

Study on the economic growth effect of free trade zones based on counterfactual simulation: an empirical analysis from shaanxi regional economy

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Abstract. The construction of Free Trade Zone (FTZ) is an important strategic initiative for China to build a new platform for comprehensive opening up and a new carrier for leading high-quality development. Based on SCM (synthetic control method) and DID (double difference method), the economic data of Shaanxi when the FTZ policy was not implemented ("counterfactual" simulation) are synthesized using quarterly economic panel data of 14 provincial regions from 2013 to 2019, and compared with the real data for analysis, in order to study the effect of the FTZ policy on Shaanxi's economic. The study finds that the impact of the FTZ policy on Shaanxi's trade and consumption is not significant. The study finds that the FTZ policy has a significant enhancement effect on Shaanxi's economic development and a significant promotion effect on trade, while the promotion effect on consumption is not significant. The innovation and features of this paper are two: firstly, based on the "counterfactual" simulation, the study investigates the growth effect of the FTZ policy on the regional economy in Shaanxi, and explores the mechanism of the FTZ policy affecting the regional economic growth from the perspective of trade and consumption, changing the existing studies which are only based on the analysis of the impact of the FTZ policy on the regional economy, without further exploring the mechanism of the impact. Secondly, the SCM and DID methods are used to evaluate the economic effects of the FTZ policy in Shaanxi, and the robustness of the research results is verified from multiple perspectives, such as replacement and pseudo-time.

1 Introduction

China's Pilot Free Trade Zone (FTZ) is an important high ground for institutional innovation and liberalisation in China. Since the establishment of the Shanghai FTZ in 2013, the FTZ has undergone six expansions. By the end of 2022, China has established 21 Pilot Free Trade Zones (FTZs), forming a new paradigm of opening up across East, West, South, North and Central China. The FTZs have made bold innovations in promoting foreign trade, regional consumption, green trade and other areas, effectively promoting regional economic development and becoming an important engine of China's economic growth. As one of the first inland FTZs and the only FTZ in Northwest China, the establishment of Shaanxi FTZ is a major initiative to expand opening up, accelerate the construction of "One Belt, One Road", and promote the development of western China.

The Fifth Plenary Session of the 19th CPC Central Committee proposed to accelerate the construction of a new development pattern with the domestic general circulation as the main body and the domestic and international double circulation promoting each other, and Shaanxi FTZ should accelerate the pace of development under the new development pattern to promote the rapid development of the regional economy. The 20th Party Congress

proposed that high-quality development is the primary task of economic and social development, and Shaanxi FTZ should put the quality of development in a more prominent position to create an inland FTZ demonstration site with bursting vitality.

The specific impact of the FTZ on Shaanxi's economic growth needs to be carefully considered, in view of this, this study takes Shaanxi FTZ as the research object, observes the extent of the economic growth effect by comparing the changes in Shaanxi's real and synthetic GDP before and after the implementation of the FTZ policy, and further digs into the mechanism of the FTZ policy's impact on regional economic growth from the perspective of trade and consumption.

The marginal contribution of this study to the current literature: (1) This study investigates the growth effect of Shaanxi's FTZ policy on the regional economy, and further digs into the mechanism by which the FTZ policy affects regional economic growth from the perspective of trade and consumption. (2) On the basis of the existing econometric models, the DID and SCM methods are comprehensively applied to assess the economic effects of the Shaanxi FTZ policy from multiple perspectives, and the robustness of the findings is verified from multiple perspectives, such as replacement and pseudo-time.

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The rest of the paper is organised as follows. Section 2 presents the literature review related to this study. Section III presents the specific research methodology and data. Section IV discusses the empirical results and conducts robustness tests. Section V concludes with a discussion of future work.

2 Literature review

Existing research on the impact of FTZ policies on regional economies focuses on the following two categories, the first of which is the study of the economic effects of FTZ policies. Park finds that the construction of FTZs promotes the process of trade liberalisation in China, and promotes the rapid and sustainable development of the regional economy. Ravikumar finds that the FTZs have further developed the regional economy by means of attracting foreign investment, among other things. [9]Song Liying finds that the FTZ policy has promoted the growth of local financial resources with a lag. Lv analyses the impact of college students' entrepreneurship on the regional economy of the FTZ. Usman discusses the impact of the Hainan FTZ on the tourism industry of Hainan Province, which drives the economic development of Hainan Province. [9]Zhang Ying objectively evaluates the effect of FTZ policy on Liaoning province's economy and innovation capacity, and provides scientific basis for Liaoning province's FTZ strategic planning. zhang finds that the FTZ policy accelerates the development of Shanghai's financial and shipping industries, and promotes the economic development of the Shanghai region. Liu Chengjie studies the economic effects of free trade zones in the Yangtze River Economic Belt and finds that the economic effects of the implementation of FTZ policies on the region are generally significantly upward. Li finds that the Shaanxi FTZ strongly promotes the economic and trade development of the region through various institutional innovations. The first type of research above is mostly focused on analysing the economic effects of coastal (or riverine) FTZs, with less research on inland FTZs; at the same time, the existing research has not further explored the mechanism of FTZ policies affecting regional economic growth, leading to a lack of relevance of policy innovation.

The second category is the research on the evaluation methods of FTZ policies, and the DID model and SCM model are widely used in the evaluation of FTZ policy effects. Zhang Hongxia empirically examined the relationship between the establishment of the Pilot Free Trade Zone, institutional innovation and regional high-quality development by using the progressive double difference model. Li Rui used a multi-period double-difference method to assess the effect of foreign investment under the FTZ policy based on annual provincial panel data from 2009-2017. A-cheng Zhang empirically examines the economic growth effect of FTZs in seven prefecture-level cities using the double-difference propensity-matched score method (PSM-DID).Li employs a double-difference model to explore how the FTZ policy affects the development performance of listed companies of ports in the FTZ based on the panel data of 16 listed companies of ports in

China during the period 2010-2016.[3]Cai proposes a dynamic panel data assessment method to explore the impact of the FTZ policy implemented in Shanghai at the end of 2013 on the local GDP growth rate. Li Qiong empirically examines the impact of the implementation of the FTZ policy on Shanghai's financial openness based on Shanghai's panel data using the synthetic control method. Ruidong Han adopts the synthetic control method to study the impact effect of the establishment of cross-border capital flows in the FTZs of Shanghai, Tianjin, Guangdong and Fujian based on provincial panel data from 2004 to 2006. In the second type of studies mentioned above, the DID model is subjective in selecting the control group and assumes a parallel trend, i.e., the control group and the control group have the same development trend before the policy is implemented, otherwise there will be a problem of policy endogeneity; while the SCM model is based on the data-driven selection of the optimal control group, which avoids the subjectivity of the selection of the control group and the problem of policy endogeneity. Most of the existing studies use one method to assess the economic effects of FTZs, and seldom study the economic growth effects of FTZs through multiple methods and perspectives, which leads to a slight deficiency in the assessment of the significance of FTZ policies.

Compared with the existing studies, this study has the following innovations and features: (1) Based on the "counterfactual" simulation, the study investigates the growth effect of Shaanxi FTZ policies on the regional economy, and explores the mechanism of the FTZ policies affecting the regional economic growth from the perspectives of trade and consumption, which has changed the existing studies that are only based on the analysis of the impact of FTZ policies on the regional economy, without further exploring the mechanism of the impact. The existing research only focuses on analysing the impact of FTZ policies on the regional economy, but does not further explore the mechanism of the impact of the shortcomings. (2) Comprehensively applying the DID and SCM methods to evaluate the economic effects of Shaanxi FTZ policies from multiple perspectives, and verifying the robustness of the research results from multiple perspectives, such as replacement and pseudo-time. Through the research of this study, the growth effect of the FTZ policy on the regional economy and its mechanism are revealed, providing a decision-making basis for policy formulation.

3 Research methodology and data

3.1 Shaanxi FTZ policy effect assessment and testing model

Based on the SCM[4] and DID methods, this study synthesises the economic development of Shaanxi without the implementation of the FTZ policy ("counterfactual" synthesis) and compares it with the economic development of Shaanxi in reality in order to assess the economic effects of the FTZ policy, and analyses the robustness of the findings through the tests of replacement and pseudo-time. Further, in order to explore the mechanism of Shaanxi FTZ policy affecting regional economic growth,

this study analyses the role of Shaanxi FTZ in influencing trade and consumption.

3.1.1 SCM-based model for evaluating the effect of Shaanxi FTZ policy

Assuming that there are several regions, among which only the first region (Shaanxi) has implemented the FTZ policy, i.e., the control group, and Shaanxi has been continuously affected by the policy after the implementation of the FTZ policy; the rest of the regions are the control group. Y_{it}^N denotes the economic status of the region when it was not affected by the FTZ policy ($i = 1, \dots, J + 1$; and $t=1, \dots, T$); T_0 denotes the economic status of the region when the FTZ policy was implemented ($1 \leq T_0 < T$). Y_{it}^I denotes the moment t when the FTZ policy was implemented, and denotes the economic condition of the region i when it was affected by the FTZ policy ($t \in [T_0, T]$). Since the FTZ policy has no effect on the economy before its implementation, then for all $t \in [1, T_0)$, in the period of $t \in [1, T_0)$, there is $Y_{it}^I = Y_{it}^N$. Let α_{it} denote the economic change of the region i under the influence of FTZ policy in the period t ($1 \leq T_0 < T$), then

$$Y_{it}^I = Y_{it}^N + \alpha_{it} \quad (1)$$

Assuming that D_{it} represents a dummy variable that takes the value of 1 if the region i is affected by the FTZ policy in the period t , and 0 otherwise, then Y_{it}^I denotes the economic status of the region i in the period t is:

$$Y_{it}^I = Y_{it}^N + \alpha_{it} D_{it} \quad (2)$$

Since only the first region (Shaanxi) implemented the FTA policy in period T_0 , $D_{it} = 1$ when $i = 1$ and $t \geq T_0$; otherwise $D_{it} = 0$.

The objective of this study is to estimate ($a_{1T_0+1}, \dots, a_{1T}$), in period $t > T_0$,

$$\alpha_{1t} = Y_{1t}^I - Y_{1t}^N = Y_{1t} - Y_{1t}^N \quad (3)$$

Since Y_{1t}^I is observable, estimation of Y_{1t}^N is required in order to estimate α_{1t} . The factor model proposed by Abadie et al. (2010) is introduced to estimate Y_{1t}^N :

$$Y_{1t}^N = \delta_t + \theta_t z_i + \lambda_t \mu_i + \varepsilon_{it} \quad (4)$$

where δ_t is a time fixed effect that affects the economies of all regions; z_i is an observable vector of columns ($r \times 1$), representing control variables that are not affected by the FTA policy and do not vary over time; θ_t is a vector of positional parameters ($1 \times r$); λ_t is a vector of unobservable common factors ($1 \times F$), i.e., common shocks faced by different regions; μ_i is a vector of unobservable individual fixed effects in the ($F \times 1$) dimensional dimension, as well as common shocks, λ_t , that do not have the same response across regions; and ε_{it} denotes unobservable short-run shocks that are equal in magnitude to the mean of the regional level.

In order to assess the impact of the FTA policy on the regional economic growth effect, it is necessary to use the control group to simulate the control group in the following way: there is a vector of ($J \times 1$) weighted columns, $W = (w_2, \dots, w_{J+1})$, which satisfies for any j , $w_j \geq 0, j=2, \dots, J+1$, and, $w_2 + \dots + w_{J+1} = 1$. Each vector W , is taken as a potential synthetic control process, i.e., it is a specific weighting of all the districts in the control group.

Thus, the synthetic control results are obtained after weighting the weights:

$$\sum_{j=2}^{J+1} w_j a_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j z_j + \lambda_t \sum_{j=2}^{J+1} w_j \mu_j + \sum_{j=2}^{J+1} w_j \varepsilon_{jt} \quad (5)$$

To obtain an optimal set of weight vectors $w^* = (w_2^*, \dots, w_{J+1}^*)$ such that it satisfies:

$$\begin{aligned} \sum_{j=2}^{J+1} w_j^* a_{j1} &= a_{11}, \sum_{j=2}^{J+1} w_j^* a_{j2} = a_{12}, \dots, \\ \sum_{j=2}^{J+1} w_j^* a_{jT_0} &= a_{1T_0} \text{ and } \sum_{j=2}^{J+1} w_j^* z_j = z_j \end{aligned} \quad (6)$$

Let the value of the mean forecast error (RMSPE) before the policy is implemented be minimised:

$$\min RMSPE_j = \min \sqrt{\frac{1}{T_0} \sum_{t=1}^{T_0} (Y_{1t} - \sum_{j=2}^{J+1} \omega_j^* Y_{jt})^2} \quad (7)$$

Where Y_{1t} is the economic data for Shaanxi in period t , and $\sum_{j=2}^{J+1} \omega_j^* Y_{jt}$ is a weighted average of the economic conditions in the control group of regions, representing the "counterfactual" results for Shaanxi in period t . The impact of the FTZ policy can then be assessed. Once vector group w^* is identified, the impact of the FTA policy can be assessed.[5][6]

3.1.2 Methods for testing the robustness of Shaanxi FTZ policy assessment effects

When evaluating the results of policy impacts, it is necessary to test their robustness, and this study uses the placebo test and the DID test to test the effects of Shaanxi FTZ policy evaluation, and the following is a description of the ideas of each method:

Placebo testing methods

The term "placebo" comes from randomised experiments in medicine, for example to test the efficacy of a new drug. At this point, the participants in the experiment can be randomly divided into two groups, one of which is the experimental group, taking the real drug; and the other group for the control group, taking a placebo (for example, useless sugar pills), and do not let the participants know that they are taking the real drug or a placebo, in order to avoid due to the subjective psychological effects of the experimental effect, known as "the placebo effect". The placebo effect. The placebo test borrows the idea of a placebo; are the FTA policy effects estimated using synthetic controls driven entirely by chance? To this end, this study conducts a series of placebo tests to analyse whether the changes in economic data in Shaanxi Province are caused by the FTZ policy.

Displacement test. Select a region in the control group, assume that the region has implemented the FTZ policy, use the SCM to synthesise its "counterfactual" economic situation, and compare the trend of its real and synthetic economic data. If the trend of its change is similar to that of the control group (Shaanxi), then it means that the results of the economic growth effect of the FTZ in Shaanxi are not robust; conversely, it means that it is robust. then it indicates that it is robust.

Sorting test. Firstly, a region in the control group is randomly selected (repeated until all regions are selected) and assumed to implement the FTZ policy in the second

quarter of 2017, and then SCM is applied to construct the synthetic value of its economic condition, finally, the difference between the real data and the synthetic data of the region is calculated and compared with the control group (Shaanxi), and if there is a significant difference in the difference of the benefit between the two, then it proves that the FTZ policy has a significant effect on the Shaanxi's economic development gain effect is significant.

Pseudo-time intervention test. Advance the policy implementation time of the control group (Shaanxi) and synthesise it through SCM, compare the trend of change between the present synthesised results and the results under the original policy implementation time, if the difference in the trend of change under the results with the original policy implementation time is not obvious, and the moment of change in Shaanxi's real and synthesised economic data coincides with the time of implementation of the original policy, then it proves that the implementation of the FTZ policy has a stable effect on Shaanxi's economic growth of the FTZ policy.

DID test method

This study uses the DID model to examine the impact of the implementation of the FTZ policy on the economic growth effect in Shaanxi, and after estimating the net effect of the implementation of the FTZ policy on the economic growth effect, it compares it with the net effect obtained by the synthetic control method. The model is as follows:

$$I_{it} = \beta_0 + \beta_1 sp_i \times Quarter + \lambda X + \delta_i + \gamma_t + \varepsilon_{it} \tag{8}$$

where I_{it} is the variable denoting the economic growth effect of the FTA policy, and for sp_i is a dummy variable for $sp_i = 1$ if region i implements the FTA policy, and $sp_i = 0$ otherwise; the start of the Shaanxi FTA policy is in the second quarter of 2017, and *Quarter* is assigned a value of 1 after the second quarter of 2017, and 0 before that; the coefficient of the interaction term between sp_i and *Quarter*, β_1 , is the net effect of the FTA policy on growth; X is the set of control variables; λ is the coefficient to be determined; δ_i is the fixed effect of an individual; γ_t is the time-fixed effect; and ε_{it} denotes the short-run unobservable shocks, which have mean value of 0 at the regional level.

3.2 Stata

The State Council issued the Overall Scheme of China (Shaanxi) Pilot Free Trade Zone on 15 March 2017, and in the same year, Shaanxi FTZ was officially inaugurated on 1 April. Considering that the policy implementation period is not long, in order to increase the sample size, this study adopts the quarterly panel data from 2013-2019, in which, the 2nd quarter of 2017 serves as the effective point of the FTZ policy. In this study, Shaanxi is used as the control group, and the control group is selected from the regions that have not implemented the FTZ policy, and 18 regions such as Shanghai, Guangdong, and Tianjin have implemented the FTZ policy during the study period (Table 1), which need to be excluded from the control

group. The final 13 regions of Beijing, Shanxi, Inner Mongolia, Jilin, Jiangxi, Anhui, Hunan, Guizhou, Qinghai, Gansu, Ningxia, Tibet and Xinjiang were selected as the control group (Hong Kong, Macao and Taiwan were not considered).

Table 1. When and where China has implemented its FTA policy

period	Areas implementing FTA policies
March 2013	Shanghai
April 2015	Shanghai (new area), Guangdong, Tianjin, Fujian
March 2017	Liaoning, Zhejiang, Henan, Hubei, Chongqing, Sichuan, Shaanxi
October 2018	Hainan Island
August 2019	Shanghai (new area), Shandong, Jiangsu, Guangxi, Hebei, Yunnan, Heilongjiang
Provinces that did not implement FTA policies during the study period	Beijing, Hunan, Anhui, Shanxi, Inner Mongolia, Jilin, Jiangxi, Guizhou, Gansu, Qinghai, Ningxia, Tibet, Xinjiang, Hong Kong, Taiwan, Macao

In order to study the growth effect of Shaanxi's FTZ policy on the regional economy and to further explore the mechanism by which the FTZ policy affects the regional economic growth from the perspectives of trade and consumption, the variables needed are explained as follows (Table 2):

Table 2. Variable description

Re-search	Explanatory Variable	Control Variable
Economic growth effects	GDP	Total investment in fixed assets as a share of GDP
		Imports and exports as a share of GDP
		Year-on-year growth rate of retail sales of consumer goods
		Percentage of secondary sector
		Percentage of tertiary sector
Trade growth effect	Import and export value	Government fiscal expenditure as a share of GDP
		Growth rate of imports
		Growth rate of exports
		Year-on-year growth rate of industrial value added
		Year-on-year growth rate of investment in fixed assets
		Percentage of secondary sector
Consumption growth effects	Consumption expenditure per urban resident	Percentage of tertiary sector
		Government fiscal expenditure as a share of GDP
		Per capita income of urban residents
		Retail commodity price index
		consumer price index CPI
		Year-on-year growth rate of industrial value added
		Year-on-year growth rate of investment in fixed assets
Percentage of secondary sector		
Percentage of tertiary sector		
Government fiscal expenditure as a share of GDP		

Variables for the study of economic growth effect. In view of the fact that gross regional product (GDP) is an important indicator for measuring the economic situation and development level of a region, this study selects GDP as the explanatory variable for the study of economic growth effect. When choosing control variables, considering that the main factors affecting GDP include investment, trade and consumption, as well as industrial structure and government size, this study chooses six indicators as control variables, namely, fixed asset investment as a proportion of GDP, import and export as a proportion of GDP, growth rate of retail sales of consumer goods, proportion of secondary industry, proportion of tertiary industry, and proportion of government fiscal expenditures as a proportion of GDP.

Variables for the study of trade growth effect. Since the import and export volume is the most important indicator reflecting regional openness to the outside world and trade, this study selects the import and export volume as the explanatory variable for the study of trade growth effect. When choosing control variables, since the factors affecting trade growth include import volume, export volume, regional economic growth, regional investment level, industrial structure and government scale, this study chooses import volume growth rate, export volume growth rate, industrial value-added growth rate, fixed-asset investment growth rate, proportion of the secondary industry, proportion of the tertiary industry, and proportion of the government's fiscal expenditure to GDP as seven indicators as control variables.

Variables for the study of consumption growth effect. Because per capita consumption expenditure of urban residents is an important indicator to reflect the regional consumption level, this study selects per capita consumption expenditure of urban residents as the explanatory variable for the study of consumption growth effect. When choosing control variables, because the factors affecting consumption growth include income growth, inflation, regional economic growth, regional investment level, industrial structure and government scale, this study chooses urban residents' per capita income, retail price index, consumer price index, proportion of the secondary industry, proportion of the tertiary industry, proportion of the government's financial expenditure to GDP, growth rate of industrial added value and fixed asset investment growth rate as the control variables. Growth rate of industrial added value and fixed asset investment as control variables.

In order to eliminate the effects of seasonal differences, this study used Eviews software to perform X12 seasonal adjustment for variables with seasonal characteristics; to ensure the smoothness of the data, the seasonally adjusted data were taken as logarithms.

4 Analysis

4.1 Economic growth effect results and tests

4.1.1 Empirical analysis

Stata15 software is used to solve the above equations (4), (5),(6) and (7),to obtain the optimal weights of the control group (Table 3). It can be seen that the "counterfactual" economic situation of Shaanxi is synthesised by the economic situation of Jilin, Hunan and Gansu provinces, among which the weights of Jilin and Hunan are larger with 0.471 and 0.436 respectively. Table 4 shows the comparison of the real and synthetic means of the relevant control variables before the implementation of the FTZ policy. Table 4 shows the comparison between the true and synthetic means of the relevant control variables before the implementation of the FTZ policy. where the real values are the real data of Shaanxi Province that can be observed, and the synthetic values are the data calculated by the formula (4). The results show that the difference between the real and synthetic values of the control variables of the Shaanxi FTZ is small, and the RMSPE value is only 0.008, which indicates that the SCM model fits the economic situation of Shaanxi before the implementation of the FTZ policy very well. This suggests that the economic growth effect of the Shaanxi FTZ policy can be assessed by SCM.

Table 3. Control group weight

Province (autonomous region, municipality directly under the central government)	Weight
Jilin	0.471
Hunan	0.436
Gansu	0.093

Table 4. Comparison of real and synthetic values of control variable

Control variable	Shaanxi FTZ	
	Actual value	Synthetic value
Percentage of secondary sector	0.521	0.472
Percentage of tertiary sector	0.415	0.408
Total investment in fixed assets as a share of GDP	2.009	1.409
Growth rate of retail sales of consumer goods	11.995	11.510
Imports and exports as a share of GDP	0.066	0.058
Government fiscal expenditure as a share of GDP	0.549	0.584
RMSPE	0.008	

In order to intuitively reflect the development trend of the real and synthetic GDP of Shaanxi Province from 2013-2019, Fig.1 and Fig.2 are generated. In Fig.1, the solid line represents the change of the real GDP of Shaanxi Province, the dashed line represents the change of the synthetic GDP of Shaanxi Province, and the vertical dotted line indicates the implementation time of the FTZ policy in Shaanxi Province. It can be seen that before the implementation of the FTZ policy, the real and dashed

lines basically overlap, indicating that the simulation of Shaanxi's GDP synthesised by the SCM ("counterfactual") is good; after the implementation of the FTZ policy, the difference between Shaanxi's real and synthesised GDP is getting bigger and bigger, and the real value has been above the synthesised value, which indicates that the FTZ policy's economic growth. The curve in Fig.2 represents the difference between the real and synthetic GDP of Shaanxi, which more intuitively reflects that the difference has been fluctuating up and down around 0 before the implementation of the FTZ policy; after the implementation of the FTZ policy, the difference has been growing positively, which illustrates that the implementation of the FTZ policy has a very obvious effect of the gain on the economy of Shaanxi Province.

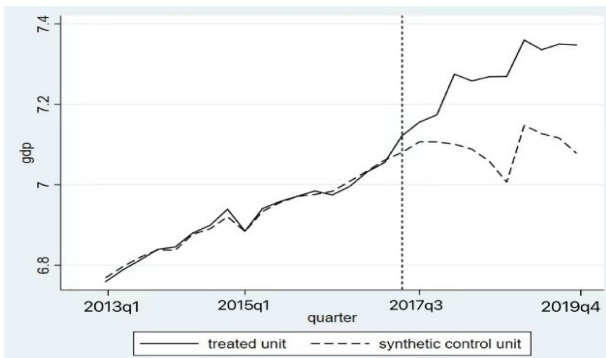


Fig. 1. Real and Synthetic Comparison of Gross Regional Product in Shaanxi Province

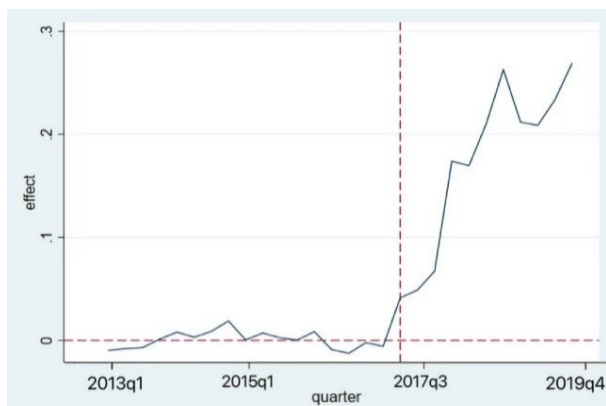


Fig. 2. Effect of FTZ policy on economic gain in Shaanxi Province

4.1.2 Robustness check

As mentioned above, a significant difference between the real and synthetic Shaanxi GDP after the implementation of the FTZ policy was found by SCM, but it is not possible to determine that this difference is necessarily caused by the FTZ policy, and it is possible that it is caused by other policies implemented in Shaanxi. In view of this, this study analyses the robustness of the above findings by means of the placebo test and the DID test method (Liu Youjin et al., 2018).

Placebo test

Replacement test. Through the replacement test, the robustness of the FTZ policy in the policy object can be tested to ensure that Shaanxi's GDP growth is indeed due

to the implementation of the FTZ policy. Jilin Province, the province with the largest weight share, is taken as the replacement object, and the "counterfactual" results after the implementation of its FTZ policy are synthesised to generate a graph comparing the real value of Jilin's GDP with the synthesised value (Fig.3). The results show that Jilin's real and synthetic GDP trends are not the same as Shaanxi's after the implementation of the FTZ policy, and this test indicates that the implementation of the FTZ policy has had a positive effect on Shaanxi's economic development to a certain extent during the study period, rather than other factors.

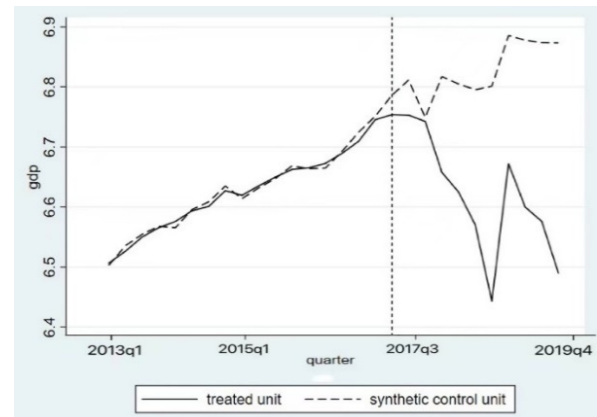


Fig. 3. Permutation test

Sorting test. The sorting test can test the robustness of the FTA policy in terms of statistical results and excludes the possibility that the above empirical test results are obtained by chance combinations of regional weights. Fig.4 is the graph of all 14 regions (Formula(3)), and Fig.5 is the graph of the remaining 9 regions after removing the 5 regions of Shanxi, Hunan, Guizhou, Tibet, and Xinjiang whose RMSPE values are much larger than those of Shaanxi. It can be seen that the gap between the real and synthetic GDP changes between Shaanxi and other regions was not large before the second quarter of 2017, but after the second quarter of 2017, the gap between Shaanxi and other regions began to gradually widen and the value is above all control groups, indicating that the implementation of the FTZ policy has had a positive and significant effect on Shaanxi's economic growth.

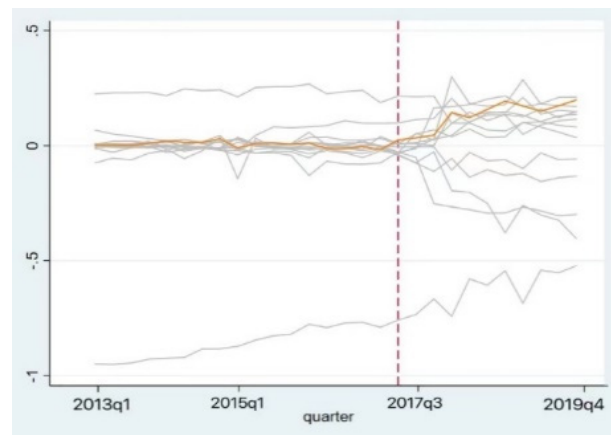


Fig. 4. Sorting test

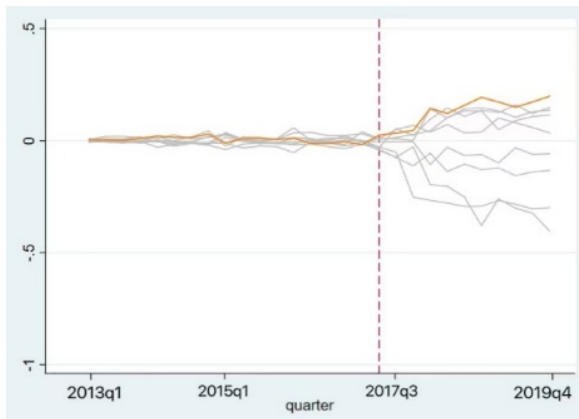


Fig. 5. Sorting test

Pseudo-time intervention test. Although the policy implementation time is the second quarter of 2017, considering that the FTZ policy has already had some impact on Shaanxi's economy before the policy implementation, in order to test the temporal robustness of the implementation of the FTZ policy, the implementation time of the FTZ policy is advanced by three quarters to generate the comparison of Shaanxi's synthetic GDP with the real GDP in Fig. 6. It can be seen that, although the implementation time of the policy is advanced in the model, the the difference between real and synthetic GDP is not significant until the second quarter of 2017, after which a significant difference emerges, i.e., proving the robustness of the results.

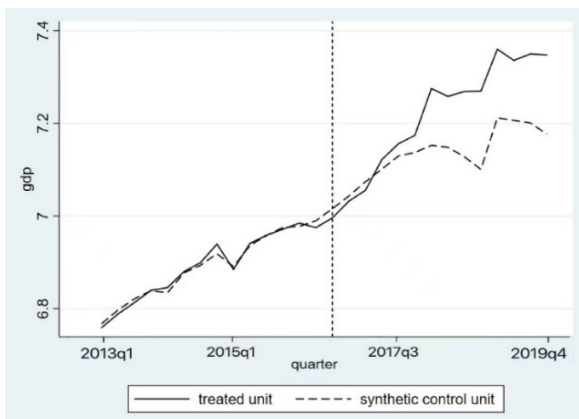


Fig. 6. Pseudo-time intervention test

DID test

The placebo test is the baseline test method for SCM to conduct robustness testing, and the placebo test proves the promotion effect of the FTZ policy on Shaanxi's economic growth. In order to further test the reliability of the conclusion, the DID test is used, i.e. to re-examine the economic growth effect of the Shaanxi FTZ policy from the perspective of changing the test model. Due to the subjectivity of DID in the selection of the control group, in order to reduce the error of DID on the estimation results, this study chooses the three regions in Table 3 as the control group, i.e. Jilin, Hunan and Gansu.

Stata software is used to solve the above Formula(8) and obtain the estimation results of the DID method Table 5. Model(1) is the estimation result without considering the control variables in the study of the economic growth effect and the control group is Jilin, Hunan and Gansu;

model(2) indicates the estimation result with considering the control variables in the study of the economic growth effect and the control group is Jilin, Hunan and Gansu; model E indicates the estimation result with considering the control variables in the study of the economic growth effect and the control group is 13 districts; model(3) indicates the estimation result with considering the control variables in the study of the economic growth effect and the control group is 13 districts. growth effect study, and the control group is the estimation results in the case of 13 regions. The results show that the coefficients of the cross terms of the three models are significantly positive, indicating that the implementation of the FTZ policy has a gain effect on the Shaanxi economy and is robust.

Table 5. Impact of the implementation of the FTA policy on the economic effects of Shaanxi (DID)

	Model (1)	Model (2)	Model (3)
Cross-cutting item	0.49*** (0.18)	0.37*** (0.07)	0.45*** (0.16)
X	unconsidered	onsidered	onsidered
Constant term (math.)	6.78*** (0.05)	8.38*** (0.71)	7.41*** (0.37)
Observations	112	110	384
R2	0.066	0.875	0.679

Note: t-statistics are in parentheses and *** represents the 1 per cent significance level.

4.2 Further analysis

From the above, it can be seen that the Shaanxi FTZ policy has a significant economic growth effect, in order to further explore the mechanism of the FTZ pulling the regional economy, this study analyses the impact of the FTZ policy on regional trade and consumption.

4.2.1 Results and tests of trade growth effect

In order to show the development trend of the real and synthetic import and export volume of Shaanxi Province, the real and synthetic comparison chart of the import and export volume of Shaanxi Province is generated (Fig.7) and the chart of the gain effect of the FTZ policy on the import and export volume of Shaanxi Province (Fig.8). It can be seen that, after the implementation of the FTZ policy, the import and export volume of Shaanxi Province has obvious changes, which indicates that the FTZ policy has a gain effect on the import and export volume of Shaanxi Province and the effect is significant.

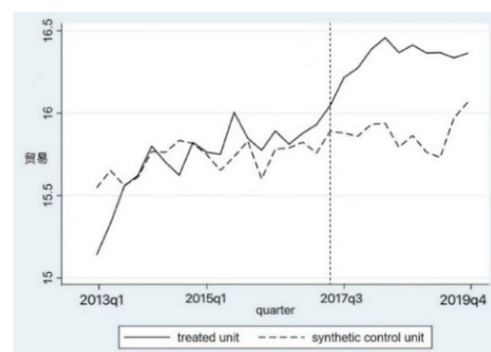


Fig. 7. Results of trade growth effects

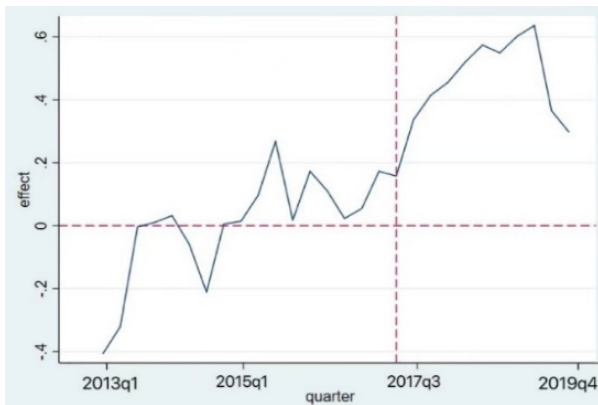


Fig. 8. Results of trade growth effects

In order to verify that the difference between the real and synthetic import and export value of Shaanxi is caused by the FTZ policy, the robustness of the results is analysed by replacement test. Fig.9 shows the comparison between the real and synthetic values of import and export value of Jiangxi Province, it can be seen that after the implementation of the policy, the synthetic import and export value of Jiangxi Province is not smaller than the real import and export value, which proves that the implementation of the FTZ policy on the results of trade growth effect on Shaanxi Province is significant.

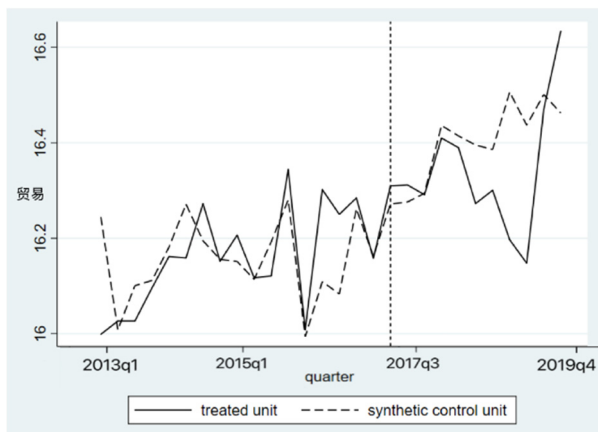


Fig. 9. Robustness tests for trade growth effects

4.2.2 Consumption growth effect results and test

In order to study the impact of the FTZ on consumption in Shaanxi Province, the real and synthetic comparison charts of per capita consumption expenditure of urban residents in Shaanxi Province are generated (Fig.10) and the chart of the gain effect of the FTZ policy on per capita consumption of urban residents in Shaanxi Province (Fig.11). It can be seen that there is no obvious difference in the per capita consumption expenditure of urban residents in Shaanxi Province after the implementation of the FTZ policy, which indicates that the gain effect of the implementation of the FTZ policy on per capita consumption of urban residents in Shaanxi Province is not significant.

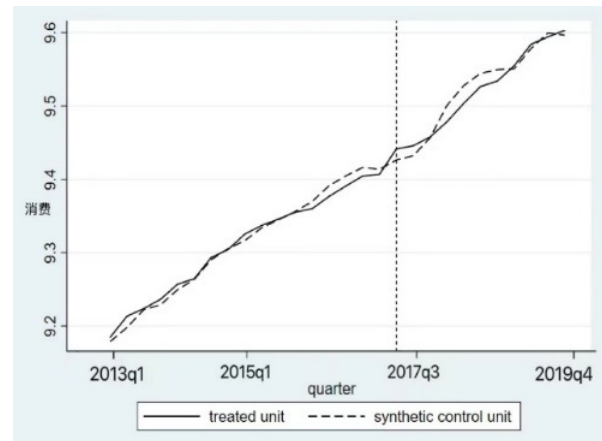


Fig. 10. Consumption growth effect results

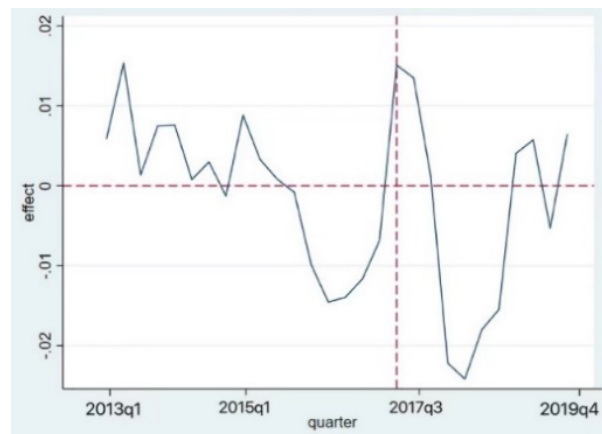


Fig. 11. Consumption growth effect results

In order to prove that the consumption growth effect of the FTZ policy on Shaanxi Province is not significant, the robustness of the results is analysed by replacement test. Fig.12 shows the comparison of real and synthetic values of per capita consumption expenditures of urban residents in Jilin Province, and it can be seen that after the implementation of the policy, the consumption growth effect in Jilin Province is also insignificant, which proves that the FTZ policy has no significant consumption growth effect on Shaanxi Province.

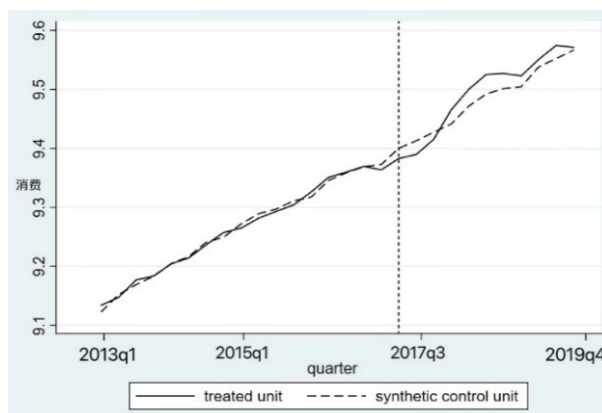


Fig. 12. Robustness tests for consumption growth effects

5 Conclusion

Taking the national strategy of Shaanxi's FTZ policy as an entry point, this study evaluates the economic growth

effect of the FTZ policy based on the quarterly panel data of 14 provincial regions from 2013-2019, using the SCM and DID methods, and tests the robustness of the results of the study. The study finds that: the SCM well simulates the "counterfactual" results of Shaanxi's non-implementation of the FTZ policy; the FTZ policy has a significant driving effect on Shaanxi's economic growth; the FTZ policy has a very significant gain effect on Shaanxi's import-export trade, but not on residents' consumption.

Based on the above conclusions, this study puts forward the following suggestions for the development and construction of FTZs in Shaanxi Province during the period of the "14th Five-Year Plan": Firstly, although the FTZ policy has promoted Shaanxi's economic growth, it should continue to intensify its development efforts, so as to make the FTZ policy more and more close to the development trend of Shaanxi Province's own economy. Second, as the only province in Northwest China to implement the FTZ policy, it should take the initiative to seek changes, and in addition to continuing to invest in institutional innovation, economic development and opening up to the outside world, it should also find another way to examine the positive impact of the FTZ on residents' consumption. According to macroeconomic theory, the process of economic growth in a region is a long-term dynamic process, and raising the per capita consumption level of a region is the fundamental purpose of the region's economic growth, so the development of the FTZ should also have a positive effect on people's lives, stimulate the level of people's consumption, and further drive the economic development. The ultimate goal of policy implementation is to better serve the people, only the people's sense of well-being can be enhanced, the sense of identity and participation in the policy will increase, which can further drive the regional economic growth, so that the implementation of the FTZ policy more smoothly.

This study still has some limitations. Firstly, the limited number of control cities in the control group reduces the robustness of the results. Secondly, the recommendations of the study need to be tested over time, and in the future more objective and theoretically based methods need to be considered to assess the effects of FTZ policies from a long-term perspective.

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