k^{X_2}\right) = j'\left(k^{Y}\right), \quad (31)$$

$$u_1: p_1\left[f\left(k^{X_1}\right) - k^{X_1}f'\left(k^{X_1}\right)\right] = j\left(k^{Y}\right) - k^{Y}j'\left(k^{Y}\right), \quad (32)$$

$$u_2: p_2\left[g\left(k^{X_2}\right) - k^{X_2}g'\left(k^{X_2}\right)\right] = j\left(k^{Y}\right) - k^{Y}j'\left(k^{Y}\right), \quad (33)$$

$$K: \varphi\left[p_1 s_1 f'\left(k^{X_1}\right) + p_2 s_2 g'\left(k^{X_2}\right) + (1-s_1-s_2)j'\left(k^{Y}\right) - \bar{r}\right] = 0, \quad (34)$$

$$A: \varphi\bar{r} = -\dot{\varphi} + \beta\varphi, \quad (35)$$

$$\varphi: \dot{A} = p_1 u_1 f\left(k^{X_1}\right) + p_2 u_2 g\left(k^{X_2}\right) + (1-u_1-u_2)j\left(k^{Y}\right) - p_1 C^{X_1} - p_2 C^{X_2} - C^{Y} + \bar{r}A - \bar{r}K, \quad (36)$$

And transversality condition for $\lim_{t\to\infty}\varphi A e^{-\beta t} = 0$.

The macroeconomic model includes the necessary conditions for optimality of the above explanatory variables (27)–(36), plus the balance conditions of capital input, leisure agriculture production, and infrastructure construction:

$$u_1 k^{X_1} + u_2 k^{X_2} + (1-u_1-u_2)k^{Y} = K, \quad (37)$$

$$u_1 f\left(k^{X_1}\right) = C^{X_1} + D_1(p_1, T) \quad (38)$$

$$u_2 g\left(k^{X_2}\right) = C^{X_2} + D_2(p_2, T) \quad (39)$$

13 equations jointly determine the $C^{X_1}, C^{X_2}, C^{Y}, p_1, p_2, k^{X_1}, k^{X_2}, k^{Y}, u_1, u_2, \varphi, A$ *and* K.

2.4.2. The Influence of Leisure Agriculture on the Total Capital under the Open Economy

From Equations (30), (31) and (34), we obtain the arbitrage-free conditions for physical capital and lending, written as follows:

$$p_1 f'\left(k^{X_1}\right) = p_2 g'\left(k^{X_2}\right) = j'\left(k^{Y}\right) = \bar{r} \quad (40)$$

That is, the return on physical capital equals the return on borrowing. That is, we assume that physical capital and loans are fully fungible assets.

Assume boundary conditions $\beta = r$ to satisfy $\dot{\varphi} = 0$. Based on this assumption, the above model can be regarded as a static model. Through the Equations (30)–(33), we can according to the relative price, $k^{X_1} = k^{X_1}(p_1)$, $k^{X_2} = k^{X_2}(p_2)$, and $k^{Y} = k^{Y}(p)$ to solve the problem of the capital labor ratio the three departments. The generation into the no-arbitrage condition $p_1 f'(k^{X_1}) = p_2 g'(k^{X_2}) = j'(k^{Y}) = \bar{r}$, we can deduce the relative price p_1, p_2 and exogenous rate $\bar{r}$ relationship:

$$p_1 = \Psi_1(\bar{r}) \quad (41)$$

$$p_2 = \Psi_2(\bar{r}) \quad (42)$$

The equation above determines the fundamental properties of the model. The supply side determines only the capital/labor ratio and relative prices. The five variables $p_1, p_2, k^{X_1}, k^{X_2}, k^Y$ change over time, and are independent of the leisure agriculture development demand impact, namely, $p_{1T} = p_{2T} = k^{X_1} = k^{X_2} = k^Y = 0$. In addition, through the total differentiation of Equation (36), we can derive that $\varphi_T = 0$ by Equation (40) and the static condition model.

Conclusion 3: Under the condition of open economy, the development of leisure agriculture will change the capital accumulation of households, and the change of the total capital is exactly offset by the change of the loan. Therefore, the total number of assets is constant.

2.4.3. The Influence of Leisure Agriculture on Related Industries in an Open Economy

Now we test whether the development of leisure agriculture will have a negative impact on related industries. The most direct method of analysis is to examine the Equations (27)–(29). When p_1, p_2, φ are known, these three equations determine the consumption levels, C^{X_1}, C^{X_2} and C^Y. In addition, we know that p_1, p_2, φ are independent with respect to T, that is, these three variables will not change due to exogenous changes in leisure agriculture. It should be pointed out that farmer's income is not the same as farmer's welfare, and farmer's welfare is related to its utility. The increase in the farmer's family income does not necessarily lead to the improvement of family welfare level. Therefore, the family utility is only related to consumption, and we can directly infer that the development of leisure agriculture will not affect the family welfare level. Consider the possible impact of leisure agriculture on related industries. We distinguish the clearing conditions of non-trade commodity market $X_1 = C^{X_1} + D_1$ and $X_2 = C^{X_2} + D_2$ under the impact of leisure agriculture exogenous activities T. Since C^{X_1}, C^{X_2} are not related to T, we obtain $X_{1T} = D_{1T} > 0$ and $X_{2T} = D_{2T} > 0$. In addition, it is easy to prove that $Y_T = -\left(\frac{j}{f}\right) X_{1T} < 0$ based on Equations (27) and (37). That is, the development of leisure agriculture leads to the transfer of production resources from the trade commodity sector to the leisure agriculture sector and the infrastructure sector.

Conclusion 4: Under the condition of open economy, the development of leisure agriculture has a negative impact on the development of trade commodity sector (traditional agriculture and agricultural processing industry), and a positive impact on the development of infrastructure construction sector, and will not change the level of social welfare.

2.5. The Influence of Leisure Agriculture Industrialization Development on Capital Accumulation and Related Industries

The derivation of the two-part general equilibrium model theoretically verifies that the rapid development of leisure agriculture may have an impact on the development of traditional industries in rural areas. How to solve the above problems, so that rural traditional industries can also benefit from the upgrading of industrial structure, become the key to the further development of leisure agriculture. In fact, leisure agriculture is essentially an industry with strong correlation, comprehensiveness, and mobility. It is a concrete manifestation of agricultural versatility. The industry types of leisure agriculture need to be continuously enriched, and the development mode should be transformed from the single primary forms of rural tourism and farmhouse entertainment to the large-scale intensive and multi-industry integration of leisure agriculture pastoral complex. Leisure agriculture needs to further realize economic, social, and ecological benefits through industrialization development, driving rural economic development, and enhancing the competitiveness of rural regional economy.

When the industrialization of leisure agriculture develops, we modify the above model. At this time, it is assumed that leisure agricultural commodities produced by families have been integrated with planting, breeding and processing, production, supply, and marketing after industrialization. However, the part that did not participate in upgrading industrial integration is traditional agricultural commodities. The other, under the condition of open

economy, interest rates are determined by the preferential policies for rural rates $\bar{r}$, setting the interest rate at r^*, $r = \bar{r} < r^*$, and constructing the following model:

2.5.1. Household Lifetime Utility Function and Production Function

There are only two types of household consumption: the integrated commodity C^X after the industrialization of leisure agriculture (hereinafter referred to as the integrated commodity) and the traditional industrial commodity C^Y. The family's lifetime utility function is as follows:

$$U = \int_0^{\infty} \frac{\left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{1-\sigma} - 1}{1-\sigma} e^{-\beta t} dt, \ \ \sigma > 0, \ \ 1 > \beta > 0, \tag{43}$$

The utility weights of fusion goods and traditional industrial goods are ε and $1-\varepsilon$, $\sigma > 0$ is the reciprocal of the intertemporal elasticity of substitution in the consumption bundle, and β is the constant time preference rate.

Still giving the household a unit of labor, it is allocated to the part of the production of the convergent good X is $u(0 < u < 1)$, and the part allocated to the production of traditional industrial goods is $1-u$. At the same time, households also accumulated physical capital K and decided that the portion of the existing capital stock allocated to the production of converged goods would be $sK(0 < s < 1)$, and the portion allocated to traditional industrial goods is $(1-s)K$. The production techniques of the two commodities $X(u, sK)$ and $Y((1-u), (1-s)K)$ are assumed to conform to the law of marginal production decline, the inputs are homogeneous and linear, and the returns to scale are constant. Therefore, the production function is changed to the following:

$$X = uf\left(k^X\right) \tag{44}$$

$$Y = (1-u)j\left(k^Y\right) \tag{45}$$

Here $k^X \equiv \frac{sK}{uL}$ and $k^Y \equiv (1-s)\frac{K}{(1-u)L}$ represents the capital/labor ratio of upgrade and traditional industries. In fact, $k^X > k^Y$, upgrading industries is (relatively) capital intensive, while traditional industries are labor intensive. If it's $k^X < k^Y$, then it is the other way around.

2.5.2. Demand Function and Market Clearing

Imagine an economy with outside tourists in addition to local consumers. It is assumed that outside visitors only have a demand for fusion goods. The demand functions of external tourists for integrated commodities are as follows:

$$D = D(p, T), \ \ D_p < 0, \ \ D_T > 0. \tag{46}$$

The subscript is the partial derivative. The term p represents the relative price of the fusion commodity relative to the traditional industrial commodity, while T is the exogenous parameter of the industrialization upgrading activity. Then, the market clearance conditions of integrated commodities are the following:

$$X = C^X + D \tag{47}$$

Suppose that the traditional industrial good Y is used for consumption or investment, while the fusion good X is used only for consumption. Therefore, the household's instantaneous budget constraint can be written as the following:

$$\dot{A} = pX + Y + rA - rK - pC^X - C^Y \tag{48}$$

Here $A \equiv K - B$ is the net assets, B is the stock of loans, and r is the interest rate. Let's assume that loans are allowed in the current situation, $B > 0$.

In this case, by substituting the household instantaneous budget constraint into the household maximum utility function, the Hamilton function of the present value of the household can be obtained, written as follows:

$$H = \frac{\left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{1-\sigma} - 1}{1-\sigma} + \gamma\left[puf\left(k^X\right) + (1-u)j\left(k^Y\right) + rA - rK - pC^X - C^Y\right] \quad (49)$$

The term γ is the utility of net asset A, and interest rate is expressed by r. The necessary conditions for the optimality of explanatory variables are as follows:

$$C^X : \left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{-\sigma}\varepsilon\left(C^X\right)^{\varepsilon-1}\left(C^Y\right)^{1-\varepsilon} = p\gamma, \quad (50)$$

$$C^Y : \left[\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{1-\varepsilon}\right]^{-\sigma}(1-\varepsilon)\left(C^X\right)^{\varepsilon}\left(C^Y\right)^{-\varepsilon} = \gamma, \quad (51)$$

$$s : pf'\left(k^X\right) = j'\left(k^Y\right), \quad (52)$$

$$u : p\left[f\left(k^X\right) - k^X f'\left(k^X\right)\right] = j\left(k^Y\right) - k^Y j'\left(k^Y\right), \quad (53)$$

$$K : \gamma\left[psf'\left(k^X\right) + (1-s)j'\left(k^Y\right) - \bar{r}\right] = 0, \quad (54)$$

$$A : \gamma\bar{r} = -\dot{\gamma} + \beta\gamma, \quad (55)$$

$$puf\left(k^X\right) + (1-u)j\left(k^Y\right) - pC^X - C^Y + \bar{r}A - \bar{r}K, \quad (56)$$

And transversality condition for $\lim_{t\to\infty}\gamma Ae^{-\beta t} = 0$.

The macroeconomic model includes the necessary conditions for optimality of the above explanatory variables (50)–(56), plus the balance conditions for capital input, leisure agricultural commodities and infrastructure construction, and the balance conditions for upgrading industrial commodities:

$$uk^X + (1-u)k^Y = K \quad (57)$$

$$f\left(k^X\right) = C^X + D(p,T) \quad (58)$$

Determine 9 unknown parameters together $C^X, C^Y, p, k^X, k^Y, u, A, \gamma$ and K.

2.5.3. The Influence of the Industrialization of Leisure Agriculture on the Steady State of Capital under the Closed Economy

From the Equations (52) and (54)–(56), we can derive the dynamic changes of γ and A:

$$\dot{\gamma} = \gamma\left[\beta - j'\left(k^Y(p)\right)\right], \quad (59)$$

$$\dot{A} = (1-u(K,p))j\left(k^Y(p)\right) - C^Y(p,\gamma) + pD(p,T) + \bar{r}(A-K). \quad (60)$$

We consider the influence of the steady state (that is, all variables remained unchanged), based on the Equation (59) and $\dot{\gamma} = 0$, and we have $j'\left(k^Y(p)\right) = \beta$. This shows that at steady state, relative prices can be obtained by solving the time preference equation:

$$\widetilde{p} = \theta(\beta) \quad (61)$$

where the tilde represents the steady-state value of any variable. Equation (61) show that leisure to relative prices have no long-term impact on the development of agricultural

industrialization, namely $\widetilde{p}_T = 0$. In the short term, the development of the upgrading industry increases the demand for converged goods and shifts the demand curve of the upgrading industry goods to the right, which leads to the rise of the relative price between the converged goods and the traditional industrial goods. As the prices of convergent commodities rise, inputs to them gradually increase, which in turn shifts the supply curve of convergent commodities to the right. Therefore, the steady value of relative prices of integrated commodities and traditional industries caused by the development of leisure agriculture industrialization remains unchanged. In fact, it also shows that the results of a demand shock have no long-term effect on relative prices.

In order to test the long-term impact of the development of the upgrading industry, we conduct full differentiation of Equations (59) and (60), and obtain the following:

$$\begin{bmatrix} p_\gamma & p_K \\ -C_\gamma^Y & (1-u_K)j \end{bmatrix} \begin{bmatrix} \widetilde{\gamma}_T \\ \widetilde{A}_T \end{bmatrix} = \begin{bmatrix} -p_T \\ -pD_T \end{bmatrix}, \tag{62}$$

Therefore, the following is the case:

$$\widetilde{\gamma}_T = \frac{(k^X - k^Y)\varepsilon f' p D_T}{[\varepsilon j + (1-\varepsilon)pf]C_\gamma^X} > 0 \tag{63}$$

$$\widetilde{A}_T = \frac{(k^X - k^Y) p D_T}{\varepsilon j + (1-\varepsilon)pf} > 0 \tag{64}$$

Conclusion 5: The capital intensity of the industrialization development of leisure agriculture is higher than that of traditional industries, which leads to the increase in the overall capital intensity and thus increases the overall steady-state level. The conclusion is also well understood. Since the industrial development sector is capital intensive compared with the traditional industrial sector, it increases the overall capital intensity; that is, it increases the capital intensity of the integrated agriculture and agricultural processing industry. The flow of capital leads to more capital accumulation, thus increasing the overall capital stock.

2.5.4. The Influence of the Industrialization of Leisure Agriculture on Related Industries under the Open Economy

From Equations (52) and (54), it can be concluded that the arbitrage-free conditions for physical capital and external lending are as follows:

$$pf'\left(k^X\right) = j'\left(k^Y\right) = r^* \tag{65}$$

That is, the rate of return on physical capital equals the rate of interest on external borrowing. That is, we assume that physical capital and external borrowing are fully fungible assets.

Assume boundary conditions $\beta = r^*$ to meet $\dot{\gamma} = 0$. Based on this assumption, the above model can be regarded as a static model. Through the Equations (53)–(56), we can solve the capital-labor ratio problem of the two sectors in terms of relative prices $k^X = k^X(p)$ and $k^Y = k^Y(p)$. By substituting these conditions into the arbitrage-free condition $pf'\left(k^X\right) = j'\left(k^Y\right) = r^*$, we can derive the relationship between the relative price p and the external interest rate r^*:

$$p = \Psi(r^*) \tag{66}$$

The equation above determines the fundamental properties of the model. The supply side determines only the capital/labor ratio and relative prices. The three variables p, k^X, k^Y change with time and are independent of the demand impact caused by the development of leisure agriculture, namely $p_T = k^X = k^Y = 0$. In addition, to total differential Equation (56) through the Equation (62), static condition model and $\bar{r} < r^*$, we can derive $\gamma_T > 0$. In other words, with the increase in farmers' borrowing and the implementation of favorable

agricultural financial policies, the development of leisure agriculture will change the capital accumulation of households, and the change of the total capital is higher than that of the loan. Therefore, the number of total assets is going up, and its relative utility value γ is going up.

Conclusion 6: Due to the state's financial support for "agriculture, rural areas and farmers," the lending interest rate of rural development is lower than the external interest rate, resulting in the increase in the total capital, thus improving the overall level of economic development in rural areas. Under the strong support of the state, external funds flow into the countryside, increase the total capital stock in rural areas, accelerate the development of rural areas, and thus increase the overall stable level of capital. Therefore, the development of leisure agriculture industrialization will bring the increase in material capital. In the process of industrialization, the capital steady level of traditional agriculture and agricultural processing industry is increased, which will also promote the development of traditional agriculture and agricultural processing industry.

3. Conclusions

Based on the derivation of the two-sector general equilibrium model, this paper constructs the family lifetime utility model, production function, and demand function, respectively, and analyzes the influence of the industrialization development of leisure agriculture on capital accumulation and related industries by using Hamilton function under closed economy and open economy. The research results show the following:

(1) When household consumption only considers leisure agricultural commodities, infrastructure and traded commodities, the development of leisure agriculture will have an impact on traditional rural industries. Under the closed economy, the steady state level of physical capital in leisure agriculture has been increased, and the development of leisure agriculture makes the capital flow from the trade sector to the leisure agricultural product sector. The development of leisure agriculture has resulted in the decrease in investment in traditional agricultural production and agricultural processing industry, while increasing investment in infrastructure construction sector. Under the development economy, the development of leisure agriculture changes the capital accumulation of households, and the change of the total capital will be offset by the change of the loan. The development of leisure agriculture has a negative impact on the development of trade sector and a positive impact on infrastructure construction sector.

(2) Leisure agriculture is an industry with strong industrial correlation. After adjusting the commodities produced by households into integrated commodities and traditional agricultural commodities, the model analysis results show that under the closed economy, the industrialization of leisure agriculture is more capital-intensive than that of traditional industries, and the overall stable level has been improved. Under the open economy, China's financial support for "agriculture, rural areas, and farmers" makes the borrowing rate lower, more external capital flows into rural areas, and the increase in material capital improves the development level and stability of traditional agriculture and agricultural processing industry.

The study of this paper explains the influence of leisure agriculture industrialization on rural economy from the theoretical level, but there may be some shortcomings. Considering the limitation of space, the general equilibrium model constructed in this paper mainly selects traditional agricultural production, agricultural processing industry, and infrastructure construction, which are the most critical industries for the development of leisure agriculture. Since there are many sectors involved in leisure agriculture, the analysis in this paper may have limitations. Later scholars can add related industries for further analysis on the basis of this study.

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