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Evaluating the Effect of Sanctions imposed on the Economy in Iran on Foreign Direct Investment Using Synthetic Control Method

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Abstract

Foreign direct investment (FDI) is considered as an inseparable features of an open and influential global economic system and a key factor for growth and development between countries. Due to having huge amount of oil and gas resources as well as relatively large markets, Iran has a great potential for attracting FDI far more than its performance. However, various sanctions imposed on the country in recent years has led to a decrease in FDI by creating a hostile psychological environment and high risk for economic activities. In this paper, we are going to examine the widespread impacts of economic sanctions imposed by the US on the FDI of Iran between 1980 and 2020 through a model called the synthetic control (SCM). Through SCM we estimate the difference in FDI between the treated country (Iran) and the counterfactual (Synthetic Iran). The results show that the sanctions leads to almost 12 billion \$ reduction in the FDI compared to the no-sanctions situation. Following the escalation of sanctions under the Trump administration and the withdrawal of the US from the JCPOA, the adverse effects of declining FDI peaked at 20 billion \$ in 2020. The placebo tests also show that there are statistical significance in findings (at the 10%¹).

Highlights

- Relationship between FDI and sanctions
- Huge negative impact of sanctions on FDI (in Iran)
- Estimation of treated effects of the sanctions on FDI in Iran through the SCM.

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1. Introduction

Most developing countries face a shortage of resources for investment in their efforts to improve their economic situation, create jobs, and achieve sustainable economic growth and development. In the modern world where capital can be easily transferred, attracting foreign direct investment is one of the best ways to compensate for the shortages of investment. Therefore, attracting foreign capital can be considered as an essential factor for economic growth, complementary domestic capital, and expanding and strengthening capacities in developing countries. Given the appropriate policies of the host country and the initial level of development, most studies show that foreign direct investment leads to technology spillover in addition to providing capital which contributes to the formation of human capital, the integration of international trade, the creation of a more competitive business environment for domestic enterprises, and finally to a higher economic development of countries which is the strongest tool for lowering poverty rate in developing countries. In addition to economic benefits, FDI may contribute to improving environmental and social issues in the receiving country, for example, by providing "cleaner" technologies.

The amount of foreign capital entering Iran is small compared to many countries in the world, so that according to the UNCTAD report, Iran's share of attracting foreign capital in 2018 is only about 0.3% of the world's foreign capital inflow. Although after the approval of the foreign investment promotion and support law in Iran, a different process has started in attracting FDI in Iran, the maximum amount of foreign investment in Iran was only about 5 billion dollars in 2017.

Sanctions are one of the factors that hinder the attraction of foreign direct investment. Peksen (2009) introduces economic sanctions as manipulation of economic relations in order to achieve political goals. In other words, sanctions are economic sanctions that are imposed by one country (or a group of countries) against another country to meet the political goals of the sanctioning countries. In recent decades, economic sanctions have been referred to as a superior policy or an alternative to military means (war) at a lower cost. That is why countries use economic sanctions to get their political goals, such as regime change. (Shokri et al., 2020).

After the revolution, due to the lack of compromise and peaceful coexistence with the superpowers of the East and the West and the world domination system, Iran has always faced numerous unilateral or multilateral economic and non-economic sanctions of the Western countries.

In recent years, especially since 2006, the severity of American sanctions against Iran increased compared to the sanctions of other countries, aiming at limiting foreign exchange and financial resources, causing business disruptions, collapsing of the national currency, reducing the attraction of foreign direct investment and ultimately limiting the country's economic growth.

Considering the negative effects of economic sanctions on various aspects of Iran's economy, including foreign direct investment, this article estimates the

economic effects of unilateral US sanctions against Iran on FDI in 2005. While earlier papers studying macroeconomic effects of sanction Imposed on Iran have used time-series analysis techniques, this research is the first study which has been done by a method called synthetic control (SCM) for case studies between 1980 and 2020, and it quantifies the impact of US sanctions on Iran's foreign direct investment. SCM provides the possibility to compare FDI in Iran prior to and after sanctions imposed by the USA with the weighted average FDI obtained from a group of countries with no sanctions.

The remaining sections of the article is organized as follows: In the second part, the theoretical foundations and research background is described. The third section presents the methodology of the model. The fourth section reports and discusses the experimental results. Finally, in the fifth section, the discussion and conclusions are discussed.

2. A Review of the Related Literature

2.1. Theoretical foundations

US sanctions against Iran are divided into three general categories: sanctions imposed before 2006, sanctions from 2006 to 2015, and new sanctions imposed since 2018 with the return of previous sanctions. Sanctions were not fully implemented until 2006 due to the non-alignment of third countries with the US government's foreign policy. In 2015, with the approval of JCPOA, other Security Council resolutions regarding Iran's nuclear activities were canceled. However, in 2018, after the United States withdrew from the JCPOA, newer unilateral sanctions were imposed by the US government along with the previous unilateral sanctions against Iran. (Piri & Sohrabi 2020). Among these sanctions, the sanctions imposed in 2006 and after are among the most severe sanctions that have been imposed against Iran so far. In general, in the theory of sanctions, from 2005 onwards, economic sanctions has led to internal inefficiency and then weak economic growth and development. Also, one of the most important factors on which the effects of the wave of sanctions have slowed down the speed of economic growth and development in the country is the issue of foreign direct investment, and unfortunately the adverse effects of sanctions have prevented Iran from achieving this important factor of economic growth. Despite the positive effects of foreign direct investment, the facts show that Iran's economy has performed poorly in terms of attracting foreign direct investment compared to the world and the region in the second half of the century due to the economic sanctions imposed by the West, especially the United States.

As Table (1) shows, Iran has performed poorly compared to neighboring countries like Saudi Arabia and Turkey. The highest amount of foreign direct investment was 4662 million US\$ in 2012.

Table 1. Amount of foreign direct investment in Iran, Turkey, and Saudi Arabia (in a million us dollars)

Year	Iran	Turkey	Saudi Arabia
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2005	2889.192	10031	12097.33
2006	2317.539	20185	18293.17
2007	2017.792	22047	24318.56
2008	1979.988	19851	39455.86
2009	2983.422	8585	36457.67
2010	3648.972	9099	29232.71
2011	4276.719	16182	16308.28
2012	4661.734	13744	12182.37
2013	3049.945	13563	8864.693
2014	2105.494	13337	8011.787
2015	2050	19263	8141.027
2016	3372	13835	7452.533
2017	5019	11042	1418.844
2018	2373	12822	4247.107
2019	1508	9266	4562.574
2020	1342	7600	5399.216

Source: World Development Indicators (WDI)

Therefore, economic sanctions may have severe effects on Iran's economy. Figure 1 shows the mechanism of the effect of economic sanctions exerted on foreign direct investment on Iran's economy.

2.1.1. The effects of sanctions through the banking system on foreign direct investment

Among all the sanctions that were aimed at hitting Iran's economy, the bank sanctions affected the country's economy more than other sanctions. One of the influences of these sanctions on the Iranian economic system is the decrease in the currency value, as it is estimated that since 2011, the exchange rate of the rial in the market has fallen by 80% and has reached a figure of about 35 thousand rials against one dollar. This sanction strongly affected the prosperity of investment because a main pillar of foreign investment is the existence of advanced and international banks that can provide all financial facilities to investors at any moment and in any part of Iran to other countries, connect points in the world and make profit and capital transfers possible. Economic embargo through bank embargo increases country risk and imposed costs. In addition, applying successive sanctions in different fields deprives the country's economy of security and peace and provides the basis for the outflow of capital from the country. By sanctioning banks through increasing the cost of transactions, interrupting the SWIFT system and disrupting foreign exchange operations, it affects foreign direct investment.

2.1.2. The effects of sanctions through imbalance in the foreign exchange market on foreign direct investment

The exchange rate is one of the macro-economic indicators, the method of determining and changing it is very important in the economic process of the country, because the exchange rate is one of the tools of economic activity in the global environment and basically the price of foreign currency in terms of domestic currency.

Examining the developments of the foreign exchange market in recent years shows that the increase in oil and financial sanctions against Iran since the end of 2010 and especially in 2011 has led to the reduction of the country's main source of foreign exchange income and the limitation of the available foreign exchange reserves. Also, in addition to the oil embargo, another very important issue is the embargo on the banking network, especially the embargo on the Central Bank of Iran, which has brought many costs to Iran due to the restriction of international financial exchanges. This, along with the reduction of oil revenues, has created extensive restrictions on the supply of currency during the period of economic sanctions.

Economic sanctions against Iran, as one of the most important factors in creating the recent currency crisis in the country, continue dynamically, which has resulted in adverse consequences in the foreign investment sector.

Fluctuations and erratic currency changes are among the factors that cause instability in foreign investment, so that any change in the exchange rate can result in the foreign investor facing huge crises that may lead to the loss of capital for him. Some of the consequences of exchange rate fluctuations that affect investment are an increase in production costs (investment), early changes in currency regulations, a decrease in asset value, currency facilities, and an increase in the inflation rate.

2.1.3. The effects of sanctions through increasing investment risk on foreign direct investment

One of the main conditions that every foreign investor considers before investing is the investment security and expected return of profit and capital. The attraction of foreign capital depends on several factors, the most important of which is the country's risk criterion for the target (host) country. The risk index of each country actually expresses the political, economic and social situation of the country and shows how much it can be trusted to invest in a country and return the profit. Absorption of foreign capital is directly affected by the risk of the host country. In general, a higher degree of risk reduces the level of FDI and leads to its greater distribution among different sectors. The degree of risk tolerance and security of capital is also influenced by the political-economic conditions of each country and the stability of these conditions. In situations where governments face political instability or so-called political instability, investment risk will increase.

Foreign investment will be very expensive for a country like Iran, which is subject to US economic sanctions. Undoubtedly, if the foreign investor wants to

invest only for economic reasons, he will not do so in the conditions of sanctions and will transfer his capital to hundreds of other places in the world that do not have the conditions of danger and risk, because foreign capital enters a country where its security is guaranteed and its risk tolerance level is low. Among the major risks that have affected the decision-making process of foreign investors in the conditions of sanctions, we can mention inflation rate risk, exchange rate of fluctuation risk, liquidity risk, commercial risk and political risk.

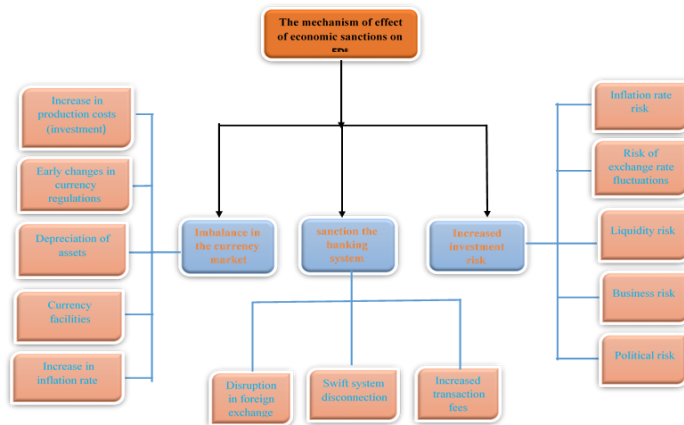


Figure 1. The mechanism of the effect of economic sanctions on FDI

Source: Research findings

Accordingly, the present empirical study analyzes the impact of past economic sanctions imposed on Iran's foreign direct investment. The purpose of this empirical study is to determine whether the economic sanctions have affected the country's macroeconomics, according to the explanations given above, and also to compare what the economy would be like if the US sanctions had not been imposed on Iran since 2005; It is using the combined control method (SCM).

SCM defines the systematic selection of units of comparison (usually countries or regions, often called control units or composite controls) in comparative studies. Specifically, SCM assigns weights to control units in order to match these units in the best way possible with the pre-treatment characteristics of the treated unit. Due to these features, SCM quantitatively estimates the treatment effect in the post-intervention period.

The weights are measured in a way that the synthetic Iran has features similar to features of Iran before 2005 US sanctions. The SCM reduces the distance between the vector of features of actual Iran and its synthetic counterpart prior to imposing sanctions.

The great advantage of this method of study is that, just like comparative empirical studies, it provides the possibility of comparing the application of a policy such as sanctions on the country of Iran under treatment (actual Iran) with a group to which the policy was not applied (synthetic Iran) and today this method

is more popular in economics and has been used in many applications ([Billmeier & Nannicini, 2013](#)).

Estimation with the method of synthetic control method has a number of merits compared to other approaches. First, it offers a well-designed approach in order to have a counterfactual comparison unit when no actual counterpart is available. Second, the “goodness of the fit” in the synthetic control is not subjective; Rather, it is a statistical benchmark which estimates how closely the actual unit is followed by the synthetic unit. Third, it employs statistical data on a macro-level which creates less amount of noise in comparison with the micro-level data employed by difference-in-differences models. Fourth, it relaxes the presupposition of a similar distinction (parallel path) between the treated unit and the control when there is no treatment. Fifth, unlike the comparative study method in which the findings have a descriptive and qualitative nature, this approach provides results which qualitative, which can be considered more reliable and meaningful. ([Fesharaki, 2017](#)).

The SCM has been used by [Mirкина \(2018\)](#) in investigating the influence of sanctions on investments made directly by foreign companies for a many target countries, and [Farzangan \(2019\)](#) in evaluating the Effects of Sanctions on Military Spending of Iran. Considering the "smart" nature of sanctions imposed on Iran, in estimating the influences of sanctions imposed by the United States of America on investment made by foreign countries. This research will answer this question: What levels are the outcome variables of FDI when no sanctions have been applied in Iran since 2005?.

The robustness of the findings is also verified by conducting placebo studies based on the suggestions provided by [Abadie et al. \(2010\)](#) and [Chelwa et al. \(2015\)](#). The robustness of the results to random control groups is evaluated according to the approach of [Chelwa et al. \(2015\)](#). The robustness of results to random donor pools is evaluated according to the approach of [Chelwa et al. \(2015\)](#).

2.2. research background

Due to the importance of the subject of sanctions and its profound effects on the economies under sanctions, several studies have been done by the researchers of the countries, and in this section we will have an overview of the most important of them:

[Shokri et al. \(2020\)](#) Considering the importance of attracting foreign capital in Iran's economy, investigated the influences of sanctions imposed on economy and uncertainty in exchange rate on the attraction of FDI in Iran based on the fuzzy regression model during the period 1370-1397. The results show that sanctions with high-intensity, including economic and comprehensive ones, had a greater impact on attracting investment to the country than low-intensity sanctions. In addition, the sanctions with high intensity are one of the main obstacles to attract foreign direct investment in Iran and has caused a sharp reduction in foreign direct investment incentives.

Rasouli Ghahroudi & Choy Chong (2020) evaluated macroeconomic determinants and the impact of sanctions on foreign direct investment in Iran using linear regression for the time period of 1991-2014. The results indicate the long-term impact of macro-determining factors such as infrastructure, exchange rate and investment return on foreign companies' investment in Iran; But sanctions play no significant moderating role between macroeconomic factors and foreign direct investment. also, international sanctions seem to be positively related to the attraction of foreign direct investment and exert a positive effect on the inflation rate and exchange rate as well as economic growth in Iran.

Mirkina (2018) analyzed the impact of sanctions on the attraction of foreign direct investment in 184 countries, by panel data during 1970 to 2010. The results show that depending on the costs of sanctions, the impact of sanctions imposed on investments made by foreign companies changes over time, so that in the short term severe sanctions cause a significant decrease in foreign direct investment, but they have no effect in the long term.

Eisazadeh et al. (2022) examined the effect of economic sanctions imposed on Iran's GDP per capita by the United States of America using the combined control method between 1990 and 2020. The findings of the research indicate a significant decrease in GDP per capita by 33% compared to the situation without sanctions, so that the negative effects of continuing to intensify sanctions after 2016 caused a decrease in per capita income by 44% in 2020. This potential increase shows the long-term effect of sanctions.

In her thesis, Fesharaki (2018) evaluated three articles about Iran's political economy and economic growth, including: social assets, the economic consequences of sanctions, and group-based injustices. The economic consequences of the recent trade and financial sanctions of the United States and the United Nations on Iran's economy was examined as one of the most important problems of economy in Iran in the third article. This study presents a more up-to-date method to calculate the economic consequences of sanctions at the aggregate level using a synthetic control and the resulting gap between Iran's real GDP and synthetic Iran. The results show a significant decrease in Iran's GDP after financial sanctions in 2010, unlike the negligible effect of previous sanctions.

Gharehgozli (2017) also in research using the approach of synthetic control investigated the economic cost of international sanctions on Iran's GDP for the period of 1980-2014. Thus, they used a data-driven synthetic control unit to estimate the impact of the negative intensification of sanctions during the period of 2011-2014. The year of 2011 has been considered as the year of heavy sanctions on Iran and as a result, the year of intervention. The findings of this research indicate the difference between the GDP of actual Iran and synthetic Iran of 2011 to 2014, so that this difference after 2011 shows the severe negative impact of sanctions on the country's GDP.

Najafi Kangarloui et al. (2021) analyzed the effects of sanctions imposed on Iran's economy employing a model consisting of both sanctions intensity and a modified fuzzy DEMATEL in the period of 1984-2020. According to the model

introduced in this research, the results show that international sanctions have exerted the most significant effect on trade sanctions and oil sanctions, but have a less impact on individual sanctions. Also, the greatest impact of international sanctions has reached its peak between 2010 and 2015.

[Nakhli et al. \(2021\)](#) in research analyzed the effects of oil sanctions and their transmission channels on Iran's economy using a DSGE model. They showed that oil sanctions in the oil industry cause a decrease in foreign and government investment, the oil extraction level and export technology, and as a result, in oil production.

[Keshavarz Haddad et al.\(2020\)](#) used the VARMAX GARCH-IN-Mean Asymmetric BEKK model to investigate the effects of oil revenue shocks and sanctions on the economy of Iran between 1370:1 and 1396:4. The results show that any impulse from the growth of oil incomes or the sanctions index affects all three sectors of production, the foreign exchange market and the stock market. Also, increasing the pressure of sanctions causes spillover of uncertainty, reduction in production activities, increases in exchange rate as well as the relative share of the stock market in the chosen portfolio of investors.

In another study, [Faraji Dizji & Farzangan \(2018\)](#) investigated the short-term and long-term influences of sanctions on Iran's spending on military affairs using the autoregression model with extended intervals (ARDL) between 1960 and 2017, and show that Iran's military budget will decrease as severity of sanctions increases, and only multilateral sanctions in both short-term and long-term periods will cause a significant negative effect on military spending by Iran.

In a study, [Farzanegan \(2019\)](#) investigated the impact of international sanctions imposed on banking systems and energy on Iran's military spending through the synthetic control method between 2012 and 2015. Thus, they compared the synthetic Iran's military expenditures (without sanctions) with the actual Iran (with sanctions) between 2003 and 2015 by constructing a synthetic control group similar to Iran's economic characteristics before the international sanctions of 2012. The research results indicate a reduction of \$119 per year per capita in military spending over the entire period, which is approximately 54% of the 2012 baseline level.

[Moeeni \(2022\)](#) estimates the effects of United Nations' economic sanctions imposed on Iran in 2006 on children's education using synthetic control analyses. The results show that sanctions reduce the total years of education of children by 0.1 years and the probability of attending university by 4.8%. They also cause a 58% reduction in education expenditure by households. Therefore, the impact of sanctions on the income of children is greater than that of their parents.

[Ghomi \(2021\)](#) examines the macroeconomic and distributional impacts of sanctions imposed on Iranian economy by the synthetic control method. The results indicate that the sanctions have not affected households working in the governmental sector and educated households, but have caused poverty in young, illiterate, and religious households living in rural areas, and the impacts of sanctions on the economy have been stable and significant.

In another study, [Biglaiser & Lektzian \(2011\)](#) investigated the impact of sanctions on US FDI using panel data for 171 countries from 1965 to 2000. The results show strong evidence of US investors exiting countries targeted by US sanctions before they are imposed, but this lack of investment is not permanent and investment will take place again after sanctions are imposed.

[Habibi et al. \(2017\)](#) conducted a study with the aim of investigating the effect of foreign direct investment on the development of GCC countries between 1980 and 2014 by the ARDL method. The findings of this research indicate that one of the most effective drivers of economic development in Iran and the countries of GCC is foreign direct investment. Also, of bound test indicates a long-term relationship between FDI and GDP in Iran and for each country of GCC, and the Granger causality test shows the existence of a unidirectional causality from FDI to the real GDP growth rate in Iran and Bahrain.

[Malebo \(2020\)](#) evaluated the effect of sanctions imposed on economy on the GDP per capita in South Africa between 1985 and 1994 by the synthetic control method. The findings show that the economic costs are more obvious after the end of the sanctions, so that by 1998 the GDP per capita of South Africa is 30% smaller than that of the synthetic South Africa. Also, the placebo tests show that the findings have statistical significance at the 10% and the structure of the donor pool cannot affect it.

[Abadie et al. \(2015\)](#) investigated the economic effect of the 1990 German reunification in West Germany on economic development by the synthetic control method, during 1960 to 2003. 1990 is the year of intervention and the control group includes 16 OECD countries. The research findings indicate the negative effect of reunification on the income of West Germany. Thus, GDP per capita decreased by 1,600 US\$ per year over the entire period from 1990 to 2003, which is around 8% of the 1990 baseline level.

Another study was conducted by [Abadie et al. \(2003\)](#) by the synthetic control method to analyze the economic impacts of terrorist conflicts in the Basque Country on economic growth between 1960 and 2000. The results indicate a decrease in per capita income in the Basque Country by about 10% compared to a synthetic control area which is not threatened by terrorism, after terrorism emerged in the late 1960s.

In another study, [Abadie et al. \(2010\)](#) used the method of synthetic control to evaluate the effects of California's proposal 99, between 1970 and 2000, which includes 19 years of data before the intervention, and 38 states members of the control group. Research findings indicate a reduction in tobacco consumption in California relative to a synthetic control region, so that the annual amount of per capita cigarette sold in California by 2000 was almost 26 packs fewer than they would have been when Proposition 99 was not available

Most previous studies have generally investigated sanctions and their impact on economic variables using econometric methods. Only a few of these studies, including the research of [Moeini \(2022\)](#), [Farzangan \(2019\)](#), [Ghomi \(2021\)](#) and

Qara-Gozli (2016), have investigated the effect of sanctions impose on the economic system in Iran using the combined control method.

Contrary to the mentioned studies, which have examined the effect of international sanctions on military spending, children's education, income inequality and GDP of Iran's economy for the intervention years of 2010 and 2012; and Considering the severity of the sanctions imposed by the US and its allies as well as the sanctions on a number of banks, companies, airlines, shipping lines and the serious efforts of the US for international consensus to sanction Iran, since 2005, severity of the sanctions reached its peak in 2020, and as we saw in the literature review, the investigation of impact of sanctions on Iran's FDI was not done by the SCM method. Therefore, in this study, by introducing the SCM method, we want to examine the impact of sanctions in recent years, especially after the intensification of sanctions by the United States, by re-emphasizing this point, that this method shows us the ability to quantify and extract the effect of interventions (sanctions) compared to a situation where there is no sanction.

3. Methodology

This section briefly provides model specifications and also elaborates on data and the method employed to choose control countries in the donor pools.

3.1. Model Specification

As previously mentioned in the literature review, Abadi used this method for the first time to apply the effects of intervention policies (Abadie et al. 2010 and 2015). In this paper, the synthetic control method (SCM) developed by Abadie and Gardeazabal (2003) was further extended to study the impacts of US economic sanctions on Iran's economy. Also, in this study, in order to estimate the effect of sanctions on Iran's economy, using the combined control method, R software and installing Synth and SCTools packages have been used.

Synthetic control methods have been widely used in empirical research in different fields including economic studies fields. (Abadie et al. 2003 and 2010). In the recent decades, synthetic controls have been employed as the most significant way for analyzing data for various aspects of the issues in previous studies on the impacts of immigration (Borjas, 2017; Peri & Yasenov, 2019) and minimum wage (Allegretto et al., 2017; Jardim et al., 2017; Neumark & Wascher et al., 2017). (Abadie, 2020).

SCM begins with defining the treated study unit (where the intervention happens) and selecting the outcome of interest, which should be evaluated both before and after the intervention was administered. The second step is choosing a 'donor pool', i.e., a collection of potential control units considered to bear some underpinning structural resemblance to the treated unit based on the processes that lead to the outcome. The pool can be explained as all units in the same region, or units that are similar with regard to covariates typically employed in regressions or in matching. These could consist of socioeconomic features (per capita income, transportation infrastructure, educational achievement for many output),

biophysical circumstances (precipitation, percent riparian for land use output) and political regimes (the same country or state).

In this study, the method of synthetic control method was used to build a synthetic control unit for Iran to evaluate the influences of sanctions on FDI, which shows the expected FDI figures based on a scenario that did not consider any sanctions after 2005; we name this control unit “synthetic Iran. The description of this method is surveyed here as follows:

The following model presents a rationale for using synthetic control methods in a comparative case study. In fact, we observe $J + 1$ regions in which just the first region is given the intervention of interest, and consequently J remaining regions are considered as potential control groups as “donor pool”.

The impact of treatment (i.e. sanctions programs) at time t for country i is shown as:

$$\alpha_{1t} = Y_{1t}^I - Y_{1t}^N = Y_{1t} - Y_{1t}^N \quad t > T_0 \quad (1)$$

where Y_{it}^I is the outcome variable at time period t for the country i

which the treatment has been administered on at time period $T_0 + 1$ to T .

And Y_{it}^N is the outcome variable observed at time period $t = 1, \dots, T$ for country i , which the treatment had been administered on. . Given that the intervention did not have any effects before T_0 , for all $t < T_0$ we have $Y_{it}^I = Y_{it}^N$. Since Y_{1t}^I is given, to estimate the effects of intervention, $\hat{\alpha}_{it}$, we

just need to calculate Y_{it}^N for $t \geq T_0$. This is the unobserved variable, i.e. the counter-factual variable which is made by a convex combination of control countries on which no intervention had been administered, and whose weights are selected optimally. The optimal weights, W_j^* , are selected to reduce the pre-

intervention distinction between the affected country and its synthetic counterpart based on covariates of the outcome variable. That is, to reduce some distance $\|X_1 - X_0W\|$ Between X_1 and X_0W , That is, $W^* = \min \|X_1 - X_0W\|$ being

selected, subject to $w_2 \geq 0, \dots, w_{j+1} \geq 0$, $w_2 + \dots + w_{j+1} = 1$ To examine the discrepancy between X_1 and X_0W , we will use

$\|X_1 - X_0W\| = \sqrt{(X_1 - X_0W)'V(X_1 - X_0W)}$, where V is some symmetric and positive semidefinite matrix, so that the mean squared prediction error (MSPE) of the outcome variable is reduced for the pre-intervention periods. Diagonal elements are weights that show the relative importance of the variables in X_1 and X_0 . Also,

X_1 is vector including the predictive values of the unit under intervention and

X_0 is matrix consisting of the values of the same variables for the units in the donor pool.

given that there are $N + 1$ countries and the influenced country is shown by $i = 1$, the unbiased estimator of causal effect of the treatment, proposed by Abadie et al. (2010), is as follows:

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{N+1} w_j^* Y_{jt} \quad t \geq T_0 \quad (2)$$

where the weights ($w_j^* \geq 0, \sum_{j=2}^{N+1} w_j^* = 1$) satisfy $\sum_{j=2}^{N+1} w_j^* Z_j = Z_1$ and $\sum_{j=2}^{N+1} w_j^* Y_{jt} = Y_{1t}$ for $t < T_0$.¹

After estimating the effects of sanctions, we use placebo tests to examine whether the estimated effects by the synthetic control for the country under treatment is more significant than than the calculated effects for the randomly selected country or not.

in the next subsection, details on data and the method to select control countries are presented.

3.2. Data

A panel data set² of the countries that cover the period 1980-2020 was used. The treatment period is 2005–2020. As US sanctions were imposed in 2005, this provides a pre-intervention period of 25 years. Foreign direct investment net inflows (FDI, billion US\$) is measured as an outcome variable. For pre-sanctions characteristics of foreign direct investment, we follow the corresponding literature of Barseghyan, G. (2019). The predictors of the outcome chosen ought to consist of variables that are able to examine the path of the country influenced by the treatment. however, it ought not to consist of variables that predict the impacts of the treatment. Predictors with incomplete data for a year or more before the intervention was administered were removed. Also, variables are employed as predictors as they can give a better pre-intervention fit between synthetic IRAN and actual IRAN. Thus, we use the predictors presented in Table 2 to examine the effect of economic sanctions on FDI.

Table 2. Description of FDI predictive variables

Variable	Description	Variable abbreviation
Foreign direct investment, net inflows	(billion US\$)	FDI
Exports of goods and services	(\$constant 2015 US)	Exp
Imports of goods and services	(\$constant 2015 US)	Imp

¹ For more details on SCM, see Article 2022 Eisazadeh et al.

² Data for this work are taken from the World Development Indicators(WDI) of the World Bank

Final consumption expenditure	(constant 2015 US\$)	expenditure
GDP	(\$constant 2015 US)	GDP
GDP per capita growth	(% annual)	GDPGper
Gross fixed capital formation	(constant 2015 US\$)	capital
Merchandise exports	(current US\$)	Merchandise
Merchandise imports	(current US\$)	Merimp
Net foreign assets	(current LCU)	assets
Official exchange rate	LCU per US\$, period) (average	exchange
Population growth	(% annual)	Populg

* *Source: Research findings*

3.3. Control countries

To determine control countries following [Mirkina,2018](#); [Neuenkirch & Neumeier, 2015](#); [Eisazadeh et al, 2022](#), the target countries, i.e., the countries that have put sanctions on Iran and also other countries subject to sanctions since 1980 were excluded from the analysis. To have an unbiased data of sanction trajectory of Iran after sanctions imposed in 2005, the control countries for creating synthetic Iran were supposed not to have had a main exogenous shock (e.g., war, revolution) from 2005 to 2020; Therefore, we excluded Libya, Iraq, Lebanon and Syria from the donor pool. After some countries were excluded because of data unavailability, there remained 29 countries in the donor pool.

4. Empirical Results

In this section, the main results of the effects of the sanctions on FDI for the economy of Iran as well as placebo tests along with the robustness analysis of the results are presented.

4.1. Estimated effects

Table 3 shows the calculated weights of the predictors with the combined control method, which have obtained high GDP, GDP per capita growth, and import and export of goods and services. These high forecast weights show that the weights of the countries are mainly selected according to GDP, GDP per capita growth and import and export of goods and services, and the results are mainly guided by these macroeconomic indicators.

Table 3. Weight of FDI predictors

Variables	Weight of predictors of control countries
Expenditure	0.23
Assets	0.04
Imp	0.006
Exp	0.124
FDI.1980.2005	0.182
GDP.1982.2005	0.17
Populg.1980.2005	0.018

GDPGper.1982.2005	0.169
Merchandise.1980.2005	0.123
Merimp.1980.2005	0.135
special.capital.1987.2005	0.01
exchange.1980.2005	00

* *Source: Research findings*

Synthetic Iran is made through a convex combination of countries with positive weight in the donor pool, subjects resemble the actual Iran to a great extent in terms of the values of the predictors of the FDI variable before the sanction. Table 4 displays the weight of the donor countries in the synthetic Iran. Iran counterfactual in the model consist of following countries: Japan (0.025%), India (0.303%), and Paraguay (0.672%). As it shows India and Paraguay have the highest weight in the synthetic Iran, and the others have got zero weight.

The reason for having high positive weight for countries like India in synthetic Iran is that, India had a high foreign direct investment during 2005-2020 due to the removal of its restrictive FDI policies as well as competition with successful Asian economies to obtain a larger share of FDI in the world. As a result, the growth of synthetic Iran has increased in this period and has caused a greater gap between synthetic Iran and actual Iran.

Table 4. Country weights

Unit numbers	Unit names	W weights
1	Argentina	0.000
2	Bangladesh	0.000
3	Bolivia	0.000
4	Cameroon	0.000
5	Congo, Rep.	0.000
6	Ecuador	0.000
7	Egypt, Arab Rep.	0.000
8	Gabon	0.000
9	India	0.303
10	Jordan	0.000
11	Kenya	0.000
12	Malaysia	0.000
13	Mexico	0.000
14	Morocco	0.000
15	New Zealand	0.000
16	Nicaragua	0.000
17	Paraguay	0.672
18	Peru	0.000
19	Senegal	0.000
20	Sri Lanka	0.000
21	Tunisia	0.000
22	Indonesia	0.000
23	Japan	0.025
24	Korea, Rep.	0.000
25	Nigeria	0.000

26	Turkey	0.000
27	Colombia	0.000
28	Togo	0.000
29	Mali	0.000

Source: Research findings

Table 5 compares the values of FDI predictor variables for actual Iran with synthetic Iran before sanctions in 2005. As it is given in most features, the synthetic Iran presents a closer fit for the actual Iran than the average of the countries in the pool before the sanctions. As the values of the predictors cannot be completely matched, the two predictors of the indices of total exchange and expenditure as a proportion of GDP are significantly different in terms of size between the Iran's country and its synthetic counterpart. Therefore, there does not exist linear combination of countries of donor pool in which exchange and assets of Iran is completely reproduced. It is not uncommon to observe predictors that are different in values between the treated country and their synthetic counterpart given that the treated county could have some extreme predictors (Chelwa et al., 2015). If the difference size of these predictors increases, they can be removed from the model. As shown in Table 5, the synthetic Iran largely matches with the actual Iran in its pre-sanctions features. Therefore, we can use the synthetic Iran to estimate the treatment effects of sanctions.

Table 5. Characteristics of Treated and Synthetic Iran (billion US\$)

Variables	Treated	Synthetic	Sample Mean
Expenditure	141.86	233.91	205.99
Assets	35767.26	2641.81	181.00
Imp	96.65	28.86	16.73
Exp	66.88	34.05	40.13
FDI.1980.2005	0.47	0.66	1.20
GDP.1982.2005	222.04	280.27	256.83
Populg.1980.2005	2.42	2.25	2.09
GDPGper.1982.2005	1.49	1.39	1.37
Merchandise.1980.2005	23.09	23.00	37.90
Merimp.1980.2005	17.61	20.48	26.71
special.capital.1987.2005	53.60	75.49	73.79
exchange.1980.2005	1883.30	1434.37	199.42

Source: Research findings

The effect of intervention -vertical distance between FDI for Iran and synthetic Iran- is shown between 1980-2020 in Figure 4-1. It is clear that the synthetic Iran closely follows actual Iran's foreign direct investment (the under intervention unit) before the sanctions imposed. After the intervention in 2005, the line of synthetic Iran FDI lies above of the actual line. in other words, the influence of sanctions result in a downward trend in FDI for the under intervention unit (Iran). The effects of the sanctions on Iran's economy is sever after 2016, and it continues until the last year of study (2020), increasing the distance between the under intervention unit and synthetic control.

The impact of the sanctions is cleared, by comparing the features of Iran after the sanctions with those before the sanctions. For example, the difference in FDI between the actual Iran and the synthetic Iran is approximately 15.221 billion US dollars in 2019, which supports [Mirкина's \(2018\)](#) findings. Thus, any sanctions imposed by foreigners have had a huge long-run effects on economy through the different channels such as FDI. Not only does the sanctions deteriorate the economy in short-run, but it also affects it severely in long-term because it leads to plummet of the foreign investment capacity in long-term in Iran

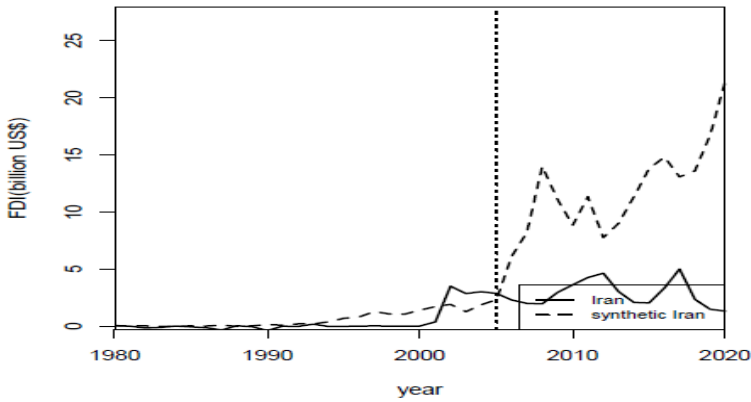


Figure 4.1. Synthetic versus Iran FDI

Source: Research findings

Figure 4-2 is another way to show the effects of intervention that measures the FDI gap between Iran and Synthetic Iran (intervention effect) using the line in the diagram.

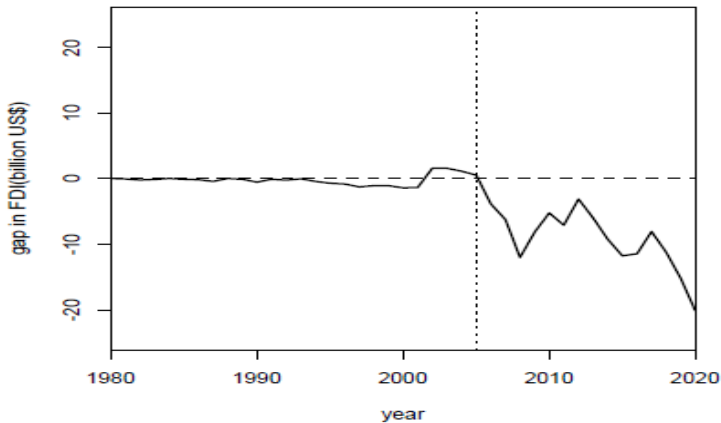


Figure 4.2. Synthetic versus Iran Gap (Synthetic Treatment Effect)

Source: Research findings

Table 6 shows the actual estimation of the intervention effect. During the intervention period, actual Iran's FDI was lower than that of synthetic Iran, indicating the negative effect of the intervention. Iran's synthetic FDI exceeded actual Iran from 2005 to 2008, and then FDI decreased slightly and reached approximately 3.11 billion US\$ until 2012. In 2013, due to the re-intensification of sanctions by the US and its allies, the inflow of foreign direct investment for new projects into Iran completely stopped, and therefore FDI reached the minimum level in 2015. Since the agreement of JCPOA on April 2, 2015, multinational companies have again shown interest in investing in Iran's oil and gas sector, and thus the doors of world trade opened for Iran with this agreement. Therefore, the impact of sanctions on FDI reduced. However, the risk of foreign investment in Iran, increased again in 2018 after the United States withdrew from the JCPOA, and as a result, it caused a sharp decrease in attracting FDI, and then foreign direct investment in Iran reached 20.131 billion dollars by 2020, which was the least FDI in the history of Iran.

Table 6. Synthetic versus Iran Gap (Treatment Effect): FDI (billion US\$)

Year	FDI Iran	(FDI) Synthetic Iran	Treatment (FDI) effect	Treatment effect (%)
2005	2.89	2.34	0.55	18.91
2006	2.32	6.14	-3.82	-164.79
2007	2.02	8.25	-6.23	-308.88
2008	1.98	13.99	-12.01	-606.56
2009	2.98	11.10	-8.12	-272.16
2010	3.65	8.86	-5.21	-142.80
2011	4.28	11.35	-7.07	-165.43
2012	4.66	7.77	-3.11	-66.76
2013	3.05	9.00	-5.95	-195.25
2014	2.11	11.34	-9.23	-438.40
2015	2.05	13.79	-11.74	-572.66
2016	3.37	14.82	-11.44	-339.40
2017	5.02	13.08	-8.06	-160.55
2018	2.37	13.61	-11.24	-473.53
2019	1.51	16.73	-15.22	-1009.41
2020	1.34	21.47	-20.13	-1500.12
RMSPE				0.92

Source: Research findings

4.2. Placebo studies

Statistical inference play an important role in supporting the estimates of the synthetic control method. If the treatment effects of Section 4-1 are randomly

generated, in this case, they will not be statistically significant. To evaluate the reliability of the results, the inferential techniques proposed by [Abadie et al. \(2015 and 2010\)](#), which include two “in- space placebos” and “in-time placebo” tests, are used. In the “in- space placebos”, test is performed for each country in the donor pool by means of the synthetic control method iteratively and it measures the treatment effect. If the distance between the treated country and the synthetic countries in the “in- space placebos” test shows a significant amount, the estimation will not represent significant evidence of the sanctions on FDI as an intervention policy effect because we do not expect that the donor pool countries has had as much intervention effects as the country under intervention.

Figure 4-3 shows the treatment effect of FDI for Iran and all control units in the donor pool in the in-space placebos test, and the black line shows the FDI gap between Iran and its synthetic counterpart. As it can be seen in the figure, due to the higher MSPE (MSPE measures the size of the gap in the desired outcome variable between each country and its combined counterpart) of some donor pool countries and Iran before the intervention, the synthetic control method does not provide a good fit for Iran and many control countries before the sanctions period in 2005. As a result, “in- space placebos” test cannot reproduce FDI for these countries. Therefore, the gap obtained after the intervention time will not be reliable.

In order to correct the results, we can eliminate countries whose MSPE or MSPE ratio after /before the intervention is higher than Iran's ratio. In this study, as mentioned above, due to the relatively poor fit of the estimated placebo effect in the pre-intervention period, distribution of MSPE before the intervention is used in Figure 4-3. In this regard, at first we exclude the countries whose MSPE (before the sanctions in 2005) is more than 10 times as high as that of Iran's MSPE. The result of this estimation is shown in Figure 4-4. Since there is still a poor fit before the treatment, we exclude the countries whose MSPE before the sanctions are more than 5 times or greater than Iran's MSPE. The results are shown in Figures 4-5 and 4-6. The deviations from the border line completely disappeared and the estimated negative effect of FDI reduction due to sanctions is more for Iran than pool countries.

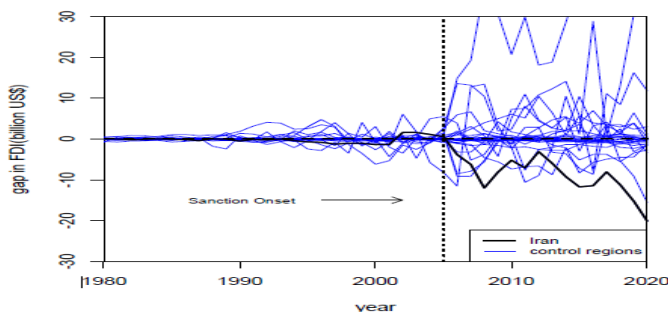


Figure 4.3. Iran FDI gap against control countries 1980-2020

Source: Research findings

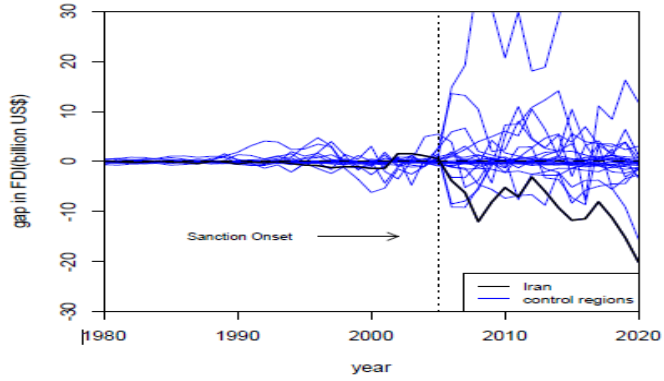


Figure 4.4. FDI gap versus control countries By Excluding countries with MSPE 10 times more than Iran

Source: Research findings

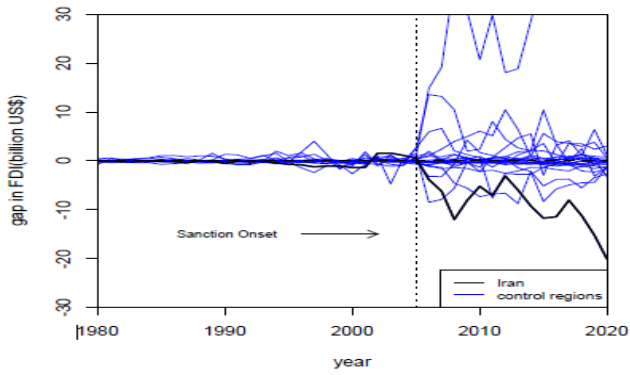


Figure 4.5. FDI gap versus control countries By Excluding countries with MSPE 5 times more than Iran

Source: Research findings



Figure 4.6. FDI gap versus control countries By Excluding countries with MSPE larger and equal to Iran

Source: Research findings

Another placebo test is the “in-time placebo” at the beginning of the intervention, when the actual sanctions are not imposed, in which the FDI trend between actual and synthetic Iran should not have a drastic change by varying the intervention year. Therefore, to check “in-time placebo” test, it is supposed that economic sanctions in 2005, have been applied only 1 year earlier than actual time of the start of the sanctions. Figure 4-7 illustrates that the trend line of actual Iran and synthetic Iran is almost the same as the actual year of the start of sanctions, and there is no significant difference in results. Therefore, due to the effect of actual sanctions in 2005 on FDI in Iran, the results of this placebo test confirm the SCM forecast power and the gap obtained in Figure 4-7-.

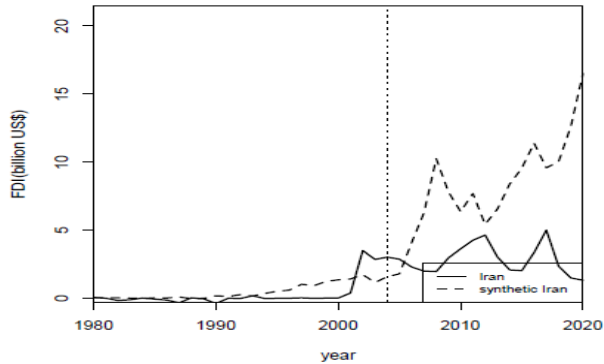


Figure 4.7. synthetic Iran vs. actual Iran (FDI) - Sanctions starting in 2004

Source: Research findings

As [Barseghyan \(2019\)](#) recommends, another way to examine the significance of estimated results when the predicted placebo effect is large because of poor fit in the pre-intervention phase is using the distribution of MSPE ratios after the intervention to before the intervention, which provides another measure of goodness of fit.

Figure 4-8 shows the ratio of MSPE after to before sanctions in Iran. This ratio for Iran is higher than all control countries except India. That is to say, the probability that any country will experience the intervention effect as much as that of Iran is $2/30 = 0.0666$ percent, which is approximately 0.07 or 7% and below the 10% threshold. Therefore, these results are statistically significant and reliable at 10% level. The 10% level is suggested as an accurate threshold for inference under SCM because the control countries usually include a small number of countries.

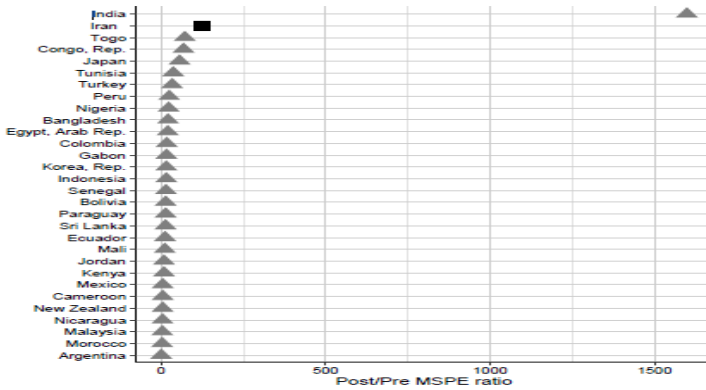


Figure 4.8. MSPE ratio after intervention to before intervention

Source: Research findings

4.3. Robustness

In this section, in order to check the sensitivity treatment effects on the donor pool, we evaluate the robustness of the intervention effects. For this purpose, we exclude the countries that have positive weights in the donor pool in Table 4 once from the donor pool, and we re-evaluate the treatment effect with a new iteration of estimating. Through the method it is clear that our results are not driven by individual donor country with a positive weight.

As an example, Figures 4-9 and 4-10 (countries with a high positive weight and a low positive weight), show the results of excluding the countries of Japan and Paraguay with positive weight in the donor pool which both show almost the same trend as the pattern of the path of synthetic Iran in figure 4-1.

Table 7 compares the main results with the actual estimates of the effects treated unit (Iran) from the robustness tests resulting from excluding any country with positive effects. The treatment effects are obtained as the percentage of annual deviation from the corresponding counterfactual (synthetic) trend line.

Column (2) shows the main results while columns (3) and (4) show the results of excluding Japan and Paraguay with positive weights from the donor pool.

The trend of estimating the effects treatment with the elimination of the countries of Japan and Paraguay in columns (3) and (4) are almost the same as the trend of the intervention effect in the main results until 2020. The RMSE of the main results is almost consistent with the RMSE of removing positive weight countries in the control group. Therefore, our estimates of treatment impacts of the treatment are independent of the structure of the donor pool, and thus, the results are affected the composition of the donor pool. (Chelwa et al., 2015).

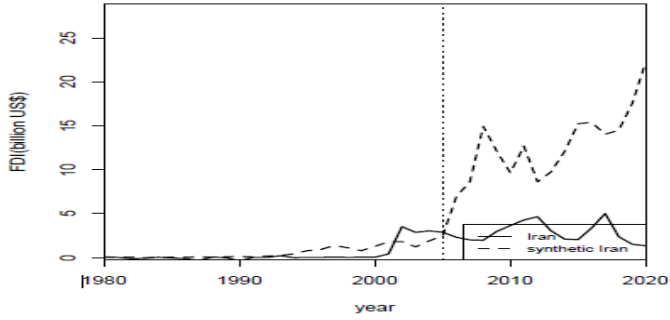


Figure 4.9. Actual Iran vs. Synthetic Iran (FDI) - Excluding Japan
 Source: Research findings

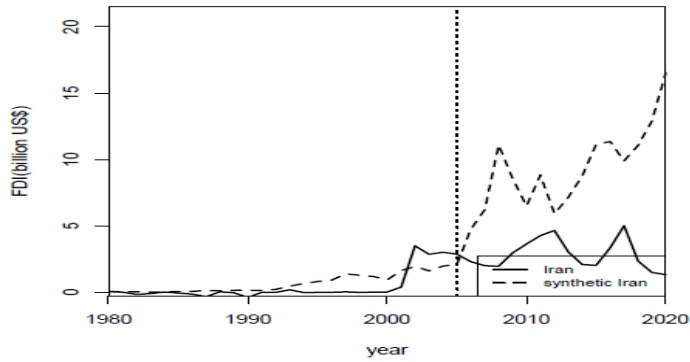


Figure 4.10. Actual Iran vs. Synthetic Iran (FDI) - Excluding Paraguay
 Source: Research findings

Table 7. Fortifications: Comparison of the effects of intervention With the Excluding of Japan and Paraguay

Year	Main results	Excluding of Japan	Excluding of Paraguay
2005	18.91	14.55	26.68
2006	-164.79	-198.30	-105.22
2007	-308.88	-327.23	-209.37
2008	-606.56	-654.36	-460.71
2009	-272.16	-304.85	-186.96
2010	-142.80	-164.56	-78.37
2011	-165.43	-196.45	-106.55
2012	-66.76	-84.79	-27.24
2013	-195.25	-219.66	-134.54
2014	-438.40	-473.90	-317.61
2015	-572.66	-643.17	-444.14
2016	-339.40	-356.56	-236.95
2017	-160.55	-179.72	-97.35
2018	-473.53	-510.78	-366.38

2019	-1009.41	-1063.73	-756.58
2020	-1500.12	-1556.32	-1131.95
RMSPE	0.92	0.92	0.90

Source: Research findings

5. Concluding Remarks

This paper surveyed the impact of economic sanctions imposed by the US on Iran's foreign direct investment using synthetic control method (SCM) in the period of 1980-2020. The SCM measures the economic impact of sanctions through predicting the difference between the FDI of the intervention (or treated) country (Iran) and the counterfactual (synthetic Iran) since 2005.

This analysis, focusing on the FDI outcome variable, showed that sanctions have caused a plummet decrease in FDI. by tightening these sanctions, the gap between Iran's synthetic FDI and actual Iran until the JCPOA agreement in 2015, was almost 12 billion US dollars and following the victory of Trump and the withdrawal of the United States from the JCPOA, this gap reached its peak at 20 billion dollars in 2020.

The result shows the synthetic Iran reflects actual Iran in the pre-intervention. Also, considering the increase in economic costs between 2018 and 2020, the results indicate the long-term impact of sanctions on the economy.

The Placebo tests indicate that the findings have statistical significance at the 10% level. Also, in the robustness checks of the results, by removing the countries which had positive weight from the donor pool or moving the year of the start of sanctions to 2004, the results were obtained similar to the initial results. Furthermore, the finding are not influenced by the structure of the donor pool or to the time the sanctions started

As the findings of this research also showed, the amount of investment attraction is not consistent with the rest of the macroeconomic goals. also, FDI has not performed proportionately with the rest of the variables, and the entry of foreign capital into Iran is small compared to many countries in the world. According to the UNCTAD report, Iran's share of attracting foreign capital in 2018 is only about 0.3% of the world's foreign capital inflow. Although after the approval of the foreign investment promotion and support law in Iran, a different process has started in attracting FDI in Iran, the maximum amount of foreign investment in Iran was only about 5 billion dollars in 2017. Therefore, in order to access the growth rates of the higher perspective and the sixth and seventh plans (8 percent), it is necessary to attract sufficient foreign direct investment due to the removal of capital restrictions and technology transfer. Considering the importance of investment and capital formation in the country's economic growth, the attraction of foreign direct investment can definitely solve many economic knots in the field of employment and supply and demand of goods. Accordingly, in the conditions of embargo, efforts to remove obstacles to foreign direct investment and the use of technology transfer methods should be in the center of attention of policymakers and planners of the country.

Author Contributions:

Conceptualization, all authors; methodology, SCM.; validation, SCM.; formal analysis, all authors; resources, SCM.; writing—original draft preparation, SCM.; writing—review and editing, all authors; supervision, SCM. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

Data Availability Statement:

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