

Article

Impact of National Key Ecological Function Areas (NKEFAs) Construction on China's Economic Resilience under the Background of Sustainable Development

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Abstract: National Key Ecological Functional Areas (NKEFAs) play an important role in forestry restoration, water source conservation, soil and water conservation, windbreak and sand fixation, and biodiversity maintenance. They are the strategic core of ecosystem protection and restoration projects, not only directly related to ecological environment construction, but also profoundly affecting the sustainable development capacity of regional economy. This article selects 1256 ecologically and economically representative counties in China with complete data as research objects. Based on the data of the selected counties from 2007 to 2021, the entropy weight TOPSIS method is used to construct an economic resilience index, and a multi-period difference-in-differences (DID) model is adopted to explore the specific impact of the establishment of national key ecological functional areas on China's economic resilience. Research has shown that national key ecological functional areas can enhance the resilience of county-level economies by promoting economic agglomeration and factor agglomeration, increasing fiscal expenditure and investment levels, and promoting sustainable development of county-level economies. The establishment of national key ecological functional areas in economically underdeveloped areas has had a positive effect on economic resilience, and the establishment of water source conservation, soil and water conservation, and biodiversity maintenance ecological functional areas has a significant impact on economic resilience. Therefore, national key ecological functional areas have generally promoted the improvement of China's economic resilience, but in the process of policy implementation, the establishment of national key ecological functional areas should be promoted according to local conditions. This article not only provides empirical evidence for the effectiveness of China's national key ecological function areas policies, but also provides methodological inspiration for formulating more precise and scientific ecological protection policies, which has reference significance for the implementation of similar policies in other regions around the world.

Keywords: national key ecological functional areas; sustainable development; economic resilience; multi-period difference-in-differences (DID) model



Citation: Wang, Y.; Wang, Y.; Wu, J.; Ma, L.; Deng, Y. Impact of National Key Ecological Function Areas (NKEFAs) Construction on China's Economic Resilience under the Background of Sustainable Development. *Forests* **2024**, *15*, 1531. <https://doi.org/10.3390/f15091531>

Academic Editor: Pankaj Lal

Received: 17 July 2024

Revised: 18 August 2024

Accepted: 27 August 2024

Published: 30 August 2024



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1. Introduction

Sustainable development is the common pursuit of all humanity, with the core goal of achieving long-term social progress, environmental balance, and economic growth [1,2]. Long-term economic growth, as a material guarantee for achieving this goal, includes both the growth of regional real output value and the growth of its economic dynamic adjustment ability, reflecting the level of sustainable development of the regional economy. As the foundation for achieving this goal, the ecological environment plays an irreplaceable role in maintaining human social stability [3]. From the perspective of China, the process

of urbanization and the expansion of non-agricultural activities have driven the country's economy to achieve high-speed growth in the short term, but in the long run, they have become a major bottleneck restricting sustainable economic and social development [4]. On the one hand, such expansion is accompanied by a significant demand for natural resources, posing challenges to the protection and sustainable utilization of forestry resources. In this process, ecological and environmental problems such as the disorderly expansion of regional construction land, illegal logging and overgrazing, and unplanned reclamation activities have become increasingly prominent, seriously squeezing the spatial scope of ecological land and further limiting the development of economic activities due to the reduction of natural resources [5–7]. On the other hand, traditional production and lifestyle in the process of urbanization are often accompanied by an increase in environmental pressure, especially the worsening of air pollution [8], which not only affects the health of residents but also poses a threat to the long-term well-being of society. In the process of urbanization, China still relies on traditional high-input, high-consumption, and high-pollution production methods to drive economic growth. In the short term, this will increase residents' income levels, and the increase in medical expenses caused by income growth will generate additional human capital [9]. While promoting production, it further exacerbates pollution levels and brings higher environmental costs [10]. In response to this situation, China issued the “National Overall Functional Area Plan” in December 2010. Based on the different resources and environmental capabilities of different regions, the national land space is divided into four types: optimized development areas, key development areas, restricted development areas, and prohibited development areas. National key ecological functional areas are also established to improve the quality of the ecological environment and enhance the supply of ecological products [11,12]. The establishment of ecological functional areas can effectively resolve the dual problems of continuous deterioration of the ecological environment and low sustainability of economic development and has become a key link in achieving a win-win situation with both economic and social benefits (Figure 1) [13,14].

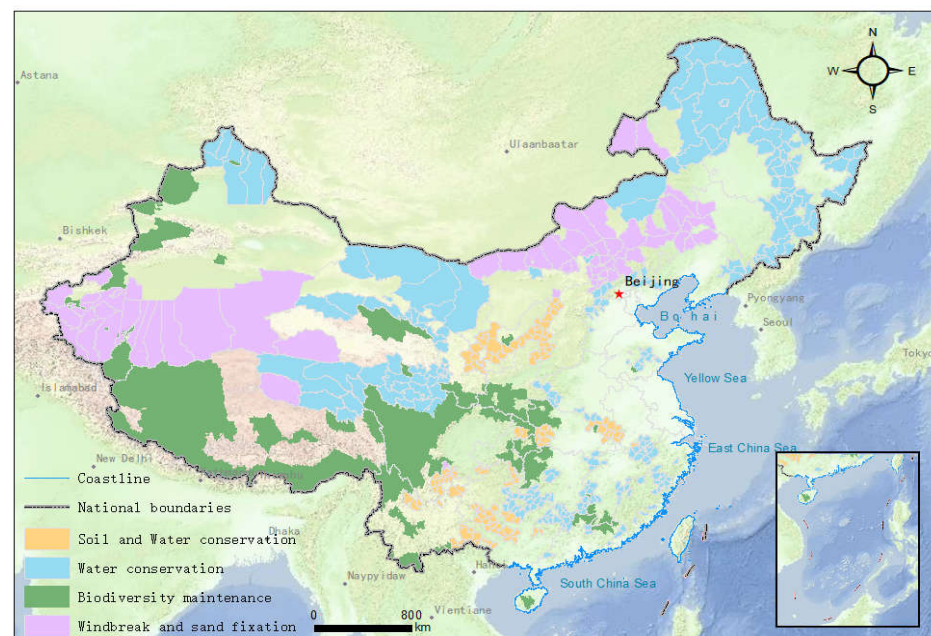


Figure 1. Distribution map of national key ecological function areas.

The construction of national key ecological functional areas is an important carrier for maintaining ecological balance and supporting the ecological security red line for sustainable economic and social development. It undertakes important ecological functions such as forestry restoration, water source conservation, soil and water conservation, wind

and sand fixation, and biodiversity maintenance. The current academic research on the effectiveness of pilot policies for national key ecological functional areas can be broadly categorized into three types. One is to assess the ecological protection effect of national key ecological functional areas, and this type of literature has deeply analyzed the impact of the establishment of national key ecological functional areas on regional air quality [15], environmental quality [16] and the level of ecological green development [17]. The second category focuses on exploring the effects of the transfer payment policy in national key ecological functional areas, and studies have confirmed that the transfer payment policy in national key ecological functional areas can not only incentivize local governments and enterprises to reduce pollution emissions [18], but also promote economic development and increase the gross regional product [19]. Third, it explores the impact of the establishment of national key ecological functional areas on the regional economy, such as Fei and others [20] based on the panel data of China's county-level administrative units from 2007 to 2015, and utilized a multi-period DID model to derive that the establishment of the ecological functional areas significantly improved the level of economic development of the counties at both the aggregate level and the per capita level. However, most of this literature only focuses on the short-term benefits of ecological function area policies, such as their impact on regional economic levels, and there are few studies that discuss them from the perspective of sustainability and county-level economic resilience. Toughness originates from physics, which means the ability of a system to maintain stability and restore its original state after suffering a shock, and later Martin expanded it to the field of economics and put forward the concept of economic toughness [21]. Economic resilience refers to the ability of a region to quickly restore its original economic growth mode or create new growth modes after the end of an impact. It aims to measure the level of regional economic sustainability and has become a hot topic in academic research in recent years. At present, most research on economic resilience focuses on how to construct and measure the economic resilience of a certain region [22,23]. A small number of scholars have conducted research on and explored the factors influencing economic resilience [24–29].

Based on the existing literature, there are still two research gaps in the academic community. Specifically, on the one hand, most scholars' research on economic resilience only focuses on the city level, including the exploration of its measurement and influencing factors. The research on the resilience of the county-level economy urgently needs to be improved. On the other hand, there is a lack of literature evaluating China's national key ecological function area policies from a sustainability perspective. Currently, the evaluation of the economic benefits of this policy only stays at the level of output value growth, failing to explain the long-term impact of this policy on the regional economic dynamic adjustment ability. In addition, the scope of implementation of this policy is mainly at the county level in China, directly targeting specific issues or resources within the county, such as forest management and soil and water conservation. As a relatively small administrative unit, the internal management and policy implementation of counties are also more refined. In view of this, this article aims to explore in depth the policy effects of China's ecological functional areas from the perspective of the sustainable development capacity of county-level economies. Based on panel data of county-level administrative units from 2007 to 2021, a county-level economic resilience evaluation system was constructed using the entropy weight TOPSIS method. The multi-period DID model was used to clarify the impact of national key ecological function area policies on the resilience level of county-level economies, and further explore their specific mechanisms and differences.

The marginal contribution of this article lies as follows: (1) In terms of research methods, this article innovatively integrates information entropy theory and TOPSIS evaluation technology to construct a multidimensional economic resilience evaluation model. This model not only considers the resilience level of China's county-level economy from multiple dimensions such as regulation and adaptability, resistance and recovery, innovation and transformation but also enhances the objectivity and accuracy of the evaluation process through the introduction of information entropy theory, ensuring the scientific determi-

nation of the weights of various evaluation indicators. Compared with the core variable method used in the existing literature [30,31], this model dynamically considers the sustainable development capacity of the regional economy, which can effectively identify potential economic risks and vulnerable links when the economic environment changes, providing a more accurate and reliable analytical tool for empirical research on county-level economic resilience; (2) In terms of research content, regarding the establishment of China's national key ecological functional areas, this study goes beyond the traditional focus on a single dimension of economic growth and is based on the concept of sustainable development [19]. It deeply explores the key role of this policy in enhancing the dynamic adjustment capacity of county-level economies. Innovatively integrating ecological development with sustainable development theory, a comprehensive and integrated analytical framework was constructed, providing new ideas for understanding the path of economic sustainable development driven by policies; (3) In terms of research significance, firstly, based on clarifying the practical problems of continuous deterioration of ecological environment and low sustainability of economic development, the role of national key ecological functional areas in enhancing the resilience of county-level economy is systematically expounded. The research results are of great significance for achieving ecological protection goals such as forest restoration, soil and water conservation, wind prevention and sand fixation, and promoting sustainable socio-economic development. Secondly, this article conducts a detailed heterogeneity analysis of China's key ecological functional areas located in different levels of economic development and types of countries. This not only enriches the understanding of policy effects but also provides a precise decision-making basis for policy makers in determining the coverage of ecological functional areas, enhancing the pertinence and effectiveness of policies.

2. Theoretical Analysis and Research Hypotheses

National Key Ecological Functional Areas (NKEFAs), as specific areas in the system of major functional areas for maintaining ecological functions and ensuring ecological security, have now become the largest regional ecological compensation policy implemented in China [32]. China established two batches of ecological functional areas in 2010 and 2016, covering a total area of approximately 5.06 million square kilometers, relying on ecological lands such as forests and grasslands, and covering a population of nearly 200 million. In order to realize its goal of enhancing the supply of ecological products and improving the quality of the ecological environment [33], the ecological functional area implements a strict industrial access system. However, this does not mean not pursuing economic development or artificially reducing the level of economic development, but rather realizing the green transformation of economic development mode [34,35]. Therefore, this paper will focus on the impact of ecological functional areas on the level of county economic resilience, starting from the four effects of economic agglomeration, factor agglomeration, expansion of the scale of financial expenditure and increase in the level of investment, to specifically explore how the construction of the national key ecological functional areas plays a role in the economic resilience of counties and to analyze the heterogeneity of regional differences in the conditions of the impact of the policy effect.

1. Ecological function protection areas play an important role in maintaining national and regional biosafety, restoring forests and water sources, and ensuring long-term stability and sustainable development [36]. While improving the ecological environment and providing ecological products [37], they also enhance the resilience of the county economy by promoting the upgrading of the county's industrial structure, improving investment promotion effectiveness, and cultivating new drivers of economic growth. The policy role of ecological functional areas not only depends on the economic development level of the county where they are located but also closely related to their resource endowment conditions. The abundance, quality, and potential for development and utilization of resources such as forests and water sources are

important factors that affect the effectiveness of policies. Based on this, this article proposes hypothesis H1.

H1: *National key ecological functional areas promote county economic resilience, and there is regional heterogeneity in the policy effects of ecological functional areas.*

2. The establishment of national key ecological functional areas aims to strengthen ecological protection and management while seeking a coordinated development path between the economy and the environment. Under this policy framework, the county-level economy exhibits significant agglomeration effects through the rational development and utilization of specific ecological resources such as forests. On the one hand, the establishment of ecological functional areas has promoted economic agglomeration in the region. The ecological functional area belongs to a county that is far away from the city center, and its poor location, transportation, and other conditions lead to problems such as low development quality. However, the implementation of ecological functional area policies has improved the weak economic foundation of the region through forest restoration, water source conservation, and other means, attracting a large number of eco-friendly industries such as ecotourism, understory planting, ecological agriculture, and green industry to gather, making economic activities more frequent in the county. This economic agglomeration effect has a positive impact on economic growth [38] and is conducive to improving the resilience level of county-level economies. On the other hand, the establishment of ecological functional areas promotes the aggregation of regional factors. Factor agglomeration, as a resource allocation method in a market economy, can play an effective role in promoting local economic growth and regional economic linkage development. In promoting the agglomeration of factors for regional economic development, particular attention should be paid to the agglomeration of human capital [39,40]. The establishment of ecological functional areas promotes the development of ecological industries in counties, helps to facilitate the flow of labor between industries, attracts the return of labor from various industries, especially agriculture, forestry, animal husbandry, and fishery, and to some extent alleviates the problem of human resource loss in related counties. It is conducive to the improvement of regional innovation capabilities and further enhances the resilience of county economies to promote sustainable social development. Based on this, this article proposes hypotheses H2 and H3.

H2: *National key ecological functional areas have an impact on county economic resilience through economic agglomeration effects.*

H3: *National key ecological functional areas have an impact on county economic resilience through the factor agglomeration effect.*

3. There is a common problem of insufficient endogenous driving force for economic development in counties and cities belonging to national key ecological functional areas, mainly manifested in unreasonable industrial structure and low degree of openness to the outside world. The establishment of ecological functional areas can promote the development of a county-level economy through two key levers that affect macroeconomic regulation, namely fiscal expenditure and investment level. During this process, as the core component of ecological functional areas, the restoration and protection of forest land not only directly affect the improvement of regional ecological environment, but also profoundly impact the transformation and upgrading of the county-level economy. The imbalance between central and local finances has formed a transfer payment system [41], and transferring payments to national key ecological functional areas is an important measure to solve the regional gap between the cost of ecological environment protection and ecological benefits [42]. The national key

ecological functional areas have enhanced the scale of central transfer payments and the level of local government fiscal expenditures. Not only does it provide necessary financial support for public areas such as county-level infrastructure construction, education, healthcare, and social security, promoting improvement in people's livelihoods and social equity, but it also supports forest restoration projects through special funds, such as afforestation, ecological forest construction, and restoration of degraded forest land, laying a solid foundation for economic growth and promoting sustainable social development. In addition, the optimization of the transfer payment structure has also improved the governance capacity of local governments [43] and enhanced the adjustment ability of county-level economies. However, the development of the regional economy cannot be achieved solely through national financial support [44], and further efforts are needed to increase the degree of economic openness to the outside world. The national key functional areas have innovated the mechanism for realizing the value of ecological products by promoting the development of green industries such as understory planting, breeding, and forest product processing through functions such as forest land restoration and water conservation. This has attracted local governments and social capital to invest in green ecological industries, forming a diversified investment pattern. The increase in investment attractiveness and changes in investment patterns have enhanced the resilience and competitiveness of county-level economies.

H4: *The national key ecological functional areas have an impact on county economic resilience through the fiscal expenditure scale expansion effect.*

H5: *The national key ecological functional areas have an impact on the county's economic resilience through the effect of the increase in the level of investment.*

The path of the role of national key ecological functional areas in influencing the economic resilience of Chinese counties is shown in Figure 2.

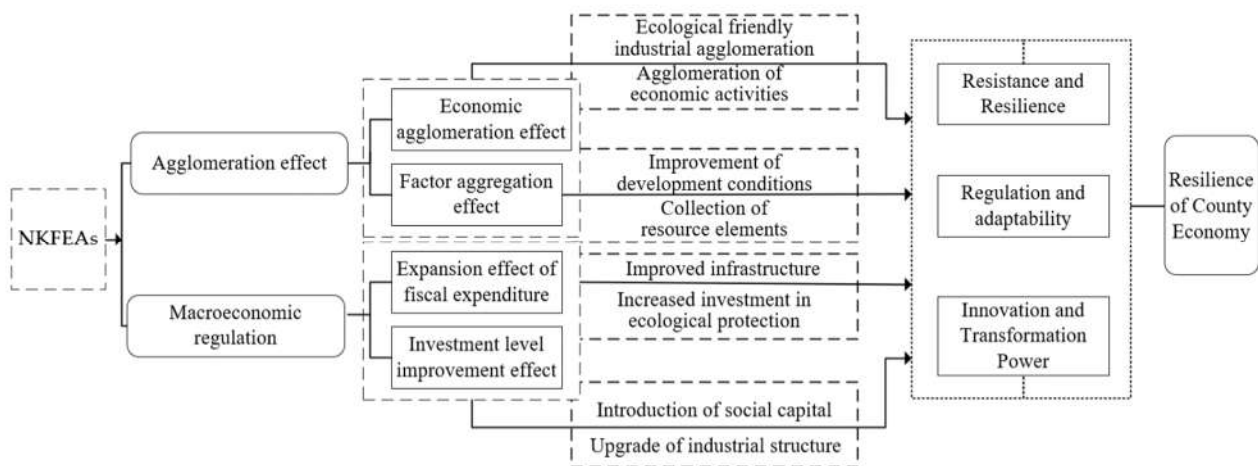


Figure 2. Mechanism analysis of NKFEAs to enhance economic resilience.

3. Materials and Methods

3.1. Modelling Setting

The benchmark regression model is set up as follows (all formulas in the text were edited using MathType 6.9):

$$Resilience_{it} = \beta_0 + \beta_1 Treat_i \cdot T_t + \beta_2 control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Among them: subscripts i and t , respectively, represent the county and year. The dependent variable is county-level economic resilience ($Resilience_{it}$), representing the

economic resilience of county i in year t . The core explanatory variable is whether it was impacted by the national key ecological function area policy ($Treat_i \cdot T_t$). The panel data are divided into an “experimental group” that was impacted by the policy and a “control group” that has not been affected by the policy. When a county is included in the national key ecological function area, the value is 1, otherwise, it is 0; $Treat_i$ is a grouping dummy variable. If county i is impacted by national key ecological function area policies, $Treat_i$ takes on a value of 1, otherwise it takes on a value of 0; T_t is a dummy variable for policy implementation, with a value of 0 before policy implementation and a value of 1 in the year and after policy implementation; $Treat_i \cdot T_t$ is the interaction term between grouping dummy variables and policy implementation dummy variables; $control_{it}$ is a control variable that affects the county’s economic resilience, including the human capital, science and technology level, county population density, industrial structure, urban–rural gap, tax level; μ_i is the county fixed effect, which is used to control the factors that do not change over time in a specific county, such as the advantages and disadvantages of geographic location and the cultural characteristics of historical accumulation; γ_t refers to the year fixed effect, which is used to control the global characteristics that are not affected by regional differences but evolve over time, such as the fluctuation of the macroeconomic situation shared by different counties; ε_{it} denotes the error term. The core concern of this study is the parameter β_1 , which reflects the impact of the establishment of national ecological functional areas on the economic resilience of the established areas; if $\beta_1 > 0$, it indicates that the policy of ecological functional areas improves the level of economic resilience of counties.

3.2. Variable Definition

Specific definitions of the variables are given below.

1. Dependent variable: county economic resilience ($Resilience_{it}$). Drawing on the research of Briguglio, Tan et al. and Martin [45–47], the county economic resilience evaluation index system is constructed from the three dimensions of regulation and adaptability, resistance and resilience, and innovation and transformation. Considering the significant lack of data in county-level yearbooks, this article, based on the principles of data availability, rationality, and scientificity, and referring to existing research [48,49], selects a total of 10 tertiary indicators to measure the resilience level of county-level economies. The indicators are shown in Table 1.

Table 1. County economic resilience measurement indicator system.

First Level Indicator	Secondary Indicators	Tertiary Indicators	Indicator (Nature)
County Economic Resilience	Regulation and Adaptability	Total retail sales of consumer goods	X1 (+)
		Financial self-sufficiency rate	X2 (+)
		Number of beds in hospitals and health centers	X3 (+)
		Balance of loans to financial institutions	X4 (+)
	Resistance and Resilience	GDP per capita	X5 (+)
		Percentage of value added of secondary industry	X6 (–)
		Balance of savings deposits of urban and rural residents	X7 (+)
		total grain production	X8 (+)
	Innovation and transformational power	Percentage of tertiary sector value added	X9 (+)
		Number of industrial enterprises above designated size	X10 (+)

For the measurement method of county-level economic resilience, this article draws on the practices of Xu et al., Öztürk et al., Du et al. [50–52], and uses the entropy weight TOPSIS method to process panel data containing 1256 counties in China from 2007 to 2021 to measure the level of county-level economic resilience. The entropy weight TOPSIS method effectively solves the shortcomings of traditional TOPSIS method in reflecting the

relative importance of variables by integrating information entropy and TOPSIS evaluation technology. It can objectively determine the weight of indicators and improve the scientificity and feasibility of evaluation [53]. The specific calculation steps are as follows.

① Raw matrix normalization. Construct the county economic resilience evaluation index system, and set the raw index data matrix of m evaluation indexes in year n as U the following equation. x_{ij} denotes the raw data of the j th indicator in year i , where $i \in [1, n]$ and $j \in [1, m]$.

$$U = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (2)$$

The evaluation indicator system contains positive and negative indicators of different natures; therefore, the data are standardized to eliminate the influence of the scale between different factors, making the indicators comparable. The standardization formulas for positive and negative indicators are as follows:

Positive indicators:

$$X' = \frac{X_{ij} - \min\{X_{ij}\}}{\max\{X_{ij}\} - \min\{X_{ij}\}} \quad (3)$$

Negative indicators:

$$X' = \frac{\max\{X_{ij}\} - X_{ij}}{\max\{X_{ij}\} - \min\{X_{ij}\}} \quad (4)$$

After normalization, the matrix V is obtained as:

$$V = (V_{ij})_{m \times n} = \begin{bmatrix} V_{11} & V_{12} & \dots & V_{1n} \\ V_{21} & V_{22} & \dots & V_{2n} \\ \vdots & \vdots & \dots & \vdots \\ V_{m1} & V_{m2} & \dots & V_{mn} \end{bmatrix} \quad (5)$$

② Calculate the weight p_{ij} and entropy value e_j of the j th indicator in year i .

$$p_{ij} = \frac{X_{ij}'}{\sum_{i=1}^n X_{ij}'} \quad (6)$$

$$e_j = -k \sum_{i=1}^n p_{ij} \ln p_{ij} \left(k = \frac{1}{\ln n}, 0 < e_j < 1 \right) \quad (7)$$

③ Calculate the coefficient of difference for the j th indicator $g_j = 1 - e_j$ and the weight W_j of the evaluation indicator:

$$W_j = \frac{g_j}{\sum_{j=1}^m g_j} \quad (8)$$

④ Obtain the weighted norm matrix G :

$$G = W_j \times V_{ij} = \begin{bmatrix} G_{11} & G_{12} & \dots & G_{1n} \\ G_{21} & G_{22} & \dots & G_{2n} \\ \vdots & \vdots & \dots & \vdots \\ G_{m1} & G_{m2} & \dots & G_{mn} \end{bmatrix} \quad (9)$$

⑤ Calculate the positive and negative ideal distances D_i^+ , D_i^- with the following equations:

$$D_i^+ = \sqrt{\sum_{j=1}^m (G_{ij} - G_j^+)^2} \quad (i = 1, 2, \dots, n) \quad (10)$$

$$D_i^- = \sqrt{\sum_{j=1}^m (G_{ij} - G_j^-)^2} \quad (i = 1, 2, \dots, n) \quad (11)$$

Among them: G_j^+ is the most preferred value of the j_{th} indicator in previous evaluations, and G_j^- is the least preferred value of the j_{th} indicator in previous evaluations.

⑥ Calculate the relative proximity of the indicator values of each evaluation object to the positive and negative ideal solutions, respectively, as the comprehensive evaluation value of the county economic resilience level $Resilience_{it}$:

$$Resilience_{it} = \frac{D_i^-}{D_i^+ + D_i^-} (i = 1, 2, \dots, n) \quad (12)$$

2. Core independent variable: Has it been impacted by the national key ecological function area policy ($Treat \cdot T$). This article considers national key ecological functional areas as exogenous policy shocks and explores the impact of the establishment of national key ecological functional areas on the resilience of county-level economies. In addition, due to the implementation of China's national key ecological functional area policy at the end of 2010 and 2016, considering the time lag effect of policy implementation, the policy time is set to 2011 and 2017. Use T to represent the year of policy identification, set the year of regional policy implementation and beyond as 1, otherwise as 0. Based on this, this study follows the basic steps established by the multi-period DID model and constructs virtual variables for the experimental group and control group based on whether the district or county is included in the national key ecological function area in the current year as the judgment criterion. Among them, the experimental group consists of 346 counties included in the national key ecological function areas during the investigation period, set as 1. The control group refers to counties and districts that have not yet been included in the national key ecological function area, defined as 0.
3. Mechanism variables: Mechanism analysis includes four mediating variables: economic agglomeration, agglomeration of factors, scale of fiscal expenditure, and investment level.

Economic agglomeration (Ea): Economic agglomeration is a key indicator for measuring the degree of concentration of economic activities in a region. Its core lies in the geographical concentration of economic activities, that is, the aggregation of related industries or economic activities in a specific region, forming scale effects, scope effects, and cluster effects, thereby promoting economic growth and competitiveness improvement in that region. Economic density, as a direct reflection of the degree of concentration of economic activities in geographical space, is an accurate measure of economic output per unit area in a specific region, usually quantified by the value of land per square kilometer produced. Generally speaking, the higher the economic density of a region, the higher its resource utilization efficiency and stronger economic vitality. Therefore, following the approach of Ma et al. and Wang et al. [54,55], the logarithm of the ratio of regional gross domestic product (GDP) to administrative land area (Laa) (ten thousand yuan/square kilometer) is selected to represent the concentration of economic activities in the region. The specific formula is as follows:

$$Ea = \ln\left(\frac{GDP}{Laa}\right) \quad (13)$$

Agglomeration of factors (*Fa*): Factor agglomeration refers to the process of spatial concentration and combination of production factors through market mechanisms or policy guidance, mainly achieved through the flow of labor. Within a specific region, the flow of labor force can drive production factors such as capital, technology, and information to gather in specific industries or areas, thereby improving their resource allocation efficiency and accelerating the formation of efficient industrial agglomeration in the region [56]. In addition, with the improvement of the ecological environment and the enhancement of ecological service value, traditional industries such as agriculture, forestry, animal husbandry, and fishery have developed rapidly, making them important areas for attracting labor. Therefore, this article selects the proportion of a number of employees in agriculture, forestry, and fishery (*Eaff*) in the year-end total population (*Yep*) to represent the level of factor aggregation. The specific formula is as follows:

$$Fa = \frac{Eaff}{Yep} \quad (14)$$

Scale of fiscal expenditure (*Sfe*): refers to the total amount of fiscal expenditure arranged by the government through budget within a fiscal year. It reflects the amount of social resources directly controlled by the government during a certain period of time and the government's ability to meet public needs. It is an important indicator to measure the scale of government expenditure during a certain period of time. Therefore, this article selects the proportion of local general budget expenditures of local finances (*Gbe*) in the regional gross domestic product (*GDP*) to represent it. The specific formula is as follows:

$$Sef = \frac{Gbe}{GDP} \quad (15)$$

Investment level (*Inv*): Investment, as one of the main drivers of economic growth, is Usually measured by the ratio of total investment in fixed assets (*Fai*) to *GDP*. The amount of fixed assets investment represents the total amount of economic activities used to build and purchase fixed assets in a certain period of time. It can intuitively reflect the investment scale and intensity in infrastructure construction, industrial upgrading, technological transformation and other aspects in various regions, and is one of the important indicators for evaluating the vitality and potential of regional economic development. The specific formula is as follows:

$$Inv = \frac{Fai}{GDP} \quad (16)$$

4. Control variables: Referring to the common practice of existing research, in order to control the impact of other factors on the resilience of the county-level economy, this article selects the following control variables:

Human capital (*Hc*): Human capital refers to the non-material forms of capital such as knowledge, skills, and cultural and technological levels possessed by workers, and is one of the important factors affecting economic development. Generally speaking, the richness of regional human capital is often directly proportional to its economic development potential. High levels of human capital can promote the improvement of labor productivity, accelerate the optimization and upgrading of industrial structure, and enhance the resilience of the economy to external shocks. As an important component of human capital, education level is a direct reflection of labor innovation ability and technological adaptability, usually expressed as the ratio of number of students in secondary schools (*Nss*) to year-end population (*Yep*). Therefore, in analyzing the role of national key ecological functional areas in economic resilience, this article incorporates human capital as a control variable into the regression model to eliminate potential interference from differences in labor quality on the results. The specific formula is as follows:

$$Hc = \frac{Nss}{Yep} \quad (17)$$

Science and technology level (*Stl*): The level of science and technology is a key indicator for measuring the innovation potential and technological development level of a region, closely related to its economic growth potential and industrial competitiveness. Therefore, in order to alleviate the endogeneity problem caused by the omission of important variables, the natural logarithm of number of patent authorizations (*Npa*) is used as a control variable to control the impact of scientific and technological levels on the county economy. The specific formula is as follows:

$$Stl = \ln Npa \quad (18)$$

County population density (*Cpd*): Population density can reflect the size of a regional market and the frequency of economic activities. Areas with high population density typically mean larger market sizes and more frequent economic activities, which may have a significant impact on the resilience of county-level economies. Therefore, the ratio of the year-end total population (*Yep*) to the land area of administrative area (*Laa*) is used as a control variable to control for the impact of population density on the resilience of the county economy. The specific formula is as follows:

$$Cpd = \frac{Yep}{Laa} \quad (19)$$

Industrial structure (*Ind*): The transformation and upgrading of industrial structure involves optimizing resource allocation between different industries in the economic system, as well as enhancing technological progress and innovation capabilities within the industry. With the upgrading of industrial structure, economies can more effectively transfer resources from low-value-added industries to high-value-added industries, promoting the improvement of production efficiency and sustained economic growth. To control the impact of regional industrial structure upgrading on the resilience of the county-level economy, this article uses the ratio of relative indicators value added of the tertiary industry (*Vat*) to value added of the secondary industry (*Vas*) to represent the transformation of regional industrial structure. The specific formula is as follows:

$$Ind = \frac{Vat}{Vas} \quad (20)$$

Urban–rural gap (*Urg*): Urban–rural gap reflects the balance of economic development within a region. A large urban–rural gap may imply unequal resource allocation and unequal opportunities, which may weaken the economy’s ability to withstand external shocks and thus affect its resilience level. Therefore, this article uses the ratio of disposable income per capita of urban residents (*Diu*) to disposable income per capita of rural residents (*Dir*) as the control variable to control for the impact of uneven urban–rural economic development on economic resilience. The specific formula is as follows:

$$Urg = \frac{Diu}{Dir} \quad (21)$$

Tax level (*Tl*): Tax revenue is an important component of local finance, and its stability is crucial for local governments’ long-term planning and ability to withstand external shocks. A higher tax level represents strong fiscal autonomy and income stability of local governments, which may have an impact on the level of economic resilience. When evaluating the policy effects of national key ecological functional areas on economic resilience, the ratio of tax revenue (*Tr*) to general budget revenue of local

finance (*Brlf*) is used to control the tax level and strip away the influence of other economic factors. The specific formula is as follows:

$$Tl = \frac{Tr}{Brlf} \quad (22)$$

The meanings and descriptive statistics of the main variables are shown in Table 2.

Table 2. Meaning of key variables and descriptive statistics.

Variable Classification and Name		Symbol	Observed Value	Average Value	Standard Deviation
Dependent variable	County Economic Resilience	$Resilience_{it}$	5898	0.092	0.071
Core independent variable	Construction of National Key Ecological Function Areas	$Treat \cdot T$	5898	0.162	0.368
Intermediary variable	Economic agglomeration	Ea	5898	6.275	1.982
	Agglomeration of factors	Fa	5898	0.201	0.079
	Scale of fiscal expenditure	Sfe	5898	0.225	0.149
	Investment level	Inv	5898	0.378	0.111
Control variable	Human capital	Hc	5898	0.046	0.015
	Science and technology level	Stl	5898	1.982	1.544
	County population density	Cpd	5898	0.038	0.031
	Industrial structure	Ind	5898	1.022	0.736
	Urban–rural gap	Urg	5898	2.324	0.613
	Tax level	Tl	5898	0.866	0.394

3.3. Data Sources

This article constructs an economic resilience index based on 1256 counties in China from 2007 to 2021, and explores the impact of the establishment of national key ecological functional areas on economic resilience. Among them, the three-level indicators, mechanism variables, and control variables in the resilience evaluation index system of county-level economies are sourced from the “China County Statistical Yearbook” from 2007 to 2021, and some missing values are supplemented by provincial and municipal statistical yearbooks and linear interpolation methods. Due to incomplete historical data records for some variables, in order to ensure the reliability and rationality of the empirical results, this article excludes counties and years with severe data gaps. Among the 1256 counties ultimately retained, the experimental group consisted of 346 counties and the control group consisted of 910 counties. The data on national key ecological functional areas are compiled based on the “National Main Functional Area Plan” and the “Notice of the General Office of the Development and Reform Commission on Clarifying the Types of Newly Added National Key Ecological Functional Areas”.

4. Econometric Analysis of Results

4.1. Benchmark Regression Results

Based on the above analysis, this article regards whether each county was approved to establish national key ecological functional areas as a quasi-natural experiment [57]. The multi-period DID model was used to test the impact of the establishment of national key ecological functional areas on the resilience level of the county-level economy. The benchmark regression results are shown in Table 3 (all parts of the empirical analyses are completed using Stata17 software). Among them, column (1) of Table 3 only controls the estimation results of area-fixed and year-fixed effects, and the results show that the establishment of national key ecological functional areas significantly improves the level of

county economic resilience at the 1% level. Table 3, column (2) shows the regression results after adding six types of control variables: human capital, science and technology level, county population density, industrial structure, urban–rural gap, tax level. The $Treat \cdot T$ regression coefficients after each control variable are included in the model are still positive and significant at the 1% level. From an economic perspective, compared to samples that were not impacted by national key ecological function areas, the implementation of this policy increased the economic resilience level of the treatment group by 1.52%, which can explain 16.52% (0.152/0.092) of the standard deviation change during the observation period of the sample. This indicates that the establishment of national key ecological functional areas has a significant positive impact on county economic resilience, and hypothesis H1 is verified.

Table 3. Benchmark regression results.

Variant	Explained Variable: Economic Resilience	
	Uncontrolled, Double Fixed (1)	Control, Double Fixed (2)
$Treat \cdot T$	0.0151 *** (5.682)	0.0152 *** (5.850)
R^2	0.537	0.565
Control variable	No	Yes
Urban Fixed	Yes	Yes
Year fixed	Yes	Yes
Number of observations	5898	5898

Note: The values of *** is significant at 1%. The values of t are shown in brackets and are the same in the following tables.

4.2. Parallel Trend Test

The important prerequisite for conducting the multi-period DID model is that the experimental and control groups have parallel trends before the policy is implemented. Referring to related studies [58,59], an event analysis is conducted to test whether there is a parallel trend in the policy. The test results are shown in Figure 3. The results showed that the estimated coefficients of the dummy variables in each year before the establishment of the national ecological functional area were not significant and fluctuated around 0, indicating that there was no significant difference in the resilience of the county economy between the experimental treatment group and the control group before the establishment, which satisfies the parallel trend hypothesis; After the establishment of the ecological functional area, the estimated coefficients of the dummy variables in each year were significantly positive, indicating that the establishment of the ecological functional area has a positive promoting effect on the resilience of the county economy, and this promotion role is increasing with the passage of time.

4.3. Placebo Test

To ensure that the double difference method is not affected by unobserved factors, this study conducted non repetitive random sampling on all counties and policy times and constructed a virtual policy implementation time setting with a pseudo experimental group, a pseudo control group, and a pseudo policy impact time for placebo testing. As of 2021, there were a total of 346 counties belonging to the national key ecological functional areas. Therefore, 346 counties were randomly selected from 1256 counties without replacement as the pseudo experimental group, and the remaining samples were used as the pseudo control group. Subsequently, a random year was selected from 2007 to 2021 as the establishment time of a national key ecological function area, and a randomized experiment was constructed at the regional implementation time level. To further enhance the persuasiveness and explanatory power of the placebo test, the random process was repeated 1000 times to obtain the kernel density distribution map of the estimated coefficients under

1000 random policy shocks, as shown in Figure 4. The placebo test results showed that the mean estimated coefficient values of the fictional treatment group were 0, approximately following a standard normal distribution, and the p-values of most estimated coefficients were greater than 0.1. The estimated baseline regression coefficient is located at the right tail end of the placebo regression coefficient distribution. This indicates that the estimation results in this article were not obtained by chance and can exclude the influence of other policies or random factors. The results of the placebo test once again confirmed the true effectiveness of the policy effects on national key ecological functional areas.

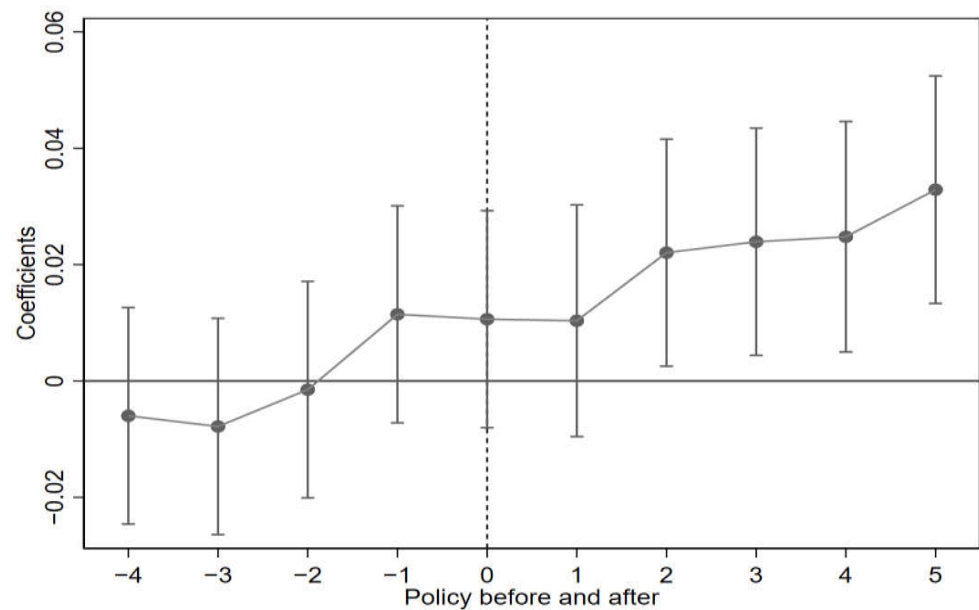


Figure 3. Parallel trend test.

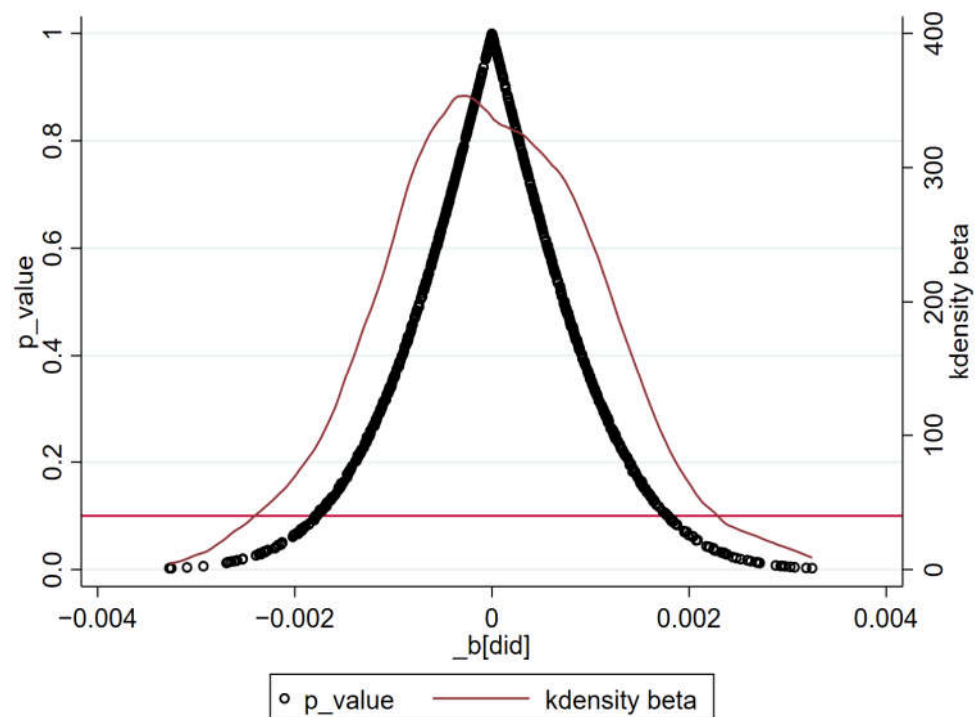


Figure 4. Placebo test for national key ecological function areas.

4.4. Robustness Test

To verify the robustness of the benchmark regression results, this study conducted stability tests by replacing the measurement method of the dependent variable, lagged the control variable for one period, excluding the second batch of pilot counties, using heterogeneous robust estimators, controlling for endogeneity using instrumental variable method, and excluding other policy influences. The specific methods are as follows:

1. Other measurement methods for the dependent variable

To avoid the potential impact of the measurement method of the dependent variable on the robustness of the regression results and to test the rationality of the construction of the economic resilience indicator system in this article, this article refers to the approach of Martin et al. [60] and Wang et al. [61], and calculates the difference between the total economic change of each county and the national benchmark to construct a GDP relative change indicator to re measure economic resilience. If a county's economic performance is more stable or recovers faster compared to the national benchmark when facing the same impact, it indicates that the county's economic resilience is higher. The specific formula is as follows:

$$Resilience'_{it} = (\ln GDP_{it} - \ln GDP_{i,t-k}) - (\ln GDP_t - \ln GDP_{t-k}) \quad (23)$$

In the formula, $\ln GDP_{it}$ is the regional gross domestic product of county i in the t_{th} year; $\ln GDP_t$ is the logarithm of the national gross domestic product in year t , while $\ln GDP_{t-k}$ represents the quantity of the national gross domestic product k years ago. The larger the indicator, the higher the level of regional economic resilience. The second column of Table 3 presents the regression results after replacing the dependent variable, indicating that the establishment of national key ecological functional areas has a significant positive impact on economic resilience at the 1% level. The conclusion is consistent with the benchmark regression results, proving that the benchmark regression results are robust.

2. Control variables lagged one period

Considering the possible reverse effect between the selected variables and the establishment of national key ecological functional areas, in order to avoid the estimation bias arising from this, this paper incorporates all the control variables into the regression model after one period of lagging, and the empirical results are shown in column (3) of Table 4. The coefficient sign and significance level of the core explanatory variables in this regression are consistent with the baseline model, which verifies the robustness of the conclusions.

Table 4. Results of four robustness testing methods.

	(1) Economic Resilience	(2) Economic Resilience	(3) Economic Resilience	(4) Economic Resilience	(5) Economic Resilience
<i>Treat · T</i>	0.0152 *** (5.85)	0.0302 *** (3.19)	0.0182 *** (5.62)	0.0118 ** (2.32)	0.0330 *** (5.60)
R ²	0.565	0.356	0.594	0.574	0.862
Other measurement methods for the dependent variable	No	Yes	No	No	NO
Control variables lagged one period	No	No	Yes	No	No
Exclusion of the second batch of pilot cities	No	No	No	Yes	No
Heterogeneous robust estimator	No	No	No	No	Yes
Urban fixed	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes
Number of observations	5898	5898	4368	5358	10,106

Note: The values of *** and ** are significant at 1% and 5%, respectively. The values of t are shown in brackets and are the same in the following tables.

3. Excluding the second batch of pilot counties

In December 2010, the China issued the National Main Functional Areas Plan, identifying China's first batch of national key ecological functional areas. In 2016, the China again issued the Approval Reply on Agreeing to Add Some Counties (Municipalities, Districts, and Flags) into the National Key Ecological Functional Areas, which added new national key ecological functional areas at the county-level administrative units. The second batch of national key ecological functional areas is similar to the first batch of national key ecological functional areas in terms of ecological environment background and development situation. Therefore, this paper excludes the sample of the second batch of pilot counties for regression, and the regression results are shown in column (4) of Table 4, and the relevant conclusions remain robust.

4. Heterogeneous robust estimator

The traditional DID model is a statistical method for evaluating the effectiveness of policies or interventions, which estimates policy effects by comparing the differences in changes between the treatment group and the control group before and after policy implementation. Its essence is a weighted average of individual treatment effects. However, the latest DID theory research shows that when there are differences in the timing of policy implementation among different individuals, using traditional multi time point DID models may result in mistakenly treating the earlier treatment group as the control group, leading to a "negative weight" problem and inaccurate estimation of policy effects [62]. Therefore, this article refers to Cengiz et al.'s method [63] and uses the stacked double difference method to re-evaluate the impact of the establishment of national key ecological functional areas on the resilience of China's county-level economy. Stacked DID refers to the integration of individual data with similar processing points within a specific time frame before and after policy implementation, to construct a dataset that includes individuals affected by policies, unaffected by policies, and those yet to be affected by policies. The regression results are shown in column (5) of Table 4. The regression coefficient of $Treat \cdot T$ is still significantly positive, consistent with the baseline regression, indicating that the analysis results of this paper do not rely on undetermined estimators and are robust.

5. Instrumental variables

Due to the inherent problem of endogenous selection in the selection of national key ecological functional areas, some unobservable factors may simultaneously affect the selection of ecological functional areas and the resilience level of the county economy. Therefore, this article aims to weaken the endogeneity bias caused by the possibility of incomplete random sample selection in the experimental group of national key ecological functional areas, and further attempts to use an instrumental variable method to examine the robustness of the previous conclusions.

The instrumental variable needs to satisfy both the exogeneity and the correlation conditions; therefore, this article intends to use the Quantity of rainfall (Rainfall) as the instrumental variable [64]. The reasons for choosing this instrumental variable are: First, there is a certain correlation between precipitation and the establishment of national key ecological functional areas. Since the establishment of ecological functional areas is often based on the natural conditions and ecosystems of the region, precipitation is a crucial factor in these natural conditions, which not only affects the ecological balance of the region, but also directly relates to the effect of ecological protection and restoration. Therefore, precipitation, as a natural factor, is intrinsically and logically linked to the establishment of national key ecological functional areas and satisfies the requirement of relevance. Secondly, Rainfall itself does not directly bring about an increase in the level of economic resilience of the county, and this instrumental variable is extremely unlikely to affect the explanatory variables by other means except for whether the county is included in the national key ecological functional areas, it can satisfy the condition of exogeneity of the instrumental variable. To summarize, the instrumental variable has the characteristics of strong relevance and exogeneity, which meets the conditions for the selection of instrumental variables.

The regression results of taking precipitation as an instrumental variable are shown in Table 5. The first stage regression results show that the instrumental variable significantly contributes to the establishment of national key ecological functional areas at the 1% level. The Kleibergen-Paap rk LM test results show that there is no problem of under-identification of the instrumental variable. The Kleibergen-Paap rkWald F test value is 44.58, which is greater than the Stock-Yogo test at the 10% level critical value, indicating that there are no weak instrumental variables. Therefore, the first-stage regression results prove that the instrumental variables selected in this paper satisfy the basic conditions. And the second-stage regression results show that the national key ecological function areas significantly increase the level of county economic resilience at the 5% level. Overall, after using the instrumental variable method to address endogeneity issues, the national key ecological functional areas were still able to significantly improve the county's economic level, further testing the robustness of the regression results in this article.

Table 5. Instrumental variables approach regression results.

Variant	First Phase		Second Phase	
	NKEFAs		Economic Resilience	
	Ratio	Robust Standard Error	Ratio	Robust Standard Error
NKEFAs			0.0954 **	0.0406
Instrumental variable	−0.3056 ***	0.0619		
Control variable		Yes		Yes
Urban fixed		Yes		Yes
Year fixed		Yes		Yes
Non-identifiability test		24.015 ***		
Weak instrumental variables test		24.382		

Note: The values of *** and ** are significant at 1% and 5%, respectively. The values of t are shown in brackets and are the same in the following tables.

6. Excluding other policy effects

Considering that the precision poverty alleviation policy (2013) and the pilot reform of the rural collective property rights system (2015) carried out during the period studied in this article will have an impact on the resilience level of county-level economies, thereby affecting the policy effectiveness of the second batch of national key ecological functional areas, which may interfere with the above conclusions, this article will include these policy dummy variables in the benchmark regression model for regression again. The first column of Table 6 controls for the impact of targeted poverty alleviation policies and excludes samples from poverty-stricken counties. The second column controls for the sample from counties that exclude the impact of pilot policies for rural collective property rights system reform. The third column simultaneously excludes the impact of both policies. The regression results indicate that the coefficient of the core explanatory variable remains significantly positive, and the policy effects of national key ecological functional areas remain robust. In addition, based on excluding the impact of policies during the same period, this article lagged the control variables by one period to improve the accuracy of the estimation results. The regression results are shown in columns (4)–(6) of Table 6. The estimated coefficients and significance levels of the core explanatory variables in the above regression are consistent with the baseline regression, verifying the robustness of the regression results in this paper.

Table 6. Robustness tests: excluding other policy effects.

Variant	Explained Variable: Economic Resilience					
	(1) Exclusion of Poor Counties	(2) Exclusion of Rural Collective Property Rights Systems	(3) Preclude	(4) Exclusion of Poor Countie	(5) Exclusion of Rural Collective Property Rights Systems	(6) Preclude
<i>Treat · T</i>	0.0143 *** (5.51)	0.0149 *** (5.76)	0.0141 *** (5.44)	0.0165 *** (5.07)	0.0180 *** (5.57)	0.0163 *** (5.04)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Control variables lagged one period	No	No	No	Yes	Yes	Yes
Urban fixed	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	5898	5898	5898	4368	4368	4368

Note: The values of *** is significant at 1%. The values of t are shown in brackets and are the same in the following tables.

4.5. Analysis of Policy Mechanisms

The previous empirical analysis shows that the establishment of national key ecological functional areas can significantly enhance the level of county economic resilience, but the mechanism of the impact of ecological functional areas policy on county economic resilience still needs to be further verified. According to the theoretical analysis section, this article explores the driving effects of ecological functional areas on county economic resilience from four perspectives: economic agglomeration effect, factor agglomeration effect, fiscal expenditure expansion effect, and investment level improvement effect. On the basis of the benchmark model, construct a mediation effect model for testing:

$$Mediator_{it} = \beta_0 + \beta_1 Treat_i \cdot T_t + \beta_2 control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (24)$$

In the formula, $Mediator_{it}$ is the mechanism variable, including economic agglomeration, factor agglomeration, scale of fiscal expenditure and social fixed investment, and the other symbols are the same as those of the benchmark regression expression. If the policy implementation coefficient β_1 in the region is significant, it can indicate that the construction of national key ecological functional areas can affect the resilience level of the county economy through mediating variables.

1. Economic agglomeration effect

The establishment of ecological functional areas has effectively curbed the disorderly expansion of high-pollution and high-energy-consumption industries in the region through environmental regulation [65], prompting the concentration of resources to high-efficiency and high-value-added industries that meet the ecological requirements. This policy orientation accelerates the optimization and upgrading of industrial structure, promotes the agglomeration and development of green and low-carbon industries, and then enhances the economic output per unit of land area, i.e., the level of economic agglomeration. Secondly, the ecological function areas have strengthened ecological protection and restoration work, improved the quality of regional ecological environment, and provided a good development space for eco-friendly industries. The high-quality natural resources and environment have attracted more environmentally friendly enterprises and innovative elements, promoted the spatial agglomeration of economic activities, and enhanced the economic agglomeration effect. In addition, the policy of ecological functional areas promotes the formation of green economic agglomeration areas through various incentives to guide social capital toward green industries. This agglomeration effect not only improves the efficiency

of resource utilization but also significantly enhances the resilience and competitiveness of the county economy through mechanisms such as knowledge spillover and technological innovation. The estimation results are shown in column (1) of Table 7, and the coefficient of economic agglomeration is significantly positive at the 1% level, indicating that the national key ecological functional areas significantly increase the level of economic agglomeration in the county, thus enhancing the county's economic resilience. H2 is thus verified.

Table 7. Transmission mechanism test of national key ecological function areas.

Variant	(1) Economic Agglomeration	(2) Agglomeration of Factors	(3) Scale of Fiscal Expenditure	(4) Investment Level
<i>Treat · T</i>	0.0440 *** (2.03)	0.0145 *** (5.40)	0.0122 *** (4.66)	0.0508 *** (3.69)
R ²	0.987	0.913	0.929	0.811
Control variable	Yes	Yes	Yes	Yes
Urban fixed	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Number of observations	5898	5898	5898	5859

Note: The values of *** are significant at 1%. The values of t are shown in brackets and are the same in the following tables.

2. Factor agglomeration effect

The establishment of ecological functional areas is conducive to the development of eco-friendly industries, especially the transformation and upgrading of traditional industries such as agriculture, forestry, animal husbandry, and fisheries. With the improvement of the ecological environment and the enhancement of ecological service value, traditional industries have attracted a large influx of labor. The proactive population migration policy further enhances this population agglomeration and absorption capacity. The flow of labor and other production factors to these industries has led to an increase in the proportion of employees in agriculture, forestry, animal husbandry, and fisheries relative to the total population at the end of the year, that is, an increase in the level of factor agglomeration. This agglomeration of factors not only optimizes the regional industrial structure, but also promotes the modernization and specialized development of traditional industries, drives the extension and expansion of related industrial chains, and provides stable human resource support for the regional economy. The regression results in column (2) of Table 7 indicate that the establishment of national key ecological functional areas significantly improves the resilience of county-level economies at the 1% level. H3 is thus verified.

3. Fiscal Expenditure Expansion Effect

The overall improvement of ecological quality brought about by ecological environment protection has obvious public product attributes. Due to insufficient investment in the private sector, the government needs to regulate it through public financial means. The establishment of ecological functional areas directly promotes the increase in local government financial investment in ecological environment protection. In order to fulfill the responsibility of ecological protection, local governments need to increase the expenditure on pollution control, ecological restoration, environmental monitoring, etc. Since ecological functional areas often carry important ecological service functions, their protection and development needs have led to a corresponding expansion of the scale of financial expenditures. In addition, due to the increase in economic activities brought about by factor agglomeration, it also puts forward higher requirements for the supply of public services by local governments, including infrastructure construction, education and medical care, social security and other aspects, which indirectly promotes the growth of fiscal expenditures. The regression results are shown in column (3) of Table 7, which shows

that the establishment of national key ecological functional areas significantly increases the scale of county fiscal expenditures at the 1% level. H4 is thus verified.

4. Investment level enhancement effect

The implementation of this policy has led to a change in the investment structure, guiding the flow of capital to high-efficiency, high-value-added industries that meet the requirements of ecological protection, thus promoting the structural optimization of the investment in fixed assets of the whole society. Specifically, with the strengthening of ecological protection and restoration in ecological functional areas, as well as the restriction of high-pollution and high-energy-consumption industries, more investments were made in related environmental protection facilities and technological transformation projects, which not only improve the quality of the regional ecological environment but also lead to the rapid development of related green industries. At the same time, policy incentives such as financial subsidies, tax incentives, etc., effectively reduce the investment cost of the green industry, enhance the willingness of social capital investment, and further promote the whole society's fixed asset investment in the field of green economy increase. This shift in investment flows not only enhances the efficiency of resource utilization but also strengthens the resilience and competitiveness of the regional economy through the industrial agglomeration effect, laying a solid foundation for long-term sustainable development. Therefore, the establishment of national key ecological functional areas has had a far-reaching impact on the level of investment in fixed assets of the whole society, promoting the green transformation and high-quality development of the investment structure. The regression results are shown in column (4) of Table 7, where the establishment of national key ecological functional areas significantly increases the level of regional fixed investment at the 1% level, thus enhancing the county's economic resilience. H5 is thus verified.

In summary, the establishment of national key ecological functional areas can promote the continuous improvement of county economic resilience through the economic agglomeration effect, factor agglomeration effect, financial expenditure expansion effect and investment level enhancement effect.

4.6. Analysis of Heterogeneity

Although the benchmark regression results indicate that the establishment of national key ecological functional areas will significantly enhance the resilience of county-level economies, and the robustness of the results once again confirms this conclusion, its impact on economic resilience may be influenced by factors such as economic development level and natural environmental conditions. Therefore, the following text will focus on the differences in economic development levels and types of national key ecological functional areas, and conduct a comprehensive analysis of the impact of economic resilience on ecological functional areas.

1. Analysis of economic heterogeneity

The level of economic development in a region may affect the policy effectiveness of national key ecological functional areas. Specifically, there are significant differences in industrial structure, fiscal strength, and population structure among counties with different economic levels, which may lead to differences in the economic recovery ability and resilience of counties in the face of external shocks. To distinguish the economic level of different regions, this article divides the sample into groups based on the average regional GDP from 2007 to 2021. Regions above the average are classified as economically high-level areas, while those below the average are classified as economically low-level areas. Table 8 reports the results of heterogeneity analysis based on different levels of economic development.

Table 8. Analysis of economic heterogeneity.

Variant	(1) Higher Economy	(2) Lower Economy
<i>Treat · T</i>	0.0046 (0.46)	0.0035 *** (1.99)
R ²	0.910	0.728
Control variable	Yes	Yes
Urban fixed	Yes	Yes
Year fixed	Yes	Yes
Number of observations	1779	4119

Note: The values of *** are significant at 1%. The values of t are shown in brackets and are the same in the following tables.

The regression results show that the establishment of national key ecological functional areas has a significant positive impact on economic resilience in areas with low economic levels, but has no effect in areas with high economic levels. There are significant differences in the effects of ecological functional area policies among regions with different levels of economic development. This may be due to the fact that in areas with weaker economic foundations, ecological functional area policies are seen as a new economic growth point, which helps to promote the optimization and upgrading of economic structure and enhance the endogenous growth momentum of the regional economy. The protection and restoration of ecology can improve the quality of life of residents, enhance social stability, and indirectly enhance the resilience of the economic system to shocks. In contrast, in economically advanced areas, the establishment of national key ecological functional areas has no significant impact on economic resilience. A possible reason is that these regions already have a relatively complete economic system and a high level of development, and have implemented strict environmental protection measures. The marginal effect of ecological functional area policies is relatively small, and additional policy support may not bring significant economic resilience improvements.

2. Analysis of type heterogeneity

According to the differences in natural resource endowment and the types of major ecological functions undertaken, ecological functional areas can be divided into four types: water source conservation type, soil and water conservation type, biodiversity maintenance type and windbreak and sand fixation type. Differences in ecological protection focus, natural environment status, etc., lead to differences in the policy effects of the four types of ecological functional areas; in order to explore such differences, this paper analyzes the heterogeneity based on the four types of national key ecological functional areas. The regression results are listed in Table 9. The results showed that the estimated coefficients of water conservation functional areas were significantly positive at the 1% level, while the estimated coefficients of soil and water conservation and biodiversity maintenance functional areas were significant at the 5% level, with a positive direction. These three types of national key ecological functional areas have all had a positive promoting effect on the economic resilience of their respective counties. The establishment of windproof and sand-fixing ecological functional areas has no significant impact on the resilience level of the county's economy.

Table 9. Analysis of type heterogeneity.

Variable Name	County Economic Resilience			
	Water Source Conservation (1)	Windbreak and Sand Fixation (2)	Soil and Water Conservation (3)	Biodiversity Maintenance (4)
<i>Treat · T</i>	0.0171 *** (5.12)	0.0226 (0.68)	0.0114 ** (1.97)	0.0165 ** (2.31)
R ²	0.856	0.857	0.857	0.855
Control variable	Yes	Yes	Yes	Yes
Urban fixed	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Number of observations	5210	4590	4854	4774

Note: The values of *** and ** are significant at 1% and 5%, respectively. The values of t are shown in brackets and are the same in the following tables.

The potential reasons are as follows: ① From the perspective of differences in ecological protection priorities, water conservation, soil and water conservation, and biodiversity maintenance functional areas focus more on protecting and restoring key elements in natural ecosystems, such as water sources, soil, and biodiversity, which are crucial for maintaining and enhancing the stability and resilience of ecosystems. Therefore, the establishment of these functional areas may promote the improvement of the ecological environment in the region, thereby providing a more stable and sustainable development foundation for the local economy, and enhancing the economic resilience of the county. ② From the heterogeneity of policy implementation effects, although windbreak and sand fixation functional areas also play an important role in ecological protection, their policy focus may be more on preventing environmental degradation rather than directly promoting economic development. These types of policies often require long-term investment and show slow results, so their short-term impact on improving the resilience of county-level economies may not be as significant as the other three types of functional areas. ③ Considering the differences in the current state of the natural environment, functional areas for water conservation, soil and water conservation, and biodiversity maintenance are often distributed in areas with relatively abundant ecological resources and superior natural environmental conditions. This provides unique conditions for the development of local ecotourism, green agriculture, etc., thereby helping to enhance economic resilience. In contrast, windbreak and sand fixation functional areas may be located in ecologically fragile or severely degraded areas, where economic development is limited by harsh natural conditions. Even with policy support, it is difficult to significantly improve economic resilience in the short term.

5. Discussion

Space regulation involves restrictions on land use, resource development, and other aspects [66]. Against the backdrop of controversy over the impact of ecological space regulation on economic development [67–69], this article takes China’s national key ecological functional area policy as an example to explore in depth the policy’s impact on China’s economic dynamic adjustment ability, in order to evaluate its economic effectiveness and demonstrate its positive role in the overall sustainability of economic operation.

Firstly, based on data from 2007 to 2021, this article selects 1256 counties as research objects and uses the entropy weight TOPSIS method to comprehensively construct a county-level economic resilience index system from three aspects: economic regulation and adaptability, innovation and transformation ability, and resistance and recovery ability, in order to measure the resilience level of each county’s economy. There are two main differences between it and previous literature on economic resilience: on the one hand, most studies still use the core variable method to evaluate economic resilience. Davies and Brakman et al. evaluated the economic recovery capacity of European countries after

the financial crisis by analyzing urban unemployment rates and gross domestic product (GDP) growth rates [70,71]. Doran and Fingleton introduced a dynamic spatial panel model to measure the resilience of the US economy [72]. However, the limitations of using the core variable method to evaluate economic resilience in a single dimension cannot fully capture the complexity and dynamics of the economic system. This method may overlook regional differences, long-term impacts, and gradual changes in economic structure. On the other hand, some scholars have attempted to measure economic resilience using the comprehensive indicator method. Briguglio proposed a comprehensive evaluation method for economic resilience that includes indicators from multiple dimensions such as macroeconomic stability, microeconomic market efficiency, governance quality, and social development [73]. However, most studies on the comprehensive indicator system tend to analyze the economic resilience of cities from a static perspective, without fully considering dynamic stages such as pressure and response. This has led to a lack of comprehensive understanding of the evolution process of urban economic resilience, and more research is needed to view regional economic resilience as a continuous dynamic development process. Therefore, based on this, this article improves the limitations of single indicator measurement and the static evaluation limitations of the comprehensive indicator method. By introducing the entropy weight TOPSIS method, the economic resilience level is measured from the three aspects of “pressure state response”, so as to more comprehensively reflect the true ability of each region in the face of economic fluctuations and evaluate the sustainable development level of the county-level economy.

Secondly, this article evaluates the impact of national key ecological function area policies on the resilience of China’s county-level economy through a multi-period DID model. The results showed that the construction of national key ecological functional areas has a positive promoting effect on the resilience level of China’s county-level economy. This discovery is essentially consistent with Yang et al.’s finding that the establishment of nature reserves has increased the income of local residents, aiming to explore the impact of ecological and environmental policies on the economy [74]. Although the academic community generally believes that the increasingly serious environmental pollution problem will weaken economic momentum and growth potential, posing a significant threat to the long-term sustainable development of the economy and society [75–77]. However, existing research has shown that policies for national key ecological functional areas, especially transfer payment measures, not only reduce carbon emission intensity but also significantly improve the ecological environment quality of pilot areas [78]. The improvement of environmental quality is conducive to reducing poverty and enhancing the quality of life for residents [79]. On the basis of previous research, this article not only focuses on the actual economic growth, such as residents’ income levels, but also comprehensively considers multiple dimensions such as government fiscal self-sufficiency, social welfare, industrial structure, and food supply when examining the economic effects of the national key ecological function area policy, in order to comprehensively evaluate the long-term impact of the policy on the regional economic dynamic adjustment ability and sustainable economic development.

Finally, this article explores the impact path of national key ecological functional areas on the resilience of county-level economies in China and conducts an in-depth analysis of the economic resilience effects of ecological functional areas based on differences in economic development levels and types of national key ecological functional areas. The results indicate that national key ecological functional areas can enhance the resilience of county-level economies through agglomeration effects, which are mainly manifested in economic agglomeration and labor factor agglomeration. This discovery is similar to the research results of Qin et al. on national key ecological functional areas and economic resilience. Qin et al. found that rural labor mobility is one of the main ways to alleviate regional poverty when measuring the poverty alleviation effect of the national key ecological function area transfer payment policy [80]. The agglomeration effect of elements in national key ecological functional areas is mainly achieved through labor mobility. The

establishment of national key ecological functional areas is conducive to the development of eco-friendly industries and promotes the concentration of the labor force in specific industries or regions. Liu et al.'s research found that population agglomeration can significantly improve the level of economic resilience [81]. Wang et al. found that the development of a marine economy can improve the economic resilience of coastal areas through industrial agglomeration effects when exploring the impact of marine economic development on economic resilience [82]. This is consistent with the findings of this study that economic agglomeration, as a concentrated manifestation of industrial agglomeration, is one of the pathways through which national key ecological functional areas affect economic resilience. At the same time, this article also found that the establishment of national key ecological functional areas can enhance the resilience of county-level economies by increasing fiscal expenditure and investment levels, in order to promote sustainable development of county-level economies. Wu et al.'s research on national key ecological functional areas also confirmed that the significant increase in rural residents' income largely depends on local government financial intervention. In addition to fiscal intervention, this article also introduces investment pathways. Zhang et al. and Yang et al. also explored the impact of government intervention level and investment level on economic resilience, and the results showed that both significantly and positively affect the level of regional economic resilience [83,84]. In addition, the heterogeneity analysis results indicate that the establishment of national key ecological functional areas for water conservation and biodiversity maintenance has a more significant impact on the resilience of county-level economies. Compared with Deng et al.'s heterogeneity analysis of three types of ecological functional areas based on a single province, this study has a broader scope, not only expanding the research object to 1256 counties across the country but also covering all four types of ecological functional areas, providing cross-regional guidance for policy-making in various counties in China.

Although this article delves into the impact of national key ecological functional areas on the resilience of China's county-level economy, there are still certain limitations. First of all, due to the lack of data in remote areas such as Xizang, China, this paper only selects 1256 counties as research objects to analyze the impact of ecological functional area policies on economic resilience. In the future, if we can obtain more data from counties, we can further conduct more detailed research. Secondly, although this article explores the impact path of national key ecological functional areas on economic resilience, it fails to explain the specific pathways through which different types of ecological functional areas affect regional economic resilience. In future research, it is necessary to explore the impact mechanism of different types of ecological functional areas on economic resilience, which is conducive to improving the accuracy and effectiveness of policy implementation. Finally, this article points out that China still relies on the extensive production mode of high input, high consumption, and high pollution, but there is no effective data support for the unsustainable growth scenario experienced by the Chinese economy. Therefore, in the future, we will quantify China's sustainable economy by calculating the net economic growth value after excluding pollution and identifying its determining factors.

6. Conclusions

This article uses county-level panel data from 2007 to 2021 and constructs an indicator of county-level economic resilience using the entropy weight TOPSIS method. Through a multi-period DID model, it deeply explores the specific impact of the implementation of the national key ecological function area establishment policy on county-level economic resilience, aiming to evaluate the role of the policy implementation in the sustainable development capacity of the regional economy. Research has found that the establishment of national key ecological functional areas significantly enhances the resilience level of county-level economies. This conclusion has passed parallel trend tests, placebo tests, and a series of robustness tests. This indicates that the policy of promoting China's national key ecological functional areas not only protects the ecological environment but also plays a

positive role in enhancing the long-term economic adjustment capacity of the region, which is conducive to the achievement of environmental and economic sustainable development goals. Specifically, the policy of ecological functional areas can optimize the regional industrial structure and resource allocation level through economic agglomeration and factor agglomeration effects, enhance the dynamic adjustment ability of the county-level economy, and promote sustainable social development; On the other hand, it is possible to effectively guide the flow of social capital and enhance the sustainable development capacity of county-level economy by increasing the expansion effect of fiscal expenditure and the improvement effect of investment level. The heterogeneity analysis in this article indicates that the policy of national key ecological functional areas significantly enhances the economic resilience of areas with low economic levels, while it has no significant impact on areas with high economic levels. Meanwhile, the establishment of different types of ecological functional areas has varying effects on promoting economic resilience. Among them, water conservation, soil and water conservation, and biodiversity maintenance functional areas have significant positive effects on enhancing economic resilience, while the establishment of windbreak and sand fixation ecological functional areas does not affect the level of economic resilience in the region. This result indicates that in the process of policy implementation, differentiated policy measures should be formulated according to the economic foundation, natural conditions, and ecosystem characteristics of different regions, in order to better play the role of ecological functional areas in achieving sustainable development goals.

Based on the above conclusions, this paper puts forward the following policy recommendations:

(1) Continuously promoting the construction of national key ecological functional areas, achieving a “win-win” situation for the environment and economy, and promoting the achievement of sustainable development goals. The establishment of ecological functional areas can enhance the resilience of county-level economies while achieving environmental protection, and this ecological policy tool should be utilized effectively. Further consolidate and expand ecological land, especially forest land, implement strict forest land use control and ecological red line delineation, ensure stable forest land area, and gradually improve forest coverage and quality, in order to achieve the goal of ecologically sustainable development. At the same time, establish a sound policy system for ecological functional areas and provide more policy guidance and support for counties included in ecological functional areas. Through reasonable policy arrangements, promote the development of the county economy, improve the dynamic adjustment ability of the county economy, and achieve the goal of sustainable economic development. At present, China has taken a series of policy measures, including strict control of development intensity, guidance of rational industrial development, comprehensive delineation and regulation of ecological red lines, strengthening ecological function assessment and ecological environment supervision, etc. And this study also provides a new implementation path for policy implementers. For example, in the process of promoting policies for national key ecological functional areas, various regions can provide subsidies and allowances to workers in response to the phenomenon of labor force transferring to environmentally friendly industries, increase the agglomeration of labor force elements, and better drive production factors such as capital, technology, and information to gather in specific industries or regions, thereby improving their resource allocation efficiency and accelerating the formation of efficient industrial agglomeration in the region. In addition, to ensure the smooth implementation of policy objectives, monitoring and evaluation of the effectiveness of ecological function area construction can be strengthened to ensure that various policies and measures can effectively promote the achievement of sustainable development goals. Special attention should be paid to the health status of forest ecosystems and the performance of ecological functions. Remote sensing monitoring, ground surveys and other means should be used to regularly monitor and evaluate forest resources, and timely identify and solve ecological problems. The improvement of the ecological environment and long-term economic development are

the foundation for achieving social stability. The national key ecological functional areas have further accelerated the achievement of social sustainable development goals while promoting ecological and economic sustainable development.

(2) Cultivating characteristic ecological industry economy and enhancing agglomeration and investment effects are key to achieving sustainable development goals. Key ecological functional districts and counties should fully utilize their own resource advantages, lead industrial transformation and upgrading with the concept of green development, and cultivate emerging industrial models such as agroforestry. Promote the agglomeration of economic activities and labor factors within the region, guide the flow of factors into regional characteristic industries, especially eco-friendly industries such as forestry, and further expand the agglomeration effect to enhance the role of the county-level economy. At the same time, by establishing special funds, providing tax exemptions, offering land incentives, and breaking down barriers to forest rights transfer, the investment threshold and risks of social capital can be lowered, attracting more social capital to participate in the construction and operation of ecological functional areas, especially encouraging the landing of green investment, ecological tourism, ecological agriculture, understory planting, forest health and other projects, forming a diversified investment pattern, and enhancing the sustainable development level of county-level economy.

(3) Actively demonstrate the leading demonstration effect of central ecological compensation transfer payments, and enhance the economic development regulation capacity of local governments in achieving sustainable development goals. On the one hand, the central government should continue to increase the investment of compensation funds to ensure full coverage and reasonable evaluation of the direct ecological protection costs and sacrificed development opportunity costs in the compensated areas. Not only does it help to implement precise policies and promote the balanced development of ecology and economy, but it also meets the dual requirements of environmental protection and economic development for sustainable development goals. On the other hand, this study proposes to systematically optimize the performance evaluation system of national key ecological functional areas and introduce a periodic evaluation mechanism based on the value of ecosystem services. This move aims to achieve continuous monitoring and scientific evaluation of the effectiveness of ecological protection and ensure the compliance of fund allocation and the effectiveness of resource allocation through a transparent information disclosure mechanism. In addition, the implementation of this mechanism will promote local governments to prioritize the protection needs of the ecological environment in resource allocation decisions, thereby aligning with the core principles of the Global Sustainable Development Agenda (SDGs) and promoting the construction of an environmentally friendly, economically efficient, and socially inclusive sustainable development model. Through this comprehensive policy framework, it can promote the ability of local governments to achieve coordinated economic, social, and environmental development, providing a solid theoretical and practical foundation for building ecological civilization and achieving sustainable development goals.

(4) Promote the construction of ecological functional areas according to local conditions. In the process of promoting the construction of national key ecological functional areas, it is necessary to conduct in-depth research on key factors such as natural conditions, economic development level, and resource endowment in each county, accurately identify regional differences, scientifically plan the development positioning and comparative advantages of different counties, implement differentiated ecological protection and economic development strategies, and ensure consistency with sustainable development goals. For economically underdeveloped areas, policy makers should strengthen ecological protection and restoration work, and optimize industrial layout in order to promote sustainable economic development and enhance economic resilience. For economically advanced regions, the focus of policies may need to be more on improving the precision and efficiency of policies to achieve a win-win situation between environmental protection and economic development. For functional areas with poor ecological foundation and widespread distri-

bution of forest resources, such as windproof and sand-fixing functional areas, the overall trend of ecological environment deterioration has not been completely curbed. Therefore, it is necessary to continue to strengthen the development of their ecological governance functions, and research and promote adaptable and ecologically beneficial forest tree varieties and afforestation technologies. And by increasing policy support, we can explore industrial transformation directions that are compatible with the local ecological environment and positioning, while ensuring ecological protection. We can actively develop ecological agriculture or service industries to promote sustainable economic development. Meanwhile, considering the significant positive effects of water conservation, soil and water conservation, and biodiversity maintenance ecological functional areas in enhancing economic resilience, this study suggests further expanding the establishment and protection scope of these key areas. By optimizing the layout of ecological functional areas, it is possible to more effectively protect and restore ecosystems, enhance their adaptability to climate change, and maintain biodiversity. In addition, strengthening inter-regional cooperation and linkage, encouraging cooperation and exchange between economically high-level areas and economically low-level areas, especially in the protection and utilization of forest resources, promoting ecological resource sharing, environmental governance coordination, and economic strategic docking, and building a new regional development model with complementary advantages and mutual benefit, is an effective way to achieve sustainable development goals. Through these measures, it can be ensured that the construction of ecological functional areas not only focuses on current ecological and economic needs but also lays a solid foundation for long-term sustainable development.

Author Contributions: Conceptualization, Y.W. (Yameng Wang) and Y.D.; methodology, Y.W. (Yameng Wang); software, Y.W. (Yameng Wang); validation, Y.W. (Yameng Wang) and Y.D.; formal analysis, Y.W. (Yimeng Wang) and J.W.; investigation, J.W.; resources, L.M.; writing, Y.W. (Yimeng Wang). All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Shandong Province social science planning research project (Grant No. 23DJJJ08), the General Project of Philosophy and Social Science Research Project of Colleges and Universities in Shandong Province (Grant No. 2024ZSMS172), the Excellent Youth Innovation Team of Colleges and Universities in Shandong Province (Grant No. 2022RW041), the Science and Technology Bureau of Rizhao (Grant No. RZ2022ZR45), Sichuan Provincial Philosophy and Social Science Foundation Project (Grant No. SCJJ23ND423), the Project of Philosophy and Social Science Key Research Base-Industrial Transformation and Innovation Research Center of Zigong Municipal Federation of Social Sciences (Grant No. CZ23B02), the Key Laboratory of Philosophy and Social Science of Sichuan Province—Key Laboratory of Digital Intelligent Management and Ecological Decision Optimization of Baijiu in the Upper Yangtze River Region (Grant No. zdsys-02).

Institutional Review Board Statement: Ethical review and approval were waived for this study as the study does not collect any personal data of the respondents, and respondents were informed that they could opt out any time from giving a response.

Data Availability Statement: The data will be provided upon request by the corresponding author.

Acknowledgments: We would like to thank the journal experts who edited this paper. We also appreciate the constructive suggestions and comments on the manuscript from the reviewer(s) and editor(s).

Conflicts of Interest: The authors declare no conflict of interest.

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