Does Regional Development Policy Promote Industrial Structure Upgrading? Evidence from the Yangtze River Delta in China

Weimin Zhang, Wangrong Ma * and Qiwei Chen

School of Public Administration, Central China Normal University, Wuhan 430079, China; zhangweimin@mails.ccnu.edu.cn (W.Z.); albertchan@mails.ccnu.edu.cn (Q.C.)
*Correspondence: ma675848048@mails.ccnu.edu.cn; Tel.: +86-188-7329-2155

Abstract: The “Regional Development Plan of the Yangtze River Delta (YRD),” or the “YRD Development Policy”, is a national policy of China aimed at promoting industrial structure upgrading and the high-quality development of the regional economy in the YRD. To test the implementation effect of this policy, this work applied the synthetic control method (SCM) to explore the impact of the YRD Development Policy on industrial structure upgrading in the YRD based on 15-year panel data of 30 provinces in mainland China. The results showed that, as a whole, the implementation of the YRD Development Policy has contributed to industrial structure upgrading in the YRD. The trend of industrial structure upgrading is more rapid in the original YRD than in the new YRD. From a local perspective, the YRD Development Policy has hindered the upgrading of the industrial structure in Anhui Province but promoted upgrading in the rest of the YRD. From a long-term perspective, the effectiveness of the YRD Development Policy is limited, presenting a clear N-shaped development trend. In terms of industrial structure changes, the impact of the YRD Development Policy on the three types of industries in the YRD shows obvious regional differences. Furthermore, economic development, urbanization, and technology innovation have a significant and positive impact on the industrial structure upgrading of the YRD. These findings have policy-making implications, enrich the research on the impact of the YRD Development Policy on industrial structure upgrading, and provide empirical reference for subsequent policy improvements.

Keywords: Yangtze River Delta; regional policy; industrial structure upgrading; synthetic control method; difference-in-differences

1. Introduction

In the 21st century, China has experienced unprecedented economic growth and dramatic changes in its industrial structure, while China’s extensive economic development mode has brought high costs that cannot be ignored [1]. According to the most recent data from China’s National Bureau of Statistics in 2021, the share of three industries’ added value in GDP changed from 15.1%, 45.9%, and 39.0% in 2000 to 7.7%, 37.8%, and 54.5% in the present. Although the proportion of the tertiary industry has surpassed that of the secondary industry and increased approximately 14.5% in 20 years, there is still much potential for optimizing China’s industrial structure when compared with the case of developed countries. In essence, upgrading the industrial structure can broaden the space for economic growth and drive high-quality economic development [2]. How to effectively achieve the optimization, upgrading, and coordinated development of the industrial structure is one of the most pressing challenges that needs to be addressed in the current process of China’s economic development [3].

To achieve industrial structure upgrading and high-quality economic development, the Chinese government has creatively put forward a series of regional development
policies, including the well-known YRD Development Policy proposed in 2010. A crucial aspect of the YRD Development Policy is to take advantage of industrial synergies and technological innovation [4]. Previously, local governments chose to build trade barriers between administrative areas to protect local industries and promote the local economy [5]. The primary concern in establishing regional cooperation, then, is to address the barriers created by administrative powers, remove local protectionist barriers, and deepen regional interdependence [6]. The policy mentions that the YRD region needs to accelerate the cultivation of a great quantity of future industries and advanced enterprises with international competitiveness to promote the upgrading and transformation of traditional industries. Not only can it promote closer regional development, but it also provides valuable opportunities for the YRD to better participate in international competition.

The YRD is one of the regions with the most dynamic economic development, the highest degree of openness, and the strongest innovation capacity in China. It is located on the eastern coast of China and now consists mainly of the four provinces of Shanghai, Jiangsu, Zhejiang, and Anhui. The area of the YRD region is 358,000 square kilometers, accounting for approximately 3.7% of China’s land area. The specific geographical distribution of the YRD in China is shown in Figure 1. As the largest economic circle in mainland China, the economic volume of the YRD accounted for 24.1% of China’s GDP in 2020 [7]. The proportion of added value of the three industries in the YRD has also changed from 5.8:48.5:45.7 in 2010 to 4.1:38.3:57.6 at present. Since the implementation of the YRD Development Policy, the proportion of primary and secondary industries in the YRD has decreased by 1.7% and 10.2%, respectively, while the proportion of the tertiary industry has increased by 11.9%. This shows that the overall strength of the tertiary industry in the YRD has been greatly enhanced. This phenomenon leads to an important question: whether the YRD Development Policy plays an effective role in promoting the upgrading of the industrial structure in the YRD. As such, an in-depth evaluation of the effectiveness of the YRD Development Policy on industrial structure upgrading in this region is of great practical significance.

Figure 1. Geographic distribution of the YRD in China.

Industrial structure upgrading refers to the transformation of the economic growth model from a production function to a service and consumption function. Previous
research confirmed that different dimensions of influencing factors, including urbanization, technology innovation, trade openness, infrastructure condition, and various types of macro policies, can affect the upgrading of the industrial structure. In terms of the impact of national policies, previous research has mainly focused on environmental policies, such as emission standards, energy prices, and licensing transactions, on the upgrading of industrial structures. However, few have paid attention to the potential impacts of regional development policies on the upgrading of the industrial structure. This work concentrated on the impact of the YRD Development Policy on industrial structure upgrading. Thus, it is particularly important to select an appropriate policy evaluation method to assess the impact effects of the policy.

Compared with the “black box” operation of traditional measurement, the results of research using the SCM are more credible and reliable. The SCM was first proposed by Abadie in 2003 and was first used in 2014 to evaluate economic benefits [8]. This approach with counterfactual characteristics provides strong evidence for the empirical results. As a powerful policy evaluation tool, the SCM prevents the averaging of experimental results and the excessive extrapolation of policy outcomes by researchers. The method also precludes the randomness of subjective selection of control groups by the researchers. Based on the above, for this work, we chose to apply the SCM to deeply explore the question of whether the YRD Development Policy can be an effective tool to promote the upgrading of the YRD industrial structure.

Specifically, we divided the YRD into three experimental groups, namely, the original YRD (Shanghai, Zhejiang, and Jiangsu), the new YRD (Shanghai, Zhejiang, Jiangsu, and Anhui), and the newly added Anhui Province. Then, the study was carried out in the following aspects. First, based on 15-year panel data of 30 provinces in mainland China, we adopted the SCM to construct a synthetic control group with counterfactual characteristics for the YRD. Moreover, we compared the differences in industrial structure upgrading between the synthetic YRD and the real YRD. Second, we used the DID method to verify the impact of industrial structure upgrading and further explore the regional differences in policy effects. In addition, we clarified which factors are more effective in industrial structure upgrading through a series of predictor variables. Finally, we proposed targeted improvement recommendations inspired by the study results. This study is of great practical significance. More importantly, it also may bring about policy value for the formulation of emission reduction policies in the YRD and, thus, could provide scientific support for policy makers to promote regional coordinated development.

2. Review of the Literature

In an increasingly globalized economy, regions with an advantageous geographical location and central government policy support tend to be more competitive [9]. Currently, along with the increasing overlap between individual and regional interests, the relationship between local governments is evolving from competition to cooperation [10]. Regional cooperation has become an institutional solution for cities and regions addressing regional issues, providing an opportunity to overcome the negative effects of political fragmentation in regional and megacity development [11].

Numerous studies have emphasized the role of local governments endowed with financial autonomy in promoting economic and social development. Previous empirical evidence indicated that local governments are better able to promote local economic growth by taking on more public service delivery functions [12,13]. Tiebout (1956) and Brennan (1980) stated that financial autonomy, as an intense and constraining instrument, is not only effective in restraining the self-interested behavior of local governments, but also helps to improve the efficiency of public service provision [14,15]. Knight (2014) similarly emphasized that the incentives and commitment mechanisms created by financial autonomy can lead local governments to better promote the marketization process and, thus, economic development [16]. However, an excessive emphasis on the
benefits of financial autonomy can overlook its own negative effects. Chapman (1999) and Barbera et al. (2017) argued that financial autonomy may lead to the increased vulnerability of local governments to local interest groups, resulting in policy bias and macro-economic volatility [17,18]. Beeri and Navot (2013) also pointed out that financial autonomy can lead to more local government corruption and loss of efficiency when competition between local governments is weak [19]. What is more, excessive financial autonomy can drive local governments with poorer resource endowments to adopt more predatory policies, and appropriate financial competition and regional alliances can be an effective means of constraining local government behavior [20,21].

Given the potential benefits of cooperation, McCarthy (2003) suggests that more effective cooperation between local governments has implications not only for the prosperity of cities and regions but also for their national economies [22]. The European Union (EU), one of the most successful regional association organizations in the world today, has certain similar characteristics to the YRD region of China. Specifically, the interaction of such regional alliances needs to be centered around economic factors [23]. Many previous studies have discussed the effects of EU cooperation. For example, Herok and Lotze (2000) point out that the welfare gains and economic gains of the EU come from the creation of trade between EU member states [24]. Murphy (2006) found that the EU can have a positive impact on the macroeconomy [25]. Baas and Brucker (2010) further argued that the enlargement of the EU did contribute to real GDP growth and higher employment levels in both the German and British economies [26]. Additionally, 46% of Europeans believed that the enlargement of the EU had increased prosperity for all Europeans and saw the regional union as an engine of peace and stability [27]. However, some scholars realized that the enlargement of the EU had made it increasingly clumsy and bureaucratic [28,29]. They argued that the enlargement of the European Union will benefit only the new member states [30]. For example, Halkos and Tzeremes (2009) conducted a study on the impact of a European economic and monetary union and showed that the new EU member states gained more benefits [31]. Richard et al. (1997) examined the prospects and problems of the European Union and found that there were significant differences in the level of economic development between Eastern European countries and the existing EU member states [32]. Nahuis (2004) contended that this asymmetry would lead to industrial restructuring and political unrest in the EU member states [33]. Alt et al. (2014) indicated that the joint development of fiscal rules at national and EU levels without policy monitoring could lead to further economic inequalities between EU member states [34]. In addition to the practice of the EU, there are cases of international economic integration cooperation, such as the Economic Association of Southeast Asian Nations and the North American Free Trade Area, that have had a very important impact on the economic development of the member countries.

Previously, the US government developed the Appalachian region in a fruitful manner. The region’s economy has been improved by restructuring industries and improving infrastructure [35]. In China, there are similar regional cooperation development policies formulated to promote regional economic development, such as the Beijing–Tianjin–Hebei collaborative development, Pearl River Delta integration, and Yangtze River Economic Belt. According to Fang et al. (2018), although collaborative development within the Beijing–Tianjin–Hebei region has tended to slow down over time, some progress has been made in promoting urbanization, building transportation networks, protecting the environment, and improving living standards [36]. Hou and Li (2011) suggested that the integration of the Pearl River Delta has facilitated intra-regional trade and investment and promoted the free flow of capital, goods, and services [37]. Peng et al. (2021) stated that the Yangtze River Economic Belt development policy has contributed to the region’s healthy economic development and a significant increase in comprehensive transport capacity and openness to the outside world [38]. However, Deng et al. (2022) pointed out that the Yangtze River Economic Zone is now facing major challenges due to social conflicts, a large population but a lack of resources, and uneven
The upgrading of the industrial structure, another important aspect of economic development, can bring about significant physical improvements and rapid economic growth for regional development [40]. It is also one of the key variables that will directly determine the success of the country’s economic transformation and upgrading [41]. Previous studies showed that different dimensions of influencing factors can affect the upgrading of industrial structures. Tamazian et al. (2009) and Turok (2013) considered financial development as an essential process for economic development, not only for technological progress but also as a positive influence in the upgrading of industrial structures [42,43]. Some scholars have concluded that there is a strong relationship between the level of urbanization and the upgrading of industrial structure. For example, Turok and McGranahan (2013) explored the relationship between the level of urbanization and economic development in two regions, Asia and Africa, and found a strong positive correlation between industrial structure and urbanization [44]. While the removal of barriers to urban–rural mobility in cities may boost economic growth, over-concentrated levels of urbanization may constrain the development of certain industries [45]. Some scholars have discussed the impact of information technology on the upgrading of industrial structures. For example, information technology is becoming increasingly important to different industries, and a well-developed information infrastructure can meet the specific needs of industrial structural upgrading [46]. In contrast, Carlsson (2012) argued that not all industries affected by information technology are conducive to increasing productivity and upgrading the industrial structure [47]. In addition, several other studies showed that international trade, social demand, and policy changes may have a significant impact on industrial structural upgrading [48–50].

Recently, the Chinese government has been active in proposing a series of public policies to promote industrial restructuring and upgrading. Kenderdine (2017) pointed out that China’s transition economy experiment relies heavily on state-driven industrial policies to structure the economy [51]. It has also been argued that an inadequate and incoherent definition and implementation of public policy may lead to limited upgrading of industrial structures [52]. Many scholars have provided evidence for the potential role of some of the policies implemented in China in the upgrading of industrial structures. For example, Zhang and Wen (2008) found that environmental regulation policies can influence industrial development and have a long-term contribution to industrial structural upgrading. When the level of economic development is high, the impact of environmental regulation policies on industrial structural upgrading is stronger [53]. Several studies have reported on the impact of industrial and fiscal policies. Zhuo et al. (2021) and Ma et al. (2021) found that the establishment of free trade zones is not only an important channel for the optimization and upgrading of regional industrial structure, but also a core element among many factors that influence the optimization and upgrading of industrial structure [54,55]. Song et al. (2020) and Sun et al. (2020) revealed that regional tax incentives can accumulate a large number of production factors in the short term and play a more important role in promoting the upgrading of industrial structure and the level of openness to the outside world [56,57]. Other scholars have noted that low-carbon city construction can promote industrial upgrading through technological innovation and reducing the share of high-carbon industries [58,59]. The above studies concentrated on exploring the impact of a specific policy or measure on changes in industrial structure. However, few empirical studies have systematically verified the potential impacts of regional development policies on the upgrading of the industrial structure, especially in a major national development area such as the YRD. In this paper, we intend to incorporate the YRD Development Policy into the analysis of this issue.
It is undeniable that public policy is an effective strategy developed by governments to address public problems. Although previous research into the effects of macro policies on the upgrading of China's industrial structure provided us with valuable information, some deficiencies still exist. First, many studies have focused on the time series of industrial structure changes rather than on their relative long-term stability and effectiveness. Second, previous studies paid more attention to changes in individual regions in the absence of a control group, leading to overly biased findings. In addition, when measuring industrial structure upgrading, although researchers have chosen different measurement methods, they still essentially measure industrial structure advancement [1]. Therefore, in a comprehensive comparison, this work measured industrial structure upgrading by using the industrial structure hierarchy coefficient, an index called ISA [60].

Policy evaluation is an important part of examining the effectiveness of policies. First, because random control groups are constructed by data-driven creation, it can reduce the error in subjective judgment and prevent the arbitrariness of the researcher’s subjective selection of control groups [8]. Second, a data-driven approach to determine the optimal weights of control groups offers a clear view of the contribution of control objects to counterfactual events. Third, it prevents the averaging evaluation of experimental results and excessive extrapolation of policies [61]. This work applied the YRD Development Policy as a policy shock event to fill the research gap on the impact of regional development policies on industrial structure upgrading. More importantly, this paper provides a reference for subsequent policy improvement and adjustment, which have very important policy value and practical significance.

3. Materials and Methods

3.1. Synthetic Control Method

This work systematically assessed the impact of the YRD Development Policy on industrial structure upgrading based on the SCM proposed by Abadie [8]. As an effective method for identifying policy effects, the core idea of the SCM is the counterfactual framework, that is, how a region would have changed if it had not been subjected to a policy shock. Furthermore, a synthetic control group with counterfactual characteristics was constructed from the weighted average of the reference groups. The impact of the policy shock was then assessed by comparing the difference between the treated and synthetic groups after the policy implementation. Specifically, panel data for a total of J regions in periods T were collected regarding industrial structure upgrading. Since the policy occurred in 2010, it is denoted by \( T_0 \) in this paper. Among them, there were \( N \) regions that were impacted by the YRD Development Policy during \( T_0 \) (\( 1 \leq T_0 \leq T \)). Then, the remaining \( J-N \) regions that were not impacted by the YRD Development Policy were the potential control units of this paper, which are also called “donor pools”. For this purpose, we derived the following equation.

\[
\alpha_{it} = Y_{it1} - Y_{it0},
\]

where \( \alpha_{it} \) represents the actual situation of industrial structure upgrading in province \( i \) in year \( t \), \( Y_{it1} \) represents the outcome when province \( i \) is impacted by the YRD Development Policy in year \( t \), and \( Y_{it0} \) represents the result when province \( i \) is not impacted by the YRD Development Policy in year \( t \). According to Equation (1), we developed Equation (2).

\[
Y_{it} = Y_{it0} + D_{it}\alpha_{it}.
\]

In Equation (2), \( D_{it} \) is a dummy variable. When \( t \) is less than 2010, \( D_{it} \) is 0. This means that province \( i \) was not affected by the YRD Development Policy until 2010. Conversely, if \( D_{it} \) is 1, it means that province \( i \) has been affected by the policy since the implementation of the YRD Development Policy in 2010. For the four provinces of the YRD, we can
measure industrial structure upgrading from the collected data. Therefore, $Y_{it}$ is tractable in this paper. To measure the impact of the policy on industrial structure upgrading, that is, $\alpha_{it}$, we need to estimate $Y_{it}$. Then, to achieve this purpose, a model with counterfactual characteristics was constructed for this work.

$$Y_{it0} = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it},$$  

(3)

where $\delta_t$ represents the time fixed effect, $\theta_tX$ is a vector of unknown parameters, $Z_i$ represents predictor variables that are not affected by the YRD Development Policy, $\lambda_t$ is a vector of unobservable public factors representing public factors that can affect all regions, $\mu_i$ is unobservable province fixed effects, and $\varepsilon_{it}$ is an error term and a short-term shock with an unobservable mean of zero.

Next, a weighted averaging of the J–N control groups that are not subject to the policy shock can be performed to calculate the optimal weights. The weight vector is $W = (w_2, \ldots w_k)$. Among them, for any $w_k \in W$, there is $w_k \geq 0$ and $w_2 + \ldots + w_{k+1} = 1$. For the YRD, the vector $W$ represents the combination of potential synthetic control groups. Each $w$ in this combination represents the contribution to the experimental group subjected to the policy shock. This yields Equation (4):

$$\sum_{k=2}^{k+1} w_k Y_{it0} = \delta_t + \theta_t \sum_{k=2}^{k+1} w_k Z_k + \lambda_t \sum_{k=2}^{k+1} w_k \mu_k + \sum_{k=2}^{k+1} w_k \varepsilon_{kt},$$  

(4)

where there exists an optimal weight $w^*$; Abadie (2010) justified that the right side of the equation, $Y_{it0} - \sum_{k=2}^{k+1} w^* Y_{kt0}$, is close to 0. This indicates that $\sum_{k=2}^{k+1} w^* Y_{kt0}$ can better estimate $Y_{it0}$. Then, the estimated value of the policy effect $\alpha_{it}$ can be measured based on Equation (5):

$$\alpha_{it} = Y_{it0} - \sum_{k=2}^{k+1} w^*_k Y_{kt0}.$$

(5)

### 3.2. Variable Descriptions

#### 3.2.1. Outcome Variables

The outcome variable of this paper is industrial structure upgrading. We adopted an index called ISA in this study. The measurement formula is shown below.

$$ISA_{it} = \sum_{m=1}^{3} m \times y_{imt}, \; m = 1, 2, 3,$$

(6)

where $y_{imt}$ represents the share of GDP of industry $m$ in province $i$ in year $t$ in the regional GDP. Formula (2) is actually a weighted sum of the weight of primary, secondary, and tertiary industries, and the three industries were assigned weights $(3, 2, 1)$ according to the level of the hierarchy. When $W$ is larger, it indicates that the industrial structure hierarchy coefficient is larger and the industrial structure is more advanced.

#### 3.2.2. Predictor Variables

Referring to the relevant literature on industrial structure upgrading, the predictor variables set in this paper are shown in Table 1. It is important to emphasize that to reduce the impact of heteroskedasticity on the accuracy of the data estimation, the logarithm of data observations with large differences in values was taken in this work.
Table 1. Description of indicators for the predictor variables.

<table>
<thead>
<tr>
<th>Number</th>
<th>Indicator</th>
<th>Indicator Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic development</td>
<td>GDP per capita</td>
</tr>
<tr>
<td>2</td>
<td>Process of urbanization</td>
<td>The proportion of the urban population to the total regional population</td>
</tr>
<tr>
<td>3</td>
<td>Level of trade openness</td>
<td>The proportion of foreign capital to the total regional GDP</td>
</tr>
<tr>
<td>4</td>
<td>Technological innovation</td>
<td>Patents per capita</td>
</tr>
<tr>
<td>5</td>
<td>Government support</td>
<td>The proportion of financial expenditure to the total regional GDP</td>
</tr>
</tbody>
</table>

3.3. Data Sources

This work took the implementation of the YRD Development Policy in 2010 as the time point for the experiment. The impact of the YRD Development Policy on industrial structure upgrading was systematically evaluated. The data required for the study were obtained from the official website of the National Bureau of Statistics of China and the statistical yearbooks of Chinese provinces and cities. Some of the missing data were filled in by consulting the official websites of the provinces and cities and using the mean interpolation method. Because the statistical standards of data from Hong Kong, Macao, and Taiwan in China are different from the standard in mainland China and the data are difficult to obtain and because the data from Tibet are seriously missing, these four regions were excluded from the treatment. Finally, for this paper, we selected the data of 30 provinces in mainland China from 2005–2019 for an empirical study.

4. Empirical Analysis

4.1. Synthetic Control Method Test

In this study, a high-fit synthetic control region was constructed by linearly combining the remaining non-YRD provinces in the donor pool. Table 2 demonstrates the weights of the respective synthetic areas of the original YRD, the new YRD, and the new provinces added to the YRD. First, in the synthesis of the upgrade state of industrial structure in the original YRD, regions with similar characteristics include Tianjin (0.588), Chongqing (0.218), Beijing (0.157), and Inner Mongolia (0.037). This implies that, until 2010, the original YRD could be synthesized by four provinces: 0.588 of Tianjin, 0.218 of Chongqing, 0.157 of Beijing, and 0.037 of Inner Mongolia. Second, in the synthesis of the upgrade state of industrial structure in the new YRD, the synthesis areas with high fit mainly include two provinces, Guangdong (0.466) and Fujian (0.426). The economic development level of Anhui Province, which was recently added to the YRD, is far behind that of the three provinces of the original YRD. Therefore, the average level of the new YRD is more similar to that of Fujian and Guangdong.

Table 2. Weights of synthetic control regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Province</th>
<th>Unit Weight</th>
<th>RMSPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Yangtze River Delta</td>
<td>Tianjin</td>
<td>0.588</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chongqing</td>
<td>0.218</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beijing</td>
<td>0.157</td>
<td>0.00336</td>
</tr>
<tr>
<td></td>
<td>Inner Mongolia</td>
<td>0.037</td>
<td></td>
</tr>
<tr>
<td>New Yangtze River Delta</td>
<td>Guangdong</td>
<td>0.466</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fujian</td>
<td>0.426</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beijing</td>
<td>0.065</td>
<td>0.00217</td>
</tr>
<tr>
<td></td>
<td>Tianjin</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shanxi</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hubei</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Newly Added Province</td>
<td>Qinghai</td>
<td>0.344</td>
<td>0.00220</td>
</tr>
<tr>
<td></td>
<td>Henan</td>
<td>0.302</td>
<td></td>
</tr>
</tbody>
</table>
According to the optimal weights of the synthetic control regions above, Table 3 presents the average values between the real and synthetic region predictor variables. It is clearly seen that the level of economic development and the state of urbanization of the synthetic areas are close to the development levels of the areas in reality. There are significant differences among regions in geographic location, resource environment, and economic structure. This leads to a greater distance between the real and synthetic values of the levels of technological innovation, trade openness, and government support than is the case for the other predictor variables. However, the values are still very close to the real situation and are within the acceptable range. This suggested that this work could construct a control group with counterfactual characteristics by better fitting and merging using the SCM. Furthermore, we used the SCM to assess the impact of the implementation of the YRD Development Policy on the upgrading of industrial structure.

Table 3. Fitting and comparison of predictor variables.

<table>
<thead>
<tr>
<th>Region</th>
<th>Variables</th>
<th>ED</th>
<th>U</th>
<th>GS</th>
<th>TI</th>
<th>TO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treated</td>
<td>4.643</td>
<td>0.668</td>
<td>3.295</td>
<td>4.625</td>
<td>8.423</td>
</tr>
<tr>
<td></td>
<td>Synthetic</td>
<td>4.507</td>
<td>0.673</td>
<td>2.957</td>
<td>3.638</td>
<td>7.505</td>
</tr>
<tr>
<td></td>
<td>D-value</td>
<td>0.136</td>
<td>−0.005</td>
<td>0.338</td>
<td>0.987</td>
<td>0.918</td>
</tr>
<tr>
<td>Original YRD</td>
<td>Treated</td>
<td>4.514</td>
<td>0.602</td>
<td>3.261</td>
<td>4.385</td>
<td>8.113</td>
</tr>
<tr>
<td></td>
<td>Synthetic</td>
<td>4.505</td>
<td>0.603</td>
<td>3.266</td>
<td>4.349</td>
<td>8.302</td>
</tr>
<tr>
<td></td>
<td>D-value</td>
<td>0.009</td>
<td>−0.001</td>
<td>−0.005</td>
<td>0.036</td>
<td>−0.189</td>
</tr>
<tr>
<td>New YRD</td>
<td>Treated</td>
<td>4.147</td>
<td>0.396</td>
<td>3.145</td>
<td>3.657</td>
<td>1.828</td>
</tr>
<tr>
<td></td>
<td>Synthetic</td>
<td>4.192</td>
<td>0.395</td>
<td>2.957</td>
<td>3.344</td>
<td>1.642</td>
</tr>
<tr>
<td></td>
<td>D-value</td>
<td>−0.045</td>
<td>0.001</td>
<td>0.188</td>
<td>0.313</td>
<td>0.186</td>
</tr>
<tr>
<td>Newly added province</td>
<td>Treated</td>
<td>4.514</td>
<td>0.602</td>
<td>3.261</td>
<td>4.385</td>
<td>8.113</td>
</tr>
<tr>
<td></td>
<td>Synthetic</td>
<td>4.505</td>
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<tr>
<td></td>
<td>D-value</td>
<td>0.009</td>
<td>−0.001</td>
<td>−0.005</td>
<td>0.036</td>
<td>−0.189</td>
</tr>
</tbody>
</table>

Note: In the table, ED is economic development, U is urbanization, GS means government support, TI is technological innovation, and TO represents trade openness.

Figures 2–4 show the trends of industrial structure upgrading in the real and synthetic regions for the three experimental groups, the original YRD, the new YRD, and the newly added province (Anhui). Before the policy implementation (2010), the smaller the difference observed between the real and synthetic regions, the better the fit between the two was indicated. As shown in Figure 1, the real and synthetic regions maintained almost the same upward trend until 2010. This indicates that the synthetic control unit fits well with the development path of upgrading the industrial structure in the original YRD. After 2010, the development gap between the original YRD and the new YRD in terms of upgrading the industrial structure started to widen. It can be clearly seen that the development path of the real region was better than that of the synthetic region. In contrast, the newly joined Anhui Province is characterized by a development that first declines and then improves. It was only after 2015 that the industrial structure upgrading of the real Anhui Province and the synthetic Anhui Province started to show a clear divergence.
Figure 2. The trends of ISA in the real and synthetic original YRD.

Figure 3. The trends of ISA in the real and synthetic new YRD.

Figure 4. The trends of ISA in the real and synthetic Anhui.
Figure 5 demonstrates the changing trend of industrial structure upgrading in the three experimental groups of the YRD. In Figure 5, the development trend of industrial structure upgrading in the original YRD is more rapid than that in the new YRD, and the level of industrial structure upgrading in Anhui Province is far behind the average level of the original YRD. For example, in 2015, the average industrial structure upgrading level in the original YRD reached 2.51, while in Anhui Province it was 2.35, so that the level of industrial structure upgrading in 2015 in the new YRD reached only 2.47. As is evident, the accession of Anhui Province has not contributed to the development of the industrial structure upgrading in the original YRD. Since the accession of Anhui Province, the level of industrial structure upgrading in the new YRD has dropped to 2.46. It can be said that the newly added Anhui Province did not contribute to the promotion of the industrial structure upgrading of the original YRD but dragged down the industrial structure upgrading of the original YRD.

![Figure 5](image)

**Figure 5.** Comparison of ISA development trends in the Yangtze River Delta.

### 4.2. Robustness Test

The first step in the robustness test used for this paper was to perform the DID test. A parallel trend test is required before the DID test can be performed. This is to demonstrate that the trends of the experimental and control groups were consistent before the policy was implemented. The results are shown in Figures 6–8.
Figure 6. Parallel trend test in the original YRD.

Figure 7. Parallel trend test in the new YRD.
Before the implementation of the YRD Development Policy (current = 2010), the coefficients of the parameter estimate of the industrial structure upgrading of the three experimental groups in the YRD fluctuated around the value of 0, and the confidence intervals of the coefficients all contained the value 0. This indicates that the work passed the parallel trend test. Furthermore, as shown in Figures 6 and 7, in the years following the implementation of the YRD Development Policy, the policy did have a driving effect on industrial structure upgrading in both the original YRD and the new YRD. However, this effect gradually became less pronounced in the third and fifth years after the implementation of the policy. From a long-term perspective, the YRD Development Policy has limited influence on the upgrading of industrial structure in the original and new YRD, presenting a clear N-shaped development trend.

Table 4 shows the test results of the three experimental groups in the YRD by using DID. Columns (1) to (3) successively represent the policy effects of implementing the YRD Development Policy on the upgrading of industrial structure in the original YRD, new YRD, and newly added Anhui Province. Since the development of the industrial structure upgrading may be influenced by various factors, it was necessary to control a certain number of predictor variables to obtain realistic research results. After adding predictive variables, we found that the coefficient of the treatment effect representing the industrial structure upgrading in the original YRD was 0.056 ($p < 0.01$) and significant at the 1% level. It means that the implementation of the policy had a positive impact on the upgrading of the industrial structure in the original YRD. Meanwhile, we also found that the coefficient of treatment effect of the YRD Development Policy on industrial structure upgrading in the New YRD was 0.023, which was not statistically significant. Then, the coefficient of the treatment effect of the newly added Anhui province was $-0.073$ ($p < 0.01$) and was significant at the 1% level. It can be stated that the accession of Anhui Province slowed down the progress of industrial structure upgrading in the new YRD. This result is consistent with the test result of SCM, which proves the robustness of the test result.
The second step of the robustness test in this work was to conduct a placebo test. We
selected a control group from the donor pool that was not affected by the policy for the
SCM test. By replacing the experimental object, a virtual experimental group can be
constructed to examine the relationship between the new experimental objects and their
synthetic objects. In the SCM, the most suitable object for the placebo test was the synthetic
control unit with the highest fitting degree and the largest composition weight. According
to this principle, Tianjin (0.588), Guangdong (0.466), and Qinghai (0.344) were selected as
new subjects. The placebo test results are shown in Figure 9, with the three graphs on the
left showing the prediction error for the real region and the three graphs on the right
showing the placebo test for the original experimental groups. Among them, the thick,
black line represents the prediction error of the new experimental groups. The gray,
dashed line represents the prediction error of the stochastic control unit. The prediction
error referred to here is essentially the difference between the real and synthetic regions
under a policy shock, that is, the policy effect.

It was assumed that the three regions of the new experimental group, Tianjin,
Guangdong, and Qinghai, were affected by the YRD Development Policy in 2010 and then
observed the policy effect of the new experimental group. In fact, the newly selected
subjects were not affected by the YRD Development Policy; therefore, the final result
presented did differ significantly between the original YRD, the new YRD, and the newly
added Anhui Province. Moreover, the policy effect of industrial structure upgrading in
the new experimental group showed an obvious negative trend, which represents that the
policy effect of the synthetic region in the new experimental group was better than that of
the real region. This conclusion is completely opposite to that of the original three
experimental groups of the YRD. Once again, it proves that the research findings of this
paper are robust.
4.3. Analysis of Industrial Structure Changes

To investigate in depth the industrial structure changes caused by policies in the YRD, this work further explored the share of each of the three industries in regional GDP as a proxy variable to measure the regional industrial structure changes.

First, as shown in Columns (1), (4), and (7) in Table 5, the primary industry in the YRD was basically unaffected by the policy. The coefficients of the three experimental groups were 0.007, 0.006, and 0.002, respectively, and were not statistically significant. Second, from Columns (2), (5), and (8), we find that policy implementation had a significant impact on the development of the secondary industry in the three experimental groups in the YRD. Under the policy impact, the treatment effects of the secondary industry in the original YRD and the new YRD were \(-0.068 (p < 0.01)\) and \(-0.032 (p < 0.05)\), respectively, while the effect in Anhui Province was \(0.073 (p < 0.01)\). This represents a policy that inhibits the development of the secondary industry in the original YRD but promotes it in Anhui. After Anhui became part of the YRD, it slightly eased the inhibiting effect of the policy on the secondary industry in the YRD. Then, we discovered that the effect of policy on the tertiary industry of the three experimental groups in the YRD happened to be opposite to the effect of policy on the secondary industry. The policy has significantly promoted the development of the tertiary industry in the original YRD and the new YRD, with treatment effects of \(0.063 (p < 0.01)\) and \(0.029 (p < 0.1)\), respectively.
However, there has been no promotion of the development of the tertiary industry in Anhui Province.

In fact, the development of the tertiary industry plays a very important role in the process of industrial structure upgrading. The original YRD, of Zhejiang, Jiangsu, and Shanghai, is China’s most prosperous economic region, and the level of the tertiary industry is second to none in China. Compared with that in the original YRD, the secondary industry in Anhui Province is developing rapidly and the development of the tertiary industry lags far behind that of the secondary industry. Consequently, after Anhui became a member of the new YRD, it naturally dragged down the development process of the tertiary industry in the YRD.

### Table 5. Regional industrial structure changes.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Original YRD</th>
<th>New YRD</th>
<th>Newly Added Province</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td></td>
<td>(7)</td>
<td>(8)</td>
<td>(9)</td>
</tr>
<tr>
<td>Treated</td>
<td>0.007</td>
<td>-0.068 ***</td>
<td>0.063 ***</td>
</tr>
<tr>
<td></td>
<td>(1.25)</td>
<td>(-5.42)</td>
<td>(5.62)</td>
</tr>
<tr>
<td>Control variables</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PF effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>YF effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Constant</td>
<td>0.674 ***</td>
<td>0.335 ***</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(8.49)</td>
<td>(2.89)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Observation s</td>
<td>450</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.565</td>
<td>0.287</td>
<td>0.618</td>
</tr>
</tbody>
</table>

Note: ***, *p < 0.01, **p < 0.05, *p < 0.1. PF effect represents province, fixed effect. YF effect represents year, fixed effect.

### 4.4. Analysis of the Impact Mechanism

This paper identifies the reasons behind the results by examining the influence of each predictive variable on the three experimental groups in the YRD. The regression results of the impact mechanism are shown in Table 6. The levels of economic development, urbanization, and technological innovation all significantly contribute to the process of industrial structure upgrading in the three experimental groups in the YRD at the 1% level. Due to the difference in government support for industrial development in each region, there are differences in industrial structure upgrading. We found a positive and insignificant coefficient of 0.009 for the effect of government support on industrial structure upgrading in the original YRD. However, in Anhui Province, where the effect of industrial structure upgrading is obviously negative, the government focuses on supporting the vigorous development of the secondary industry. This is obviously inconsistent with the development path of the industrial structure upgrading of Anhui Province, so that it inhibits the development of the industrial structure upgrading of Anhui Province. In addition, it is obvious that the level of trade openness in all three experimental groups in the YRD has a significant negative effect on industrial structure upgrading. Their effects are very close, at -0.078 (p < 0.01), -0.078 (p < 0.01), and -0.077 (p < 0.01), respectively. This indicates that the level of trade openness in the YRD is not coordinated with the requirement of industrial structure upgrading. Therefore, it leads to an insufficient impetus of trade openness for industrial structure upgrading.
Table 6. Mechanism of the impact of ISA in the YRD.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Original YRD</th>
<th>New YRD</th>
<th>Newly Added Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated</td>
<td>0.056 ***</td>
<td>0.023</td>
<td>−0.073 ***</td>
</tr>
<tr>
<td></td>
<td>(4.30)</td>
<td>(1.48)</td>
<td>(−3.57)</td>
</tr>
<tr>
<td>Economic development</td>
<td>0.261 ***</td>
<td>0.257 ***</td>
<td>0.275 ***</td>
</tr>
<tr>
<td></td>
<td>(6.20)</td>
<td>(6.41)</td>
<td>(6.18)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>0.530 ***</td>
<td>0.531 ***</td>
<td>0.488 ***</td>
</tr>
<tr>
<td></td>
<td>(9.05)</td>
<td>(9.08)</td>
<td>(7.07)</td>
</tr>
<tr>
<td>Government support</td>
<td>0.009</td>
<td>0.012</td>
<td>−0.016</td>
</tr>
<tr>
<td></td>
<td>(0.38)</td>
<td>(0.57)</td>
<td>(−0.60)</td>
</tr>
<tr>
<td>Technological innovation</td>
<td>0.038 ***</td>
<td>0.036 ***</td>
<td>0.050 ***</td>
</tr>
<tr>
<td></td>
<td>(3.69)</td>
<td>(3.36)</td>
<td>(4.49)</td>
</tr>
<tr>
<td>Trade openness</td>
<td>−0.078 ***</td>
<td>−0.078 ***</td>
<td>−0.077 ***</td>
</tr>
<tr>
<td></td>
<td>(−8.50)</td>
<td>(−8.63)</td>
<td>(−8.01)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.329 ***</td>
<td>1.346 ***</td>
<td>1.316 ***</td>
</tr>
<tr>
<td></td>
<td>(8.85)</td>
<td>(9.43)</td>
<td>(8.37)</td>
</tr>
<tr>
<td>Observations</td>
<td>450</td>
<td>450</td>
<td>405</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.726</td>
<td>0.724</td>
<td>0.682</td>
</tr>
</tbody>
</table>

Note: ***p < 0.01.

5. Discussion and Research Implications

5.1. Discussion and Conclusion

Currently, China’s industrial structure upgrading is of great significance to its high-quality economic development, which also represents an important breakthrough for the rapid transformation and growth of the economy. Evaluating the implementation effects of the YRD Development Policy on industrial structure upgrading in the YRD provides an important reference value for the future economic development of China and even the Asia–Pacific region. Based on 15-year panel data of 30 provinces in mainland China, this work explored the impact of the YRD Development Policy on industrial structure upgrading in the YRD by using the SCM.

First, this paper confirms that the YRD Development Policy has short-lived and limited implementation effects on industrial structure upgrading in the YRD, presenting a clear N-shaped development trend. Our results revealed that the development trajectory of industrial structure upgrading in the real YRD was indeed superior to that of the synthetic YRD. In addition, the industrial structure upgrading of the YRD was 5.6% higher than that of the control groups, while that of the newly added Anhui Province decreased by 7.3% instead. This finding implies that the YRD Development Policy significantly promoted the industrial structure upgrading of the original YRD. This also implies that the accession of Anhui Province dragged down the upgrading of the industrial structure in the YRD. Under the guidance of the YRD development policy, a large number of high-tech industries flocked to the YRD at the same time and the original YRD, of Shanghai, Zhejiang, and Jiangsu, transferred traditional industries by way of counterpart support [62]. Although it appears that the accession of Anhui Province has dragged down the industrial structure upgrading of the YRD, Anhui Province has made a great contribution to the original YRD by actively undertaking industrial transfer [63].

Second, this paper reveals that the impact of the YRD Development Policy on the three types of industries in the YRD shows obvious regional differences. Under the policy shock, the YRD Development Policy inhibited the development of the secondary industry in the original YRD but promoted the tertiary industry there. The development trend of secondary and tertiary industries in Anhui Province is completely opposite to that of the original YRD. Specifically, compared to the original YRD, Anhui’s secondary industry is 14.1% in advance and its tertiary industry is 13.7% behind, but the primary industry is
largely unaffected by the policy. This suggests that the YRD Development Policy can promote the complementary strengths of the original and the new YRD. It also contributes to the transformation of the original YRD into an upper industrial chain and the development of Anhui Province. Furthermore, this stage offers both an opportunity and a challenge for Anhui Province. On the one hand, regional industrial transfer can bring abundant capital, technology, and other high-level factors to the undertaking region [64]. On the other hand, if there is no industrial selection and filtering standard in the region undertaking industrial transfer, random undertaking will bring unpredictable drawbacks [65].

Third, this paper verifies that the three predictor variables of economic development, urbanization, and technological innovation have significant and positive impacts on the industrial structure upgrading of the YRD. This is in accordance with reality. In China, the YRD is first in terms of economic development level and far ahead of the other regions in terms of its ability to innovate in science and technology. In contrast, the level of trade openness has a significant inhibitory impact on the industrial structure upgrading of the YRD. It is worth noting that this result is different from the conclusion obtained by Wang et al. [66]. They reported that trade openness can not only promote the upgrading of local industrial structure but also radiate to other regions and further promote the development of its industry. This indicates that the level of trade openness in the YRD is incompatible with the regional industrial structure upgrading requirements of the YRD. Furthermore, under policy guidance, government support has not shown a very significant effect but rather a negative effect on industrial structure upgrading in Anhui Province. Our findings confirm that the accession of Anhui Province did not contribute to the upgrading of the industrial structure of the YRD.

5.2. Research Implications

The potential contributions of this paper are reflected in the following aspects. First, this study organically linked the YRD Development Policy with the development of the regional industrial structure and accurately examined the impacts of the policy on industrial structure upgrading. The findings fill the research gaps regarding the impacts of national regional development policies on the upgrading of the regional industrial structure. Second, this paper reveals that the impacts of the predictor variables in the YRD vary greatly. This finding provides an empirical reference with which more effective development policies with local characteristics can be formulated in the future. Third, this study selected a more accurate method of policy evaluation. Since the weights of the random control groups were determined by data-driven decisions, the subjective judgmental errors associated with the artificial selection of control groups were reduced [67]. Then, we added DID for testing, and the results were more credible and valid. Finally, we applied the SCM to measure the effect of regional development policies on industrial structure upgrading, again corroborating the applicability of the theoretical approach in China.

Inspired by the research findings, several practical suggestions can be proposed. First, government departments should more effectively balance the interests of all participants through macro policies. On the one hand, the industrial choice of each region can be optimized by means of industrial policies, fiscal policies, and tax policies. On the other hand, a sustainable benefit-sharing mechanism can be constructed. Second, the original YRD is the major subject of industrial transfer and its local governments should make clear and reasonable industrial development plans when making decisions. They should not only pay attention to the pacing and direction of industrial development but also prevent the phenomenon of industrial hollowing out. Anhui Province, as a place undertaking industrial transfer, should further improve the standards of industrial filtering and selection. In addition, the independent choice of industry transfer should be strengthened to prevent various drawbacks brought by random undertaking. Third, when making strategic arrangements, government departments should give priority to the less-
developed region of Anhui Province to prevent low-level and inefficient redundant construction. New policies that are in line with the development advantages and economic infrastructure of the region should be simultaneously formulated. Under the guidance of national strategic deployment, the development gap should be narrowed and the overall balanced development of the YRD should be promoted.

5.3. Limitations and Future Research

This paper has some limitations that merit modification through future research. First, several predictor variables could not be used in the SCM analysis due to the lack of data, including the level of infrastructure development and the amount of environmental inputs. Future research could consider including more relevant predictor variables, as they can increase the sensitivity of empirical tests when there are enough predictor variables. Second, the external validity of this paper cannot be justified explicitly. The original YRD, as one of the most economically developed regions in China, enjoys the most liberal economic policies granted by the state, which would strengthen the external validity of these results. In addition, the YRD, although it is one of the more economically developed regions in Asia, is still a small sample. Therefore, caution is needed in generalizing this result and related research should be conducted in regions with similar economic characteristics. Last, there is the issue of the ecological fallacy in that there is no unique way to measure industrial structure upgrading. The measurements chosen in this paper are relatively valid, but different measurements will produce different impact results.

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References


