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Ecological Benefit Spillover and Ecological Financial Transfer of Cultivated Land Protection in River Basins: A Case Study of the Yangtze River Economic Belt, China

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Abstract: The ecological benefit of cultivated land is the non-market value or ecological service value created by cultivated land protection. Based on the trinity concept of comprehensive protection of quantity, quality, and ecology of cultivated land, this study calculates the ecological benefits of cultivated land protection in the Yangtze River Economic Belt. Through the theory of ecological supply and demand balance, the study estimated the ecological benefit spillover of cultivated land protection in the basin. The amounts and paths of ecological financial transfers for cultivated land are then examined by balancing the protection responsibilities and financial power of cultivated land. We found that overall the ecological benefits of cultivated land protection in the Yangtze River Economic Belt increased, reaching 773.224 billion RMB in 2017. Therein the upper, middle, and lower reaches compose 20.81%, 53.89%, and 25.30% of the ecological benefits. There are significant differences in the ecological benefits, respectively. There are significant differences in the ecological benefits and their variations of cultivated land within the River Basins. The ecological benefits of cultivated land in the Yangtze River Economic Belt demonstrated spatial spillovers within and between the upper, middle, and lower reaches. The middle reaches of the economic belt are the main ecological surplus areas of cultivated land. The ecological deficit areas of cultivated land are mainly distributed in the lower reaches. The spillover effect of the ecological benefits is evident between provinces. The increase of regional economy and ecological compensation policy for cultivated land can effectively stimulate the ecological benefits whereas the pressure of cultivated land protection and power spillovers are adverse to cultivated land ecological protection. The vertical and horizontal fiscal transfers in 2017 respectively amounted to 230.14 billion RMB and 27.24 billion RMB. Particularly, the upper, middle, and lower reaches received 13.07%, 58.41% and 28.52% of the ecological fiscal transfers, respectively. It is important to strengthen spatial spillovers and improve the horizontal and vertical ecological fiscal transfers for protecting ecology of cultivated land.

Keywords: ecological compensation; spatial spillover; fiscal transfer; Yangtze River Economic Belt

1. Introduction

Cultivated land is not only a basic element of agricultural production, but also an important natural resource, and a type of scarce natural capital that provides necessary agricultural products

and ecological services for human beings. China implements a strict cultivated land protection system, and has achieved remarkable results in preserving the quantity and quality of cultivated land. However, with the advancement of urbanization and the transformative of economic development, the excessive transfer and replacement of high-quality cultivated land, the external input beyond the environmental capacity, and the adoption of environmentally unfriendly farming methods have produced serious negative externalities, which have brought irreversible environmental spillover and ecological benefit loss to the region. These losses have not been reasonably compensated, and the pressure for cultivated land to produce valuable exports has increased. Scientifically defining the ecological benefits of cultivated land protection and compensation standards, and improving the incentive and restraint mechanisms of cultivated land protection are important ways to promote the development of an eco-friendly society and ensure food security.

The ecological benefit of cultivated land is the nonmarket value or ecological service value created by cultivated land protection [1,2]. In recent years, scholars have discussed the calculation of both the ecological benefits and ecological compensation for cultivated land in different theoretical perspectives. For example, based on the non-market value theory, the contingent valuation method and the choice experiment method are used to calculate the willingness of citizens to pay for the ecological landscape of cultivated land under different scenarios [3–5], as well as willingness of farmers to be compensated for the protection of cultivated land [6,7]. From this, we can determine the ecological benefits of cultivated land protection on a micro scale [8–10]. Based on the theory of ecological service value, the ecosystem service function of cultivated land is classified, and the equivalent factor method is used to estimate the ecosystem service value of cultivated land [11]. The equivalent factor method is especially suitable for regional scale ecosystem value assessment. Based on the perspective of cost-effectiveness, land conservation costs and opportunity costs are taken as the basis of land ecological compensation [12–14] to measure the ecological value of cultivated land. This also provides ideas for calculating the ecological benefits of cultivated land. Based on the perspective of land development rights, the unfair loss of regional development caused by differences in the protection responsibilities of cultivated land is also an important basis for calculating the ecological benefits of cultivated land [1–15]. The Zhejiang [16] and Chongqing models [17] are typical practices for combining government and market objectives. From the perspective of externalities, these models determine the net ecological benefits of cultivated land protection by calculating the positive externalities such as grain production and ecological services brought by cultivated land protection, as well as the negative externalities caused by the application of chemical fertilizers and pesticides [18]. Using other methods from different perspectives, such as the multi-level interaction boundary model [19], the Integrated Biosphere Simulator model [20], the virtual farmland flow model [21,22], the energy analysis method [23], a combination of multiple methods [24], and the VEST model [25] also provide new ideas for the calculation of cultivated land ecological benefits.

There are deviations in the cognition of the ecological function of cultivated land from different theoretical perspectives, and the methods for calculating the ecological benefits of cultivated land also have a spatial scale-dependent effect [26]. For example, the ecosystem service value method is suitable for measuring the ecological benefits of cultivated land on a macro scale [27,28], and the non-market value method is suitable for measuring the ecological compensation standard for cultivated land on a micro scale [29,30]. The opportunity cost method, land development rights, and external values are affected by regional differences and market development and the calculation results have a large deviation. These undoubtedly affect the calculation accuracy of cultivated land ecological benefits and the efficiency of cultivated land ecological compensation. In addition, most literature only considers the benefits of cultivated land ecological protection in the calculation of cultivated land ecological benefits and compensation, and ignores the attribute relevance and integrated protection of cultivated land quality, quantity, and ecology [16,31,32]. This is not conducive to comprehensive calculation of cultivated land ecological benefits. It also hinders the wide coverage and deep participation of cultivated land ecological compensation. From the perspective of social, economic, and ecological

total value of cultivated land, calculating the ecological benefits of cultivated land and compensation standards have gradually become more important [18,33].

The calculation of cultivated land's ecological benefit provides a basis for the ecological compensation of cultivated land. However, the implementation of ecological compensation for cultivated land must also clarify the subject, mode, and mechanism of ecological compensation for cultivated land. Internationally, the governments and the market have initiated theoretical research and deployment of cultivated land ecological compensation [34]. Cultivated land ecological compensation takes market transactions as the principle. Governments, enterprises, upstream and downstream residents, associations, and non-governmental organizations are the main participants [35,36]. Ecological compensation for cultivated land has a high degree of marketization, and the forms of compensation are diversified internationally. The ecological benefits of cultivated land calculated by market evaluation techniques can be used to achieve ecologically precise compensation through market mechanisms. When market failures occur, government economic incentive compensation measures are also necessary. For example, when externalities exist in cultivated land use, the government should appoint special organizations and formulate specific rules to implement economic incentive compensation for farmers to adopt environmentally friendly farming technologies [37]. Innovative policy will utilize appropriate government control and flexible market adjustments to enact effective ecological compensation mechanisms.

In China, the market transaction mechanism for ecological resources is imperfect. Ecological compensation is usually dominated by the government, which buys ecosystem services. Ecological compensation for cultivated land is mainly initiated by the government, with a government-led investments or fiscal transfer systems at the core [34]. The compensation standard and compensation method are relatively singular. In this context, directly using the ecological benefits of cultivated land as the standard to implement ecological compensation and fiscal transfer will inevitably face some problems, such as the fuzzy scope, single subject and standard deviation of cultivated land ecological compensation. The incentive effect of ecological compensation for cultivated land is limited. Many scholars have tried to identify the compensation area and payment area of cultivated land ecological compensation, through the ratio of cultivated land ecological value [33], the food security level [38], and the virtual cultivated land value [22]. However, it cannot directly reflect the information, such as the surplus and spillover amount of cultivated land protection ecological benefits, and their spatial flow, etc. Depending on the balance between the ecological supply and demand of cultivated land, some documents identify the surplus and overflow of cultivated land ecological benefits, and then calculate the horizontal transfer amount of cultivated land ecological compensation [12,39,40]. These can effectively solve the fuzzy scope of cultivated land compensation on the macro scale. To reduce deviation between cultivated land compensation standard and actual spillover amount, some scholars use coefficients such as the level of regional social development [18], financial ability [39], and ecological compensation zoning index [40] to modify the ecological compensation standards of cultivated land. However, it is still difficult to identify the altruistic spillover amount of cultivated land protection behavior on a micro scale. In view of this, a regional cultivated land ecosystem service payment framework based on market principles may help to improve the government's economic incentive mechanism for cultivated land ecological protection [31], but in practice, ecological compensation for cultivated land is still under constant exploration and cannot be implemented widely, especially in watershed areas.

In summary, the existing literature discusses the calculation of ecological benefits of cultivated land protection and the determination of compensation standards and financial transfer payments, which provides a reference for cultivated land ecological compensation mechanisms and policy innovation. However, due to the different cognitive deviation and calculation methods of cultivated land ecological function, there is no consensus for a standard of cultivated land ecological compensation. In addition, the basis of cultivated land ecological financial transfer is insufficient and its rationality needs to be improved. Existing research on ecological compensation of cultivated land is mainly

concentrated in provinces, cities and other administrative areas, and the ecological compensation mechanisms and policies for cultivated land in river basins need further development. In the cross-regional, the ecological spatial spillover scope of cultivated land is wide, involving many administrative units, and the boundary of spatial spillover is blurred. Ecological compensation and ecological fiscal transfer policies of cultivated land are slightly insufficient.

The Yangtze River Economic Belt, is a large basin eco-economic system. It is not only an important production base for grain and agricultural products in China, but also an economic growth pole and a densely urban zone. Through the strategy of "Yangtze River Development", the Yangtze River Economic Belt has developed rapidly and has become an important economic and strategic region for China. However, by prioritizing development and city-oriented strategies, high-quality cultivated land has decreased sharply, the ecological environment has deteriorated, and the pressure on the protection of cultivated land resources has increased. In 2016, General Secretary Xi Jinping made it clear that the restoration of the ecological environment of the Yangtze River should be a key priority, focusing on large-scale protection rather than large-scale development. Under the "Yangtze River Protection" strategy, the balance between economic development and resource protection, especially the protection of high-quality cultivated land, is is essential to China's economy as well as its food and ecological security.

With the Yangtze River Economic Belt as the research area, this study discusses the government-led ecological compensation standards for cultivated land and ecological fiscal transfer quotas at the river basin scale. This article is arranged as follows. Based on the trinity concept of comprehensive protection that addresses quantity, quality, and ecology of cultivated land, we calculate the ecological benefits of cultivated land at the river basin scale to more accurately determine its ecological benefits. Based on the theory of ecological supply and demand balance, the article identifies the spillover boundary and spillover amount of ecological benefits of cultivated land and provides a technical basis for accurate ecological compensation of cultivated land. Considering the responsibilities of cultivated land ecological protection, local economic property rights and the ecological benefits spillover of cultivated land, we determine the government-led ecological compensation standards for cultivated land and ecological fiscal plans. It is expected to provide a scientific basis for the innovation of the ecological compensation mechanism for cultivated land on a macro scale.

2. Theory and Analytical Framework of Ecological Compensation for Cultivated Land Protection

2.1. Theoretical Analysis

This section analyzes the theories and mechanisms of ecological compensation for cultivated land protection from theoretical, practical, and technical perspectives and considers key issues of cultivated land ecological compensation.

The theoretical basis of cultivated land ecological compensation is the cognition of the cultivated land ecological function. Theories of cultivated land ecological compensation, such as public goods theory, ecological service value theory, sustainable development theory, and externality theory, deepen the understanding of the ecological function of cultivated land from different perspectives. It becomes apparent that protecting the ecology of cultivated land warrants compensation [41]. For example, as a public resource, cultivated land resource displays obvious characteristics of public goods, and it is necessary to implement cultivated land protection compensation. Simultaneously, cultivated land is also an important ecological service system [42], and needs to be preserved for its ecological service value. From a sustainability perspective, cultivated land ecological protection involves a balance of intra-generational and intergenerational interests. Compensation can effectively solve the problem of interregional poverty caused by bearing the cost of cultivated land ecological protection. According to the externality theory, the utilization and protection of cultivated land present significant externalities. Cultivated land ecological compensation can externalize these externalities and maximize the comprehensive benefits of cultivated land [43]. The cognition of the cultivated land

ecological function provides a basic basis for cultivated land ecological compensation. With deeper understanding of the cultivated land ecological function, the theory of cultivated land ecological compensation will develop further.

The need for cultivated land ecological compensation stems from the failure to protect cultivated land. Government policy tools such as spatial planning, use control, and growth management can control cultivated land conversion and effectively protect cultivated land. However, compulsory government restraint mechanisms will put the region under development and political pressure and cause local authority spillover and new inter-regional equity issues, resulting in insufficient economic incentives for cultivated land ecological protection and low efficiency. On the other hand, introducing market mechanisms to improve cultivated land ecological protection has become a global focus. For example, the Conservation Reserve Program plan of the United States, the Environmental Sensitive Areas Programs and Countryside Stewardship Schemes plan of the United Kingdom, the Ecological Fiscal Transfer plan in Brazil, as well as China's Zhejiang and Chongqing models. However, there are problems in the calculation of ecological compensation. First, there are existing biases between regions, groups and strategies. Also, policies are restricted by factors such as information asymmetry, fixed location of land, lagging development of the land market and more. Other problems include incomplete coverage of cultivated land ecological protection projects, low farmer participation, and lack of bargaining power of altruistic behavior. These problems can cause market failure. In the face of the dilemma of government and market protection failure, it is vital to improve the ecological compensation mechanisms for cultivated land.

The technical basis of cultivated land ecological compensation is the calculation of ecological spillover. The essence of ecological compensation for cultivated land protection is the economic incentive of ecological spillover stemming from protecting cultivated land [4,13]. If the spillover and non-exclusiveness of the ecological benefits of cultivated land protection are misplaced with the cost-bearing and benefit-sharing subjects, the enthusiasm for cultivated land ecological protection will be restrained. As a public resource, the ecological benefit of cultivated land is an inseparable external consumption effect with spatial spillover. Therefore, the regions that bear the responsibility for the ecological protection of cultivated land or where the ecological spillover is altruistic should be compensated, while the regions that that benefit from the spillover should bear the cost. In addition, the ecological function and value of cultivated land cannot be achieved through market transactions like the economic production function of cultivated land, and the protection cost is difficult to internalized. Therefore, the ecological service value and spatial spillover of cultivated land also need to be quantified and compensated to share the protection cost. In practice, cultivated land ecological compensation also compensates for the inequality of regional development opportunities caused by different responsibilities of cultivated land protection and development [15], based on the spatial transfer of the value of cultivated land development rights. We see that there are spatial spillovers in the altruistic externalities, ecological services, public benefits and the value of land development rights of cultivated land ecological protection, and the measurement of spillover should be the main technical basis of cultivated land ecological compensation.

The above analysis has clarified the framework of cultivated land ecological compensation mechanisms, but several key problems still need to be solved, the first is the calculation of a cultivated land ecological benefit standard. The cognitive bias of the cultivated land ecological function makes the identification and calculation methods of cultivated land ecological benefits different, and the calculation standards must be unified. The second is the calculation of the ecological benefit spillover of cultivated land. It is difficult to define the boundary between egoism and altruism, and between inside and outside. The scale bias, starting bias, strategy bias and payment vehicle bias of market and non-market technology in cultivated land ecological spillover assessment [44,45] also affect the measurement accuracy. The third is the innovation of cultivated land ecological financial compensation policy. The lack of vertical transfer incentive and horizontal transfer basis makes it difficult to implement cross basin (regional) ecological compensation and the efficiency of cultivated land ecological protection

is low. There is an urgent need to innovate the policy of ecological financial compensation for cultivated land, such as the matching of administrative power and financial rights, the balance of protection responsibilities and development rights of cultivated land, and the combination of vertical and horizontal financial transfer for cultivated land compensation. In addition, the inter-basin cultivated land ecological protection responsibility and obligation as well as the ecological spillover and compensation need to be throughly explored due to the difficulty of ecological compensation and poor coordination in cross-region, especially watershed cultivated land.

2.2. Framework Construction

Based on the above analysis, this paper constructs an analytical framework of "ecological function cognition–ecological benefit spillover–ecological financial transfer" (Figure 1). First, according to the trinity concept of comprehensive protection of quantity, quality, and ecology of cultivated land, the ecological benefits of cultivated land protection are calculated to provide a theoretical basis for cultivated land ecological compensation, as well as maintain land quality in its three aspects. Quantity protection is the guarantee of the ecological function of cultivated land, which determines the total ecological value of cultivated land. Quality protection is the guarantee of the ecological function of cultivated land, which ensures higher ecological benefits of cultivated land. Ecological protection is the basis for maintaining the ecological function and curbing the negative externalities of cultivated land. The trinity concept of comprehensive protection of cultivated land fully interprets the ecological functions and characteristics of cultivated land.

Secondly, based on the perspective of ecological supply and demand balance, we identified the ecological remainder or deficit of cultivated land and the ecological spillover or dependence of cultivated land in the basin to provide a technical basis for ecological compensation of cultivated land. The cultivated land protection area has lost economic benefits due to the increase of administrative power and limited development. In addition to meeting the ecological needs of a local region, the ecological benefits of cultivated land protection are also provided to other areas in the form of spatial spillover. The protection area is an ecological surplus area and needs compensation. On the contrary, the areas where the responsibility and obligation for the ecological protection of cultivated land have overflowed have obtained development opportunities and financial rights are called ecological deficit areas and should bear the cost of ecological protection of cultivated land.

Finally, we design an ecological financial transfer plan of cultivated land to innovate the ecological compensation policy for cultivated land. There are many administrative units in the river basin and significant differences in cultivated land resource endowments. The administrative and financial rights of cultivated land protection are more likely to be misallocated in river basin. We try to innovate the combination of vertical and horizontal ecological financial transfer mechanism between the central government and the river basin, and between river basin areas, to get out of the realistic predicament of the government failure of cultivated land protection. Spatial spillover amount of ecological benefits of cultivated land, protection responsibility of cultivated land, and regional economic power are the factors that must be considered and the main basis to design the ecological financial compensation mechanism for cultivated land.

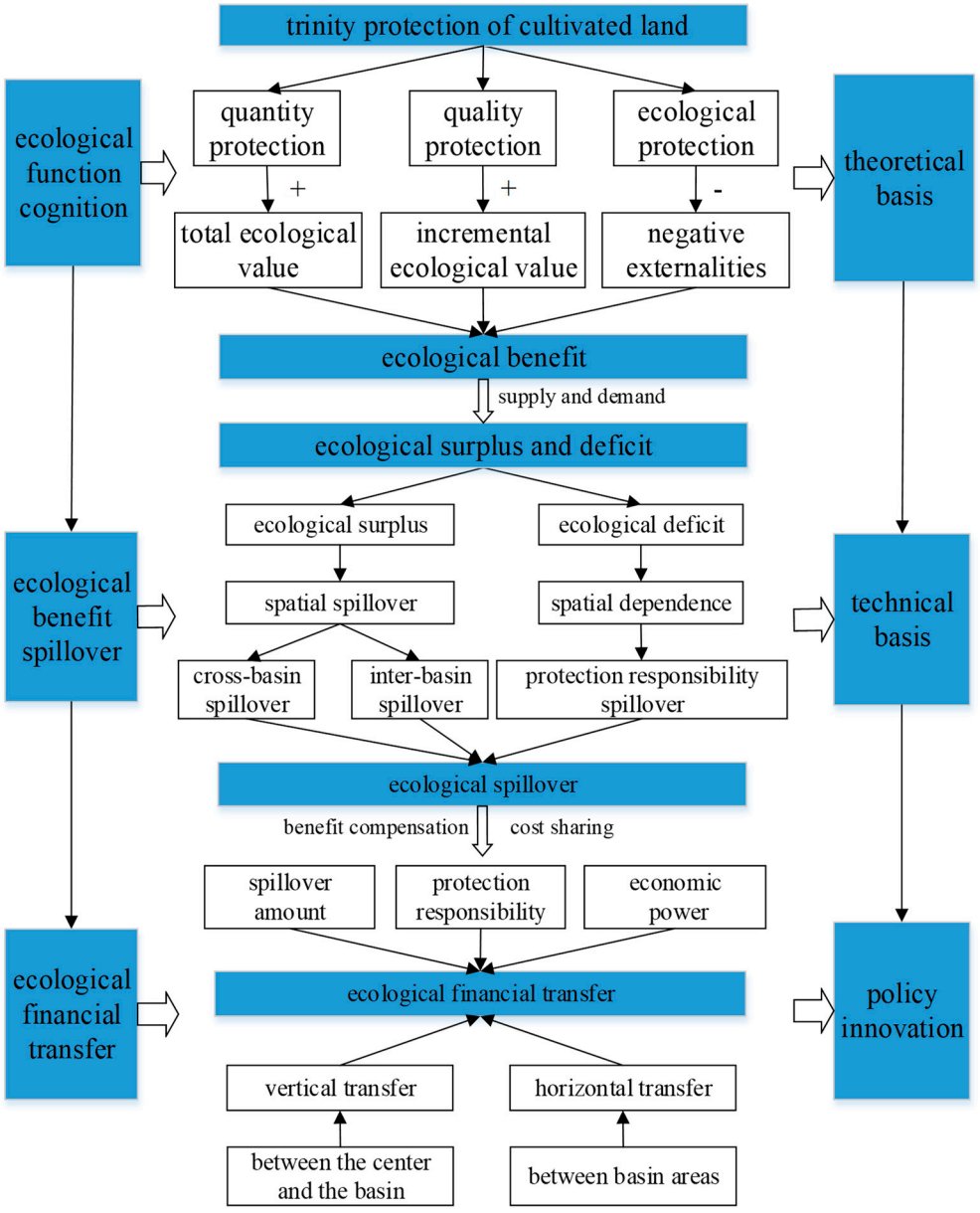

Figure 1. The theoretical analysis framework of ecological compensation for cultivated land.

3. Measurement Method of Ecological Benefit and Compensation of Cultivated Land Protection

3.1. Methods for Measuring the Ecological Benefits of Cultivated Land Protection

The ecological benefit of cultivated land is the ecological service value created by cultivated land protection [1,2]. The ecological benefit of cultivated land protection is calculated, based on the trinity concept of comprehensive protection of quantity, quality, and ecology of cultivated land. Cultivated land quantity protection maintains and enhances the total ecological benefit of cultivated land. The equivalent factor method is used to calculate the ecological benefits of cultivated land quantity protection (*FQB*), and the formula is:

$$FQB = E_k \times F \times R \times S \quad (1)$$

where R is the correction coefficient of multiple cropping index, which is expressed by the ratio of regional cultivated land multiple-crop index to national cultivated land multiple-crop index. F is the

biological equivalent factor of cultivated land per unit area. After excluding the production value of food and raw materials of cultivated land, the value is 6.59 [32]. S is the area of cultivated land, and E_k is the value of unit biological equivalent factors. The formula is as follows:

$$E_k = 1/7 \sum_{i=1}^{n} \frac{a_i p_i q_i}{A} \quad (2)$$

where n is the type of grain crops, mainly including wheat, corn, rice and soybeans, p_i, q_i are the national average price and unit yield of the i-th grain crop, a_i is the sown area of the i-th food crop, A is the total sown area of n kinds of crops, and 1/7 is the ratio of the value of unit biological equivalent factors to the market value of national average grain yield.

The quality protection of cultivated land is conducive to its versatility and is the guarantee of its ecological function. At the same time, the improvement of cultivated land quality can also adjust the planting structure and reduce the pollution of man-made development and utilization. The cultivated land quality coefficient (λ_i) is introduced to reflect the influence of cultivated land quality protection on cultivated land ecological benefits, and the formula is as follows:

$$\lambda_i = \sum_{j=1}^{m} \frac{s_{ij}}{s_i} f_j / Z \quad (3)$$

where λ_i is the cultivated land quality coefficient of region i, s_{ij} is the area of cultivated land in the i-th area and j-th grade, s_i is the total cultivated land area of region i, and Z is the cultivated land quality coefficient of the national average level. f_j is the score of the j-th grade land, assuming that the score of the 1st grade land is 100, and the score of the 15th grade land is 0, and the equal spacing method is used to determine the quality score of each grade of cultivated land. The larger the cultivated land quality coefficient is, the higher the ecological benefit of cultivated land protection.

The negative ecological externality of cultivated land protection mainly refers to the loss of cultivated land ecological benefits caused by the destructive behaviors of cultivated land utilization and management. Here, we mainly consider the negative externalities caused by man-made agricultural production behavior, such as the use of chemical fertilizers, pesticides, and mulching films. The replacement cost method to calculate the ecological negative value (FNB) of chemical fertilizers, pesticides and mulching film on cultivated land, and the formula is as follows:

$$FNB = NB_f + NB_p + NB_m \quad (4)$$

where NB_f, NB_p, NB_m represent the negative value of fertilizer, pesticides, and mulching film, respectively, and the calculation formula is as follows:

$$NB_f = Q_f \times \left(1 - \eta_f\right) \times P_f + Q_f \times C_f \quad (5)$$

$$NB_p = Q_p \times \left(1 - \eta_p\right) \times P_p + Q_p \times C_p \quad (6)$$

$$NB_m = Q_m \times \eta_m \times M_i \times \mu \times P_i \quad (7)$$

where Q_f, Q_p, Q_m represent the amount of fertilizer used, the amount of pesticide used and the area covered by mulching film respectively, and M_i is the per unit area yield of grain. n_f, n_p, n_m are the fertilizer utilization rate, pesticide utilization rate and mulching film residue ratio respectively, and μ is the grain loss rate. According to the research results of previous literature [18], n_f, n_p, n_m, μ take values of 34.17%, 35.00%, 41.7% and 10%, respectively. p_f, p_p, p_m represent fertilizer price, pesticide price and grain market price, respectively. C_f, C_p are the environmental costs of using chemical fertilizers and pesticides which are recorded as 603.27 RMB/ton and 18316.83 RMB/ton, respectively, by adopting the research results of existing literature [46].

Based on the trinity concept of comprehensive protection, the ecological benefits of cultivated land quantity protection are the foundation of cultivated land ecological benefit. The cultivated land quality

coefficient is used to modify the ecological benefit of quantity protection. The ecological negative externalities of cultivated land use are deducted. The ecological benefits of cultivated land protection (*FEB*) can be expressed as:

$$FEB = \lambda_i \times FQB - FNB \tag{8}$$

3.2. Methods for Measuring the Ecological Benefit Spillover of Cultivated Land Protection

The ecological benefit spillover of cultivated land protection is the key technical basis for cultivated land ecological compensation. Many methods have been used to divide the compensation/payment area of cultivated land to accurately estimate the ecological benefit spillover, such as the ratio of cultivated land ecological value [33], the food security level [38], and the virtual cultivated land value [22]. However, these methods cannot reflect the spillover amount and spatial flow of ecological benefits of cultivated land. Based on the balance theory between ecological supply and demand, this part defines the spillover boundary and measures the spillover amount of ecological benefits of cultivated land.

First, the ecological footprint model and ecological carrying capacity model are used to identify the ecological profit and loss of cultivated land. The ecological footprint of cultivated land refers to the area of cultivated land needed to produce the resources people consume and absorb the waste caused by their consumption, which reflects the ecological demand of cultivated land. The calculation formula is as follows:

$$FEF = N \times E_f = N \times \sum_{i}^{n} \alpha \frac{C_i}{P_i} \tag{9}$$

In the above formula, *FEF* is the regional ecological footprint of cultivated land. N is the total population of the region, and E_f is the ecological footprint of cultivated land per capita. α is the balanced factor of cultivated land, using the research results of Wackernage [47], et al., with a value of 2.17. C_i represents the regional per capita consumption and P_i represents the national average productivity of the first consumption item. The consumption items include rice, wheat, corn, and soybeans. C_i/P_i represents the area of biologically productive cultivated land converted into the consumption item of the region per capita.

The ecological carrying capacity of cultivated land refers to the area of biologically productive cultivated land that is actually owned in the region, reflecting the supply capacity of cultivated land. The calculation formula is as follows:

$$FEC = N \times E_c = 0.88 \times N \times A \times \beta \times Y \tag{10}$$

where, *FEC* is the ecological carrying capacity of regional cultivated land, E_c is the ecological carrying capacity of cultivated land per capita, β is the equilibrium factor, and A is the area of biological productive cultivated land per capita. Y is the yield factor of productive cultivated land, expressed as the ratio of regional cultivated land output to the national average output. According to the report by the World Commission on Environment and Development (WCED), the supply of the regional ecological footprint should be 88% of the regional ecological carrying capacity.

Secondly, the ecological profit or loss status and the ecological benefit spillover of cultivated land are identified by comparing the balance between ecological supply and demand of cultivated land. When the ecological carrying capacity of cultivated land is greater than the ecological footprint, the area is an ecological remainder area, which denotes ecological spillover; Conversely, it is an ecological deficit area of cultivated land, which is ecologically dependent.

Finally, the ecological overload index of cultivated land is introduced to calculate the spillover amount of cultivated land ecological benefits. The ecological overload index of cultivated land is an important indicator to measure the level of ecologically sustainable use of cultivated land. The index can be expressed as the ratio of the difference between the ecological carrying capacity and ecological

footprint of cultivated land to the ecological carrying capacity of cultivated land. Thus, the ecological benefit spillover of cultivated land (*FES*) can be calculated. The formula is:

$$FES = \frac{FEC - FEF}{FEC} \times FEB, \tag{11}$$

If $FES > 0$, it indicates that there is a spatial spillover of the ecological benefits of regional cultivated land protection, which should require ecological benefits compensation. Otherwise, the ecological benefits of cultivated land in this area are spatially dependent and the cost of ecological protection of cultivated land should be shared.

3.3. Measurement Method of Ecological Financial Transfer of Cultivated Land Protection

In order to match the financial and administrative rights of cultivated land ecological protection and avoid unrealistic ecological compensation standards, some studies have introduced coefficients such as socio-economic development level, comprehensive cultivated land quality level, and government ability to pay to modify cultivated land ecological compensation standards [18,33,39], but they lack theoretical and factual demonstrations. In the balance between cultivated land development and protection, local governments tend to develop cultivated land and increase economic and financial rights. However, under land use control, the local governments must bear the responsibility of cultivated land protection and increase the administrative power. The balance between farmland development and protection is a conflict between the administrative and financial rights of farmland protection. By adjusting the local financial and administrative rights through the compensation of cultivated land ecology, the incentive and constraint of cultivated land ecological protection can be realized, and the coordinated development of regions can also be promoted.

Local governments obtain economic and financial rights through the development of cultivated land and have stronger financial payment capabilities. They are more willing to reduce the power of protecting cultivated land through financial transfer and obtain opportunities for social and economic development. With the development of the regional society and economy, the ecological function value of cultivated land is more recognized, and the willingness to pay for ecology is also stronger. On the other hand, local governments assume the responsibility of farmland protection, which reduces the power of economic development and finance. Therefore, financial transfers are needed to support regional social and economic development. Meanwhile, some areas are limited by resource endowment, and the conversion benefit of cultivated land is insufficient, so they are more willing to protect cultivated land to obtain additional economic benefits. In order to verify the influence of financial rights and administrative power on the ecological benefit of cultivated land protection, the econometric model of influencing factors of cultivated land ecological protection is constructed:

$$lnFEP_i = C + \alpha_1 lnSED_i + \alpha_2 lnFPP_i + \alpha_3 lnECP_i + \varepsilon, \tag{12}$$

where, FEP_i is the ecological benefit of cultivated land per unit area of the i-th region; SED_i, FPP_i, ECP_i are the socio-economic development level, cultivated land resource endowment and cultivated land ecological compensation policy of the i-th region; C is the constant term and ε is the residual. Cultivated land ecological compensation policy is a 0 or 1 variable; if the region implements this policy, it is 1, otherwise it is 0. And the test results can also provide a supporting basis for the implementation of cultivated land ecological compensation. The influencing factors tested are taken as the adjustment coefficient of ecological spillover of cultivated land protection, and the ecological financial transfer of cultivated land protection is modified. Taking the river basin as a whole, the amount of vertical financial transfer of cultivated land protection between the central government and the basin can be expressed as follows:

$$EFT_o = \begin{cases} FES \times SED_r / SED_c, FES < 0 \\ FES \times FPP_r / FPP_c, FES > 0 \end{cases}, \tag{13}$$

In the formula, EFT_o, SED_r, SED_c, FPP_r, FPP_c refer to the vertical transfer of ecological finance of cultivated land protection in the river basin, the level of socio-economic development of the river basin, the level of social-economic development of the whole country, the endowment of cultivated land resources of the river basin, and the endowment of national cultivated land resources, respectively. If $EFT_o < 0$, it indicates that the river basin is a vertical transfer payment area of cultivated land ecological finance. The greater the financial rights are, the higher the payment will be; otherwise, it is a vertical transfer compensation area of cultivated land ecological finance, the greater the administrative rights, the higher the compensation. The horizontal financial transfer amount of cultivated land protection between basins can be expressed as:

$$EFT_w = \begin{cases} \sum_i^n FES_i \times SED_i / SED_{max}, FES_i < 0 \\ \sum_i^n FES_i \times FPP_i / FPP_{max}, FES_i > 0 \end{cases} \quad (14)$$

where, EFT_w, FES_i, SED_i, FPP_i, are respectively the horizontal transfer amount of cultivated land ecological finance in the basin, the spillover amount of cultivated land ecological benefits in the *i*-th region of the basin, the level of socio-economic development, and the endowment of cultivated land resources. $SED_{\max}$, $FPP_{\max}$ are respectively the maximum socio-economic development level and the maximum cultivated land resource endowment of the unit in the basin. If $EFT_o < 0$ the river basin is a vertical transfer payment area of cultivated land ecological finance, the greater the financial power, the higher the payment; otherwise, the river basin is a horizontal transfer compensation area of cultivated land ecological finance, the greater the protection power, the larger the compensation is.

4. Empirical Analysis of the Yangtze River Economic Belt

4.1. Data Sources

Taking 11 provinces of the Yangtze River Economic Belt as the research area, the main social, economic and agricultural data come from the statistical yearbooks of provinces and cities from 1995 to 2018, and the China Agricultural Yearbook and the Chinese Rural Statistical Yearbook. Among them, the grain price mainly comes from the *China Yearbook of Agricultural Price Survey*, the pesticides, fertilizer, and mulching film prices come from the *China Agricultural Development Report* and the *National Agricultural Product Cost and Income Data Compilation*, and are calculated according to the price index. The cultivated land quality coefficient comes from the *Study on Investigation and Assessment of Cultivated Land Quality Grade in China* (national volume). Among the above units, the area is unified as hm^2, the price is RMB/kg, and the unit output is kg/hm^2.

4.2. Calculation and Analysis of Ecological Benefits of Cultivated Land Protection

Using the data of the Yangtze River Economic Belt from 1995 to 2017, according to formulas (1)–(8), the ecological benefits of cultivated land protection in the economic belt and the ecological benefits of cultivated land per unit area can be obtained (Table 1). The results show that the ecological benefits of cultivated land protection in all provinces of the Yangtze River Economic Belt are more than 0, showing an overall growth trend, indicating that the ecological benefits of cultivated land quantity and quality protection are greater than the ecological negative externalities of cultivated land use, and the ecological value of cultivated land is constantly prominent.

Table 1. Ecological Benefits of Cultivated Land Protection in the Yangtze River Economic Belt.

Area	Ecological Benefits of Cultivated Land Protection per Unit Area (RMB/hm^2)				Ecological Benefits of Cultivated Land Protection (10^4 RMB)			
	1995	2005	2015	2017	1995	2005	2015	2017
Shanghai	12,768.37	16,233.59	37,661.99	32,625.31	37.03	38.52	71.49	62.51
Jiangsu	10,209.70	12,418.59	29,790.65	27,924.66	454.16	596.24	1362.88	1277.09
Zhejiang	10,062.07	10,748.69	15,738.89	13,616.44	162.78	171.29	311.41	269.20
Anhui	6636.64	8610.29	16,069.82	15,596.48	284.79	352.38	944.36	915.01
Jiangxi	9823.90	13,719.02	23,387.52	23,549.87	226.80	287.84	720.97	726.75
Hubei	12,538.45	19,058.02	24,548.88	25,467.53	421.04	602.46	1290.04	1333.46
Hunan	13,426.67	9375.20	29,340.88	28,711.40	436.33	357.76	1218.67	1191.82
Chongqing	6776.31	6768.19	14,687.33	13,445.12	110.40	94.70	356.97	318.63
Sichuan	12,048.11	8363.59	14,936.73	14,391.07	549.44	326.68	1005.46	967.82
Guizhou	3764.84	4183.22	5696.46	5402.09	69.27	73.35	258.47	244.11
Yunnan	2857.14	2936.48	7959.66	6853.84	82.55	123.09	494.18	425.85
Yangtze River Economic Belt	9173.84	10,219.53	19,983.53	18,871.25	2834.60	3024.30	8034.90	7732.24

Note: To save space, only part of the year calculation results are presented.

From the change of ecological benefits of cultivated land per unit area, the ecological benefits of cultivated land per unit area in the Yangtze River economic Belt increased by two times from 1995 to 2017, and the ecological benefits of cultivated land per unit area in 2017 reached 18,871.25 RMB/hm^2. In 2017, the ecological benefits per unit area of cultivated land in each province were 5402.03 RMB/hm^2–32625.31 RMB/hm^2, which was higher in Shanghai, Jiangsu, Hunan and Hubei, and lower in Yunnan and Guizhou, with significant differences. From the perspective of the river basins, the ecological benefits of cultivated land per unit area in different basins are different, and the middle and lower reaches are generally higher than the upper reaches. From the perspective of total ecological benefits, the ecological benefits of cultivated land protection in the Yangtze River Economic Belt have been increasing overall, from 283.46 billion RMB in 1995 to 773.224 billion RMB in 2017, an increase of 2.07 times. In 2017, the ecological benefits of cultivated land in the economic belt accounted for 2.31% of its total output value, and the ecological protection of cultivated land also played an important role in regional economic and social development. The spatial distribution of ecological benefits of cultivated land in different river basins is uneven. The middle reaches contribute more than 50% of the benefits of the economic belt, while the lower reaches contribute only 20%, and the growth rate in the middle reaches is significantly higher than that in the upper and lower reaches. It is worth noting that, affected by the area of grain sown and cultivated land quality, the ecological benefit of cultivated land in the economic belt shows a downward trend in recent years, in which the lower reaches with better economic development see significant decline, while the upper and middle reaches with higher cultivated land resource endowment have a smaller decline. It is necessary to establish and improve the economic incentives and restraint mechanisms for cultivated land protection, to adjust local financial rights and cultivated land protection rights, and implement differential compensation policies for cultivated land ecological protection.

4.3. Cultivated Land Protection Ecological Profit and Loss and Benefit Spillover Calculation

4.3.1. Identification of Ecological Profit and Loss Status of Cultivated Land Protection

From Formulas (9) and (10), we obtain the ecological supply and demand status of cultivated land protection in the Yangtze River Economic Belt can be obtained. As seen in Table 2, the ecological footprint of cultivated land in the Yangtze River Economic Belt in 2017 was 46.421 million hm^2, the ecological demands of cultivated land in each province were between 1.51 million hm^2–7.28 million hm^2, and the ecological footprint of cultivated land among the basins was relatively balanced.

Table 2. Ecological profit and loss status and benefit spillover of cultivated land in the Yangtze River Economic Belt.

Area	Ecological Footprint (10^4 hm^2)	Ecological Carrying Capacity (10^4 hm^2)	Ecological Supply and Demand (10^4 hm^2)	Ecological Overload Degree	Ecological Benefits (10^8 RMB)	Ecological Spatial Spillover (10^8 RMB)	Type of Compensation/ Payment area
Shanghai	151.81	36.26	–115.55	–3.19	62.51	–199.20	deficit
Jiangsu	585.75	1438.94	853.20	0.59	1277.09	757.23	surplus
Zhejiang	429.35	312.44	–116.91	–0.37	269.20	–100.73	deficit
Anhui	539.64	1413.01	873.37	0.62	915.01	565.56	surplus
Jiangxi	364.14	864.67	500.53	0.58	726.75	420.69	surplus
Hubei	399.93	1056.79	656.86	0.62	1333.46	828.82	surplus
Hunan	571.14	1213.01	641.87	0.53	1191.82	630.65	surplus
Chongqing	303.44	474.47	171.03	0.36	318.63	114.86	surplus
Sichuan	727.81	1422.11	694.31	0.49	967.82	472.51	surplus
Guizhou	267.92	479.11	211.19	0.44	244.11	107.60	surplus
Yunnan	308.28	784.35	476.07	0.61	425.85	258.47	surplus
Yangtze River Economic Belt	4649.21	9495.16	4845.96	0.51	7732.24	3946.23	surplus

Notes: the ecological benefit spillover of cultivated land in the Yangtze River Economic Belt takes the river basin as a whole to export ecological value to areas outside the economic belt. The ecological benefit spillover of each province is in the inner part of the economic belt, and the spillover boundary is different. Therefore, the amount of ecological benefit spillover of cultivated land in the economic belt is not equal to the sum of the spillover amount of each province.

In 2017, the ecological carrying capacity of the Yangtze River Economic Eelt reached 94.95 million hm^2. The ecological carrying capacity of cultivated land in the middle reaches is larger than that in the upstream and downstream areas, which is the main ecological supply area of cultivated land. Within the basin, the ecological carrying capacity of cultivated land in Jiangsu, Sichuan and five other provinces exceeded 10 million hm^2, while in Shanghai, Zhejiang, Guizhou and Chongqing and other regions were relatively low. The ecological supply capacity of cultivated land is significantly different among provinces, and the ecological protection responsibility of cultivated land is unbalanced.

Comparing ecological footprints and carrying capacities of cultivated land can effectively identify the profit and loss of cultivated land ecological supply and demand. Overall, the ecological supply of cultivated land is greater than the ecological demand in the Yangtze River Economic Belt, which is the ecological remainder area of cultivated land, and the ecological benefit of cultivated land protection overflows. At the basin level, the middle and lower reaches of the economic belt all show the ecological remainder of cultivated land, while the upper reaches, such as Shanghai and Zhejiang show an ecological deficit of cultivated land. At the provincial level, Jiangsu, Anhui, Hubei, and Hunan are the main cultivated land remainder areas, and the ecological spillover of cultivated land is significant. Shanghai and Zhejiang are cultivated land deficit areas with relatively little spatial dependence. We see that the ecological protection of cultivated land in the Yangtze River Economic Belt has cultivated land ecological spillover at the national level, but the responsibilities, obligations and profit and loss status of cultivated land ecological protection within the basin are different. It is necessary to identify and make targeted compensation for the cultivated land spillover.

4.3.2. Spatial Spillover of Cultivated Land Protection Ecological Benefits

According to the formula (11), the ecological overload index of cultivated land and the spatial spillover of cultivated land ecological benefits in the Yangtze River Economic Belt can be calculated (Table 2). The results show that the ecological overload index of cultivated land in the Yangtze River Economic Belt in 2017 was 0.51. Except for Shanghai and Zhejiang, the ecological overload index of cultivated land in other areas was between 0.36 and 0.62, which was within the range of carrying capacity. The Yangtze River Economic Belt has fulfilled its responsibility and obligation for ecological protection of cultivated land, which also has altruistic ecological spillovers. In 2017, the ecological benefit spillover of cultivated land protection in the economic belt was 394.623 billion yuan, accounting for 2.08% of the regional GDP in that year. Among them, the upstream, middle, and downstream areas accounted for 24.16%, 61.98% and 11.59% of the ecological benefit spillover of cultivated land respectively. Within the economic belt, the ecological benefit spillover of cultivated

land in Shanghai and Zhejiang is negative, indicating that Shanghai and Zhejiang should be the ecological payment area of cultivated land. The ecological benefit spillover of cultivated land in Hubei, Jiangsu, Hunan, and Anhui accounts for 70.50% of the total economic belt, which is the main ecological compensation area of cultivated land. Chongqing, Yunnan, and Guizhou are also ecological compensation areas of cultivated land, but the spillover of ecological benefits of cultivated land is relatively small, accounting for only 12.18% of the basin. There are significant river basin and inter-provincial differences in the ecological benefit spillover of cultivated land in the Yangtze River Economic Belt.

4.4. Calculation of Ecological Financial Transfer Amount for Cultivated Land Protection

4.4.1. Test on the Influencing Factors of Ecological Benefits of Cultivated Land Protection

The compensation for ecological benefits of cultivated land should not only be based on the spillover amount of cultivated land ecological benefits, but also need to consider the disconnection between compensation standards and reality, and the trade-off between local cultivated land development and protection. The per capita GDP is used to indicate the level of regional socio-economic development, and the per capita cultivated land area indicates the endowment of regional cultivated land resources. The ecological compensation policy is obtained from combing regional ecological compensation policy documents. Taking 11 provinces of the Yangtze River Economic Belt from 1995 to 2017 as samples, Likelihood Ratio is used to judge model effects. The test results show that the F value is 175.146 and P value is much less than 0.5. So the fixed effects model is appropriate. To reduce heteroscedasticity and insufficient sample size, the EGLS method is used for estimation, and the results are shown in Table 3.

Table 3. Test table of influencing factors of cultivated land protection ecological benefits in the Yangtze River Economic Belt.

Variable	Coefficient	T-Statistic	Prob.
GDP per capita	0.662	23.157	0.000
Cultivated area per capita	–0.162	–18.600	0.000
Ecological compensation policy	0.043	9.334	0.000
Constant	0.223	29.782	0.000
R-squared	0.960	F-statistics	446.837
Adjusted R-squared	0.958	Prob(F-statistics)	0.000

From the estimated coefficient, per capita GDP has a positive effect on the ecological benefits of cultivated land, indicating that the improvement of the level of local social-economic development will help to increase the ecological benefits of cultivated land. On the one hand, local governments acquire economic and financial rights through the development of cultivated land and are more willing and able to realize the ecological protection of cultivated land through economic incentives, technological popularization and pollution control. On the other hand, with social and economic development, the regional ecological civilization concept is strengthened and the ecological function value of cultivated land is more recognized, and the awareness and motivation of ecological protection are also stronger. The area of cultivated land per capita has a negative effect on the ecological benefits of cultivated land, indicating that the ecological benefits of cultivated land are relatively reduced in the regions with abundant cultivated land resource endowment. The main reasons are as follows: (1) local governments assume more responsibilities and obligations for the protection of cultivated land because of the abundant endowment of cultivated land resources; (2) the increase of local authority; (3) The limitation of financial rights for development; (4) and the lack of motivation and capacity for the protection of cultivated land. Ecological compensation policies have a positive effect on the ecological benefits of cultivated land, indicating that the implementation of ecological compensation policies can help to stimulate the enthusiasm of cultivated land ecological protection and implement

the responsibility of cultivated land ecological protection. This result has been verified by the practice of cultivated land ecological compensation and the change of cultivated land ecological benefits in Shanghai, Jiangsu, Chongqing and Sichuan. We see that the trade-off between cultivated land development and protection has brought about the spillover of financial rights and administrative rights of local governments, and the spillover of financial rights helps to encourage cultivated land ecological protection while the spillover of administrative rights is not conducive to maintaining the motivation of cultivated land ecological protection. The matching of financial rights and administrative rights in cultivated land ecological protection can improve the benefit of cultivated land ecological protection and promote the coordinated development of regions. Ecological compensation of cultivated land can be one of the ways to solve the contradiction between the financial rights and the administrative rights of cultivated land development and protection.

4.4.2. Ecological Benefit Correction and Financial Transfer of Cultivated Land Protection

According to the above test results, the Formulas (13) and (14) are used to modify the spatial spillover of cultivated land ecological benefits (Table 4). After revision, the ecological benefit spillover of cultivated land in the Yangtze River Economic Belt was 230.142 billion RMB, a decrease of 41.68%. The downstream area of the economic belt is still the main ecologically dependent area, and the midstream area is the main compensated area. The amount of spillover or dependence of cultivated land ecological benefits in each province is between 7.32 billion RMB and 56.82 billion RMB, the degree of dispersion is reduced, and the inter-provincial differences in the spillover of cultivated land ecological benefits are also reduced. The revised amount of ecological benefit spillover of cultivated land tracks with the expectation of incomplete compensation, and improves the matching degree between the spillover amount of cultivated land and the administrative and financial right of cultivated land ecological protection in each province.

Table 4. The amount of ecological financial transfer payment of cultivated land in the Yangtze River Economic Belt.

Area	Correction Coefficient of Financial/ Administrative Rights	Ecological Compensation/ Payment (10^8 RMB)	Ecological Financial Transfer (10^8 RMB)	Ecological Compensation Standard (RMB/hm^2)	Fiscal Transfer Proportion in Fiscal Revenue (%)	Type of Financial Transfer
Shanghai	1.00	–199.20	–199.20	105,014.39	3.03	HTP
Jiangsu	0.44	333.28	336.29	7361.06	4.12	HVTC
Zhejiang	0.73	–73.21	–73.21	3740.27	1.27	HTP
Anhui	0.72	409.88	413.58	7057.11	14.72	HVTC
Jiangxi	0.52	217.04	219.00	7104.11	9.76	HVTC
Hubei	0.69	568.15	573.28	10,960.66	17.67	HVTC
Hunan	0.47	294.87	297.53	7175.34	10.80	HVTC
Chongqing	0.60	68.40	69.02	2915.34	3.07	HVTC
Sichuan	0.63	295.76	298.43	4442.27	8.35	HVTC
Guizhou	0.98	104.95	105.89	2345.90	6.57	HVTC
Yunnan	1.00	258.47	260.81	4202.02	13.84	HVTC
Yangtze River Economic Belt	0.58	2301.42	2301.42	5124.65	5.61	VTC

Note: HVTC represents horizontal and vertical transfer compensations, HTP represents horizontal transfer payment, and VTC represents vertical transfer compensation.

According to the situation inside and outside the ecological spillover field of cultivated land, the financial transfer amount is determined in two ways, vertically and horizontally. To balance the transfer funds of cultivated land ecological finance, the sum of vertical and horizontal transfer payments of cultivated land ecological finance are used as the source of compensation funds to be distributed within the river basin. Based on the scenario of ecological spillover off-site, the vertical transfer amount of cultivated land protection ecological finance between the central region and the river basin is determined. At the national level, the ecological benefits of cultivated land protection in the Yangtze River Economic Belt are spillover, which is beneficial to the areas outside the river basin. Therefore, it is necessary to obtain the vertical transfer of cultivated land protection ecological finance between the central and local governments across the river basin. According to the calculations, in 2017, the Yangtze River Economic Belt should have received a vertical transfer payment of 230.142 billion

RMB from the central finance, which is used to compensate for the spillover of cultivated land protection ecological benefits.

Based on the situation of the ecological spillover site, the horizontal transfer of cultivated land protection ecological finance between local governments within the basin is determined. Within the Yangtze River Economic Belt, there are differences in the responsibilities and obligations of each province in the ecological protection of cultivated land and the spillover and dependence of the ecological benefits of cultivated land protection coexist, which leads to the overflow of administrative rights in the balance between cultivated land development and protection. Areas where the ecological benefits of cultivated land protection spillover should receive ecological compensation, while areas where the benefits dependence should share the cost of protecting cultivated land. According to the calculation, in 2017, the amount of fiscal horizontal transfer payment of the Yangtze River Economic Belt was 27.24 billion RMB, and the payment areas were Shanghai and Zhejiang. And in the economic belt, the financial horizontal transfer compensation is 257.38 billion yuan, 58.41% in the middle reaches and 28.52% in the lower reaches.

4.5. Analysis on the Feasibility of Ecological Financial transfer of cultivated Land Protection

4.5.1. Analysis of Compensation Amount in the Compensated Area

For the compensated area, in order to stimulate the enthusiasm of cultivated land ecological protection and establish a long-term incentive mechanism, the cultivated land ecological financial compensation standard needs to meet two conditions: First, the ecological financial compensation amount of cultivated land should be greater than the ecological protection cost of cultivated land to ensure cultivated land ecological protection has economic benefits and incentive effects; Second, the ecological financial compensation amount of cultivated land should be less than the ecological benefit spillover of cultivated land, to ensure that the object of cultivated land ecological compensation is altruistic spillover, to achieve accurate compensation. The ecological protection cost of cultivated land is simplified as the government compensation amount that farmers are willing to accept for reducing the external inputs such as chemical fertilizers and pesticides. Referring to the research results of Cai et al. [48]., the standard of cultivated land compensation is 3354.75 RMB/hm^2. We found that the ecological compensation standard of cultivated land in the Yangtze River Economic Belt as a whole is 5124.65 RMB/hm^2 and the ecological compensation standard for cultivated land in other provinces is generally greater than the cost of ecological protection of cultivated land, except for Guizhou and Chongqing (Table 4). The ecological compensation of cultivated land in the economic zone adopts the method of incomplete compensation, and the ecological financial compensation amount of cultivated land is 58.32% of the spillover of cultivated land ecological benefits. So the amount of cultivated land ecological financial transfer is reasonable to the cultivated land ecological remainder area, which can not only play an economic incentive role, but also ensure long-term incentive effect.

4.5.2. Analysis of the Financial Burden of the Payment Area

For the payment area, the ecological financial transfer payment of cultivated land must be within the tolerance range of the local finance and can play a role in restricting cultivated land conversion, otherwise it will inevitably affect the implementation of cultivated land ecological financial transfer system. The ratio of cultivated land ecological financial transfer to local financial revenue is used to reflect the financial burden of cultivated land ecological fiscal transfer payments. In 2017, the ecological financial transfer of cultivated land in the Yangtze River Economic Belt accounted for 5.61% of the local fiscal revenue in that year, and the ecological financial transfer burden of cultivated land in each provinces was between 3% and 17.65%. As financial payment areas in Shanghai and Zhejiang, the ecological financial burden of cultivated land is 3.00% and 1.26%, both of which are within the financial affordability. Further comparison with the regional fiscal expenditure on agriculture founds, we see the ecological fiscal transfer of cultivated land in economic belt accounts for 30.62% of the

regional agricultural expenditure, that of cultivated land in Shanghai and Zhejiang accounts for 43.63% and 10.51% of the agricultural expenditure, and that of cultivated land in compensated area accounts for 17.30%–80.21% of the agricultural expenditure. So the ecological fiscal transfer of cultivated land will not increase the financial burden of the payment area, which can not only fulfill the responsibility of ecological protection of cultivated land and balance the choice of local cultivated land development and protection, but also effectively support agricultural development.

5. Conclusions and Discussion

This study calculated the ecological benefits and spatial spillover of cultivated land in the Yangtze River Economic Belt. It comprehensively considered the power of cultivated land protection and the financial rights of cultivated land development. The standards and quotas of ecological financial transfer of cultivated land in the basin were calculated. The main contributions of the paper are as follows: First, the paper provided ideas and methods for calculating the ecological benefits of cultivated land on a macro scale. Based on the trinity concept of comprehensive protection of quantity, quality, and ecology of cultivated land, we calculated the ecological benefits of cultivated land protection on a macro scale, which should help to unify the measurement standards of cultivated land ecological benefits and improve measurement accuracy on a macro scale. Second, the ecological compensation standard for cultivated land calculated in this paper not only improved the accuracy and efficiency of ecological compensation for cultivated land, but also considered regional equity. The ecological spatial spillover of cultivated land was the basis of ecological compensation for cultivated land. However, the power of cultivated land protection and the financial rights of cultivated land development also affected the ecological benefits and compensation effects of cultivated land. By weighing the power of cultivated land protection and the financial rights of cultivated land development, we designed the final standards and quotas of ecological compensation for cultivated land to make ecological compensation more accurate. The final ecological compensation standard for cultivated land improved the effect of economic incentives, while also considering the fairness problem caused by ecological compensation for cultivated land. Third, the paper innovated the mechanisms and systems of ecological economic compensation for cultivated land. Cultivated land ecological compensation has a significant spatial scale-dependent effect [26]. Considering the spatial scale characteristics and differences within and outside the watershed, we have constructed a vertical and horizontal ecological fiscal transfer policy for cultivated land in the watershed. The policy was feasible and targeted, and could provide a reference for the innovation of ecological compensation mechanisms for cultivated land.

Our research found that the ecological benefits of cultivated land in the Yangtze River Economic Belt have cross-basin spillover and inter-basin spillover, and the inter-provincial differences of the spatial spillover are obvious. The ecological benefits of cultivated land protection in the watershed are determined by the quantity, quality, and ecology of the cultivated land. The strength of cultivated land protection, the local economic financial rights, and the ecological compensation policies of cultivated land would also affect the ecological benefits of cultivated land protection. Ecological compensation for cultivated land must consider the matching scale of responsibilities and obligations, financial rights and powers of cultivated land protection in the watershed. Based on identifying the spillover boundary of the ecological benefits of cultivated land, the ecological compensation standards of cultivated land were designed, taking into account factors such as spillover, economic financial rights and powers of cultivated land protection. The ecological compensation standards could improve the effectiveness of ecological compensation for cultivated land and the feasibility of ecological financial transfers for cultivated land.

This article has significant policy implications. First, the pertinence and effectiveness of the ecological compensation policy for cultivated land in the watershed must be improved. At present, the ecological benefits of cultivated land in the watershed are heterogeneous. Moreover, the ecological compensation of cultivated land in the watershed involves many administrative units and the spillover boundary of ecological benefits of cultivated land is blurred. There is an urgent need to establish

and implement a differentiated ecological compensation mechanism for cultivated land to improve the compensation efficiency. Second, the design basis of the ecological compensation standard for cultivated land should be the spillover amount of ecological benefits, not the ecological benefits of cultivated land. It is a prerequisite for achieving precise compensation to define the spillover boundary and amounts of the ecological benefits of cultivated land protection accurately, which can also avoid the deviation of compensation standards from practice. Third, the ecological financial transfer system of cultivated land should consider the local economic rights and the power of cultivated land protection. Diversified ecological financial transfer practices should be widely adopted. Only this way can economic incentive and restraint measures of cultivated land ecological compensation be effective while ensuring fairness.

This study still has some shortcomings and problems that should be addressed. The calculation of ecological benefits of cultivated land protection draws from the estimation methods of ecological service value and negative externalities at the international and national levels.Applying the methods to the Yangtze River Economic Belt is also faced with the differences in crop types, planting structures, farming systems and field management techniques, so it needs to be further revised Through the regional cultivated land use and management characteristics.

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