Has the Yangtze river economic belt strategy promoted the construction of ecological civilization in the upper reaches of the Yangtze river?

Zhiyong Zhang[1,2,3], Lianjun Zhang[1]*, Tian Liang[3,4], Ling Cheng[5], Liuhua Fang[1], Bin Zhao[1], Jianyu Zhang[1] and Chuanhao Wen[6]*

[1]Research Center for Economic of Upper Reaches of Yangtze River, Chongqing Technology and Business University, Chongqing, China, [2]Guizhou Academy of Social Sciences, Guiyang, China, [3]Institute of Green Development, Chongqing Finance and Economics College, Chongqing, China, [4]College of Public Management, Chongqing Finance and Economics College, Chongqing, China, [5]College of Business Administration, Guizhou University of Finance and Economics, Guiyang, China, [6]College of Economics, Yunnan University, Kunming, China

As a regional development strategy based on the world's third largest river basin unit, the Yangtze river economic belt strategy plays a vital role in building ecological civilization with the core concept of "ecological priority and green development". To study the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of the Yangtze River. This paper uses the entropy power method to measure the level of ecological civilization construction in 37 prefecture-level cities in the upper reaches of the Yangtze River. It examines the impact of the Yangtze River Economic Belt Strategy on the construction of ecological civilization in the upper reaches of the Yangtze River based on the DID method. The study results show that 1) the level of ecological civilization construction in the Yangtze River's upper reaches has continuously improved from 2003 to 2020. 2) The implementation of the Yangtze River Economic Belt Strategy has a significant positive impact on the construction of ecological civilization in the upper reaches of the Yangtze River. 3) The Yangtze River Economic Belt Strategy can promote the construction of ecological civilization in the upper reaches of the Yangtze River by improving the level of science and technology innovation. 4) The implementation of the Yangtze River Economic Belt Strategy does not significantly impact the level of ecological civilization construction in the regions participating in the Belt and Road Initiative, so it is necessary to pay attention to the synergy between different policies. This study will help to raise the awareness of developing countries on economic development and ecological protection in the river basin, and provide a reference for policymakers.

KEYWORDS

Yangtze river economic belt strategy, upper Yangtze river region, ecological civilization construction, green development, DID

Introduction

With the continuous expansion of industrial development globally, people's awareness of environmental pollution is weaker and the ecological crisis has brought more and more significant challenges to human beings (Wisadha and Widyaningsih, 2018; Deng et al., 2022). Under this background, countries worldwide began to attach importance to the theoretical research and practical exploration of sustainable development and gradually realized that the harmonious coexistence of man and nature is the basis for the endless existence of human civilization, and sustainable development has gradually become an international consensus. In recent years, the Chinese government has attached great importance to constructing ecological civilization. It has written ecological civilization into the Constitution, formulated 7 laws, and revised 17 laws (Zhang and Xu, 2022). The ecological civilization construction (ECC) refers to the sustainable development activities of human beings in developing the relationship between human beings and nature and promoting the harmonious coexistence of economy, society, politics, culture, and nature, to promote the formation of spatial patterns, industrial structures, production methods, and lifestyles that conserve resources and protect the environment. The implementation of ecological civilization construction is the Chinese people's profound reflection on traditional industrialization, which breeds the cognition and pursuit of new forms of human civilization after industrial civilization (Pan, 2021). The core of ecological civilization construction is to coordinate the relationship between man and nature (Dai and Zhou, 2022). The essence is building a community of shared destiny between man and nature. The essence of ecological civilization lies in the coordination of ecological, social, and economic values (Peng et al., 2021). Although different methods have been used to measure the level of ecological civilization construction, such as the Coupling coordination degree (CCD) model (Le et al., 2021; Zuo et al., 2021), the Pressure-state-response (PSR) model (Fuguo and Peng, 2014), the force-pressure-state-influence-response (DPSIR) model (Chen et al., 2022b; Chai and Zhou, 2022), the Structural equation model (SEM) (Bing and Zhiguang, 2018), the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) model (Mi et al., 2016; Gou and Lu, 2020), the Panel data model (PDM) model (Qinlin and Ping, 2014), the Data envelopment analysis (DEA) (Pan et al., 2022) and other methods to evaluate the construction of ecological civilization. The indicators selected by different scholars are different, mainly including the industrial structure and marketization degree (economic perspective), government environmental risk awareness and green government action (political perspective), resident's well-being and corporate environmental responsibility (social perspective), cultural education The nine explanatory variables of investment (cultural perspective), green travel and ecological construction (ecological perspective) describe the level

of ecological civilization construction (Dong et al., 2021). From scholars' studies, it is easy to find that the level of ecological civilization construction can, to a certain extent, reflect the sustainable development level of the region It can not only meet the growing human demand for a beautiful ecological environment, but also promote higher quality, more efficient, more equitable, more sustainable, and safer development (Gare, 2017; Wang and Wu, 2022).

In September 2014, the Chinese government issued the "Guiding Opinions of the State Council on Promoting the Development of the Yangtze River Economic Belt by Relying on Golden Waterways," marking the initial formation of the Yangtze River Economic Belt strategy. The Yangtze River Economic Belt is an inland river economic belt with global influence, a coordinated development belt for interaction and cooperation between the East, China, and the West, and a belt for opening up to the outside world in an all-round way along the coast and along the river, and a pioneering demonstration belt for ecological civilization construction (Cao et al., 2020). Great importance is attached to regional sustainable development. The Yangtze River Economic Belt covers 11 provinces and cities, including Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Yunnan, and Guizhou, with an area of about 2.0523 million square kilometers, accounting for 21.4% of the country's total population and GDP. More than 40% of the national total. To effectively promote the development of the Yangtze River Economic Belt strategy, in December 2014, the Central Committee of the Communist Party of China established a leading group to promote the development of the Yangtze River Economic Belt. Furthermore, the relevant departments of state organs, 11 provincial and municipal governments along the Yangtze River, and responsible comrades of relevant units are members. The leading group office is located in the National Development and Reform Commission. Since implementing the Yangtze River Economic Belt strategy, scholars have taken the Yangtze River Economic Belt as a research area. They have carried out much research on urbanization, water resources, carbon emissions, ecosystem services, ecological compensation, and ecological efficiency of the Yangtze River Economic Belt (Chen et al., 2019; Yu et al., 2019; Chen et al., 2021; Wu et al., 2022). A few scholars also directly discussed the impact of implementing the Yangtze River Economic Belt strategy (Dai et al., 2022). Generally speaking, the construction of the Yangtze River Economic Belt is the best choice to promote the economic development layout of the Yangtze River Basin (Lu, 2014). For example, some scholars believe that after the establishment of the Yangtze River Economic Belt strategy, the water use efficiency of the Yangtze River Economic Belt has dramatically improved (Liu and Yuan, 2022). Some scholars have also proved through research that the strategic Policy of the Yangtze River Economic Belt reduces the local water ecological footprint, which is more significant in developed areas than in

developing areas, and more effective for agriculture than for industry (Luo et al., 2019).

To sum up, there are many research results on constructing the Yangtze River Economic Belt or ecological civilization in the academic world. However, few scholars have studied the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization from the perspective of the Yangtze River Economic Belt strategy (Tang and Li, 2022). The upper reaches of the Yangtze River, as the ecological security barrier area and water conservation area of the Yangtze River Economic Belt, have a fundamental ecological security pattern (Zhao et al., 2006; Zhang et al., 2017; Peng et al., 2018; Shi C. et al., 2022), and the level of ecological civilization construction directly affects the sustainable development level of the Yangtze River Economic Belt (Wang et al., 2019). Therefore, whether the strategy of the Yangtze River Economic Belt has promoted the construction of ecological civilization in the upper reaches of the Yangtze River and its mechanism are worthy of in-depth study. It can not only measure the implementation effect of the Yangtze River Economic Belt Strategy, but also further reveal the sustainable development level of the upper reaches of the Yangtze River. It is of great significance to optimize the regional development strategy and ecological environment protection measures formulated by China and other countries. This research expands the research perspective of sustainable development theory. It provides a reference for the development-oriented regions of the world with "ecological priority and green development" so that decision-makers can effectively integrate ecological and environmental protection when formulating economic development strategies in the policy system. It will help alleviate the damage to the ecological environment caused by economic development strategies, provide a basis for ecological compensation in the upper, middle, and lower reaches of the basin, promote the coordinated development of the upper, middle and lower reaches of the basin, and ultimately promote the sustainable development of the entire basin. We hope that this study will achieve the following three objectives:

1) Based on the entropy weight method, construct an evaluation index system of ecological civilization construction level in the upper reaches of the Yangtze River from the three dimensions of ecology, economy, and society, and measure the level of ecological civilization construction in the upper reaches of the Yangtze River. 2) Use DID to judge the strategy of the Yangtze River Economic Belt, The impact on the construction of ecological civilization in the upper reaches of the Yangtze River, and the analysis of the impact mechanism. 3) The heterogeneity analysis of the areas in the upper reaches of the Yangtze River that belong to the "One Belt, One Road" initiative and the Chengdu-Chongqing economic circle to test the Yangtze River Economic Belt Differences in the implementation effects of strategies in the upper reaches of the Yangtze River.

Materials and methods

Study area

The Yangtze River, the third longest river in the world and the longest river in China, is China's crucial biological gene treasure house and ecological security barrier and an essential support for China's sustainable economic development. For thousands of years, the Yangtze River Basin has been linked by water, connecting the upper and lower reaches, the left and right banks, and the principal and tributaries, provides precious water resources for the Yangtze River Basin and supports the livelihoods of millions of people (Huang et al., 2021), and forming an enormous economic and social system. From the scope defined by the development strategy of the Yangtze River economic belt, the upper reaches of the Yangtze River mainly include Chongqing, Sichuan, Yunnan, and Guizhou. Since the ecological environment of the entire upstream basin affects the ecological security of the middle and lower reaches, strengthening initiatives to promote the formation of ecological protection in the upper reaches of the Yangtze River is a new requirement in response to the new era of socialism with Chinese characteristics and the new stage of coordinated regional development, so the construction of ecological civilization should be studied from the perspective of the basin (Wen et al., 2022). Therefore, as shown in Figure 1, the upper reaches of the Yangtze River referred to in this paper are based on river basins, covering nine provinces, autonomous regions, and municipalities directly under the central government, including Tibet, Qinghai, Sichuan, Yunnan, Chongqing, Guizhou, Gansu, Shanxi, and Hubei, including the river basin above Yichang City in Hubei Province, starting from Geladandong on the Qinghai Tibet Plateau in the west, Yichang in Hubei in the East, Gansu and southern Shaanxi in the north, Yunnan and Northern Guizhou in the south. It covers the areas covered by nine provinces, cities and autonomous regions in the upper reaches of the Yangtze River (Wen et al., 2021).

Data sources

Starting from the availability of data and the credibility of the empirical research results, this paper considers the overall scope of the upper reaches of the Yangtze River. Among them, minority autonomous prefectures are excluded because of their large amount of missing data. The data of this study include Ankang, Baoji, Dingxi, Hanzhong, Longnan, Tianshui, Anshun, Bazhong, Chengdu, Dazhou, Deyang, and Guang'an, Guangyuan, Guiyang, Kunming, Leshan, Lijiang, Liupanshui, Luzhou, Meishan, Mianyang, Nanchong, Neijiang, Panzhihua, Qujing, Shiyan, Suining, Xiangyang, Ya'an, Yibin, Yichang, Yuxi, Zhaotong, Chongqing, Ziyang, Zigong, Zunyi, a total of 37 prefecture-level cities. Ankang, Baoji, Dingxi, Hanzhong,

FIGURE 1
Upper Yangtze river basin and specific study area map.
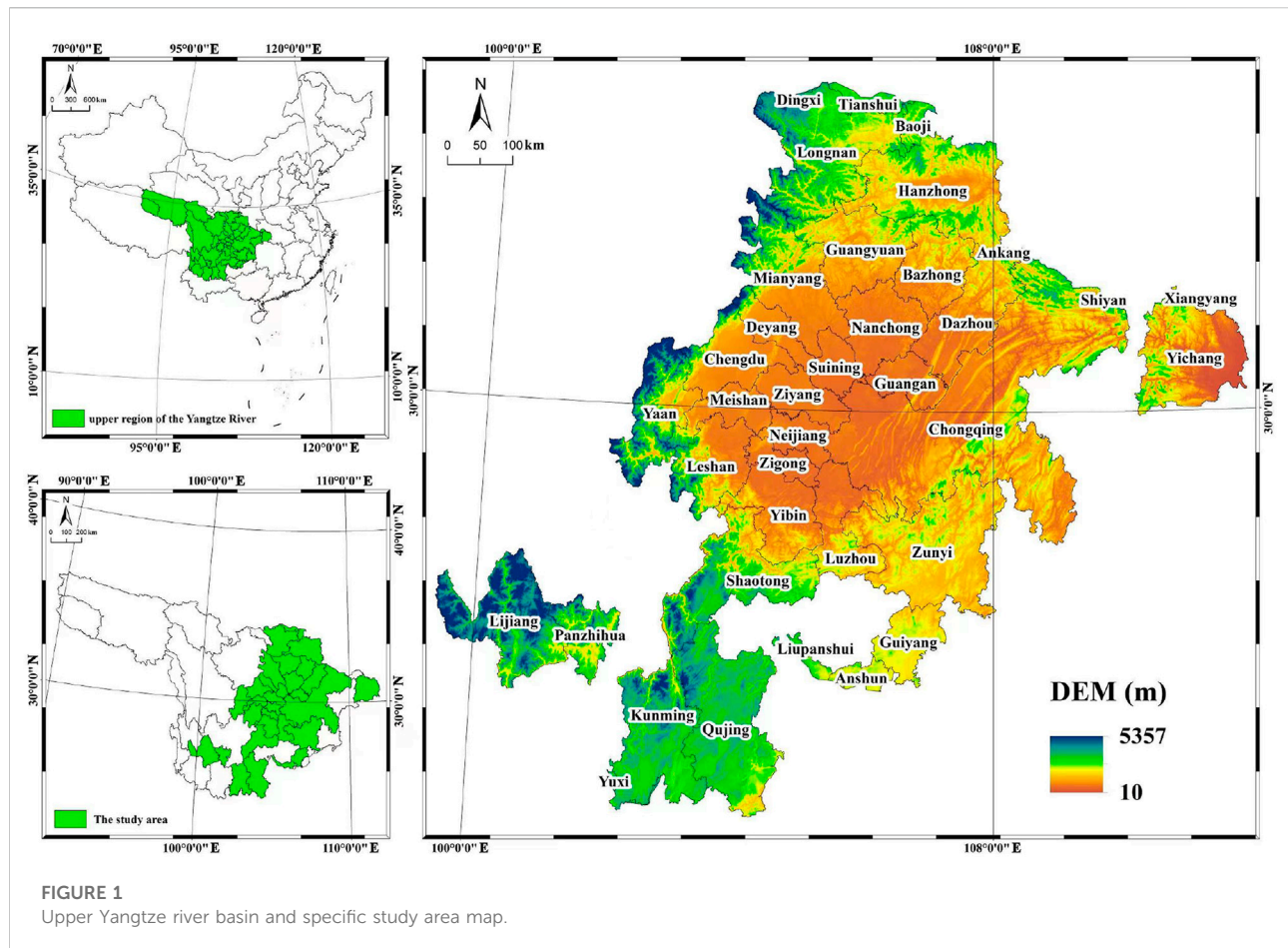
Longnan, Tianshui belong to the upper reaches of the Yangtze River Basin, but does not belong to the strategic scope of the Yangtze River Economic Belt. So Ankang, Baoji, Dingxi, Hanzhong, Longnan, Tianshui are used as the control group for this empirical study. The original data come from the China Statistical Yearbook, China Urban Statistical Yearbook, China Financial Statistical Yearbook, China Environmental Statistical Yearbook, China Education Statistical Yearbook, China Health and Family Planning Statistical Yearbook, and provinces (cities, districts) Statistical Yearbook, China Social and Economic Development Database and the official website of the National Bureau of Statistics, and so forth. Part of the missing data is filled by linear interpolation or mean interpolation. The individual missing data in the calculation process is filled by the moving average method.

Dependent variable

Many scholars have researched the evaluation of the level of ecological civilization construction. Based on existing research (Zhang and Lan, 2013; Wang D. et al., 2021; Yan et al., 2021;

Zhou J. et al., 2022; Xu et al., 2022), the indicators of the ecological civilization construction level in the upper reaches of the Yangtze River are selected from the three dimensions of ecology, economy, and society, and the ECC indicator system is constructed, as shown in Table 1. According to the PSR theory of ecological environment, the three aspects of ecological basis, pressure, and response more accurately reflect the interaction between human economic activities and the ecological environment. Based on this, the measurement indicators are selected. The ecological basis reflects the regional ecological environment and the level of essential resources. It is represented by indicators such as per capita green space area and urban green coverage rate; ecological pressure reflects the threat to the ecological environment caused by human production and life and is represented by indicators such as per capita industrial wastewater discharge, per capita SO_2 discharge, per capita smoke and dust discharge; ecological response reflects the countermeasures taken by human beings in the face of ecological environment feedback are characterized by indicators such as the comprehensive utilization rate of solid waste, the rate of harmless treatment of domestic waste, and the rate of sewage treatment. Corresponding to the ecological

subsystem indicators, the economic subsystem indicators are constructed from three aspects: economic strength, structure, and vitality. The economic strength reflects the overall basic level of regional economic development and is characterized by indicators such as per capita GDP and economic density; the tertiary industry increases the economic structure. The proportion of value and the proportion of employees in the secondary industry is characterized by indicators; the economic vitality reflects the driving ability of the regional economic "troika," which is characterized by the per capita fixed assets and retail commodity consumption. The social subsystem indicators are constructed from three aspects: social foundation, service, and security, and comprehensively reflect the degree of harmonious social development. The social foundation reflects the development of urbanization and people's living standards and is represented by indicators such as urban and rural residents' disposable income; and information level, which is represented by indicators such as the number of medical beds and the penetration rate of mobile phones; social security reflects the degree of infrastructure and agricultural security, which is represented by indicators such as road network density and per capita grain output.

Independent variable

The core explanatory variable in this study is the Yangtze River Economic Belt strategy (Yang and Jiang, 2022). We will set up a regional dummy variable according to the regional implementation of the Yangtze River Economic Belt strategy. The region in the strategic planning of the Yangtze River economic belt is 1, otherwise it is 0. The starting year of implementing the Yangtze River Economic Belt strategy is 2014, and the time variable is virtual. After 2014, the time variable is 1, otherwise it is 0.

Control variable

First, population density (PD) reflects the pressure exerted by human clusters in a region on the ecosystem in that region. Therefore, we believe that population density in a region can affect the construction of ecological civilization (Zhang and Zhang, 2011). Secondly, for the economic system of a region, Second, for a regional economic system, foreign direct investment (FDI) is an essential channel for regional capital growth (Borensztein et al., 1998), an opportunity for exposure to advanced technology and management practices (Sultana and Turkina, 2020), and an essential factor influencing green development (Wang M. et al., 2021). Thirdly, the level of human capital (HC) and fiscal decentralization (FD) can also affect the construction of regional ecological civilization to a certain extent (Wang Y. et al., 2022; Zhou R. et al., 2022). Fourth,

marketization (MKT) can affect energy utilization efficiency, so it may also affect the construction of regional ecological civilization (Chen et al., 2022a). Furthermore, in order to avoid multiple collinearity problems in the model, control variables such as marketization level, population density, foreign direct investment, human capital, and fiscal decentralization are treated logarithmically. The logarithmic results of marketization level, population density, foreign direct investment, human capital and fiscal decentralization are expressed in lnMKT, lnPD, lnFCI, lnHC and lnFD respectively.

Entropy weight method

The entropy weight method is used to determine the index weight objectively, which is widely used (Cheng et al., 2020; Ji et al., 2020). According to the index system set up above, the entropy weight method is used to calculate the weight of each index by using the information entropy principle in combination with the observed values of each index. First, based on dividing j-type indicators into positive indicators and negative indicators, dimensionless treatment is carried out for them.

$$y_{tij} = \left(x_{tij} - x_j{}^{min}\right)\Big/\left(x_j{}^{max} - x_j{}^{min}\right) \quad (1)$$

$$y_{tij} = \left(x_j{}^{max} - x_{tij}\right)\Big/\left(x_j{}^{max} - x_j{}^{min}\right) \quad (2)$$

In the formula, t represents for year, t = 1,2,3,......,18; i represents the city, i = 1,2,3,......,37; j represents index of category, j = 1,2,3,......,20. x_{tij} represents the value of the city ij index in year t; y_{tij} represents the dimensionless value of j index of the city i in year t. $x_j{}^{max}$ and $y_j{}^{min}$ represent the maximum and minimum values of index j respectively.

Then calculate the entropy and weight of indicators:

$$P_{tij} = y_{tij}\Big/\sum_{t=1}^{18}\sum_{i=1}^{37} y_{tij} \quad (3)$$

$$E_j = -\sum_{t=1}^{18}\sum_{i=1}^{37} p_{tij} \ln\left(p_{tij}\right)\Big/\ln\left(18 \times 37\right) \quad (4)$$

$$W_j = \left(1 - E_j\right)\Big/\sum_{j=1}^{20}\left(1 - E_j\right) \quad (5)$$

$$ECC_{it} = p_{tij} \times W_j \quad (6)$$

In the formula, P_{tij} represents the normalized value, E_j represents the entropy value of the j-type index, and W_j represents the weight of the j-type index, ECC_{it} represents the ecological civilization construction level of the city i in the year of t.

DID model

This study explores the impact of the Yangtze River Economic Belt strategy on the construction of ecological

civilization in the upper reaches of the Yangtze River. The DID model is the primary model used in this study. It compares the areas included in the Yangtze River Economic Belt strategy that belongs to the upper reaches of the Yangtze River and the areas that are not included in the Yangtze River Economic Belt strategy and belong to the upper reaches of the Yangtze River. The set DID model is as follows:

$$ECC_{it} = \beta_0 + \beta_1 Policy_i time + X_{it} + \delta_i + \gamma_t + \varepsilon_{it} \qquad (7)$$

In the formula, Policy is a dummy variable. When location i bbelongsto the strategic planning scope of the Yangtze River Economic Belt, Policy is 1. Otherwise, it is 0, and time is also a dummy variable because the Yangtze River Economic Belt is a dummy variable. The starting time for the implementation of the strategy is 2014. When the year is more significant than 2014, time is 1. Otherwise, it is 0. X_{it} is a control variable, including marketization, population density, technological innovation level, foreign direct investment, and human capital. δ_i is the individual fixed effect, γ_t is the time fixed effect, and ε_{it} is the disturbance term.

Results

The level of ecological civilization construction in the upper reaches of the Yangtze River

The ecological civilization construction level calculated by the entropy weight method is shown in the figure. The average value of the ecological civilization construction level in the upper reaches of the Yangtze River is 0.158, the minimum value is 0.017, and the maximum value is 0.611. On this basis, the spatial distribution map of ecological civilization construction in the upper reaches of the Yangtze River in 2003, 2007, 2011, 2016, and 2020 was drawn with the help of ArcGIS mapping software. It can be seen from Figure 2 that the construction of ecological civilization in the upper reaches of the Yangtze River showed an upward trend from 2003 to 2020. However, the spatial differences among various regions were pronounced. The higher values mainly appear in Shiyan, Yichang, Xiangfan, and Chengdu. Specifically, Chengdu had the highest comprehensive development level in 2003, which was 0.15654; Yichang was the second, at 0.12535; The lowest is Dingxi, which was only 0.01727. In 2016, Chengdu, Yichang, and Chongqing ranked the top three in emission intensity, reaching 0.33527, 0.2780, and 0.24682, respectively. Zhaotong ranked the lowest, only 0.08117. In 2020, Yichang, Chengdu, and Deyang ranked the top three in terms of comprehensive development level, with 0.35969, 0.40375, and 0.31778, respectively. Longnan still ranked the lowest, with only 0.10830.

Benchmark regression results

Table 2 presents the benchmark regression results, and column (1) presents the regression results of the influence of the Yangtze River Economic Belt strategy on the construction of ecological civilization, controlling for individual and time-fixed effects. Column (2) gives the regression results after adding control variables based on column (1), which mainly controls the influence of marketization, foreign direct investment, population density, fiscal decentralization, human capital, and other control variables on the upper reaches of the Yangtze River. The influence of regional ecological civilization construction level. In the column, the coefficient of the interaction term between Policy and time is 0.031 and is statistically significant at the 1% level. This preliminarily proves that the strategy of the Yangtze River Economic Belt can promote the construction of ecological civilization in the upper reaches of the Yangtze River. Column (2) gives the interaction coefficient between Policy and time in column 0.026. It is statistically significant at the 1% level, which proves that the control variables such as marketization, foreign direct investment, fiscal decentralization, population density, and human capital are controlled. After that, implementing the Yangtze River Economic Belt strategy still promoted the construction of ecological civilization in the upper reaches of the Yangtze River. At the same time, from the perspective of the size of the coefficient, the coefficient of the interaction term between Policy and time becomes smaller after adding the control variable, indicating that some control variables have diluted the explanatory power of the Yangtze River Economic Belt strategy to promote the construction of ecological civilization in the upper reaches of the Yangtze River. The coefficient of lnMKT and lnPD are This paper uses negative, and it has passed the significance test at the 1% level, proving that marketization and population density can restrain, the construction of ecological civilization in the upper reaches of the Yangtze River to a certain extent.

Heterogeneity test

In addition to the Yangtze River Economic Belt strategy, some regions in the upper reaches of the Yangtze River also participate in the "Belt and Road" initiative. In addition, the planned area of the Shuangcheng economic circle in the Chengdu Chongqing region, as the economic hinterland of the upper reaches of the Yangtze River, is also different from other areas in the upper reaches of the Yangtze River. To further understand the impact of the "the Belt and Road" initiative and the twin city economic circle in the Chengdu Chongqing region on the implementation of the Yangtze River Economic Belt strategy, the upper reaches of the Yangtze River Basin are further divided into the regions participating in the "the Belt and Road" initiative, the regions not participating in the "the Belt and
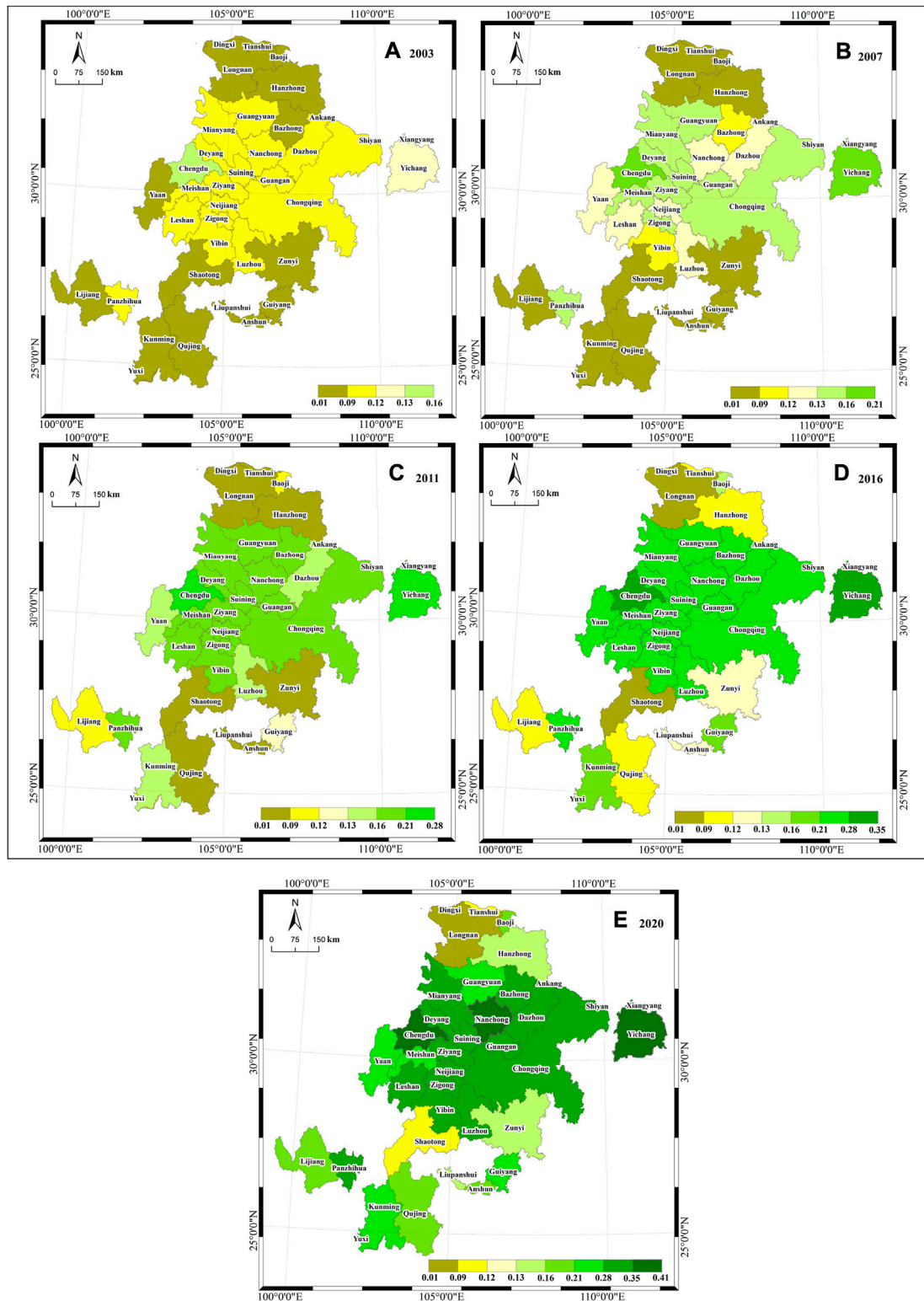
FIGURE 2
Evolution of ecological civilization in the upper reaches of the Yangtze River in 2003, 2007, 2011, 2016 and 2020.

TABLE 1 Evaluation index system of ecological civilization construction (ECC) level.

Subsystem	Primary index	Secondary index	Company
Ecology	Ecological basis	Per capita green space	hm^2/10000 people
		The green coverage rate of built-up area	hm^2/10000 people
	Ecological pressure	Per capita industrial wastewater discharge	t/person
		SO2 emission per capita	t/person
		Per capita smoke emission	t/person
	Ecological response	The comprehensive utilization rate of solid waste	%
		Harmless treatment rate of domestic garbage	%
		Sewage treatment rate	%
Economics	Economic strength	Per capita GDP	yuan/person
		Economic density	ten thousand yuan/km^2
	Economic structure	The proportion of tertiary industry	%
		The proportion of employees in secondary industry	%
	Economic vitality	Per capita retail sales of social consumer goods	yuan/person
		Per capita investment in fixed assets	yuan/person
Society	Social foundation	Per capita disposable income of urban residents	yuan/person
		Per capita disposable income of rural residents	yuan/person
	Social services	Number of medical beds per 10000 people	zhang/10000 people
		Mobile phone penetration	%
	Social security	Highway network density	km/km^2
		Per capita grain output	t/10000 people

Road" initiative and the planned regions of the twin city economic circle in Chengdu Chongqing region, and on this basis, heterogeneity analysis is conducted. In this heterogeneity analysis, 25 cities have not participated in the "the Belt and Road" initiative, 12 cities have participated in the "the Belt and Road" initiative, and 14 planned areas of the twin city economic circle in the Chengdu Chongqing region. The regression results of heterogeneity analysis are shown in Table 3. Columns (1) and (2) reflect the impact of the Yangtze River Economic Belt strategy on the ecological civilization construction in the upper reaches of the Yangtze River basin that are not participating in the "Belt and Road" initiative. Columns (3) and (4) reflect the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of the Yangtze River Basin participating in the "Belt and Road" initiative. Columns (5) and (6) reflect the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of the Yangtze River Basin, which belongs to the Shuangcheng economic circle of the Chengdu Chongqing region. Columns (1), (3), and (5) do not control the impact of the control variables. Columns (2), (4), and (6) control the control variables such as the level of marketization, population density, foreign direct investment, human capital, and fiscal decentralization. In addition to column (4), the coefficients of the interaction between Policy and time in columns (1), (2), (3), (5), and (6) are positive and significant, which proves that, first of all, the Yangtze River

Economic Belt strategy promotes the construction of ecological civilization in the upper reaches of the Yangtze River, regardless of whether it belongs to the Shuangcheng economic circle in Chengdu Chongqing region. The coefficient of areas belonging to the twin city economic circle of the Chengdu Chongqing region is slightly higher than that of areas not belonging to the twin city economic circle of the Chengdu Chongqing region. Secondly, it can be found that the Yangtze River Economic Belt strategy does not significantly promote the ecological civilization construction of the regions participating in the "Belt and Road" initiative in the upper reaches of the Yangtze River under the Control of other variables. The "Belt and Road" initiative and the Yangtze River Economic Belt strategy are out of harmony in constructing ecological civilization.

Parallel trend test

The premise of using the double difference method to estimate the effectiveness of the Policy is that the experimental group and the control group have the same growth trend before being impacted by the Policy, so it is necessary to conduct a parallel trend test on the explained variables. This paper uses two methods to test the parallel trend (Beck et al., 2010; Zhang et al., 2021).

First, the 5 years before and after implementing the Yangtze River Economic Belt strategy were selected as the period for the

TABLE 2 Benchmark regression table.

Variables	(1)	(2)
	ECC	ECC
Policy*time	0.031***	0.026***
	(6.33)	(5.00)
lnMKT		−0.033***
		(−2.90)
lnPD		−0.065***
		(−3.29)
lnFDI		0.000
		(0.53)
lnHC		0.003
		(0.83)
lnFD		0.003
		(0.73)
Constant	0.079***	0.515***
	(21.02)	(4.45)
Observations	666	666
R-squared	0.845	0.850
Number of Urban	37	37
Urban fixed effects	YES	YES
Year effect	YES	YES

Note: Values in the parentheses are t-statistics; ***, **, and * represent rejection of the null hypothesis at the 1, 5, and 10% significance levels, respectively.

parallel trend test. The ecological civilization construction levels of the treatment and control groups from 2009 to 2019 were compared. The results are shown in Figure 3A. In Figure 3A, the exgroup represents the experimental group, and the congroup represents the control group. It can be found that before the implementation of the Yangtze River Economic Belt strategy in 2014, the growth trend of the experimental group and the control group was similar. However, after implementing the Yangtze River Economic Belt strategy, the ecological civilization construction level of the experimental group and the control group showed significant differences. The growth trend of the experimental group was faster than that of the control group. Secondly, set a dummy variable for each year from 2009 to 2019, multiply it with the dummy variable of the experimental group, and then regress the level of ecological civilization construction with the dummy variable of the eight products, and they did the core explanatory variable. The results are shown in Figure 3B. In Figure 3B, the virtual variable coefficient multiplied by the years before 2015 and the experimental group is insignificant, and the virtual variable coefficient after 2015 is positive and significant. Because the effect of policy implementation often lags behind the time of policy implementation, it can be proved that the model meets the parallel trend hypothesis.

PSM-DID inspection

The control and experimental groups belong to the upper reaches of the Yangtze River; there is a certain degree of homogeneity. However, to further control the possible systematic differences between cities in the upper reaches of the Yangtze River that participate in the strategy of the Yangtze River Economic Belt and other cities in the upper reaches of the Yangtze River (Huang et al., 2021), and to further regulate the bias of the double difference estimation. This article uses the PSM-DID method to carry out the benchmark regression results. Robustness check (Qi S. et al., 2021). This paper uses marketization, population density, foreign direct investment, human capital, and fiscal decentralization as covariates. It applies the Mahalanobis distance matching method to carry out propensity score matching for the strategic cities of the

TABLE 3 Heterogeneity analysis table.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	ECC	ECC	ECC	ECC	ECC	ECC
Policy*time	0.191***	0.207***	0.018***	0.004	0.206***	0.224***
	(30.71)	(10.94)	(3.84)	(0.82)	(24.66)	(12.27)
Controlact	NO	YES	NO	YES	NO	YES
Constant	0.096***	0.118***	0.043***	0.026	0.108***	0.122***
	(21.92)	(5.40)	(9.15)	(0.66)	(18.29)	(4.37)
Observations	450	450	216	216	252	252
R-squared	0.883	0.884	0.868	0.901	0.898	0.900
Number of Urban	25	25	12	12	14	14
Urban fixed effects	YES	YES	YES	YES	YES	YES
Year effect	YES	YES	YES	YES	YES	YES

Note: Values in the parentheses are t-statistics; ***, ** and * represent rejection of the null hypothesis at the 1, 5, and 10% significance levels, respectively.
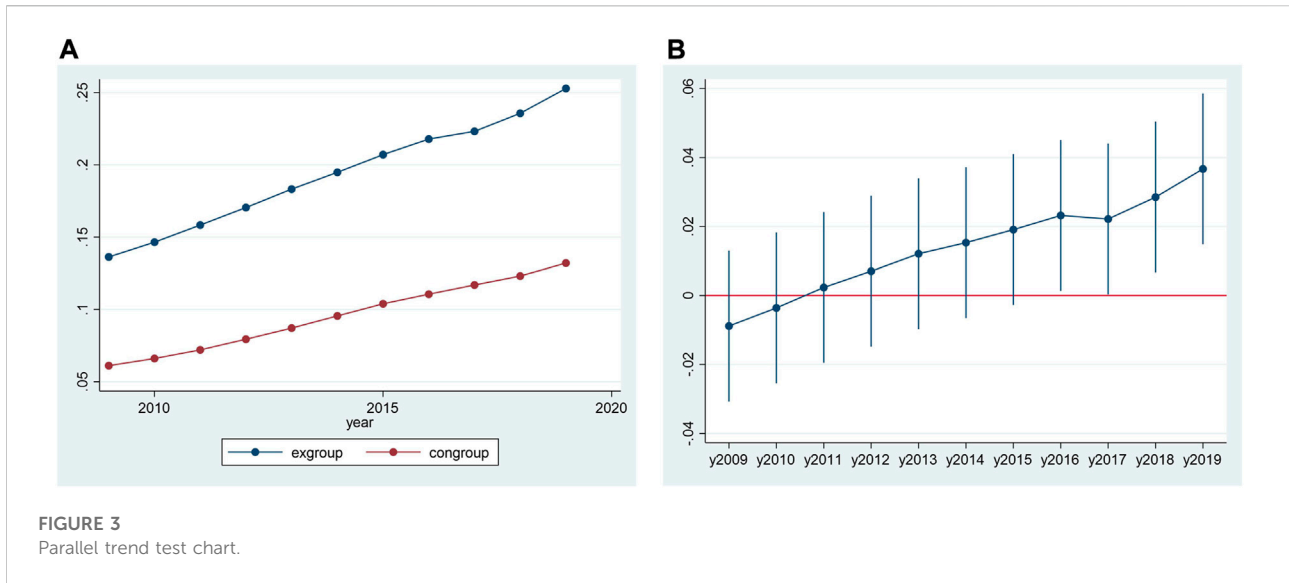
FIGURE 3
Parallel trend test chart.

TABLE 4 PSM-DID inspection form.

Variables	(1)	(2)
	ECC	ECC
Policy*time	0.031***	0.026***
	(6.33)	(5.00)
lnMKT		−0.033***
		(−2.90)
lnPD		−0.065***
		(−3.29)
lnFDI		0.000
		(0.53)
lnHC		0.003
		(0.83)
lnFD		0.003
		(0.73)
Constant	0.079***	0.515***
	(21.02)	(4.45)
Observations	666	666
R-squared	0.845	0.850
Number of Urban	37	37
Urban fixed effects	YES	YES
Year effect	YES	YES

Note: Values in the parentheses are t-statistics; ***, ** and * represent rejection of the null hypothesis at the 1, 5, and 10% significance levels, respectively.

Yangtze River Economic Belt. The matching results show that four cities cannot be matched to the appropriate control group. This paper further conducts a balance test on the matching results and finds that the balance conditions are met. Therefore, the DID method can be used for regression, and the regression results are shown in Table 4. From the sign, size, and significance of the regression coefficients, it can be seen that the regression results of PSM-DID are not much different from the benchmark regression results, so the model can be judged robust.

Placebo test

Under the condition of controlling the improvement of ecological civilization construction level brought about by time changes, to further verify whether the implementation of the Yangtze River Economic Belt strategy has promoted the ecological civilization construction in the upper reaches of the Yangtze River and to exclude the influence of unobserved urban sample characteristics on the regression results, this paper randomly selects 20 of all 37 samples as the "pseudo-experimental group" for placebo test, repeats the random sampling process 500 times, and re-regresses the product of the dummy variable with time as the core explanatory variable. Figure 4 shows the coefficient distribution of the regression result of the level of ecological civilization construction as the explained Variable. It can be seen from the figure that the distribution of the regression coefficients of the two models is concentrated around 0. It can be seen that the sample combination after random sampling has an impact on ecological civilization construction. So it can be concluded that the regression results of the participatory distinction between the experimental and Control groups in the benchmark regression are robust.

Mechanism discussion

According to the above research results, the Yangtze River Economic Belt strategy has significantly promoted the ecological
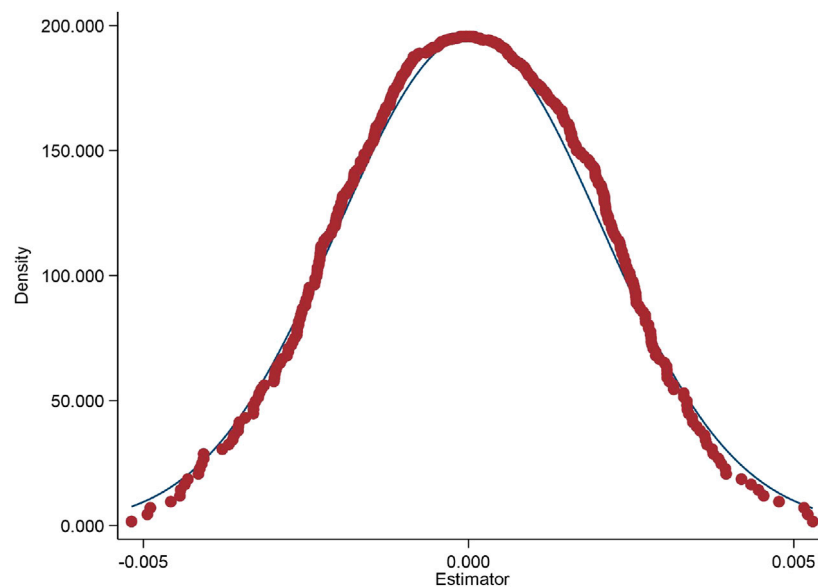
FIGURE 4
Placebo test chart.

civilization construction level in the upper reaches of the Yangtze River. This paper analyzes the mechanism of action of the Yangtze River Economic Belt strategy for constructing ecological civilization from the perspective of technological progress. On this basis, we use the method of gradual regression to discuss further the mechanism of the Yangtze River Economic Belt strategy on the ecological civilization construction level in the upper reaches of the Yangtze River. Analyze which factors influence the Yangtze River Economic Belt strategy to promote the construction of ecological civilization in the upper reaches of the Yangtze River.

$$ECC_{it} = \beta_0 + \beta_1 Policy_i time + \beta_2 medium_{it} + \beta_3 Control_{it} + \delta_i + \gamma_t + \varepsilon_{it}$$

$$(8)$$

$$medium_{it} = \alpha_0 + \alpha_1 Policy_i time + \alpha_2 Control_{it} + \delta_i + \gamma_t + \varepsilon_{it} \quad (9)$$

In the formula, $medium_{it}$ represents the mediating variable. This study mainly uses technological innovation as the mediating Variable to explore the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of the Yangtze River.

The Yangtze River Economic Belt strategy can promote the construction of ecological civilization by improving the technological innovation level of cities along the Yangtze River Economic Belt. Table 5 shows the test results of the technology improvement effect. Column (1) column reflects the impact of the Yangtze River Economic Belt strategy on technological innovation in the upper reaches of the Yangtze River without adding control

variables; column (2) adds marketization level, population density, foreign direct investment, and Control variables such as human capital and fiscal decentralization still mainly analyze whether the Yangtze River Economic Belt strategy has improved the level of technological innovation in the upper reaches of the Yangtze River. The independent variable of the column (3) is the level of ecological civilization construction. The intermediary variable is technological innovation. The control variables are marketization, population density, foreign direct investment, human capital, and fiscal decentralization. The results show that the Yangtze River Economic Belt strategy has significantly improved the level of technological innovation, and technological innovation has significantly improved the level of ecological civilization construction. It can be seen that the strategy of the Yangtze River Economic Belt can promote the improvement of the ecological civilization construction level by improving the technological level of the city.

Discussion

Contributions and limitations

Based on the existing research (Qv et al., 2021; Liu et al., 2022; Qi and Song, 2022), the spatial evolution of the ecological civilization construction level in the upper reaches of the Yangtze River is measured by using the ECC indicator system. The sustainable development level of the regions with the most excellent ecological value in the Yangtze River Basin in China can

TABLE 5 Mechanism analysis form.

Variables	(1)	(2)	(3)
	Technological innovation	Technological innovation	ECC
Policy*time	406.805***	317.515**	0.025***
	(2.93)	(2.18)	(4.82)
Technological innovation			0.000*
			(1.92)
lnMKT		−868.295***	−0.031***
		(−2.68)	(−2.68)
lnPD		701.282	−0.067***
		(1.25)	(−3.39)
lnFDI		45.738*	0.000
		(1.84)	(0.38)
lnHC		234.440**	0.002
		(2.52)	(0.63)
lnFD		−63.945	0.003
		(−0.52)	(0.77)
Constant	34.838	−1,609.220	0.519***
	(0.33)	(−0.49)	(4.50)
Observations	666	666	666
R-squared	0.111	0.141	0.851
Number of Urban	37	37	37
Urban fixed effects	YES	YES	YES
Year effect	YES	YES	YES

Note: Values in the parentheses are t-statistics; ***, **, and * represent rejection of the null hypothesis at the 1, 5, and 10% significance levels, respectively.

be seen. At the same time, we established a DID model to analyze the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of the Yangtze River. We found that since 2003, the level of ecological civilization construction in the upper reaches of the Yangtze River has gradually improved, and the implementation of the Yangtze River Economic Belt strategy has also promoted the construction of ecological civilization in the upper reaches of the Yangtze River.

Therefore, the research contributions of this paper are as follows. First of all, the research on the upstream basin is relatively rare at present with the ecological importance of the upstream basin in the whole basin being extremely prominent. The Yangtze River is the third largest river in the world and one of the most important rivers in China. ECC is a unique concept in China. ECC's goal is to measure the level of sustainable development. Therefore, in our research, we used ECC to evaluate the level of sustainable development in the upper reaches of the Yangtze River. It can not only measure the sustainable development level of the upper reaches of the Yangtze River more accurately, but also provide reference for other countries to measure the sustainable development of the river basin. Secondly, a good level of ecological civilization

construction means the common development of the three dimensions of regional economy, society and ecology (Qi Y. A. et al., 2021; Long, 2022; Yang et al., 2022), consistent with previous research. Consistently, It once again confirmed that environmental protection and economic and social development are not absolute conflicts (Tallis et al., 2008), laying a foundation for promoting the sustainable development of the entire watershed. Third, previous studies have focused more on the social and economic activities in the Yangtze River Economic Belt region (Xu et al., 2020; Li et al., 2021; Wang X. et al., 2022; Shi X. et al., 2022; Ge et al., 2022). Few scholars have considered the impact of China's major regional strategies on real life from the perspective of the implementation of the Yangtze River Economic Belt strategy. Few scholars have studied the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization. In our research, we found that sustainable economic development strategies can promote the level of ecological civilization construction. This paper expands the research perspective of sustainable development theory, providing a reference for the development-oriented regions of the world with "ecological priority and green development" and providing a reference for formulating and implementing regional development strategies. Fourth, we discussed the impact

mechanism of implementing the Yangtze River Economic Belt strategy on constructing ecological civilization. That is, to say, the construction of ecological civilization can be affected by improving the technical level. This provides new ideas for formulating regional economic strategies in the future.

However, it should be pointed out that the research methods and ideas of this paper still need to be improved:

1) The ECC evaluation method is based on evaluating the three dimensions of ecology, economy, and society. Therefore, there may be influencing factors that have not been considered in selecting indicators.
2) The upper reaches of the Yangtze River included in the Yangtze River Economic Belt strategy are Chongqing, Sichuan, Guizhou, and Yunnan provinces and municipalities directly under the central government. However, the upper reaches of the Yangtze River we hope to evaluate include Tibet, Qinghai, Sichuan, Yunnan, Chongqing, Guizhou, Gansu, Shaanxi, Hubei, and other nine provinces, autonomous regions, and municipalities directly under the central government. However, due to the limitations of the did method, Chongqing, Sichuan, and Guizhou Besides the four provinces and municipalities directly under the central government of Yunnan as the experimental group, we also took Tibet, Qinghai, Gansu, Shaanxi, Hubei, and other places as the control group. Therefore, we only evaluate the impact of the Yangtze River Economic Belt strategy on the upper reaches of the Yangtze River within the planning scope of the Yangtze River economic belt. Future research can try to evaluate the impact of regional economic strategy on the whole upper Yangtze River Basin.
3) Our research conducted a fundamental analysis of the impact of did evaluation method on the construction of ecological civilization in the upper reaches of the Yangtze River. We have not simulated and predicted the future development trend of the Yangtze River Economic Belt strategy on the ecological civilization construction in the study area, so it is difficult to comprehensively analyze and solve the ecological civilization construction in the whole Yangtze River Basin. Therefore, this will be the direction of our further research in the future.

Policy implications

This paper hopes to combine different governance strategies at the international and national levels, provide targeted governance strategies for different regions in the upper, middle, and lower reaches of the same basin to achieve ecological environment protection and coordinated economic and social development (Wu, 2022), and promote the harmonious coexistence of people and nature in the basin.

Based on the above research results, the following relevant policy recommendations are proposed:

1) In general, The Yangtze River Economic Belt Strategy is conducive to improving ecological civilization in the upper reaches of the Yangtze River, demonstrating that a regional development strategy guided by "ecological priority and green development" and "grasping great protection and not engaging in great development" can promote sustainable regional development. Therefore, to promote the basin's sustainable development, national and local governments can accelerate the introduction of regional development policies guided by "ecological priority and green development". We will build a service platform for ecological civilization construction and promote the coordinated development of the ecosystem, economic system and social system.
2) Improving technological innovation is a critical path to promoting ecological civilization in the upper reaches of the Yangtze River and is a new engine for green development. Therefore, for the ecological civilization construction in the upper Yangtze River region and other basins in the world, only by continuously promoting technological innovation, strengthening top-level design and overall planning, formulating medium- and long-term development strategic goals, improving technological innovation mechanisms for ecological civilization construction, grasping the law of green development and the dynamic needs of ecological civilization construction, further strengthening the union and coordination between departments and industries, and paying more attention to technological innovation policy In order to make new achievements in the construction of ecological civilization.
3) The implementation of the Yangtze River Economic Belt Strategy has not significantly contributed to the construction of ecological civilization in the regions participating in the Belt and Road Initiative. Therefore, it is necessary to establish a high-level communication and coordination committee to ensure the synergy between different policies and the degree of cooperation between different sectors to avoid mutual interference and suppression between policies.

Conclusion

Based on the leading function of land use and the situation of the study area, this paper selects nine provinces, cities, and autonomous regions covering the upper reaches of the Yangtze River as the study area from the perspective of the river basin. It uses the did evaluation method to investigate the impact of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the upper reaches of

the Yangtze River from the three dimensions of ecology, economy, and society and analyzes the sustainable development level of the upper reaches of the Yangtze River. The conclusions are as follows:

1) From 2003 to 2020, the level of ecological civilization construction in the upper reaches of the Yangtze River Basin continued to improve.
2) The empirical results show that implementing the Yangtze River Economic Belt strategy can promote the construction of ecological civilization in the upper reaches of the Yangtze River.
3) Some areas in the upper reaches of the Yangtze River belong to both the Yangtze River Economic Belt strategy and the "Belt and Road" initiative. The empirical results show that after participating in the "the Belt and Road" initiative, the ecological civilization construction level in the upper reaches of the Yangtze River will not be significantly promoted by the Yangtze River Economic Belt strategy.
4) Whether it belongs to the twin city economic circle of the Chengdu Chongqing region, implementing the Yangtze River Economic Belt strategy can promote the construction of ecological civilization in this region. The promotion effect of the Yangtze River Economic Belt strategy on the construction of ecological civilization in the Chengdu Chongqing region is more significant than in other regions.
5) We can promote the construction of ecological civilization in the upper reaches of the Yangtze River by improving technological innovation in the strategic areas of the Yangtze River economic belt.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material; further inquiries can be directed to the corresponding authors.

Author contributions

ZZ, LZ, and CW designed the research and collected the data, LZ, ZZ, and TL contributed to the data processing and analysis, ZZ, LZ, and LC prepared the original draft, CW edited and reviewed the manuscript, CL, LF, BZ, and JZ contributed to the discussion. All authors have read and agreed to the published version of the manuscript.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Beck, T., Levine, R., and Levkov, A. (2010). Big bad banks? The winners and losers from bank deregulation in the United States. *J. Finance* 65, 1637–1667. doi:10.1111/j.1540-6261.2010.01589.x

Bing, L., and Zhiguang, Z. (2018). Empirical research on optimizing indicators for ecological civilization and calculating Indicators'Weightings with the method of PSIR and SEM. *Resour. Environ. Yangtze Basin* 27, 779–791.

Borensztein, E., De Gregorio, J., and Lee, J. W. (1998). How does foreign direct investment affect economic growth? *J. Int. Econ.* 45, 115–135. doi:10.1016/s0022-1996(97)00033-0

Cao, R., Hu, Z., Jiang, Z., Yang, Y., Zhao, W., Wu, G., et al. (2020). Shifts in ecosystem water use efficiency on China's loess plateau caused by the interaction of climatic and biotic factors over 1985–2015. *Agric. For. Meteorology* 291, 108100. doi:10.1016/j.agrformet.2020.108100

Chai, N., and Zhou, W. (2022). The DPSIRM-Grey cloud clustering method for evaluating the water environment carrying capacity of Yangtze River Economic Belt. *Ecol. Indic.* 136, 108722. doi:10.1016/j.ecolind.2022.108722

Chen, D., Jiang, P., and Li, M. (2021). Assessing potential ecosystem service dynamics driven by urbanization in the Yangtze River Economic Belt, China. *J. Environ. Manag.* 292, 112734. doi:10.1016/j.jenvman.2021.112734

Chen, H., Qi, S., and Tan, X. (2022a). The improvement pathway for industrial energy efficiency under sustain ability perspective. *Sustain. Energy Technol. Assessments* 51, 101949. doi:10.1016/j.seta.2022.101949

Chen, H., Xu, J., Zhang, K., Guo, S., Lv, X., Mu, X., et al. (2022b). New insights into the DPSIR model: Revealing the dynamic feedback mechanism and efficiency of ecological civilization construction in China. *J. Clean. Prod.* 348, 131377. doi:10.1016/j.jclepro.2022.131377

Chen, J.-X., Zhang, Y., and Zheng, S. (2019). Ecoefficiency, environmental regulation opportunity costs, and interregional industrial transfers: Evidence from the Yangtze River Economic Belt in China. *J. Clean. Prod.* 233, 611–625. doi:10.1016/j.jclepro.2019.06.117

Cheng, W., Xi, H., Sindikubwabo, C., Si, J., Zhao, C., Yu, T., et al. (2020). Ecosystem health assessment of desert nature reserve with entropy weight and fuzzy

mathematics methods: A case study of badain jaran desert. *Ecol. Indic.* 119, 106843. doi:10.1016/j.ecolind.2020.106843

Dai, T., and Zhou, H. (2022). Building a community with a shared future for mankind, coping with climate change and ecological civilization construction. *China Popul. Resour. Environ.* 32, 1–8.

Dai, Y., Liu, Y., Ding, X., Wu, C., and Chen, Y. (2022). Environmental regulation promotes eco-efficiency through industrial transfer: Evidence from the Yangtze River economic belt in China. *Int. J. Environ. Res. Public Health* 19, 10127. doi:10.3390/ijerph191610127

Deng, X., Song, Y., He, Q., Xu, D., and Qi, Y. (2022). Does internet use improve farmers' perception of environmental polluti on? Evidence from rural China. *Environ. Sci. Pollut. Res.* 29, 44832–44844. doi:10.1007/s11356-022-19076-3

Dong, F., Zhang, Y., Zhang, X., Hu, M., Gao, Y., and Zhu, J. (2021). Exploring ecological civilization performance and its determinants in emerging industrialized countries: A new evaluation system in the case of China. *J. Clean. Prod.* 315, 128051. doi:10.1016/j.jclepro.2021.128051

Fuguo, Q., and Peng, Z. (2014). Evaluation of the eco-environmental quality of Liaohe river basin in Liaoning province based on PSR model. *Environ. Prot.* 42, 36–40.

Gare, A. (2017). From 'sustainable development' to 'ecological civilization': Winning the war for survival. *Cosmos Hist.* 13, 130–153.

Ge, K., Zou, S., Lu, X., Ke, S., Chen, D., and Liu, Z. (2022). Dynamic evolution and the mechanism behind the coupling coordination relationship between industrial integration and urban land-use efficiency: A case study of the Yangtze River economic zone in China. *Land* 11, 261. doi:10.3390/land11020261

Gou, Y., and Lu, W. (2020). Evaluation of ecological civilization construction based on combined weighted TOPSIS Model--Taking Qinghai Province as an example. *Statistics Decis.* 36, 57–60. doi:10.13546/j.cnki.tjyjc.2020.24.012

Huang, Y., Xiao, W., Hou, B., Zhou, Y., Hou, G., Yi, L., et al. (2021). Hydrological projections in the upper reaches of the Yangtze River bas in from 2020 to 2050. *Sci. Rep.* 11, 9720. doi:10.1038/s41598-021-88135-5

Ji, X., Wang, K., Ji, T., Zhang, Y., and Wang, K. (2020). Coupling analysis of urban land use benefits: A case study of xiamen city. *Land* 9, 155–220. doi:10.3390/land9050155

Li, L., Yichun, Q., and Wende, Y. (2021a). Research on the evaluation index system for ecological civilization construction in major function zoning. *J. Central South Univ. For. Technol. Sci.* 15 (04), 1–8. doi:10.14067/j.cnki.1673-9272.2021.04.001

Li, K., Zhou, Y., Xiao, H., Li, Z., and Shan, Y. (2021b). Decoupling of economic growth from CO2 emissions in Yangtze River economic belt cities. *Sci. Total Environ.* 775, 145927. doi:10.1016/j.scitotenv.2021.145927

Liu, Y., Liu, W., Yan, Y., and Liu, C. (2022). A perspective of ecological civilization: Research on the spatial coup ling and coordination of the energy-economy-environment system in the Yangtze River economic belt. *Environ. Monit. Assess.* 194, 403. doi:10.1007/s10661-022-10065-0

Liu, Y., and Yuan, L. (2022). Evolution of water-use efficiency in the Yangtze River Economic Belt based on national strategies and water environment treatment. *Ecol. Inf.* 69, 101642–119336. doi:10.1016/j.ecoinf.2022.101642

Long, H. (2022). Analysis of the key factors of ecological environment protection in the national economic sustainable development goals. *J. Environ. public health* 2022, 1–11. doi:10.1155/2022/3593587

Lu, D. (2014). Economic belt construction is the best choice of economic development layout: The enormous potential for the changjiang river economic belt. *Sci. Geogr. Sin.* 34, 769–772. doi:10.13249/j.cnki.sgs.2014.07.005

Luo, Q., Luo, L., Zhou, Q., and Song, Y. (2019). Does China's Yangtze River Economic Belt policy impact on local ecosystem services? *Sci. Total Environ.* 676, 231–241. doi:10.1016/j.scitotenv.2019.04.135

Mi, Z., Zeng, G., Shang, Y., Chen, S., and Zhu, F. (2016). The evaluation method and spatial pattern evolution of ecological civilization construction of Chinese provinces. *Econ. Geogr.* 36, 15–21. doi:10.15957/j.cnki.jjdl.2016.04.003

Pan, J. (2021). *China's global vision for ecological civilization: Theoretical construction and practical research on building ecological civilization.* Singapore: Springer.

Pan, Z., Tang, D., Kong, H., and He, J. (2022). An analysis of agricultural production efficiency of Yangtze River economic belt based on a three-stage DEA malmquist model. *Int. J. Environ. Res. Public Health* 19, 958. doi:10.3390/ijerph19020958

Peng, B., Yan, W., Wei, G., and Wan, A. (2021). Evolution and interaction of ecological civilization construction pattern from the perspective of path dependence–based on the panel data of Jiangsu Province, China. *Environ. Dev. Sustain.* 24, 12226–12247. doi:10.1007/s10668-021-01942-8

Peng, J., Yang, Y., Liu, Y., Hu, Y. N., Du, Y., Meersmans, J., et al. (2018). Linking ecosystem services and circuit theory to identify ecological security patterns. *Sci. Total Environ.* 644, 781–790. doi:10.1016/j.scitotenv.2018.06.292

Qi, Q., and Song, S. (2022). Development level evaluation of water ecological civilization in Yangtze River economic belt. *Discrete Dyn. Nat. Soc.* 2022, 1–6. doi:10.1155/2022/8576365

Qi, S., Cheng, S., and Cui, J. (2021a). Environmental and economic effects of China's carbon market pilots: Empirical evidence based on a DID model. *J. Clean. Prod.* 279, 123720. doi:10.1016/j.jclepro.2020.123720

Qi, Y. A., Yao, J., and Liu, L. (2021b). Research on evolutionary game of environmental accounting information disclosure from the perspective of multi-agent. *PloS one* 16, e0256046. doi:10.1371/journal.pone.0256046

Gong, Q., and Cao, P. (2014). Establishing and verifying evaluation index system for provincial eco-civilization construction. *J. Sichuan Univ. Soc. Sci. Ed.* 35, 109–115.

Qv, M., Chai, H., and Li, Z. (2021). Coupling research on the two-way development of marine ecological civilization and urbanization in coastal cities. *Arab. J. Geosci.* 14, 679. doi:10.1007/s12517-021-06992-w

Shi, C., Li, L., Chiu, Y.-H., Pang, Q., and Zeng, X. (2022a). Spatial differentiation of agricultural water resource utilization efficiency in the Yangtze River Economic Belt under changing environment. *J. Clean. Prod.* 346, 131200. doi:10.1016/j.jclepro.2022.131200

Shi, X., Zhao, X., Pu, J., Huang, P., Gu, Z., and Chen, Y. (2022b). Evolution modes, types, and social-ecological drivers of ecologically critical areas in the sichuan-yunnan ecological barrier in the last 15 years. *Int. J. Environ. Res. public health* 19, 9206. doi:10.1016/J.JCLEPRO.2022.131200

Sultana, N., and Turkina, E. (2020). Foreign direct investment, technological advancement, and absorptive capacity: A network analysis. *Int. Bus. Rev.* 29, 101668. doi:10.1016/j.ibusrev.2020.101668

Tallis, H., Kareiva, P., Marvier, M., and Chang, A. (2008). An ecosystem services framework to support both practical conservation and economic development. *Proc. Natl. Acad. Sci. U. S. A.* 105, 9457–9464. doi:10.1073/pnas.0705797105

Tang, J., and Li, S. (2022). Study on the multi-governance of public rental housing exit in China based on the evolutionary game theory. *Complexity* 4, 1–12. doi:10.1155/2022/3786078

Wang, D., Li, Y., Yang, X., Zhang, Z., Gao, S., Zhou, Q., et al. (2021a). Evaluating urban ecological civilization and its obstacle factors based on integrated model of PSR-EVW-TOPSIS: A case study of 13 cities in Jiangsu province, China. *Ecol. Indic.* 133, 108431. doi:10.1016/j.ecolind.2021.108431

Wang, M., Zhang, X., and Hu, Y. (2021b). The green spillover effect of the inward foreign direct investment: Ma rket versus innovation. *J. Clean. Prod.* 328, 129501. doi:10.1016/j.jclepro.2021.129501

Wang, X., Dong, Z., Xu, W., Luo, Y., Zhou, T., and Wang, W. (2019). Study on spatial and temporal distribution characteristics of coordina ted development degree among regional water resources, social economy, and ecological environment systems. *Int. J. Environ. Res. Public Health* 16, 4213. doi:10.3390/ijerph16214213

Wang, X., Wang, M., Lu, X., Guo, L., Zhao, R., and Ji, R. (2022a). Spatio-temporal evolution and driving factors of the high-quality development of provincial tourism in China. *Chin. Geogr. Sci.* 32, 896–914. doi:10.1007/s11769-022-1307-z

Wang, Y., and Wu, J. (2022). The original contribution of xi jinping thought on ecological civilization. *Sci. Social.* 03, 29–40. doi:10.1007/s11356-021-15980-2

Wang, Y., Yan, Q., and Zhang, Q. (2022b). Carbon mitigation performance of top-down administrative and fiscal de centralizations: Evidence from quasi-natural experiments in China's pilot counties. *Sci. Total Environ.* 852, 158404. doi:10.1016/j.scitotenv.2022.158404

Wen, C., Zhang, Z., and Cao, X. (2021). The connotation, strategy and path of ecological protection in the upper reaches of the Yangtze River. *Reg. Econ. Rev.* 01, 123–130. doi:10.14017/j.cnki.2095-5766.2021.0016

Wen, C., Zhang, Z., and Zhao, B. (2022). Preliminary study on the innovative mode of "five regions and five governance" for ecological protection in the upper reaches of the Yangtze River. *Study Pract.* 07, 54–64. doi:10.19624/j.cnki.cn42-1005/c.2022.07.003

Wisadha, M. a. A., and Widyaningsih, G. A. (2018). Human rights and the environmental protection:the naïveté in environmental culture. *Udayana J. Law Cult.* 2, 73. doi:10.24843/ujlc.2018.v02.i01.p04

Wu, Y. (2022). Ecological smart city construction based on ecological economy and network governance. *Comput. Intell. Neurosci.* 2022, 1–11. doi:10.1155/2022/5682965

Wu, Y., Zong, T., Shuai, C., Liao, S., Jiao, L., and Shen, L. (2022). Does resource environment carrying capacity have a coercive effect on urbanization quality? Evidence from the Yangtze River economic belt, China. *J. Clean. Prod.* 365, 132612. doi:10.1016/j.jclepro.2022.132612

Xu, S., Wu, T., and Zhang, Y. (2020). The spatial-temporal variation and convergence of green innovation efficiency in the Yangtze River Economic Belt in China. *Environ. Sci. Pollut. Res.* 27, 26868–26881. doi:10.1007/s11356-020-08865-3

Xu, W., Yi, J., Shuai, J., Yu, Z., and Cheng, J. (2022). Dynamic evaluation of the ecological civilization of Jiangxi province: GIS and AHP approaches. *PloS one* 17, e0271768. doi:10.1371/journal.pone.0271768

Yan, L., Zhang, X., Pan, H., Wu, J., Lin, L., Zhang, Y., et al. (2021). Progress of Chinese ecological civilization construction and obstacles during 2003–2020: Implications from one set of emergy-based indicator system. *Ecol. Indic.* 130, 108112. doi:10.1016/j.ecolind.2021.108112

Yang, F., and Jiang, Y. (2022). Adolescent self-control and individual physical and mental health in adulthood: A Chinese study. *Front. Psychol.* 13, 850192. doi:10.3389/fpsyg.2022.850192

Yang, Z., Gao, W., and Li, J. (2022). Can economic growth and environmental protection achieve a "Win-Win" situation? Empirical evidence from China. *Int. J. Environ. Res. Public Health* 19, 9851. doi:10.3390/ijerph19169851

Yu, S., Hu, X., Zhang, X., and Li, Z. (2019). Convergence of per capita carbon emissions in the Yangtze River economic belt, China. *Energy & Environ.* 30, 776–799. doi:10.1177/0958305x18813620

Zhang, H. W., and Lan, Z. R. (2013). Urban sustainable development evaluation index system of ecological civilization construction-A case study of tianjin city. *Appl. Mech. Mater.* 361-363, 90–96. doi:10.4028/www.scientific.net/amm.361-363.90

Zhang, H., and Xu, Y. (2022). Uphold and strengthen the leadership of the CPC and make historic, transformational and overarching changes in the building of ecological civilization progress. *J. Manag. World* 38, 1–11. doi:10.19744/j.cnki.11-1235/f.2022.0106

Zhang, H., Zhou, Q., and Zhang, C. (2021). Evaluation of agricultural water-saving effects in the context of water rights trading: An empirical study from China's water rights pilots. *J. Clean. Prod.* 313, 127725. doi:10.1016/j.jclepro.2021.127725

Zhang, J., Sun, J., Ma, B., and Du, W. (2017). Assessing the ecological vulnerability of the upper reaches of the Min Jiang River. *PloS one* 12, e0181825. doi:10.1371/journal.pone.0181825

Zhang, L., and Zhang, D. (2011). Relationship between ecological civilization and balanced population development in China. *Energy Procedia* 5, 2532–2535. doi:10.1016/j.egypro.2011.03.435

Zhao, Y.-Z., Zou, X.-Y., Cheng, H., Jia, H.-K., Wu, Y.-Q., Wang, G.-Y., et al. (2006). Assessing the ecological security of the Tibetan plateau: Methodology and a case study for Lhaze County. *J. Environ. Manag.* 80, 120–131. doi:10.1016/j.jenvman.2005.08.019

Zhou, J., Jiang, Q., Ye, G., Lin, Y., Yang, Y., Li, P., et al. (2022a). Spatial-temporal evaluation of marine ecological civilization of Zhejiang Province, China. *Mar. policy* 135, 104835. doi:10.1016/j.marpol.2021.104835

Zhou, R., Abbasi, K. R., Salem, S., Almulhim, A. I., and Alvarado, R. (2022b). Do natural resources, economic growth, human capital, and urbanization affect the ecological footprint? A modified dynamic ardl and krls approach. *Resour. Policy* 78, 102782. doi:10.1016/j.resourpol.2022.102782

Zuo, Z., Guo, H., Cheng, J., and Li, Y. (2021). How to achieve new progress in ecological civilization construction? – based on the cloud model and coupling coordination degree model. *Ecol. Indic.* 127, 107789. doi:10.1016/j.ecolind.2021.107789