The Effect of Enclave Adjustment on the Urban Energy Intensity in China: Evidence from Wuhan

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Abstract: Due to the needs of China’s rapid urbanization, enclave adjustments between districts in a city have become a national phenomenon in recent decades. However, it is rarely discussed in the literature whether this adjustment can have an impact on urban energy intensity. Taking Wuhan’s enclave adjustment in 2009 as a sample and a city-level panel dataset during the period of 2005–2014, using the synthetic control method, this paper investigates for the first time the impact of enclave adjustment between districts on the urban energy intensity. The results show that the logarithmic energy intensity paths of real and synthetic Wuhan diverge after 2009, and the enclave adjustment is indeed conducive to reducing energy intensity. Although this policy effect fluctuated slightly in 2013, it remained evident and continued to expand in subsequent years. We also further adopt the permutation test and placebo test to check the robustness of the baseline results, and this policy effect was found to still be statistically significant and persistent over time. We further verified that aligning division management, changing the incentives of local officials, promoting the agglomeration effect, and regional integration after adjustment are potential contributors to reducing urban energy intensity.

Keywords: enclave adjustment; synthetic control method; urban energy intensity; Wuhan

1. Introduction

China’s urbanization rate exceeded 60% by the end of 2019, and is widely regarded as an important component of modern economic growth that encompasses the transformation of an economy from a predominantly rural agricultural economy to a urban industrial economy [1,2]. Rapid urbanization has not only promoted the expansion of city scale but also resulted in significant energy consumption. The urban economy accounts for 90% of Chinese gross domestic product (GDP) and urban energy consumption accounts for 75% of total national energy consumption [3,4]. If energy consumption is not controlled, CO₂ emissions will also continue to rise and the air quality will suffer (problems associated with atmospheric pollutants such as particulate matter less than 2.5 micrometers in diameter (PM2.5), nitrogen oxides, and sulfur dioxide will become more serious). Thus, Chinese cities face the arduous tasks of energy saving and consumption reduction [5].

Due to the needs of rapid urban development, the adjustment of municipal districts has become a national phenomenon in recent decades [6]. This implies a substantial change in the socio-economic pattern of a city relating to the local allocation of national rights and interests within cities, and the rationalization of the spatial arrangement of the city administration, the size hierarchy of the administrative district, and the scope of the administrative district. As a single centralized state, China’s administrative divisions have
a more prominent economic function. The abolition of the administrative establishment, the size and level of the administrative district, the rationality of the scope of the district, and the setting of the administrative center also affect the development of regional natural resources, allocation of production factors, and the spatial organization of economic activities. These functions can achieve market integration, optimize internal resource allocation, and accelerate local economic growth and the supply of public services [7].

Figure 1 shows the number of municipal districts in cities per year since 1978. As of 2017, there are 289 prefecture-level cities with municipal districts. Because the management of administrative divisions in China was not standardized before the reform and opening up in 1978, the setting of municipal districts in prefecture-level cities did not need to be approved by the central government and there were no specific standards; thus, we chose 1978 as the starting point of this map. The type of municipal adjustment includes the internal adjustments, external expansion, and mix of internal adjustments and external expansion [8]. The bar shows that a total of 213 internal adjustments took place during 1978–2017, and enclave adjustment was one of the important types of internal adjustment. In general, administrative divisions usually have clear and closed boundaries. As a particular form, the enclave (chahuadi) breaks with this general principle and refers to an area with interlocking districts and no clear attribution, or an area where the management subject is unclear due to the complex boundaries and affiliation. Due to the further complication of the management of economic and social affairs, contradictions and problems are becoming increasingly prominent, and adjustments to the administrative divisions are necessary. The enclave adjustment is the rationalization of the geographical area of each municipal district, redefinition of administrative ownership, and improvement of the internal space layout. The enclave adjustment is not just an adjustment to the administrative boundary, but is also motivated by multiple factors and complex political and economic interests. Therefore, the enclave adjustment aimed at aligning the relationship between districts is an important national policy to promote regional development and urbanization [9]. The binding indicators for energy intensity proposed in China’s five-year plan (FYP) are decomposed into provinces. The assigned energy-saving targets are further decomposed into cities and then urban districts. Thus, urban districts are important units in the implementation of the task, and have taken a series of measures to achieve the energy intensity reduction targets set in the five-year plan. The existence of the enclaves has become an important obstacle to rationalize the administration of urban districts and promote integrated governance. In addition, whether the adjustment has an impact on the change of energy intensity has yet to be systematically and deeply assessed in academic research. To the best of our knowledge, the existing literature lacks in-depth research on this topic. Thus, in the current study, we attempt to fill this research gap. This paper is the first to empirically examine the impact of enclave adjustment on urban energy intensity during China’s urbanization.
In this article, we attempt to empirically analyze the energy intensity reduction effect of enclave adjustment by using city-level energy intensity data from 2005 to 2014. In order to more accurately identify the impact of Wuhan’s enclave adjustment on its energy intensity, we took 2005–2014 as the research period. The choice of this period was due to the following reasons: If our sample period extended beyond 2014, the results would be biased by the implementation of similar policies in the control group cities because some of the control group cities underwent administrative boundary adjustment after 2014. Secondly, 2005–2014 places 2009 (the year in which enclave adjustment occurred in Wuhan) in the middle of the sample period, thus meeting the assessment conditions of the synthetic control method [10]. Specifically, we investigate the changes in energy intensity of Wuhan, Hubei province, which adjusted the enclaves between districts in 2009, and we examine whether the enclave adjustment reduced urban energy intensity. The contribution of this paper mainly includes two aspects: Firstly, the paper enriches the literature on the relationship between administrative boundary adjustment and energy intensity by providing empirical evidence on the positive role of the enclave adjustment in reducing urban energy intensity. Secondly, we adopt the synthetic control method to overcome the sample selection bias and policy endogeneity that may occur in the selection of control objects. There are clearly multiple channels through which the enclave adjustment can affect urban energy intensity. We argue that the enclave adjustment will impact urban energy intensity by strengthening the administrative capacity of the city, incentives for local officials, and regional integration. Identification of the mechanism that links urban energy intensity with enclave adjustment will be one of the research directions in the future.

The remainder of the paper is organized as follows. Firstly, we review the relevant literature in Section 2, and assess the institutional background in Section 3. Section 4 introduces the research method, variables, and data. The empirical results are presented in Section 5 and discussed in Section 6. The paper is summarized in Section 7, and policy implications are provided in Section 8.

2. Literature Review

China’s urban economy has the typical dual institutional characteristics of economic zones and administrative districts, between which contradictions often exist. As economic zones continue to evolve and develop, it is necessary to adjust administrative districts [8]. The adjustment of urban municipal districts in China is thought to reflect several political economy factors, including the transfer of more financial and economic management power from upper-level government to the municipal district government through fiscal
decentralization reform. To maximize the probability of promotion, the choice of market integration or fragmentation by rational local officials in the administration boundary adjustment depends on the positive and negative external spillover effects. Growth in the population of an urban district and rationalization of its spatial layout allows full utilization of the advantages of the agglomeration economy, while also promoting regional integration through local market integration [11–13]. The impact of the above factors on the change in energy intensity is mainly focused on the following aspects.

Lipscomb and Mobarak believe that decentralization improves public service delivery and generates externalities within the jurisdiction [14]. Zhou et al., believe economic competition among local governments worsens provincial energy eco-efficiency in China, while the high degree of fiscal decentralization in state government significantly contributes to improving the energy eco-efficiency. Furthermore, the co-impact of economic competition on EEE (energy ecological efficiency) has been negatively strengthened against the background of fiscal decentralization [15]. Wu et al., argue that there is a significant U-shaped relationship between environmental regulation and green total factor energy efficiency in China. As environmental decentralization expands, it is likely to increase the negative effects of environmental regulations on the green TFEE (total factor energy efficiency) [16]. Elheddad et al., find a stable inverted U-shaped relationship between fiscal decentralization and energy consumption in China. Due to competition among provinces for economic growth, higher levels of decentralization will initially lead to more pollution. If these provinces adopt a green growth strategy, fiscal decentralization can become more environmentally friendly after a certain turning point [17].

Many scholars have emphasized the impact of local officials’ incentives on the change of energy intensity. Kahn et al., argue that as binding indicators for energy consumption and pollution are written into the annual responsibility contracts of local leaders in China, they are becoming important criteria for the evaluation of cadres’ promotion decisions [18]. Liang and Langbein argue that China has been implementing a GDP-focused incentive approach since its reform and opening up. The central government proposed the “Scientific outlook on development” in 2003, and many provinces and cities link officials’ environmental performance assessment to their promotion. They found that the environmental assessment, which mainly consists of the improvement of energy efficiency, has already had a positive effect on the probability of local official promotion, with the evaluation mechanism of local officials becoming more scientific. Therefore, local governments respond quickly when the central government introduces specific environmental governance targets into new promotion criteria, which indicates the importance of the central government choosing the “right incentive” [19]. Chen et al., find that governors can significantly reduce the energy consumption per unit of Gross Regional Product (GRP) in the province if they have work experience in an energy-constrained province. The effect of the governor is more pronounced than that of the provincial secretary [20]. Wu et al., find that local governments interfere with the work of local environmental protection bureaus and lower environmental standards, and officials who are concerned about environmental protection will have a negative impact on promotion [21].

Regional integration and agglomeration economies both lead to improvements in energy efficiency. Li and Lin argue that regional integration has significant and robust positive effects on energy consumption and CO₂ emissions performance, with more than 70% of the impact resulting from man-made obstacles rather than geographic distance [22]. Han et al., argue that the eco-efficiency of large cities is enhanced through the channel of structural optimization effects, whereas the eco-efficiency of small and medium cities is improved by promoting industrialization and specialization [23]. Huang et al., find that urban agglomerations disperse the diseconomies of agglomeration and reduce the waste of resources and pollution emissions. In addition, the dispersion of functions promotes the agglomeration of elements from large to small and medium cities and enhances the agglomeration economy and ecological efficiency of cities [24].
To a certain extent, the above literature provides a general theoretical basis and reference for the analysis of administrative boundary adjustment and change of energy intensity. Regarding the issue of the impact of enclave adjustment on urban energy intensity in China, the relevant literature focuses on strengthening the administrative capacity of the district, changing the incentives and constraints for local officials, and regional integration, as discussed below.

First, the enclave adjustment has strengthened the administrative capacity of the district, thereby enhancing its ability to perform energy-saving and consumption reduction tasks. Evidence exists that the administrative boundary adjustment is essentially a kind of institutional change that gives local governments a new lease of life and ultimately promotes the supply of public services [25,26]. Cai et al., find that the reform of administrative boundary adjustment cannot only improve administrative efficiency, but also solve the problem of cities and counties competing for profit, thus helping to improve the urban environmental quality [27]. Compared with bottom-up consolidation, Wang et al., reveal that the top-down administrative division adjustment is closer to achieving overall benefit maximization and can better provide a public product, such as a good ecological environment [28].

Second, the enclave adjustment may change the incentives and constraints of local officials in completing energy-saving tasks, thereby affecting regional energy intensity. Yang believes that behavioral biases of the local governments are important reasons for high energy consumption in China [29]. Hu et al., argue that only when local and central government objectives are consistent can a mechanism arrangement of compatible incentives be formed to effectively promote the reduction of energy consumption per unit of GDP [30]. Sun et al., argue that, as the evaluation mechanism of local officials becomes more scientific, environmental assessment, which mainly consists of the improvement of environment quality and energy efficiency, has a positive effect on the probability of local official promotion. Moreover, these effects are more significant in larger cities or cities with stronger executive power [31].

Third, the enclave adjustment can bring about market integration and optimize internal resource allocation, which can achieve the effect of energy saving and consumption reduction. Zeng and Zhao find that the agglomeration externalities brought about by regional boundary adjustment can promote the concentration of various high-quality elements through mechanisms, such as economies of scale and resource reallocation effects, which can effectively reduce the production costs of enterprises and promote the centralized use of energy [32]. Tang and Wang believe that the administrative boundary adjustment facilitates the increase in the level of regional integration and urban economic agglomeration, which can help to reduce various distortions caused by administrative barriers and promote optimal allocation of resources [33]. Tang and Geoffrey find that municipal mergers significantly increase local economic development, and the magnitude of the effect depends on the local resource endowment related to agglomeration power. After the merger, transportation infrastructure and urban agglomeration economies are potential contributors to these positive merger effects [34]. Shao et al., find that the expansion of economic scale may increase CO₂ emissions at the beginning of the implementation of related economic zone planning. However, the weakening and even elimination of market segmentation will be ultimately conducive to urban CO₂ emission reductions due to the improvement of technological progress and the green transformation of industrial structure [35].

In order to verify whether the enclave adjustments can reduce urban energy intensity, suitable samples for research must be identified. This paper selects Wuhan’s enclave adjustments in 2009 and related economic activities as an experiment on changes of urban energy intensity. The reasons for this choice are: (1) In comparison, Wuhan’s one-time and comprehensive enclave adjustment is beyond the reach of other Chinese cities where adjustments have occurred [36]. The time of enclave adjustment is in the middle of the sample period (2009), and conforms to the estimation conditions of the synthetic control
method. (2) We take the adjustment as a natural experiment in which Wuhan has only experienced this change from 2005 to 2014, which can effectively prevent the superimposed effect caused by multiple adjustments and ensure the authenticity and validity of our research. (3) After this adjustment, the administration and financial and personnel management were substantially improved in three districts that underwent adjustments. These reconfigurations of administrative rights led to the optimal allocation of economic and industrial resources, the integration of regional markets, and economic coordination [32]. The enclave adjustment in Wuhan provided a natural experiment to test if this adjustment can lead to the reduction in urban energy intensity.

3. Institutional Background

3.1. The Enclave Adjustment and Its Role in the Development of Urban Districts

Under a single system of government, China has four main administrative hierarchies from top to bottom (see Figure 2): nation, province, prefecture-level city, and county. Unlike the urban systems in the United States and Europe, each city in China has a specific administrative hierarchy, with higher-ranked cities having more economic resources and administrative power [37]. A prefecture-level city consists of urban districts, counties, and county-level cities. District governments have jurisdiction over communities and townships, and prefecture-level cities have direct jurisdiction over their districts. Usually, district governments are subordinate to prefecture-level city governments and lose their independence in urban planning, construction projects, and land supply, while receiving integrated support from higher levels of government in various areas, such as infrastructure and livelihood investment. Under the jurisdiction of prefecture-level cities, the economic and transportation links between urban districts are greatly enhanced. Therefore, all urban districts are a unity of urban economic and social policies [38].

![Figure 2. Administrative division of China. Source: Based on Ma [39].](image-url)

Owing to historical and practical reasons, there are many enclaves that are indented between districts in the city, which are the result of the implementation and development of the interlocking principle in the boundary of administrative divisions. This has caused overlapping of districts and a management vacuum. Furthermore, the relationship between the enclaves and the districts, which belongs is interrupted by the arrangement of
geographical space [40]. The diffusion effect of the core area of districts cannot be penetrated, which also results in unclear administrative responsibilities and blurred territorial and personal principles. This can lead to either multiple layers of management or a lack of management, in which areas may lack any jurisdiction. This is particularly the case in areas in which interests are difficult to manage. This does not only result in scarcity and hierarchical characteristics of urban basic services in these enclaves but is also reflected in the spatial mismatch between jurisdiction and administrative regions [41]. The enclaves have a high concentration of rural migrants and are difficult areas in which to save energy and reduce consumption due to their extensive use of inexpensive and high-energy- and pollution-intensive fuels [42]. Compared to the surrounding urban districts, it can be seen that enclave areas are high energy-consumption areas, because they are not integrated into the unified energy-saving management of district governments. Thus, they also raise the energy consumption level of the whole city.

Since the beginning of the 21st century, many cities in China have begun to deal with the problem of enclaves by administrative boundary adjustments and redistributing executive power, for example Beijing, Guangzhou, and Shanghai [43–45]. A significant change in the reorganization of enclaves is the administrative boundary adjustment between districts and redivision of the geographical area of each municipal district, which can reduce gaps in urban management, rationalize management systems, and allow districts to perform their functions effectively. This experience indicates that the enclave adjustment plays a highly important role in the spatial restructuring and spatial governance of the urban interior, which can further advance the reform of the system of the urban administrative region and is also conducive to the unified planning of urban construction and management. However, considering multiple factors, such as politics, the economy, and ethnicities, the formation of an enclave is often not due to a single cause, but the result of multiple factors superimposed. Because of this, the enclave adjustment can also trigger drastic local reactions and the reform process can be repetitive. Therefore, only by considering all kinds of influencing factors can the adjustment be effective. According to the regulations on the Adjustment of Administrative Divisions in China, there are several steps in the implementation of the enclave adjustment. Local governments (prefecture-level cities and municipal districts) first propose an adjustment plan, which must then be approved by the provincial government, and a record is made by the central government and the Ministry of Civil Affairs.

As a national resource-economical and environment-friendly society integrated support reform experimental zone, the existence of enclaves in Wuhan is a contradiction to the goal of sustainable development. Figure 3 shows that Wuhan has 13 districts (seven of these are central areas) under its jurisdiction, and the enclaves are almost all concentrated in the three districts of Wuchang, Qingshan, and Hongshan, which belong to central areas. Wuchang and Qingshan districts have lacked development space since the 1960s and the two districts could only be requisitioned from Hongshan district. The two districts have used the practice of simply managing the land wherever it was requisitioned in recent decades, which resulted in 249 plots of enclaves in these districts. Due to a variety of entangled interests, the Wuhan municipal government had already made a series of adjustments to the enclaves, but the name and number of towns were only clarified as recently as 1985. Wuhan has not clearly defined the administrative boundaries, which has resulted in an increase, rather than a decrease, in the number of enclaves in the three districts. In order to completely eradicate the negative impact of enclaves, Wuhan proposed a plan to adjust the enclaves that was approved by the Hubei provincial government in early 2009. This may have changed the expectations of the district governments in advance and influenced the formulation and introduction of related policies and measures, including energy saving and consumption reduction. Specifically, all areas of six villages and parts of five villages in the Hongshan district, accounting for approximately 9.8 square km, were assigned to Wuchang district, all areas of five communities and parts of three
communities in Wuchang district, accounting for approximately 3.6 square km, were assigned to Hongshan district, and all areas of 12 villages, parts of six villages and two communities, accounting for approximately 22.6 square km, were assigned to the jurisdiction of the Qingshan district. The handover involved a change in household registration for more than 56,000 people. The adjustments were largely completed in June and it took several months after the policy release to achieve real integration into each district. The Notice on the Adjustment of Enclave in Three Jiangnan Districts Involving Urban Village Transformation stipulates that it can clarify the administrative jurisdiction of enclaves after adjustment, which can promote the transfer of urban management and social services. The number of enclaves resolved by this adjustment accounts for 95% of the total number of remaining enclaves in Wuhan, which not only completed the boundary surveys within the three districts, but also delineated the attribution and responsibility of the enclaves. All three districts have completed the actual handover of the enclaves and formed new regional jurisdictions. Hence, this was a comprehensive one-time adjustment.

Figure 3. Location of three districts in Wuhan (a), Three districts that have undergone enclave adjustments (b) and the former enclaves in the three districts (c). Source: Based on Wuhan Municipal Bureau of Land Resources and Planning [46].

3.2. The Role of Urban District in Energy Saving and Consumption Reduction of the City

To solve the problem of high energy consumption and pollution in the current economic development of Chinese cities, the scientific outlook for development has been a major strategy that has served as the political foundation for environmental policy implementation since the 17th National Congress of the Communist Party of China (CPC). This emphasizes comprehensive, coordinated, and sustainable development. China proposed transition measures in the 11th, 12th, and 13th Five-Year Plans, including setting binding indicators for energy consumption per unit of gross domestic product (GDP). For example, a mandatory energy conservation target was added to the 11th Five-Year Plan (FYP), i.e., energy consumption per unit of gross domestic product (GDP) should decline by 20% from the 2005 level. It was also the first time the goal of energy conservation was introduced into the performance evaluation system of local governments. In the subsequent plans, the Chinese government set an energy conservation target as a basic requirement for reducing energy consumption. For example, the Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 12th Five-Year Plan, which is issued by
China’s State Council, provides that the above binding indicators proposed in the plan are decomposed into provinces, the provinces further decompose the assigned energy-saving targets into cities, and the cities further decompose the tasks into urban districts. Central and local governments have implemented a series of measures and formulated corresponding work plans to meet the energy intensity targets for the local actual situation. The development of regional energy-saving goals and measurement standards can achieve regional energy and environmental responsibilities. The decomposition and change of binding indicators take into account not only the regional economic development conditions, but also the regional consumption reduction potential to achieve consumption reduction goals and emphasize regional equity and development strategies [47,48].

Through the development of relevant work programs, cities are allocated provincial energy conservation indicators, which are further decomposed into the district governments. Indicators are inspected, and implementation performance of energy conservation and consumption reduction are required to be reported annually to the city government at the end of the year. The Wuhan municipal government issued a circular entitled the Comprehensive Work Plan for Energy Saving and Climate Change Response in Wuhan during the 12th Five-Year Plan. This document claims that all jurisdictions must ensure the completion of overall energy conservation binding indicators and annual target tasks. The city must achieve a specific goal by the end of the 12th Five-Year Plan, namely that energy consumption per unit of GDP will be 18% lower than that at the end of the 11th Five-Year Plan. The targets allocated to HongShan, Wuchang, and QingShan districts are 18%, 18%, and 20%, respectively. The specific responsibilities of each district government for energy conservation and consumption reduction include strengthening the assessment and supervision of local officials and key power users, upgrading of the industrial structure, developing a circular economy, implementing an energy-saving assessment, and carrying out energy-saving management training. Establishing and improving the responsibility and accountability system for energy conservation will create a strong work pattern to complete the tasks.

Specifically, the implementation of Wuhan’s assessment system with energy consumption per unit of GDP clearly defines, for each district government, the responsibilities for energy conservation within their jurisdiction. Furthermore, key government leaders are the first responsible persons, and a “one-vote veto” is implemented for officials that fail to complete the target tasks on time. At the same time, the district governments conscientiously implemented the Interim Provisions on Promoting the Industrial Structure Adjustment, which was issued by the State Council and encourages enterprises to participate in industrial parks. This aims to vigorously develop new industries, such as energy conservation and environmental protection, new energy, and new power vehicles, and upgrade traditional advantageous industries. The construction of key projects in the service industry will accelerate and key energy-consuming enterprises will promote energy efficiency benchmarking in the industrial field. This process also ensures that the energy consumption per unit of main products and the energy consumption of key processes of industrial enterprises are greatly reduced. It also aims to accelerate the construction of Qingshan–Yangluo chemical circular economy parks, thus further playing a leading role as a national circular economy demonstration park of Qingshan and Dongxihu. The thorough implementation of the plan for cleaner production in Wuhan further strengthens the cleaner production audit in the industrial field, and strictly controls the production and sales of high energy-consuming enterprises and products. Implementing the National Industrial Structure Adjustment Guidance Catalogue strengthens the supervision of products, equipment, and technologies that have been officially eliminated by the state. The outstanding question is whether the rationalization of the administrative system and the optimization of the spatial layout of the city resulting from Wuhan’s enclave adjustment can help complete the task of energy saving and consumption reduction,
and thus finally reduce Wuhan’s energy intensity. This paper attempts to answer this question using the synthesis control method.

4. Data and Methods

4.1. Research Methods

The key to the scientific evaluation of the impact of enclave adjustments on urban energy intensity is to identify a suitable method. The change of energy intensity caused by the enclave adjustments can be regarded as a natural experiment in Wuhan, which can provide estimated results via the comparison of the treatment group and the control group, thus reflecting the influence of the enclave adjustments on urban energy intensity. The difference-in-difference (DID) method is popular in the evaluation of policy effects and requires that the treatment group and control group are comparable before the intervention. This requirement is difficult to achieve due to the existence of regional heterogeneity, thus, bias can affect the evaluation of policy effects. In order to overcome the shortcomings of the DID method, Abadie et al., proposed a new method of identifying policy effects, i.e., the synthetic control method [10]. In this approach, a counterfactual control group is constructed for each policy intervention individual by the weighted average of the control group, that is, the synthetic control object. The city in which the enclave adjustment does not occur is simulated, and the effect of policy implementation can be assessed. This can be seen as a kind of quasi-experimental study, which is a comparative experiment on the same area at the same time during the study period. The comparison result of energy intensity between the cities with and without enclave adjustments represents the effect of the enclave adjustments on urban energy intensity. Studies have been widely undertaken on the evaluation performance of administrative boundary adjustment using the difference-in-difference (DID) or synthetic control method, such as Wang et al.’s work [7]. Thus, it is reasonable to use these methods for this paper. Secondly, the results of the synthetic control method are more objective and realistic because the approach overcomes the shortcomings of the DID method.

Assuming that there are $N + 1$ regions, region 1 starts to carry out enclave adjustment in the period $T_0$, while other $N$ regions do not carry out the enclave adjustments. $Y_{it}$ represents the potential results of enclave adjustment implemented in region $i$ at time period $t$ and $Y_{0it}$ represents the potential results of enclave adjustment not implemented in region $i$ at time period $t$. Thus, the causal effect of enclave adjustment is $\tau_{it} = Y_{it} - Y_{0it}$, where $i = 1, ..., N + 1, t = 1, ..., T$. The energy intensity observed in region $i$ at time period $t$ is $Y_{it} = D_{it}Y_{it} + (1 - D_{it})Y_{0it} = Y_{0it} + \tau_{it}D_{it}$, where $D_{it}$ represents the state of enclave adjustment of region $i$ at the time period $t$. If region $i$ is subjected to the enclave adjustment in period $t$, the value is 1, otherwise it is 0. For the convenience of description, we assume that the first region is subject to the policy intervention of enclave adjustment after the time period $T_0$, and the other $N$ regions are not subject to the policy intervention of enclave adjustment in all of the time periods. For $t > T_0$, the effect of enclave adjustment can be expressed as $\tau_{it} = Y_{1it} - Y_{0it} = Y_{it} - Y_{0it}$. Due to the implementation of the enclave adjustment in the first region, the potential result $Y_{1it}$ can be observed during the time period $t > T_0$, but the potential result $Y_{0it}$ cannot be observed if the regions were not subject to policy intervention. To estimate the counterfactual results for region 1, $Y_{0it}$ can be represented by the following model [49]:

$$Y_{0it} = \delta_t + \theta_tZ_t + \lambda_t\mu_t + \epsilon_{it}$$

(1)

where $\delta_t$ is time fixed effect and $Z_t$ is the $(K \times 1)$ vector of observed covariates, which represents the control variable that is not affected by the enclave adjustment. $\theta_t$ is a $(1 \times K)$ vector of unknown parameter vector, $\lambda_t$ is a $(1 \times F)$ vector of an unknown common factor vector, and $\mu_t$ is a $(F \times 1)$ vector of a coefficient vector. The error term $\epsilon_{it}$ is a short-term shock that cannot be observed in each region, with an assumed mean value of 0 at the regional level.
It can be seen that Equation (1) is an extension of the traditional difference-in-difference (DID) model. The DID model allows the existence of unobservable influence factors, but the effect of these influence factors does not change with time, which means \( \lambda_t \) is constant. Equation (1) allows the effect of unobservable factors to change with time, so \( \lambda_t \) is not constant.

To find \( Y_{0it} \), a \((N + 1)\) weight vector of \( W = (\omega_2, ..., \omega_{N+1}) \) is considered, where \( \omega_j \geq 0, j = 2, ..., N + 1 \), and \( \omega_2 + ... + \omega_{N+1} = 1 \). In order to avoid possible deviation caused by extrapolation, the weight is restricted to be non-negative, which is equivalent to synthesizing the control group by convex combination of the control group region. Each particular value of the vector \( W \) represents a synthetic control for region 1, that is, a weighted average of all regions in the control group by weighting the variable values of each control group, to obtain:

\[
\sum_{j=2}^{N+1} \omega_j Y_{jt} = \delta_1 + \theta_j \sum_{j=2}^{N+1} \omega_j Z_j + \lambda_j \sum_{j=2}^{N+1} \omega_j \mu_j + \sum_{j=2}^{N+1} \omega_j \varepsilon_j \tag{2}
\]

Assuming there is a weight vector \((\omega^*_2, ..., \omega^*_{N+1})\), such that:

\[
\sum_{j=2}^{N+1} \omega^*_j Y_{jt} = Y_{1i1}, \sum_{j=2}^{N+1} \omega^*_j Y_{jt} = Y_{1i2}, ..., \sum_{j=2}^{N+1} \omega^*_j Y_{jt} = Y_{1iT}, \sum_{j=2}^{N+1} \omega^*_j Z_j = Z_1 \tag{3}
\]

Abadie et al. [49] proved that if \( \sum_{t=1}^T \lambda_t^j \) is a nonsingular matrix, then:

\[
Y_{0it} - \sum_{j=2}^{N+1} \omega^*_j Y_{1it} = \sum_{j=2}^{N+1} \omega^*_j \sum_{s=1}^{T_0} \sum_{m=1}^{N} \lambda_j^s (\lambda^s_j - \lambda^s_m)^{-1} \lambda^s_m (e_{is} - e_{1is}) - \sum_{j=2}^{N+1} \omega^*_j (e_{is} - e_{1is}) \tag{4}
\]

It can be proved that Equation (4) approaches 0 under standard conditions. Thus, for \( T_0 < t \leq T \), the counterfactual results of region 1 can be approximated by a synthetic control group, and \( \hat{Y}_{0it} = \sum_{j=2}^{N+1} \omega^*_j Y_{1it} \), thus obtaining the estimated value of the policy effect:

\[
\hat{\tau}_{1it} = Y_{1it} - \sum_{j=2}^{N+1} \omega^*_j Y_{1it}, t \in \{T_0 + 1, ..., T\} \tag{5}
\]

The key to finding \( \hat{\tau}_{1it} \) is to find the weight \( W^* \) that makes Equation (3) hold, and the composite control vector \( W^* \) can be determined by an approximate solution. We choose the distance \(|X_1 - X_0 W|\) between the minimization \( X_1 \) and \( X_0 W \) to determine the weight \( W^* \), and its expression is \( ||X_1 - X_0 W|| = \sqrt{(X_1 - X_0 W)^T V(X_1 - X_0 W)} \). \( X_1 \) is the \((m \times 1)\)-dimensional feature vector of the region before the enclave adjustment. The \(j\)-th column of \( X_0 \) is the corresponding feature vector before the enclave adjustment of region \( j \). \( V \) is a \((m \times m)\) symmetric positive semi-definite matrix. Although our inferential procedures are valid for any choice of \( V \), the choice of \( V \) can influence the mean square error of the estimator, and we used the program developed by Abadie et al., to calculate \( V \) [49]. Thus, the energy intensity of the synthetic region is similar to the energy intensity trajectory of the enclave adjustment region before the policy is implemented. The energy intensity of the composite region obtained by weighting is a simulation of the energy intensity of the enclave adjustment region assuming that the policy is not implemented. The gap of energy intensity between the policy implementation regions and the synthetic regions is the impact of the enclave adjustment on the regional energy intensity.

Compared with DID method, synthetic control method can more objectively and accurately estimate the impact of enclave adjustment on urban energy intensity, especially the DID method is subjective and arbitrary in the selection of control groups. The systematic difference between the treatment group and the control group may be caused by the enclave adjustment policy implemented of the control group, there is no sufficient reason to exclude the endogeneity of the policy. If DID method is directly used for estimation,
biased results will be obtained [50]. The synthetic control method can overcome the shortcomings of the above two methods, it constructs a reference object that is completely similar to treatment group by weighting multiple reference objects. Its advantages are as follows: (1) It extends the traditional DID model and it is a non-parametric method; (2) Weights are determined by data driving, which reduce the error caused by subjective judgment and avoid the policy endogenous problems; (3) It can clearly reflect the contribution of each reference object to the counterfactual event by weighting multiple reference objects to simulate the situation before the implementation of the processing object policy.

Compared with the regression model, the synthetic control method has the advantages of transparency and avoiding excessive extrapolation. Because the control group synthesized is a weighted average of all control groups, it clearly points out the contribution of each control group in constructing a counterfactual state. This method can also clearly show the degree of similarity between the experimental areas and comparison areas synthesized by the synthetic control method before the policy is implemented, avoiding the error caused by comparing the areas with large differences [51]. The choice of weight is restricted to a positive number and the sum of all weights is equal to 1, which also avoids excessive extrapolation judgment.

4.2. Data Source and Sample Selection

As a public policy, the synthetic control method requires that the socio-economic characteristics of the control group cities are as similar as possible to those of Wuhan. The National Plan of China designates 35 cities as key cities, including Wuhan, comprising four municipalities, 26 provincial capitals, and five sub-provincial cities. These are the most important cities for China’s economic growth and infrastructure development, such as Wuhan, with similar administrative rank. Furthermore, they are regarded as cities that reflect popular lifestyles and consumption patterns, in addition to new technologies and policies. Therefore, these cities have also taken the lead in implementing key policies and measures for urban energy consumption [52]. In order to exclude the impact of other types of administrative boundary adjustment on the estimation results, we selected the 22 cities (of the total of 35) that had not implemented administrative boundary adjustments (including not implementing enclave adjustments) as the control group during 2005–2014, these are Tianjin, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Dalian, Changchun, Hangzhou, Ningbo, Fuzhou, Xiamen, Nanchang, Jinan, Zhengzhou, Shenzhen, Nanning, Haikou, Chengdu, Xi’an, Lanzhou, Xining, and Yinchuan. The empirical goal was to use the weighted average of these cities to simulate Wuhan’s energy intensity in a scenario in which enclave adjustment was not implemented, and then compare the result with Wuhan’s actual energy intensity in which enclave adjustment was implemented. This comparison represents the impact of enclave adjustment on Wuhan’s energy intensity.

Because the Chinese government uses the energy intensity indicator as a binding indicator in its Five-Year Plan (FYP), which is the ratio of energy consumption to GDP, we used the same indicator to measure changes of urban energy intensity. The biggest difficulty in the research on energy intensity of Chinese cities is the lack of direct statistical data on urban energy consumption. Although Dhakal (2009) and Liang and Zhang (2009) proposed indirect estimation of China’s urban energy consumption [52,53], we used the method of Li et al., to measure urban energy consumption [54]. This was because the research hypotheses used in the indirect methods were not consistent with the current paper. Specifically, Chinese statistics data only makes urban electricity, gas, and liquefied petroleum gas (LPG) consumption available. Taking into account different city levels, we assumed that the sum of urban electricity, gas, and LPG consumption accounting for the total urban energy consumption is equal to that of the provincial level. First, we calculated the sum of provincial electricity, gas, and LPG consumption, accounting for the total provincial energy consumption, and used the results as a “conversion factor”. Second, we divided the sum of urban electricity, natural gas, and LPG by this conversion factor to obtain urban energy consumption.
We used panel data in the period of 2005–2014 to analyze the impact of enclave adjustment on urban energy intensity, and data were taken from the China City Statistical Yearbook (2006–2015) and Chinese Urban Construction Statistical Yearbook (2006–2015). Provincial energy consumption data were mainly taken from the China Energy Statistical Yearbook (2006–2015) and China Statistical Yearbook (2006–2015). All energy consumption values were uniformly converted into 10,000 tons of coal equivalent (tce), based on the conversion factor from the Chinese Energy Statistical Yearbook. The GDP data were real gross domestic product and taken from the China City Statistical Yearbook (2006–2015).

5. Results

5.1. Impacts of Enclave Adjustment on Urban Energy Intensity

According to the synthetic control method, we chose the weights in such a way that the important impact variables on energy intensity were as consistent as possible between synthetic Wuhan and real Wuhan before the enclave adjustment. Based on previous research results [55–57], we selected predictor variables including resource endowment, industrial structure, government power, science and technology development, energy price, and level of opening-up. Table 1 compares the important predictor variables between synthetic Wuhan and real Wuhan before the enclave adjustment. The data show that synthetic Wuhan and real Wuhan are similar, that is, the differences between variables are minor.

In summary, it can be seen from the comparison of the indicators in the table that synthetic Wuhan has a better fit with real Wuhan before the enclave adjustment. Table 2 shows the weights of each control group during the construction of synthetic Wuhan: cities with the largest weights are Chengdu (0.347), followed by Tianjin (0.202), Xining (0.174), Shijiazhuang (0.125), Haikou (0.117), and Xiamen (0.036). The characteristics of Chengdu and Tianjin are most similar to those of Wuhan.

Table 1. Comparison of predictive variables.

| Variables                        | Treated | Synthetic |
|----------------------------------|---------|-----------|
| Resource endowment              | 0.0004  | 0.0083    |
| Industrial structure             | 1.2615  | 1.1419    |
| Logarithm of government power    | −2.1221 | −2.1479   |
| Logarithm of Science and technology development | −3.2967 | −3.2995   |
| Energy price                     | 107.342 | 108.524   |
| Level of opening-up              | 0.0704  | 0.0704    |

Note: Resource endowment = the ratio of urban mining industry employees to total employed persons; Industrial structure = the ratio of urban industrial output value to GDP; Government power = the ratio of urban fiscal expenditure to GDP; Science & technology development = the ratio of urban scientific research and technical service employees to total employed persons; Energy price = provincial price index of fuel and power; Level of opening-up = the ratio of urban foreign investment to GDP.

Table 2. Weight of original control group.

| City             | Weight |
|------------------|--------|
| Tianjin          | 0.202  |
| Shijiazhuang     | 0.125  |
| Xining           | 0.174  |
| Chengdu          | 0.347  |
| Xiamen           | 0.036  |
| Haikou           | 0.117  |

We used the 22 cities noted above as the control group to simulate Wuhan’s energy intensity subject to enclave adjustment. Figure 4 shows the logarithmic path of the energy
intensity of Wuhan and synthetic Wuhan. The two paths almost completely coincided before 2009, which indicates that synthetic Wuhan perfectly replicated the energy intensity path of Wuhan before the enclave adjustment. Although the logarithm of the energy intensity of synthetic Wuhan in 2009 was slightly higher than that of the real Wuhan, the gap was not significant. Subsequent to 2009, the logarithm of real Wuhan’s energy intensity began to be significantly lower than that of synthetic Wuhan, indicating the logarithm path of energy intensity appears differently between real Wuhan and synthetic Wuhan. In particular, the logarithm of energy intensity of real Wuhan dropped precipitously in 2011, and the difference between the two increased significantly. Although the gap decreased slightly in 2013, the difference was still significant. Does the gap between the two lines mean that the enclave adjustment has profoundly changed Wuhan’s energy intensity?

![Figure 4. Energy Intensity of Wuhan and synthetic Wuhan.](image)

In order to understand the impact of enclave adjustment in Wuhan on its energy intensity more intuitively, we calculated the logarithmic gap between actual Wuhan and synthetic Wuhan around 2009. Figure 5 shows that the difference between the two values fluctuated around 0 before the adjustment: the largest difference was in 2008 but the value is only 0.018. The difference remained negative and tended to increase after 2009: the logarithmic energy intensity of the real Wuhan was −0.0005, −0.011, −0.166, −0.178, −0.152, and −0.195, and these values are lower than those of synthetic Wuhan during 2009–2014. If calculated as a ratio, the logarithmic energy intensity of synthetic Wuhan decreased by an average of 0.101%, compared to 0.807% for real Wuhan, between 2009 and 2014, which is 0.706 percentage points higher than that of synthetic Wuhan. This gap is hard to ignore and shows that the enclave adjustment in Wuhan profoundly changed its energy intensity, indicating that this change was able to achieve rapid results.
Figure 5. Logarithmic gap of energy intensity between Wuhan and synthetic Wuhan.

5.2. Robustness Test

Although the results obtained through the synthetic control method showed that Wuhan’s enclave adjustment in 2009 significantly changed the trajectory of Wuhan’s energy intensity, we cannot be sure that the constructed synthetic control group can fully replicate the potential evolution path of the treatment group. One possible source of estimation bias is that the effect of the enclave adjustment we estimated is not due to the implementation of the policy and was caused by other accidental factors. In order to test the reliability of the results, the placebo test method of Abadie et al., was used to further test the robustness of the results and is similar to the test method of the falsification test [49].

5.2.1. Placebo Test

The placebo test is usually called the counterfactual test. There are two frequently used methods to construct the placebo test: the first is the time placebo test. The actual implementation time of the enclave adjustment was pushed forward from 2009 to 2007 according to the time placebo test proposed by Abadie et al. [10]. It was assumed that the implementation time was 2007 and the effect was tested using the synthetic control method. The result (Figure 6) shows that there was no significant difference between the energy intensity of real Wuhan and synthetic Wuhan around 2007, indicating that it did not result in any policy effects even if the policy is advanced to 2007. This shows that it can be good proof of the policy effects caused by the enclave adjustment to Wuhan.
Figure 6. Time placebo test.

The other placebo test is the regional placebo test. The basic idea of the method is to select a city that, like Wuhan, did not implement enclave adjustment during the sample period. Assuming the city implemented the policy in 2009, the effects of the policy implementation from 2009 to 2014 were assessed with the synthetic control method, and the policy effects in the hypothetical city were compared with those in Wuhan. No significant difference exists in the logarithm of energy intensity before and after the policy implementation in the hypothetical city, which indicates that the results are not accidental; rather, they are highly predictive and further confirm the effect of the policy implementation in Wuhan. In this study, the two cities with the largest composite weights (Chengdu and Tianjin) were selected as the treatment group, and the remaining cities (except Wuhan) were placed in the control group. Figure 7 shows that the fitting effect is better between real Chengdu and synthetic Chengdu during 2005–2008. Synthetic Chengdu has slightly higher logarithmic value of energy intensity than real Chengdu in 2009, whereas the logarithmic value of energy intensity of real Chengdu in 2010 was slightly higher than that of synthetic Chengdu, and the two then coincided again. Although the energy intensity of real Chengdu was again higher than that of synthetic Chengdu in 2014, the gap between the two lines is relatively small. The placebo test results of Tianjin (Figure 8) show that, although the logarithmic values of energy intensity between real Tianjin and synthetic Tianjin fluctuated slightly around 2009, the trends of the two lines are consistent and there is no significant difference. Based on the above analysis, we believe that the change trends of energy intensity in Chengdu and Tianjin are relatively stable and will not affect the results we obtained above.
Figure 7. Energy intensity of Chengdu and synthetic Chengdu.

Figure 8. Energy intensity of Tianjin and synthetic Tianjin.

5.2.2. Permutation Test

According to Su and Hu, the following robustness test can be performed on the policy implementation city unless the synthetic control object fits well with the policy implementation city in the early stage of policy implementation [50]. In order to confirm the validity of the empirical results, it was verified that the difference in the predictive variables was indeed due to the impact of the enclave adjustment rather than some other unobserved external factors, and the estimated policy effect was statistically significant. Abadie et al., proposed a permutation test that can be used to judge the probability that other cities exist...
with the same situation as that of Wuhan [49]. The idea of the test is to assume that all cities in the control group began the enclave adjustment in 2009, construct the synthetic control objects of the corresponding cities, and estimate the policy effects under hypothetical conditions. Then, the effectiveness of policy implementation in Wuhan with control group cities under the assumption is compared. If the gap of the policy effects is large enough, then there is reason to believe that the policy effect of enclave adjustment is significant. This method requires a good fitting effect for the city’s synthetic control objects before the implementation of the policy. The root mean square prediction error (RMSPE, a measure of the degree of fit between a city and its synthetic control objects, as detailed in Abadie et al. [49]) value is relatively large if a city’s fitting effect before 2009 is not satisfactory, and even a large difference of predictive variables obtained at the latter stage of the policy cannot reflect the effect of the policy. Therefore, the permutation test of the city will not be analyzed when the fitting effect of a city’s synthetic control objects before the implementation of the policy is not good. This is because, if the synthetic control object fails to fit the value of the predictive variable before the enclave adjustment, the difference of the predictive variable finally obtained is likely to be caused by the poor fitting effect and does not reflect the enclave adjustment. Similarly, the display of the difference of predictive variables will also be removed if the fitting effect of the control group before 2009 is not good.

Figure 9 shows the results of the permutation test. Cities in the control groups whose RMSPE value exceeded 1.5 times that of Wuhan before 2009 were excluded from the 22 cities, and 15 cities remained in the control group. It can be seen that the difference of energy intensity change between Wuhan and other cities was not large before 2009, and the gap began to widen, and its distribution was located outside that of other cities after 2009. This shows that the enclave adjustment reduced Wuhan’s energy intensity, and also indicates that it is only 1/16, that is, there is a 6.25% probability of such a large difference of logarithm of energy intensity between Wuhan and synthetic Wuhan. It can also be considered that Wuhan’s energy intensity reduction effect is at the level of 10% significance. Using the above robustness test, we found that the impact of the enclave adjustment on the urban energy intensity in all tests was consistent with the original conclusion. That is, the enclave adjustment can significantly reduce urban energy intensity, and this reduction effect is statistically significant and persistent in time.
Figure 9. Difference distribution of energy intensity among cities Note: The solid line represents Wuhan, and the dotted line represents the city whose RMSPE value is 1.5 times lower than Wuhan.

6. Discussion

The enclave adjustments are a substantive package of decentralization by the provincial and city governments, that is, the district governments that have undergone enclave adjustments face different administrative and financial powers, and relevant local officials also face new political incentives. First, the district governments have gained more administrative power after the adjustment and can implement more effective energy-saving and consumption-reduction management. For example, 37 high-energy enterprises, such as Wuhan Iron and Steel Company, can be managed in a unified way through the adjustment of enclaves. Due to the earlier unclear management body, the management of energy conservation and consumption reduction of these enterprises was previously uncoordinated. Following the incorporation into the district’s unified working arrangements, this progressively optimized administrative model has also enhanced the city’s overall energy-saving and consumption-reduction capabilities. Second, the enclave adjustments represent the strengthening of the functional power of the local officials involved, who are more motivated to achieve further political promotion through energy conservation and consumption reduction. This view is consistent with Zheng et al., who empirically found that local officials respond to political incentives in favor of energy conservation and emission reduction in their jurisdiction [58]. It is important to emphasize that the enclave adjustment is intended to rationalize the geographical area of each municipal district through the adjustment of administrative boundaries by aligning the administrative management relationship between the various urban areas, carrying out economic coordination, and promoting urban development. This is parallel to the assessment method of the district government to reduce energy intensity; that is, the district government has no incentive to deliberately reduce energy intensity in the implementation of the enclave adjustment policy. In addition, the energy-saving and consumption-reduction figures reported by each district government after the adjustment also need to be reviewed by the municipal government, thereby preventing the possibility of fabricating data. Finally, the
Wuhan municipal government explicitly ordered district governments not to rush to promote cadres before starting the enclave adjustment. It also eliminated the possibility of some officials seeking promotion opportunities, who can deliberately remove high-energy-consuming enterprises or projects from their areas to achieve the binding indicators for energy intensity.

The adjustment facilitates the efficient flow of economic production factors between regions and helps to form a coordinated and well-connected urban network. Rehousing the over-concentrated population in the original areas and changing the land use pattern can disperse part of a region’s functions to other areas and optimize the allocation of resources in a larger space. This alleviates the agglomeration diseconomy caused by excessive expansion, not only improving production, living, and ecological conditions, but also reducing the waste of resources and pollution emissions, ultimately contributing to energy conservation and consumption reduction.

This process can achieve economies of scale through the enclave adjustments, in turn affecting the spatial agglomeration of production factors, which can promote energy-saving and consumption-reduction technological innovation and knowledge spillover. In addition, the industrial concentration and the rational allocation of production factors in industrial sectors resulting from adjustments can effectively promote the intensive use of resources. This phenomenon strengthens regional specialized production, which is accompanied by spatial agglomeration or geographical proximity. The formation of regional integration reduces various distortions caused by administrative barriers, for example, the oil-to-gas conversion projects in some streets are easier to implement smoothly than in the past. The adjustment not only promotes the implementation of energy-saving investment projects, but also promotes the optimal allocation of resources, which in turn expands the scope of the city and enhances the driving force of urban development, thus providing the power and conditions for improving the overall energy saving and consumption reduction of the city.

In summary, enclave areas that were not previously part of a jurisdiction can be integrated into the unified energy-saving management of district governments after enclave adjustment. These enclave areas receive help and support from affiliated district governments in terms of industrial restructuring and other energy conservation policies.

7. Conclusions

Promoting new types of urbanization and energy conservation have become two main themes in the green transformation and development in China. Due to the needs of rapid urban development, enclave adjustment in municipal districts has become a national phenomenon in recent decades. Urban districts are inspected and required to annually report on the implementation performance of energy conservation and consumption reduction to the city government, due to the decomposition of the binding indicators proposed in the Five-Year Plan. However, the impact of such an adjustment on urban energy intensity is rarely discussed, and the effect of the enclave adjustment on the change of urban energy intensity remains an important theoretical and empirical issue. Using the case of Wuhan’s enclave adjustment in 2009, we empirically analyzed the impact of enclave adjustment on urban energy intensity for the first time and obtained the following key findings.

Overall, the logarithmic energy intensity paths of real Wuhan and synthetic Wuhan diverged significantly after 2009, and Wuhan’s enclave adjustment profoundly changed the energy intensity trajectory of the city. The effect of the enclave adjustment on the urban energy intensity had a time dimension, indicating that it did not significantly reduce the urban energy intensity in the short term but had a significant impact in the long term. The enclave adjustment of Wuhan achieved initial results in reducing the energy intensity in 2010, and this effect became more significant in 2011. Although the effect slowed slightly in 2013, it was nonetheless obvious and continued to expand. It can be seen that the role of enclave adjustment on the change of urban energy intensity is a long-term process that
enhances the influence scope of the district government’s administrative power and its ability to allocate resources through decentralization, in addition to the ability of each administrative region to coordinate urban planning, energy efficiency, and environmental protection. These are the important channels for achieving positive adjustment effects with incentivizing officials, increasing the agglomeration level, and forming regional integration. In addition, the overall administrative management ability of Wuhan continues to improve, the division definition of municipal districts is clarified, and the integration between the city and the countryside is further enhanced. Wuhan has the ability to drive the full exercise of local government authority within its jurisdiction, thus effectively contributing to the reduction of urban energy intensity.

8. Policy Implications

The above findings have resulted in a number of insights. The empirical study shows that enclave adjustments provide a smoother way of implementing policies that are the underlying reason for decreasing energy intensity. This finding can serve as an important reference for municipal governments at the same economic and administrative level as Wuhan to better implement policies of enclave adjustment. The policies of enclave adjustment are used to actively promote the reduction of urban energy intensity, thus helping to accomplish the task of energy saving and consumption reduction.

Regions inevitably require time to implement the necessary adjustments to achieve their intended goals, although enclave adjustments can reduce the urban energy intensity. In order to shorten the time required and effectively achieve the energy intensity reduction effect of the enclave adjustment, a top-down approach should be adopted in the enclave adjustment. The goal of higher levels of government is closer to the maximization of the overall benefit, and zoning management is rationalized by changing the competition pattern and the scope of authority of the relevant local governments. Thus, each district government can more effectively accomplish its own energy-saving and consumption-reduction tasks. City governments should play a key role in coordinating all relevant aspects of the process to reduce the cost of friction between various agencies and different levels of government. It is also worth noting that the natural and cultural environments of each city are very different, and the existing economic and urbanization levels are unbalanced. Thus, the adjustment of enclaves should follow the principle of adaptation to local conditions. The implementation of “one size fits all” policies for merging territories is not optimal for enclave adjustment. Before implementing the policy of enclave adjustment, detailed field surveys and theoretical analyses must be conducted, and a comprehensive plan suitable to local conditions must be developed to provide guidance for the adjusted integration.

The agglomeration economic effect should also be used via the adjustment to promote technological innovation and knowledge spillover, in addition to the rational allocation of production factors in the industrial sector. This can also reduce the various distortions of administrative barriers through the formation of regional integration. In the case of Wuhan, the government should begin to formulate supporting policies and development plans when proposing an enclave adjustment policy. It is necessary to improve the related policy of enclave adjustment to fully utilize an enclave-type economic cooperation model and adopt supporting measures focused on the promotion of the rational flow of factors, strengthening the coordinated development among districts, alleviating the diseconomies of agglomeration, and reducing the waste of resources. This will not only improve policy efficiency and facilitate the integration process between enclaves and districts, but also contribute to the reduction of the urban energy intensity.

Finally, the government should fully assess the potential impact of such policies based on the accomplishment of the energy conservation and consumption reduction task before implementing any enclave adjustment policy. The adjustment of enclaves is beneficial to urban management and economic coordination, but also detrimental to the unique social and economic functions of enclaves. Thus, the government should try to mitigate
the negative effects of such policies. Even if the energy intensity reduction effect can be achieved, the policy still requires modifications and new complementary policies to achieve higher goals and more reasonable target programs. The government should avoid implementing fragmented policies and increase its efforts to promote synergy among various policies. A series of support policies and opportunities for experimentation should be implemented by higher levels of government, and these policies and opportunities should be granted and used appropriately by local governments with a long-term perspective and a holistic view.

It should be noted that the effectiveness of such an enclave adjustment is established in the context of China’s specific political and economic system. For countries undergoing administrative boundary adjustment via a bottom-up approach, implementing similar measures might face significant resistance because this process largely relies on administrative intervention. In this case, enclave adjustment via a more bottom-up approach, such as passing a referendum, might be preferred.

The shortcomings of this study are that our sample only extends to 2014, and a study of the long-term effects of enclave adjustment on energy intensity is still necessary. In addition, more detailed urban district data is required to determine the proportion of the decreased energy intensity that is attributable to the enclave adjustment. Enclave adjustment is only one type of municipal adjustment, and the impact of other types of municipal adjustment (e.g., county-to-district reforms) on energy intensity is a topic that deserves further study. Because it takes time for government policies to be formulated and implemented, the energy-saving effects of enclave adjustment through decentralization, official incentives, and regional integration are delayed. Systematically quantifying the influence mechanisms will be an important part of our future work. Due to the above factors, the impact of enclave adjustments on urban energy intensity is complex and should be thoroughly demonstrated and carefully implemented.

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**Abbreviations**

| Abbreviation | Description                  |
|--------------|------------------------------|
| CO₂          | Carbon Dioxide               |
| CPC          | Communist Party of China    |
| DID          | Difference-in-Difference     |
| EEE          | Energy Ecological Efficiency |
| FYP          | Five-Year-Plan               |
| GDP          | Gross Domestic Product       |
| GRP          | Gross Regional Product       |
| LPG          | Liquefied Petroleum Gas      |
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PM$_{2.5}$ Particulate Matter less than 2.5 Micrometers in Diameter
RMSPE Root Mean Square Prediction Error
TFEE Total Factor Energy Efficiency

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