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Energy-Saving Effect of Regional Development Strategy in Western China

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Abstract: Improving energy utilisation efficiency is imperative to ensuring economic growth and achieving sustainable development. China's Western Development Strategy (WDS) is a major driver to accelerate the economic development of Western China. It stresses the rational control of energy consumption through the vigorous development of a circular economy to achieve the goal of energy conservation. Based on the measurement of energy utilisation efficiency at the provincial level in China, this study evaluates the impact of the WDS on energy utilisation efficiency through a synthetic control method. Then, the internal impact mechanism of the WDS on energy utilisation efficiency is investigated. In addition, this paper tests the heterogeneous effects of the WDS on energy utilisation efficiency from the perspective of the regional scale, resource endowment, performance appraisal, and institutional quality. It is found that the WDS improves energy utilisation efficiency not only through direct effects but also indirectly by accelerating the spatial agglomeration of advantage industries in Western China, which enhanced technological innovation capacity, optimised industrial structure, and improved the human capital level to ameliorate energy utilisation efficiency. Further analysis proves that the energy-saving effect of the WDS is significant in provinces with a small regional scale, less abundant resources, higher levels of the performance appraisal index and quality system. Accordingly, some targeted policy suggestions are made for the government herein.

Keywords: Western Development Strategy; energy utilisation efficiency; synthetic control method; chain mediating effects model; industrial agglomeration

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1. Introduction

As energy is one of the decisive input factors of modern economic growth, improving its utilisation efficiency is crucial for the sustainable development of the economy [1]. Since 2010, China has been the world's top consumer of energy [2]. Its energy consumption system dominated by fossil energy has led to several environmental issues. Moreover, it has negatively impacted the health of Chinese residents, the efficiency of economic operations, and the sustainable development of China's economy [3–6]. In line with green and sustainable development, it is imperative for China's economy to transform from its development mode stimulated by elements to a quality model that pursues energy conservation and environmental friendliness. Therefore, to solve the current dilemma, the Chinese government must undertake efforts to determine the factors that affect energy utilisation efficiency and seek efficient ways to improve it [7,8].

Throughout the course of China's economic development, unsustainable economic growth stimulated by large-scale investment and the accumulation of production factors has been more prominent in the western regions with higher resource endowments [9]. The economic development of the western region is in a disadvantageous position, and the gap between eastern and western regions is widening every year [10]. The western region is rich in natural resources and energy reserves. Western government officials are prone to choose extensive high energy consumption production methods to seek rapid economic growth and achieve the goal of narrowing the economic gap, inspired by their promotion championships [11–13]. To correct the unbalanced development of the regional economy, the central government undertook the strategic decision of implementing the Western Development Strategy (WDS) in 2000. Is it possible for the WDS to break the chain of the economic development, the promotion of political achievements, and the exhaustion of resources while undertaking the important task of promoting the economic development of the western region?

In policy practice, the WDS may have a double impact on energy utilisation efficiency. Policies such as 'counterpart assistance' and 'counterpart cooperation' enable the western region to create an agglomeration effect by undertaking industrial transfer. This can not only optimise resource reallocation but also create a spatial spillover effect to promote technological progress and improve energy utilisation efficiency. Concomitantly, the clustering of industries might produce a crowding effect, driving enterprises to increase production capacity through scale expansion, which not only aggravates the massive consumption of energy resources, but also reduces the efficiency of energy utilisation. Therefore, internal relations exist that cannot be ignored. In the context of sustainable development, whether WDS is worth or loss is undoubtedly a problem worth exploring.

For this study, we selected the panel data samples of 30 Chinese provinces from 1995 to 2017 and attempted to answer the following questions: As an important carrier for China's regional development strategy, can the WDS improve energy utilisation efficiency? If an energy-conservation effect exists, through which mechanism does the WDS affect energy utilisation efficiency? What types of areas are more conducive to the energy-saving effects of the WDS?

The structure of the rest of the paper is as follows. Section 2 presents the literature in the related fields. Section 3 presents the internal impact mechanism from direct and indirect paths. Section 4 describes the model construction process, indicator measurement methods, and sample data sources. Section 5 provides and discusses the empirical test results. Section 6 summarises the research conclusions and further provides effective policy recommendations.

2. Literature Review

The WDS has been a widely researched topic in the field of regional and environmental economics since its implementation. Existing studies have explored the net effects of the strategy from the perspective of regional economic growth [14,15] and environmental pollution [16–18]. The mainstream view is that strategy depends on infrastructure construction, which can boost regional economic growth by attracting business investment and reducing transportation costs [15]. On the contrary, some scholars believe that, owing to development obstacles such as institutional inertia, there is a 'policy trap' in the WDS implementation. Thus, from a long-term perspective, the WDS may widen the even result in a gradual widening of the economic gap between regions [19,20].

Several scholars have explored the impact of the strategy on environmental pollution. Yang et al. [16] reported that the WDS can effectively reduce carbon emissions by improving the level of marketisation, enhancing the employment environment, and expanding foreign trade. In contrast, Zhang et al. [17] found that the carbon emission intensity of Western China has not been effectively reduced but showed a continuous growth trend under the strategy. Liu et al. [18] discussed the relationship between the WDS and air quality. The results showed that it exacerbated regional air pollution, and structurally optimised production should be adopted to reduce pollution and to further achieve sustainable development. Wang and Feng [21] argue that the WDS limits carbon emissions through the technology gap between developed and less developed regions. Although the research on the WDS is relatively mature, the energy utilisation efficiency in this process has been ignored. It is easy for the economy to enter an extensive development mode with a high input as well as a high energy consumption and low efficiency; however, it is not beneficial for the sustainable development of the economy [22,23].

Presently, the research on energy utilisation efficiency mainly focuses on the following two aspects. First, it focuses on the measurement of energy utilisation efficiency. The existing literature mainly uses single-factor energy efficiency or total-factor energy efficiency to measure the energy utilisation efficiency. The former ignores input factors such as capital and labour, and it calculates the energy intensity by the ratio of energy input to economic output [24,25]. The latter builds a production function based on factor inputs, energy consumption, and economic output to calculate the total-factor productivity [26–28]. A data envelopment analysis (DEA) with nonparametric estimation is the main measurement method of the total-factor efficiency [29]. Liu and Feng [30] incorporated the unexpected output into the DEA model to calculate the agricultural total-factor productivity, which provides a reference for measuring energy utilisation efficiency in the paper. The second focus of the existing literature is the discussion on the driving factors of energy utilisation efficiency, mainly focusing on green credit [26,31], foreign direct investment [32,33], and industrial agglomeration [34].

In recent years, several scholars have estimated energy-saving effects based on specific policies. For instance, Li et al. [35] assessed the energy-saving effect of the carbon emissions trading policy by building a triple difference model. They found that the emissions trading mechanism has a high energy-saving potential, but it still requires the government's regulatory assistance in line with local conditions to achieve sustainable and long-term development. He et al. [36] used a dynamic ARDL model to investigate the net effect of different types of environmental tax policies affecting energy efficiency in OECD countries. The results showed that both energy tax and vehicle transportation tax policies positively affect energy efficiency, but the positive effects show heterogeneity over time. Similar studies have also been conducted by Orlov et al. [37], Pereira and Pereira [38], and Liu and Xin [39]. The WDS, as a typical representative of the regional development strategy in China, has been extensively studied by many scholars. However, its influence on energy utilisation efficiency and the internal mechanism has not been fully explored.

The WDS has gradually formed a circular economy industry chain by carrying out circular economy pilot projects. In fact, a circular economy can maximise energy utilisation efficiency through the production mode of recycling materials and recycling waste [40–42]. Moreover, through infrastructure promotion and preferential policies, the WDS can help gather enterprises in the western region to accelerate the formation of a rational industrial division system and an optimised industrial chain, which can, in turn, promote industrial agglomeration [43]. Zheng and Lin [44] proposed a theory that industrial agglomeration contributes to the improvement of energy utilisation efficiency through the scale effect, technology spillover effect, and competition effect. Nevertheless, existing research ignores the key bridging role of industrial agglomeration in the WDS and fails to analyse how strategy plays an important role in energy utilisation efficiency through industrial agglomeration, which inhibits a comprehensive and objective examination of the policy effect.

The existing studies have described the policy effects of the WDS from many perspectives. However, there are still three aspects that need further investigation. Firstly, a large number of studies have focused on the economic-growth effect and the environmental-pollution effect of the WDS, lacking attention on the energy-saving effect. Secondly, when exploring the impact of the WDS on energy utilisation efficiency, the existing studies are only based on theoretical analysis and lack empirical research. In addition, the impact mechanism still needs to be supplemented. Thirdly, the existing studies ignore the geographical characteristics and institutional environment differences of the regions, which cannot objectively reflect the effect of the WDS on energy utilisation efficiency. Therefore, there may be a deviation in the effect of the WDS on energy utilisation efficiency.

Specifically, the novelty of this study is three-fold. The first novelty is the research perspective. This study empirically investigates the impact of the WDS on energy use efficiency during a time when the global economy faces the dilemma of energy shortages.

It not only compensates for the lack of literature on strategy evaluation but also provides recommendations for developing countries to achieve the perfect combination of economic growth and sustainable development through regional development strategies. The second novelty is the research content. This study deeply analyses the impact mechanism of the WDS on the regional energy utilisation efficiency from the perspective of the spatial agglomeration of advantageous industries and investigates the heterogeneity from the perspective of geographical features and the institutional environment. It enables the western region to make full use of this regional development strategy according to its own endowments. The third novelty is the research method. This study, based on a synthetic control method (SCM) and a chain-mediating effects model, attempts to highlight the impact and internal mechanism of the WDS on energy utilisation efficiency, thus obtaining more credible results. Through systematic and rigorous theoretical and empirical research, the paper aims to provide a significant decision-making reference for developing countries to effectively achieve the goal of resource conservation, sustainable economic development, and strategic choice of regional coordinated development.

3. Theoretical Framework and Research Hypothesis

3.1. The Direct Impact of the WDS on Energy Utilisation Efficiency

As presented in Figure 1, the direct impact of the WDS on energy utilisation efficiency benefits from the institutional advantages and policy benefits of the strategy. That is, the WDS implements pilot projects of the circular economy, standardises the order of resource exploitation, advocates the order of resource exploitation, and enhances the intensity of preferential policies.

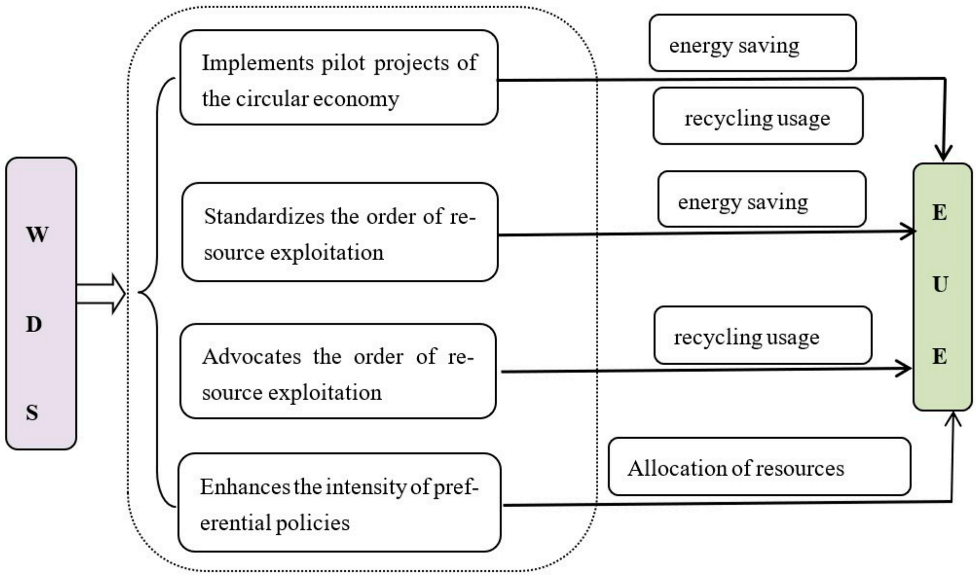

Figure 1. The direct influence mechanism of the WDS on energy utilisation efficiency (EUE).

Since the launch of the WDS, the Chinese government has focused on the significance of a recycling economy to the sustainable development of the western region. Pilot projects have been undertaken by establishing industrial parks, recycling economy pilot zones, and high-tech industry demonstration zones. Recycling economy industrial chains are gradually formed in diverse fields with distinct characteristics, such as agriculture, energy, chemical industry, metallurgy, and construction materials. This has promoted the transformation and upgrading of local industries and, thereby, the sustainable development of the western region [45]. In addition, the order of natural resource exploitation is standardised, and the comprehensive utilisation of industrial waste is advocated. Especially in the energy field, the eleventh Five-Year Plan of the WDS makes it clear that under the premise of persisting in resource development and preservation, the principle of saving at priority shall be adopted to improve mining efficiency; make full use of industrial wastes, such as waste residue and tailing; reduce the waste in the process of resource utilisation; and strengthen energy conservation and efficient utilisation.

The twelfth and thirteenth Five-Year Plan were proposed to strictly control the high energy consumption and pollution industry of low-level repeated construction and rationally strain the total energy consumption. By formulating a rigorous entrance threshold to energy exploitation and the industry, local enterprises are encouraged to improve extraction technologies and optimise energy-efficient production processes. It has considerable potential for improving energy use efficiency [46]. In addition, as a critical propeller of the regional coordinated development, the WDS is often accompanied by policy preference. For example, the WDS has increased tax incentives, enhanced financial credit support, and relaxed export tax rebate restrictions. This has provided a moderate economic stimulus for investing in businesses [47], which guides production factors to gather in the western region to optimise the allocation and improve the energy utilisation efficiency. Therefore, the study proposes:

Hypothesis 1. *WDS has significantly improved the energy utilisation efficiency.*

3.2. The Indirect Influence of the WDS on Energy Utilisation Efficiency

As presented in Figure 2, the indirect impact of the WDS on energy utilisation efficiency benefits from the agglomeration effect. That is, the WDS, by accelerating the spatial agglomeration of advantage industries in Western China, enhanced technological innovation capacity, optimised industrial structure, and improved human capital levels to ameliorate the energy utilisation efficiency.

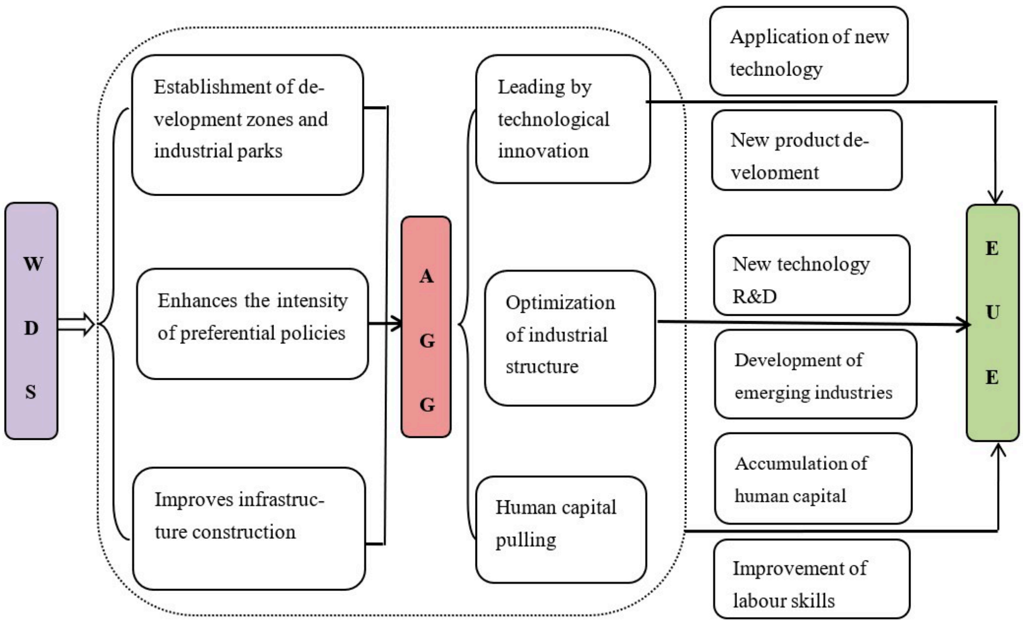

Figure 2. Indirect influence mechanism of the WDS on energy utilisation efficiency (EUE).

The WDS facilitates the clustering of characteristic advanced industries in the western region as follows. First, an important measure in the WDS is to establish development zones, economic cooperation zones, and industrial parks in western provinces. For example, the Kashgar Open Zone in Xinjiang and the Chengdu–Chongqing Economic Zone were set up as platforms for the western region to undertake the industrial transfer from the eastern region and foreign countries to promote the agglomeration of characteristically advanced industries in the western region [48]. Second, as a large-scale regional development strategy, the WDS has increased investment in the economic development of the western region through preferential policies such as taxation, land resource utilisation, fiscal support, and financial credit on the premise of clarifying the superior resources, geographical environment, and cultural landscape of each province in the western region. Under the guidance of 'policy rent', the enterprises engaged in the related competitive industries form a spatial agglomeration in the western region driven by interests. In addition, as a leading variable that determines economic development, infrastructure construction has been prioritised by the WDS. This can help improve the business environment and breed the 'centripetal force' in the western region to attract investment at home and abroad. Moreover, the WDS prioritises the development of infrastructure construction in the western region as a key project, such as the 'Qinghai-Tibet Railway', 'Five Vertical and Seven Horizontal' Highways, and the Western Airport, improving the smoothness and spatial accessibility between the western region and other regions. This will further accelerate the formation of a rational industrial division system and a sound industrial chain and promote the agglomeration of characteristic advanced industries, dominant enterprises, and advantageous resources to the western region [43]. To sum up, the WDS promotes the spatial agglomeration of advantageous industries in the western region through platform building, preferential policies, and infrastructure construction.

Industrial agglomeration can enhance technological innovation, optimise industrial structure, and improve human capital level, thus improving energy utilisation efficiency. Li et al. [49] studied industrial agglomeration and regional innovation and found that industrial agglomeration, through the spatial spillover effect, promotes the dissemination of knowledge and advanced technology and reduces innovation cost, while the market competition mechanism stimulates the innovation vitality of enterprises to enhance regional innovation ability. The improvement in the technological innovation level helps local enterprises to reduce production costs and unit energy consumption by exploring and designing energy-saving products and prioritising the use of advanced production technologies and equipment for production [8,50]. Industrial agglomeration is prone to economies of scale. By sharing labour and intermediate inputs through professional cooperation, the division of labour between upstream and downstream industries, and improving the allocation of resources, the industrial structure can be optimised and upgraded [51]. This will inevitably cause the competition between enterprises in the agglomeration to intensify. It not only forces companies to continuously improve their production technologies and processes to increase energy use efficiency [52] but also forces enterprises to increase R&D investment. In turn, increased investment reduces their resource and energy consumption through technology R&D effects to augment their production efficiency [53,54]. Simultaneously, the optimisation of the industrial structure can promote the development of new industries. It can not only make the production process more 'clean' but also save energy consumption, thus improving energy utilisation efficiency [55]. In addition, industrial agglomeration is also conducive to the promotion of human capital levels, which has a positive impact on energy utilisation efficiency through the promotion of labour skills [56]. Therefore, the study proposes:

Hypothesis 2. *The WDS accelerates the spatial agglomeration of characteristically advanced industries in the western region and significantly improves energy utilisation through enhanced technological innovation capacity, optimised industrial structure, and improved human capital levels.*

4. Research Design

4.1. Estimation Methods

The synthetic control method (SCM) was originally established by Abadie and Gardeazabal [57] and is commonly used to evaluate the effect of policy implementation. This method can identify the optimal weight through linear combination, with the advantage of avoiding the subjectivity of control group selection and endogenous policy. Considering the importance of refining the 'net effect' policy to accurately evaluate policy performance, this study evaluated the impact of the WDS on energy utilisation efficiency using the SCM method. The DID model was used to verify the robustness of the strategy in promoting energy utilisation efficiency in the western region.

4.1.1. SCM

In this study, it is assumed that the statistics of energy utilisation efficiency can be observed in $J+1$ regions, among which the first region is the target region (treatment group) for the implementation of the WDS, and the remaining regions of J are the control regions (control group) which are not influenced by the strategy. Here, the time point of the implementation of the strategy is expressed by T_0, satisfying $1 \leq T_0 \leq T$, which corresponds to 2010 in the above analysis. $Y'_{j,t}$ is defined as the data of energy utilisation efficiency at the moment t in which the region j does not implement the strategy, and $Y''_{j,t}$ is defined as the data of energy utilisation efficiency at the moment t in which the region j implements the strategy. When $t \in [1, t_0]$, $Y'_{j,t} = Y''_{j,t}$ is satisfied; when $t \in (T_0, T]$, $Y'_{j,t} = Y''_{j,t} - \beta_{j,t}$ is satisfied. In the formula, $\beta_{j,t}$ implies the data of energy utilisation efficiency improvement in the jth region at the moment t due to the implementation of the strategy, if $\beta_{j,t} > 0$, then the implementation of the strategy has a positive impact on the energy utilisation efficiency of the target regions. If $\beta_{j,t} < 0$, then the strategy has a negative impact on the energy utilisation efficiency of the target regions. However, for the region j implementing the strategy, although the energy utilisation efficiency $Y''_{j,t}$ after T_0 years can be observed directly, the energy utilisation efficiency $Y'_{j,t}$ after T_0, which is not affected by the strategy implementation, cannot be observed. Therefore, to calculate $\beta_{j,t}$, it is necessary to estimate $Y'_{j,t}$ first.

According to the benchmark model proposed by Abadie et al. [58]:

$$Y'_{j,t} = \alpha_t \delta_t Z_j + \theta_t \mu_j + \varepsilon_{j,t} \tag{1}$$

where α_t represents the time fixed effect affecting energy utilisation efficiency, and Z_j is an $(r \times 1)$-dimensional vector, which indicates the observable variable of region j that is not affected by the implementation of the strategy. δ_t is the estimated coefficient of the control variable, μ_j is an unobservable fixed effect in a specific region. θ_t represents the period effect of unobservable variables. $\varepsilon_{j,t}$ denotes instantaneous shocks not observed in each region. $Y'_{j,t}$ is calculated in formula (1), where the $(J \times 1)$-dimensional weight vector $W = \left(\omega_2, \cdots, \omega_{J+1}\right)'$ is formed in the target area affected by the strategy implementation, and any j satisfies $\omega_j \geq 0$ and $\omega_2 + \cdots + \omega_{j+1} = 1$. Regarding the target area where the strategy has been implemented, the vector W reflects the potential synthetic control combination, while ω_j is the synthetic contribution rate of the region in the control group to the target region, so the synthetic control outcome variable is as follows:

$$\sum_{j=2}^{J+1} \omega_j Y_{j,t} = \alpha_t + \delta_t \sum_{j=2}^{J+1} \omega_j Z_j + \theta_t \sum_{j=2}^{J+1} \omega_j \mu_j + \sum_{j=2}^{J+1} \omega_j \varepsilon_{i,t} \tag{2}$$

Assuming that there is a vector group $\left(\omega_2^*, \cdots, \omega_{J+1}^*\right)$, the target area $j = 1$, where the strategy is implemented, satisfies:

$$\sum_{j=2}^{J+1} \omega_j^* Y_{j,1} = Y_{1,1}, \sum_{j=2}^{J+1} \omega_j^* Y_{j,2} = Y_{1,2}, \cdots, \sum_{j=2}^{J+1} \omega_j^* Y_{j,T_0} = Y_{1,T_0}, \sum_{j=2}^{J+1} \omega_j^* Z_j = Z_1 \tag{3}$$

If the $\sum_{t=1}^{T_0} \lambda_t' \lambda_t$ is non-singular, the following formula is valid:

$$Y_{j,t}' - \sum_{j=2}^{J+1} \omega_j^* Y_{j,t} = \sum_{j=2}^{J+1} \omega_j^* \sum_{s=1}^{T_0} \lambda_t (\sum_{j=1}^{T_0} \lambda_j' \lambda_j)^{-1} \lambda_s' (\varepsilon_{j,s} - \varepsilon_{1,s}) - \sum_{j=2}^{J+1} \omega_j^* (\varepsilon_{j,t} - \varepsilon_{1,t}) \tag{4}$$

It is verified by Abadie et al. [58] that $Y_{j,t}' - \sum_{j=2}^{J+1} \omega_j^* Y_{j,t} \to 0$; therefore, the unbiased estimation of $Y_{j,t}'$ can be replaced by $Y_{j,t}' - \sum_{j=2}^{J+1} \omega_j^* Y_{j,t} \to 0$, so the estimated value of the impact of the strategy implementation on energy utilisation efficiency is:

$$\hat{\beta}_{1,t} = Y_{j,t}' - \sum_{j=2}^{J+1} \omega_j^* Y_{j,t}, t \in [T_0 + 1, \cdots, T] \tag{5}$$

4.1.2. DID Method

The policy effects of the WDS can also be evaluated by the DID model. Referring to the research of Heckman et al. [59], the benchmark regression model set in the paper is as follows:

$$EUE_{it} = \beta_0 + \beta_1 (western_{it} \times post_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \gamma_t + \theta_i + \varepsilon_{it} \tag{6}$$

where i and t represent provinces and years, respectively, and EUE_{it} is an explained variable, which indicates the energy utilisation efficiency of the *ith* province affected by the strategy in t year; *western* is the grouping variable of provinces, the number of provinces implementing the strategy is 1, and the number of non-implementing provinces is 0; *post* is a time grouping variable in which the years 1995 to 1999 are 0 and 2000 to 2017 are 1; *control* is the control variable group; γ and θ are a time- and province-fixed effect that do not change with time; ε represents a random error term. β_1 is the core estimated parameter, that is, representing the energy-saving effect of strategy implementation.

4.1.3. Mechanism Test

The mediating effects model of Baron et al. [60] was adopted as a reference to verify that the WDS can further enhance energy utilisation efficiency by accelerating the agglomeration of advantageous industries and enhanced technological innovation capacity, optimised industrial structure, and improved human capital levels to ameliorate energy utilisation efficiency. The mechanism test model is constructed as follows:

The first stage involved:

Verifying the influence of the strategy on industry agglomeration:

$$AGG_{it} = \alpha_0 + \alpha_1 (western_{it} \times post_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \tag{7}$$

Verifying the influence of the strategy on the three effects:

$$innov_{it}(stru_{it}, hum_{it}) = \gamma_0 + \gamma_1(western_{it} \times post_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \quad (8)$$

Putting both the DID term and the mediating variable into the regression equation:

$$innov_{it}(stru_{it}, hum_{it}) = \eta_0 + \eta_1(western_{it} \times post_{it}) + AGG_{it} + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \quad (9)$$

The three major effects are verified in the first stage. First, the DID term is regressed with industrial agglomeration. If the coefficient α_1 is positive and passes the significance test, it means that the WDS has promoted the agglomeration of advantageous industries in the western region. Second, the DID term is regressed with the three mediating variables. If the coefficient γ_1 is significant, it shows that the strategy has enhanced technological innovation, optimised industrial structure, and improved human capital level. Third, the DID term and industrial agglomeration are substituted into the model simultaneously and then they are regressed with the three mediating variables, respectively. If the coefficient η_1 does not pass the significance test, or passes the test but the coefficient becomes smaller, then it indicates the strategy-enhanced technological innovation capacity, optimised industrial structure, and improved human capital level by promoting industrial agglomeration.

The second stage involved:

Verifying the influence of WDS on the three major effects:

$$innov_{it}(stru_{it}, hum_{it}) = \alpha_0 + \alpha_1(western_{it} \times post_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \quad (10)$$

Verifying the influence of WDS on energy utilisation efficiency:

$$EUE_{it} = \gamma_0 + \gamma_1(western_{it} \times post_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \quad (11)$$

Putting both the DID term and the mediating variable into the regression equation at the same time:

$$EUE_{it} = \eta_0 + \eta_1(western_{it} \times post_{it}) + innov_{it}(stru_{it}, hum_{it}) + \sum_{k=1}^{n} \delta_k \vec{X}_{it} + \lambda_t + \theta_i + \varepsilon_{it} \quad (12)$$

This verifies the influence of the strategy on the energy utilisation efficiency. First, the DID term is regressed with the three effects, respectively. If the coefficient α_1 is significant, it indicates that the strategy brought out the above effects. Second, the DID term is regressed with energy utilisation efficiency. If the coefficient γ_1 is significant, it demonstrates that the strategy affects the energy utilisation efficiency. Third, the DID term is regressed with the three effects, respectively. If the coefficient η_1 does not pass the significance test, or passes the test but the coefficient becomes smaller, then it indicates that the strategy has promoted energy utilisation efficiency through enhancing technological innovation capacity, optimising industrial structure, and improving human capital level.

4.2. Variable Declaration

4.2.1. Energy Utilisation Efficiency (*EUE*)

The slacks-based measure-data envelopment analysis (SBM-DEA) model not only corrects the deviation of efficiency estimation caused by radial and angle setting but also has the advantage of considering undesirable output [61]. Based on the same, this study chose the SBM-DEA model to measure the energy utilisation efficiency of each provincial in China. The model is:

$$\min\rho = \frac{1 - \frac{1}{m}\sum\limits_{i=1}^{m}\frac{s_i^x}{x_{ki}}}{1 + \frac{1}{q_1+q_2}\left(\sum\limits_{r=1}^{q_1}\frac{s_r^y}{y_{kr}} + \sum\limits_{z=1}^{q_2}\frac{s_z^b}{b_{kz}}\right)} \tag{13}$$

$$s.t.\begin{cases} x_{ik} = \sum\limits_{k=1,k\neq j}^{n}\lambda_k x_{ki} + s_i^x, i = 1,2,\cdots,m \\ y_{rk} = \sum\limits_{k=1,k\neq j}^{n}\lambda_k y_{kr} - s_m^y, r = 1,2,\cdots,q_1 \\ b_{zk} = \sum\limits_{k=1,k\neq j}^{n}\lambda_k b_{kn} + s_n^b, z = 1,2,\cdots,q_2 \\ \lambda_k, s_i^x, s_r^y, s_n^b \geq 0, k = 1,2,\cdots,n \end{cases} \tag{14}$$

where ρ represents the energy utilisation efficiency value and is the explanatory variable. k represents each decision-making unit (DMU), z and m represent the number of DMUs, as well as the number of input factors, respectively; q_1 and q_2 represent the desired and undesired output, respectively, s_i^x, s_r^y, s_z^b are slack variables of input, desired and undesired output, respectively. λ_k is the intensity variable, x_{ik}, y_{rk}, b_{zk} are the kth DMU multidimensional vectors, and subscript 0 is the DMU to be evaluated.

Referring to previous studies [14,61,62], the quantity of labour, capital stock, and energy consumption were selected as input indicators in this study. Among them, the number of employees is used to characterise labour input, capital stock is used to characterise capital input. The capital stock is also estimated using the perpetual inventory method. The formula is:

$$K_{it} = I_{it}/P_{it} + (1-\delta)K_{it-1} \tag{15}$$

where I_{it} is the total investment in fixed assets of the whole society. P_{it} represents the corresponding fixed asset investment price index. δ is the depreciation rate, which is 9.6%, based on the study of Zhang et al. [63]. Because the total energy consumption data can reflect the energy input level of China more directly and accurately, this study has used it to express the energy consumption. In addition, the actual GDP has been used to represent desirable output, and industrial wastewater, waste gas discharge, and solid waste output are selected as the undesirable outputs.

4.2.2. Industrial Agglomeration (*AGG*)

With the implementation of the WDS, industries with distinctive advantages, such as the energy industry, mining, and processing of mineral resources, equipment manufacturing, and processing of characteristic agricultural and animal husbandry products, are expanding constantly. Most of the western regions are still in the middle or at the late stage of industrialisation, and it is still given prior importance in the western regions. Given this state of affairs and considering the continuity and integrity of data, here, the study of Guimarães et al. [64] is used as a reference, and location entropy is applied to measure the concentration level of secondary industry. The specific calculation is:

$$AGG_{ij} = \frac{X_{ij}/\sum\limits_{i}X_{ij}}{\sum\limits_{j}X_{ij}/\sum\limits_{i}\sum\limits_{j}X_{ij}} \tag{16}$$

where AGG_{ij} represents the degree of agglomeration of industry i in region j, which is expressed by location entropy index. X_{ij} is the added value of i industry in region j. $\sum_i X_{ij}$ is the GDP of j region. $\sum_j X_{ij}$ is the added value of industry i in China; $\sum_i \sum_j X_{ij}$ is the gross domestic product.

4.2.3. Control Variable

This study also controls other important factors affecting energy utilisation efficiency to improve the reliability of regression results. The ever-increasing economic development level (*eco*) will bring about productivity growth, further promoting the energy utilisation efficiency, which is characterised by the logarithmic value of GDP per capital. The ability to make technological innovation (*innov*) is the leading variable that determines the improvement of energy utilisation efficiency, which is characterised by the quantity of domestic patents granted per 100 people. Industrial structure (*struc*) is a key factor affecting energy utilisation efficiency, which is characterised by the ratio of tertiary sector to secondary sector value added. The accumulation of human capital (*hum*) is the key factor to improving regional innovation ability and workers' skills. It is expressed by setting the education years of different education levels, using the ratio of the number of people with different education levels to the total population at the end of the year as weights, and calculating the average number of years of education in each region. Government intervention (*gov*) using the ratio of government budget expenditures to GDP is to be characterised. The inflow of foreign direct investment (*fdi*) can enhance the popularisation and application of new energy-saving technologies in local and surrounding areas through the knowledge-spillover effect. The latter is characterised by the ratio of actually utilised foreign direct investment to GDP and converted at the average price of RMB exchange rate in the past years. The infrastructure level (*ifra*) is characterised by road and railway coverage per square kilometre. The level of urbanisation (*urban*) measured by the ratio of urban population to total population. See Table 1 for details.

Table 1. Statistical description of the main variables.

Variable	Obs	Mean	Std. Dev	Min	Max
EUE	690	0.6566	0.2185	0.2215	1
AGG	690	0.9262	0.1817	0.4292	1.3849
eco	690	8.6368	0.5186	7.5098	10.3350
innov	690	0.0374	0.0704	0.0002	0.4926
struc	690	1.1097	0.4063	0.4186	2.7811
hum	690	8.1372	1.2294	0.7774	12.6651
gov	690	0.8349	0.8441	0.0492	5.5271
fdi	690	0.0980	0.1081	0	0.9829
ifra	690	0.5916	0.4622	0.0190	2.1744
urban	690	47.5377	16.0928	20.36	89.6

4.3. Data Source

The data presented in this study were obtained from the China Statistical Almanac, China Energy Statistical Almanac, China Environmental Statistical Almanac, and the statistical almanac of provinces, autonomous regions, and municipalities. To ensure the integrity of data and the uniformity of statistical methods, this study excluded the provinces of Tibet, Hong Kong, Macau, and Taiwan. Because Chongqing was designated as a provincial municipality in 1997, this study separated the relevant indicators between Chongqing and Sichuan from 1995 to 1996 by consulting the local statistical data of Chongqing. In addition, the 'three waste' indicators were not counted after 2017. To preserve the integrity and continuity of the data, the time span chosen for this study is from 1995 to 2017.

5. Results and Discussion

5.1. Benchmark Estimation Results

To obtain an accurate measurement of the effect of the WDS on individual western provinces, this study undertook the independent evaluation of multiple treatment groups as an alternative to traditional combined evaluation, to decipher the impact of strategy implementation on the energy utilisation efficiency of different provinces.

Figure 3 presents a comparison of the actual and synthetic energy utilisation efficiency levels in the provinces where the WDS is implemented. The vertical dashed line represents the beginning year of the strategy implementation, the solid line represents the actual change trend of the energy utilisation efficiency in different provinces of the western region, and the dashed line indicates the changing trend of the synthetic energy utilisation efficiency. Based on the fact that there are great deviations between the actual and synthetic energy utilisation efficiency in Chongqing, Sichuan, Guizhou, Ningxia, and Xinjiang before the strategy implementation, it cannot satisfy the premise of the parallel trend hypothesis of the synthetic control method. In contrast, Inner Mongolia, Guangxi, Yunnan, Shaanxi, Gansu, and Qinghai had a better fitting effect on the actual and synthetic energy utilisation efficiency before the strategy implementation. Therefore, a follow-up study made a detailed analysis of the WDS in the six provinces.

Figure 3. The actual and synthetic energy utilisation efficiency of the provinces covered by WDS.

As shown in Figure 4, the solid line demonstrates the changing trend of the gap between the actual and synthetic energy utilisation efficiency in the provinces where the WDS is implemented, i.e., the net effect of the WDS. Before the implementation of the strategy in 2000, the solid line fluctuated around 0, which denotes that the synthetic control groups of those six provinces are in line with the actual values. Following the strategy implementation in 2000, the fluctuation range of the solid line became larger, showing an upward trend at first and then a downward trend, signalling that strategy implementation plays a positive role in improving the energy utilisation efficiency of the western region. However, the net effect of the strategy declines with time. Specifically, the actual energy utilisation efficiency of Inner Mongolia, Guangxi, and Qinghai lags behind that of synthetic provinces in the initial stage of the strategy implementation and then significantly improves, surpassing that of synthetic provinces. With time, the implementation effect of the strategy declines, and the actual energy utilisation efficiency falls behind that of synthetic provinces. The real energy utilisation efficiency of Shaanxi Province lags behind that of synthetic provinces after 2013, that is, 13 years after the WDS implementation. The real energy utilisation efficiency of Yunnan and Gansu has been higher than that of synthetic provinces since the strategy implementation. It demonstrates that the WDS significantly boosts the energy utilisation efficiency. Based on that observation, Hypothesis 1 has been verified.

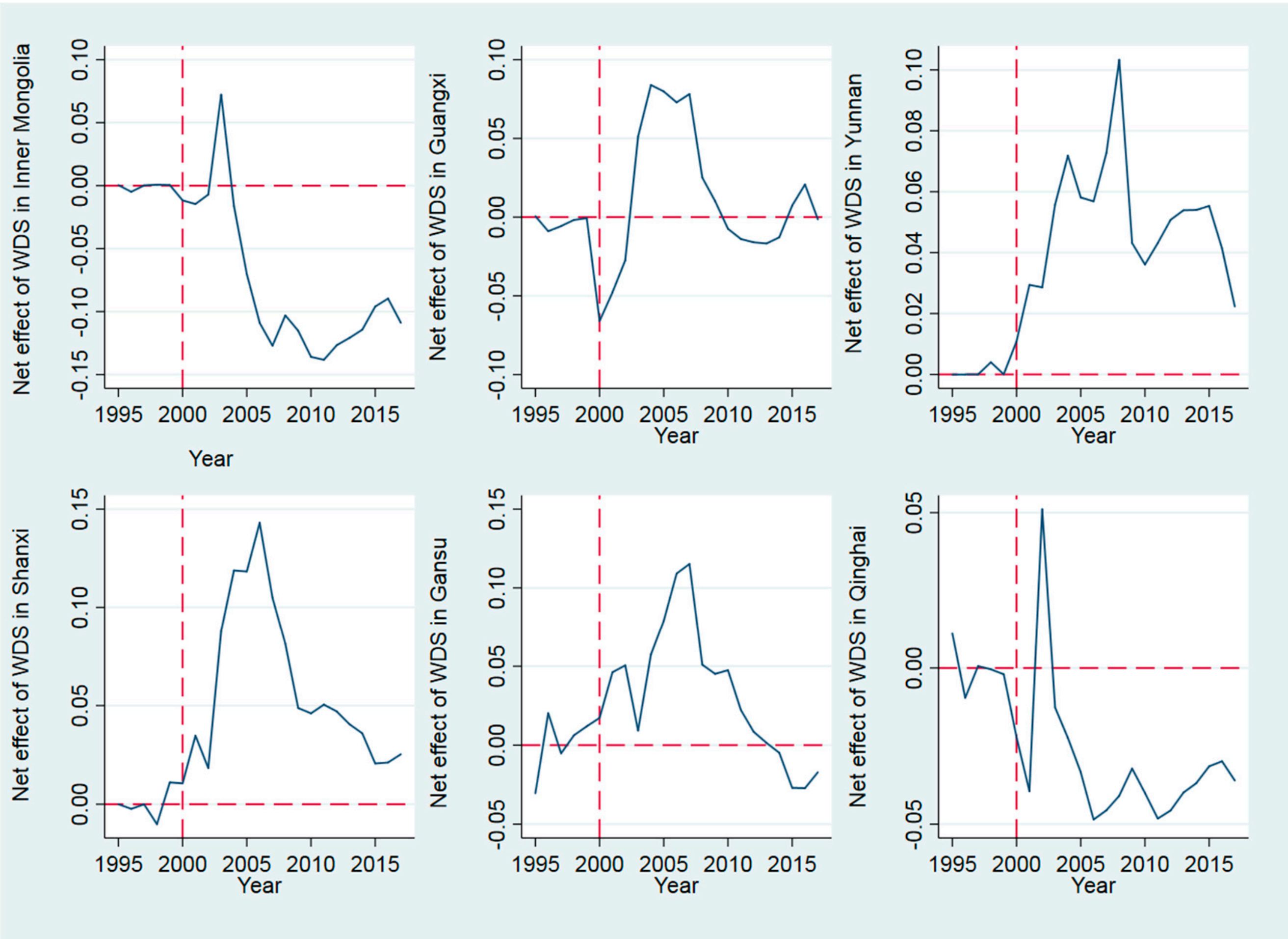

Figure 4. The net effect of WDS on energy utilisation efficiency.

5.2. Robustness Test

This study re-evaluated the effect of the WDS through re-measuring indicators, counter-factual estimation, and replacing estimation methods as follows. First, the model is estimated using the least-squares method. Second, as per Cirone and Urpelainen's [25] method, the inverted value of energy intensity is adopted to replace the energy utilisation efficiency index established above. Third, by changing the timing of the policy implementation, the counter-factual estimation is carried out, and the strategy implementation time is uniformly advanced by 2 years to verify whether the DID method meets the assumption of the parallel trend. Last, to avoid endogenous errors, the delayed first term of the energy utilisation efficiency is added to be estimated by the system GMM [65]. The specific estimation results are shown in Table 2.

Table 2. Robustness test of the effect of WDS on energy utilisation efficiency.

Variables	OLS Estimates	Replacement Indicator	Counterfactual Estimates	GMM Estimates
	(1)	(2)	(3)	(4)
L.EUE				0.654 ***
				(0.027)
western × post	0.047 ***	−0.071 ***	0.022	0.039 ***
	(0.016)	(0.018)	(0.021)	(0.013)
eco	0.417 ***	0.225 ***	0.431 ***	0.027
	(0.041)	(0.045)	(0.041)	(0.034)
innov	0.449 ***	0.149 **	0.439 ***	0.019
	(0.072)	(0.074)	(0.072)	(0.151)
struc	0.002 *	0.002	0.002 **	0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)
hum	0.043 *	0.036	0.0434 *	0.121 ***
	(0.025)	(0.026)	(0.024)	(0.019)
gov	0.022 **	0.018 ***	0.028 ***	−0.028 ***
	(0.009)	(0.007)	(0.009)	(0.007)
fdi	−0.176 ***	0.133 ***	−0.175 ***	0.100 ***
	(0.059)	(0.049)	(0.059)	(0.021)
ifra	−0.019	−0.005	−0.024	−0.022 ***
	(0.018)	(0.019)	(0.018)	(0.008)
urban	−0.007 ***	−0.009 ***	−0.007 ***	−0.004 ***
	(0.002)	(0.001)	(0.002)	(0.001)
cons	−2.673 ***	−1.095 ***	−2.846 ***	0.842 ***
	(0.383)	(0.462)	(0.382)	(0.272)
fixed effect	yes	yes	yes	
AR(1)				0.004
AR(2)				0.309
Sargan				0.999
R-squared	0.703	0.857	0.702	
Obs	660	660	660	630

Note: The statistical values of standard errors are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. AR(1), AR(2), and Sargan tests show the p-value.

In model (1), the coefficient of the cross-multiplication term is positive and passes the test, which implies that the WDS has promoted energy utilisation efficiency. After the index replacement of the explained variables, the coefficient of the cross-multiplication term in model (2) still passes the significance test and the action direction has not changed. The coefficient of the cross-multiplication term fails the significance test in model (3), which means that there is no significant distinction in energy utilisation efficiency between the treatment and control groups before the strategy implementation. The research sample in this study satisfies the parallel trend hypothesis. In model (4), the coefficients of the explained variables lagging behind the first term and the cross-multiplication term are significantly positive, which means that it is necessary to consider endogenous errors. The above test results corroborate the robustness of the paper's conclusion.

5.3. Analysis of the Results of the Mechanism Test

The estimated results in Table 3 show that the examination of the mechanisms process by which the WDS affects energy utilisation efficiency. In the first stage, the first step of model (5) is the regression result of the effect of the WDS on industrial agglomeration, and the regression coefficient of the $western \times post$ is positive and passed the test at the 10% level, which illustrates that the WDS has greatly promoted the agglomeration of characteristic advanced industries in the western region through platform building, preferential policies, and infrastructure construction. The second step of models (6), (7), and (8) are the regression results of the effect of strategy implementation on three mediating variables. The regression coefficients of cross-multiplication terms are all significantly positive, thereby indicating that strategy implementation has enhanced technological innovation capacity, optimised industrial structure, and improved human capital. The theory that strategy implementation drives the three effects through industrial agglomeration is further attested through the following: the estimated results of the third step model show that the regression coefficients of the cross-multiplication terms in (9) fail the significance test, and the regression coefficients of the cross-multiplication term in models (10) and (11) pass the significance test yet decrease. Therefore, the WDS has enhanced technological innovation capacity, optimised industrial structure, and improved human capital levels by increasing the concentration of advantageous industries in the western region.

Table 3. Mechanism test of the effect of WDS on energy utilisation efficiency (1).

Variable	Phase I						
	Step1	Step2			Step3		
	AGG	*innov*	*struc*	*hum*	*innov*	*struc*	*hum*
	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$western \times post$	0.249 *	0.141 *	2.000 ***	0.358 ***	0.091	1.463 ***	0.321 ***
	(0.132)	(0.072)	(0.630)	(0.055)	(0.071)	(0.552)	(0.058)
AGG					0.201 ***	2.156 ***	0.149 ***
					(0.028)	(0.188)	(0.027)
cons	22.916 ***	−10.729 ***	117.552 ***	−1.045	−15.343 ***	68.151 ***	−4.479 **
	(2.739)	(2.165)	(27.514)	(2.174)	(2.131)	(26.313)	(1.852)
control	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
R-squared	0.624	0.733	0.831	0.869	0.738	0.859	0.875
Obs	690	690	690	690	690	690	690

Note: The statistical values of standard errors are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

As shown in Table 4, the estimated results of the first step models (12), (13), and (14) show that the WDS has enhanced technological innovation capacity, optimised industrial structure, and improved human capital. The second step model (15) is the regression result of the effect of the WDS on energy utilisation efficiency, and the coefficient of the cross-multiplication term $western \times post$ is significantly positive. This demonstrates that the WDS significantly boosts the energy utilisation efficiency. However, the specific mechanism behind it was tested in the third step. The estimated results of the third step models (16), (17), and (18) show that after the three mediating variables and cross-multiplication terms are included in the regression equation, the mediating variables on energy utilisation efficiency are significantly positive. The coefficient of the cross-multiplication term $western \times post$ in (16) still has a significant impact on the energy utilisation efficiency promotion, and it fails the significance test in (17) and (18), yet the coefficient becomes smaller. As stated above, this result confirms that the WDS improves the energy utilisation efficiency through technological innovation, industrial structure optimisation, and human capital pulling effects. Therefore, Hypothesis 2 of this paper has been verified.

Table 4. Mechanism test of the effect of WDS on energy utilisation efficiency (2).

Variables	**Phase II**						
	Step1			**Step2**	**Step3**		
	innov	***struc***	***hum***	***EUE***	***EUE***	***EUE***	***EUE***
	(12)	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
western×post	0.141 * (0.072)	2.000 *** (0.630)	0.358 *** (0.055)	0.068 ** (0.033)	0.057 * (0.034)	0.041 (0.035)	0.033 (0.034)
innov					0.083 *** (0.013)		
struc						0.013 *** (0.002)	
hum							0.098 *** (0.035)
cons	−10.729 *** (2.165)	117.552 *** (27.514)	−1.045 (2.174)	−5.693 *** (1.135)	−4.801 *** (0.403)	−7.277 *** (1.051)	−5.591 *** (1.055)
control	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
fixed effect	yes	yes	yes	yes	yes	yes	yes
R-squared	0.624	0.831	0.869	0.871	0.881	0.883	0.882
Obs	690	690	690	690	690	690	690

Note: The statistical values of standard errors are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

6. Extended Analysis

6.1. Heterogeneity of Regional Characteristics

The above empirical results demonstrate that the WDS significantly boosts the energy utilisation efficiency. Thus, does the energy-saving effect exist in regions with different characteristics? Regarding the regional scale, large-scale regions have an economic agglomeration effect, with a correspondingly higher resource allocation and utilisation efficiency. However, small-scale regions are more susceptible to the preferential policy that enhances the agglomeration effect of advantageous industries and promotes resource allocation and energy utilisation efficiency, the methods and measures of recycling economy pilot programs, and the standardisation of the resource-exploiting order in the WDS. From the perspective of resource endowment, the utilisation efficiency of energy fluctuates with the dynamic changes in resource endowment. Regions abundant with resources are prone to a more serious wastage of resources, so the incentive effect of the WDS on the improvement of energy use might be limited in such areas. Based on the above analysis and drawing on the practices of Li and Xu [66], this study weighs the scale of the regions and the degree of resources by measuring the population density and the number of mining employees in relation to the total population at the end of the year and dividing them into three identical groups. The first is a small-scale group with low-level resource abundance, and the second and third groups are large-scale with high-level resource abundance.

The test results in Table 5, from the perspective of the regional types, show that regardless of the small- or large-scale regions, the WDS has significantly boosted energy utilisation efficiency. Nevertheless, the net effect of the WDS in small-scale areas is higher than that in large-scale areas because the resource allocation and utilisation efficiency of small-scale areas were in an unfavourable position before the strategy implementation, which leaves spacious scope for energy utilisation efficiency improvement after its implementation. However, the large-scale areas with natural strength undermine the policy effect of the strategy to some extent. Therefore, the net effect of the strategy implementation on the improvement of energy utilisation efficiency is more prominent in small-scale areas. For regions under different resource abundance levels, the strategy has significantly improved their energy utilisation efficiency, yet the promotion effect is more outstanding in the resourceless-abundant group than in the resource-abundant group. This result is not difficult to follow. Local governments in areas with sufficient natural resources are ready to pursue rapid economic growth relying on the innate resource advantages when spurred by the promotion incentive. This makes the strategy implementation less effective in improving energy utilisation efficiency in sufficient resource areas as compared to the less sufficient areas. This conclusion reinforces the viewpoint that the energy-saving effect of the WDS is more obvious in small-scale areas with relatively less resource abundance.

Table 5. Heterogeneity test of different regional scale and resource abundance.

Variables	Small Scale	Large Scale	Low Abundance	High Abundance
	(19)	(20)	(21)	(22)
western × *post*	0.078 ***	0.068 ***	0.067 **	0.035 **
	(0.026)	(0.019)	(0.0335)	(0.018)
eco	0.284 ***	0.459 ***	0.380 ***	0.326 ***
	(0.092)	(0.063)	(0.105)	(0.039)
innov	1.075 ***	0.129	0.417 ***	0.679 ***
	(0.175)	(0.083)	(0.121)	(0.088)
struc	−0.0002	0.003 **	−0.0007	0.002 *
	(0.002)	(0.001)	(0.002)	(0.001)
hum	−0.079	−0.138 ***	0.199	0.061 ***
	(0.123)	(0.112)	(0.219)	(0.023)
gov	0.009	−0.004	0.045 ***	0.009
	(0.013)	(0.022)	(0.011)	(0.012)
fdi	−0.311 ***	−0.258 ***	−0.245	−0.256 ***
	(0.104)	(0.088)	(0.169)	(0.719)
ifra	0.032	−0.033	0.079 **	−0.129 ***
	(0.035)	(0.023)	(0.032)	(0.021)
urban	0.001	−0.003	−0.014 ***	0.004 **
	(0.003)	(0.002)	(0.003)	(0.002)
cons	−1.591 *	−2.860 ***	−2.015 *	−2.646 ***
	(0.888)	(0.549)	(1.086)	(0.418)
fixed effect	yes	yes	yes	yes
R-squared	0.729	0.701	0.737	0.709
Obs	230	460	230	460

Note: The statistical values of standard errors are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

6.2. Heterogeneity of Institutional Environment

Performance appraisal is the 'baton' of government behaviour. In response to the needs of China's sustainable economic development strategy in the new era, local government performance appraisal has gradually shifted from its pure focus on GDP growth to high-quality, effective, and green sustainable development [67]. On the contrary, institutional quality also has a big stake in the success of the WDS because a sound institution can constrain the code of conduct of all stakeholders, optimise the market competition ambiance, and promote the market to effectively play its role in resource allocation [68]. Based on these considerations, we believe that strategy implementation will have an obvious impact on the improvement of energy utilisation efficiency under high-intensity performance appraisal and favourable institutions. This study refers to the practice of Deng and Yang [69]; incorporates the economic growth rate, coal consumption growth rate, and emission growth rate into the indicator system; and uses the entropy method to set up comprehensive performance appraisal indicators as per Shao and Yun [68]. In addition, the marketisation index is harnessed to measure the institutional quality, and the performance appraisal and institutional quality indicators are divided into three equal parts to distinguish between the high-level group and low-level group (the same as above).

From the test results in Table 6 based on institution type, it is evident that the net effect of the WDS on energy utilisation efficiency is significant in the high-intensity performance appraisal with good institution quality and less significant in the corresponding low-intensity performance appraisal with low-level institutional quality, which is consistent with the expectation. The Third Plenary Session of the Eighteenth Central Committee of the Communist Party of China underscores the importance of increasing the weight of energy consumption indicators in improving the appraisal and evaluation system of development achievements. As the Central Party Committee attaches importance to energy consumption, local governments are strict regarding energy exploitation and utilisation when implementing the WDS. Simultaneously, sound institutional quality can not only effectively restrain the 'grabbing hands' of government officials to improve the efficiency and quality of government affairs but also restrict the rent-seeking behaviour of local enterprises to promote the optimal allocation of resources.

Table 6. Heterogeneity test of different performance appraisal and institutional quality.

Variables	Low Political Appraisal	High Political Appraisal	Low Institutional Quality	High Institutional Quality
	(23)	(24)	(25)	(26)
western × *post*	0.039 (0.026)	0.056 *** (0.021)	0.033 (0.025)	0.107 *** (0.024)
eco	0.268 *** (0.079)	0.473 *** (0.051)	0.079 (0.063)	0.455 *** (0.063)
innov	0.563 ** (0.224)	0.461 *** (0.082)	−1.345 (0.859)	0.376 *** (0.091)
struc	−0.003 (0.002)	0.003 *** (0.001)	−0.001 (0.001)	0.009 *** (0.002)
hum	0.049 * (0.026)	−0.196 * (0.111)	−0.105 * (0.085)	−0.096 (0.167)
gov	0.012 (0.018)	0.034 *** (0.013)	0.003 *** (0.010)	0.062 ** (0.028)
fdi	−0.416 *** (0.106)	−0.115 * (0.067)	−0.795 *** (0.101)	−0.098 (0.067)
ifra	−0.029 (0.041)	−0.020 (0.022)	0.146 *** (0.045)	−0.023 (0.022)
urban	−0.001 (0.002)	−0.008 *** (0.002)	0.012 *** (0.002)	−0.007 *** (0.002)
cons	−1.283 * (0.724)	−2.750 *** (0.499)	−2.846 *** (0.503)	−3.212 *** (0.740)
fixed effect	yes	yes	yes	yes
R-squared	0.734	0.706	0.753	0.719
Obs	230	460	210	420

Note: The statistical values of standard errors are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

7. Conclusions and Policy Implications

This study constructed an analysis framework of the energy-saving effects of the WDS from a sustainable development perspective, empirically tested the impact mechanism of the strategy on energy utilisation efficiency using the SCM and chain mediating effects model, and further investigated the heterogeneous effects of the WDS on energy utilisation efficiency from the perspective of the regional scale, resource endowment, performance appraisal, and institutional quality. It was found that the WDS improves the energy utilisation efficiency not only directly but also indirectly by accelerating the spatial agglomeration of advantage industries in Western China, which enhanced technological innovation capacity, optimised industrial structure, and improved human capital level to ameliorate energy utilisation efficiency. Further analysis proved that the energy-saving effect of the WDS is significant in provinces with small-scale regions, less abundant resources, and higher levels of performance appraisal index and quality systems. The conclusions of this study have crucial guiding significance to realise sustainable development in China. The policy implications of the conclusions are as follows:

First, the WDS shall focus on economic development with high quality. On the basis of achieving coordinated regional development, the WDS shall achieve green economic development in the western region from the perspective of sustainable development and avoid pursuing economic growth at the expense of resource depletion and environmental sacrifice to narrow the economic gap between the western and eastern regions in China.

Second, the spatial development pattern should be optimised, and the agglomeration of advantageous industries should be rationally guided to implement and support the WDS. Reasonable guidance on the agglomeration of competitive industries in the western region is the primary task of the government in implementing the strategy. Meanwhile, a multi-level, distinctive, and open platform shall be built to lay a solid foundation for the western region to undertake industrial transfer. On the other hand, more attractive preferential policies shall be formulated according to local conditions, such as increasing financial support and improving the infrastructure in the western region, etc., which aim to optimise the business environment, promote the agglomeration and interaction of talents and industries, and achieve a reasonable spatial layout in the western region.

Third, the WDS should realise 'differentiation from place to place and dialectical governance'. Differentiated development modes shall be adopted to improve energy utilisation efficiency in regions with different scales and resource endowments. Specifically, for areas with large-scale and abundant resources, the energy exploitation plan should be emphasised in the strategy. For areas with small-scale and deficient resources, the idea of improving energy utilisation efficiency shall be adjusted. Blindly pursuing the expansion of infrastructure shall be banned to prevent the accelerated outflow of production factors, and attention should be given to augment the level of technological innovation in the strategy implementation, thereby improving energy utilisation efficiency. We need to give full play to the role of political performance evaluation and institutional quality in strategy implementation, continuously strengthen the role of sustainable development in the evaluation of political performance, and create a favourable institutional environment by optimising the soft environment of regional investment, thereby increasing the intensity of policy implementation and improving administrative efficiency.

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