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Abstract

This study examines the causal joint effect of a new political regime and war against Iraq on life expectancy of Iranians for the period 1978–1988 during the revolution and war. I use a synthetic control approach to construct a synthetic Iran based on a weighted average of other Middle East and North Africa ('MENA') and Organization of the Petroleum Exporting ('OPEC') countries. The synthetic Iran matches the average level of key pre-revolution life expectancy correlates and the evolution of the factual Iranian life expectancy during the post-revolution period through the end of the war. I find a sizable negative effect of the joint treatment. The results show that in total, an average Iranian has lost an accumulated 62 years of life during the post-revolution period until the end of war with Iraq in 1988. The average annual years of life lost is approximately six years. In other words, in the absence of the revolution and war, an average Iranian's life expectancy could be approximately six years longer.

JEL-Codes: C230, H560, F510, D740, Q340.

Keywords: synthetic control method, treatment effect, Iran, Iraq, war, conflict, revolution, life expectancy, health.

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Introduction

What was the effect of the Islamic revolution in Iran (1977-79) and the subsequent eight-year war with Iraq (1980-88) on the life expectancy of Iranians? Open resistance against the Mohammad Reza Pahlavi monarchy and the political system started in February 1977 and worsened in 1978. By February 1979, the Shah fled into exile and the monarchy collapsed (Kurzman 1995, Zunes 2009, and Seeberg 2014). Using the political instability and internal chaos in Iran as an opportunity, the Iraqi army, under leadership of Saddam Hussein, invaded Iran in 1980. An armed conflict started with Iraq which lasted eight years. Earlier studies have attempted to measure the economic costs of the revolution and war for Iran and have estimated losses from US$ 592 billion to US$ 1.5 trillion (e.g., Amirahmadi 1990, Mofid's 1990, Farzanegan 2020). There is no study on the years of life lost due to the revolution and war in Iran. This study aims to fill this gap as shortened life expectancy resulting from conflict, violence and war have important implications for economic development.

The purpose of this study is to understand how Iranian life expectancy could have developed in the absence of the revolution and war. To address this question, I use a quasi-experiment approach by comparing factual Iran with its counterfactual version, before and after the revolution, and then estimate the joint effect of the revolution and war on the longevity of Iranians. Employing a synthetic control methodology (SCM) and using annual data from 1970 to 1988, I quantify the magnitude of years of life lost due to the revolution and war in Iran. This study contributes to public debate about the health costs of the Islamic revolution and war with Iraq for the Iranian people.

To set the scene, the next section presents a brief review of literature on the life expectancy-economic growth nexus. The third section explains the data and method. The fourth section presents and discusses the main results. Inference procedures and sensitivity analysis are presented and discussed in the fifth section. Concluding remarks are presented in the sixth section.

Review of literature: life expectancy and economic growth

Health and economic growth are linked to each other through a variety of channels. Oster, Shoulson, and Dorsey 2013, Soares (2005), and Kalemli-Ozcan et al. (2000) have shown that lower mortality rates and longer lifespans increase a society's willingness to invest in human capital. This is based on the human capital theory which suggests that a longer life expectancy enhances the incentives to invest in skill acquisition (Becker, 1964; Ben-Porath, 1967). Human capital is shown to have important direct and indirect effects on long-term economic growth across countries (Hanushek, 2013; Hanushek and Woessmann, 2008, 2015). Thus, one of the channels through which life expectancy contributes to economic growth is through the channel of higher incentives for human capital formation.

Soares (2005), Kalemli- Ozcan (2002), Kalemli-Ozcan, Ryder, and Weil (2000), and de la Croix and Licandro (1999) also provide evidence for a causal effect of life expectancy on growth via human capital formation mechanism. Among theoretical models which included human capital, specifically health capital in determining economic growth, we can refer to Mankiw, Romer, and Weil (1992), Fogel (1994), Barro and Sala-i-Martin (1995) and Barro (1996). For example, Barro (1996) followed a Ramsey scheme and developed a growth model including physical capital inputs, level of education, health capital and the quantity of hours worked. He shows that an increase in health indicators enhanced the incentives for investment in education.

Other endogenous growth models developed by (Aghion and Howitt, 1998; Howitt, 2000, 2005; Howitt and Mayer-Foulkes 2005) also find six different channels through which improvements in the health of a population may increase long-term economic growth (i.e., productive efficiency, life expectancy, learning capacity, creativity, coping skills and inequality).

Empirical studies by Strauss and Thomas (1998) and Schultz (1999) show that enhanced health indicators have made positive impact on the learning abilities of children and also produced better educational outcomes. Fogel (1994) suggests that approximately one-third of the increase in income in Britain during the 19th and 20th centuries was due to enhancement in health and nutrition. Similar positive effects of higher life expectancy on growth are estimated in the cases of Brazil and Mexico by Mayer (2001). Weil (2007) constructed macroeconomic estimates of the proximate effect of health on GDP per capita. He shows that removing health gaps across countries would reduce the variance of logarithm of GDP per worker by approximately 10 percent and reduce the ratio of GDP per worker at the 90th percentile to GDP per worker at 10th percentile from 20.5 to 17.9. Gyimah-Brempong and Wilson (2004) show that 22% and 30% of the transition growth rate of per capita income in Sub-Saharan African and OECD countries respectively, can be attributed to improved health human capital.

The size of the impact of longer life expectancy on economic growth is also substantial. For example, Bloom, Canning and Sevilla (2004) use a production function model of economic growth and employ a cross national panel dataset. They show that an increase of life expectancy by one year increases GDP growth rate by 4%.[1]

Longer life expectancy also has a positive impact on saving rates (Kinugasa and Mason 2007; Zhang and Zhang, 2005). Lee, Mason, and Miller (2000) show that increases in life expectancy are critical in the saving behaviour of individuals. Using US household data, Hurd, McFadden and Gan (1998) show that people with higher subjective survival probabilities save more. Bloom, Canning and Graham (2003), in their theoretical and empirical study, also find that increases in life expectancy lead to higher savings rates at every age, even when retirement is endogenous.

Both higher human capital investment and savings increase labor force productivity (Cervellati and Sunde 2011). Higher longevity is positively associated with cognitive

[1] Other studies find a non-linear association between life expectancy and economic growth (e.g., Azomahou Boucekkine, and Diene, 2009; and Farauqee and Mühleisen, 2003; Cervellati and Sunde, 2011; and Hansen, 2012; Husain, Dutta and Chowdhary, 2014).

development (Jamison et al. 1996) and is shown to be one of the robust determinants of investment and economic growth (Mason 2007; Alsan, Bloom, Canning 2006; Bloom, Canning, and Sevilla 2004; Bjorvatn and Farzanegan 2013). Moreover, the level and development of life expectancy shape fertility behaviour, intergenerational transfers, and incentives for claims on pension benefits (Zhang, Zhang, and Lee 2001; Coile et al. 2002). Birth and sibling histories from the Demographic Health Surveys conducted in sub-Saharan Africa, Turan (2020) shows that increases in life expectancy will have a positive impact on growth through fertility, education and labor supply. From a public finance perspective, increased life expectancy has a positive effect on public funding for education (Gradstein and Kaganovich 2004).

In short, there are ample of studies which show a direct and indirect positive association between life expectancy and economic development across the world.

Data and Methodology

I use the synthetic control method to study the trajectory of longevity in Iran before and after the Islamic revolution. This method employs a weighted average set of control units, presenting a synthetic control unit that reflects the treated unit (i.e. Iran) in terms of predictors of outcome (i.e. life expectancy) before the shock. The SCM minimizes the gap between the vector of characteristics of Iran and its synthetic before the revolution. Abadie et al. (2010) present several distinct advantages of SCM over regression-based methods. The method employs a transparent weighting framework and controls for time-varied unobserved country characteristics to reduce concerns from simply comparing countries, which may arise in more descriptive studies. Such descriptive studies usually lack an explicit counterfactual. In their survey study, Athey and Imbens (2017) present SCM as "arguably the most important innovation in the policy evaluation literature in the last 15 years." Abadie and Gardeazabal (2003), Abadie, Diamond, and Hainmueller (2010) and Abadie (forthcoming) present a review of the methodology of the synthetic control and its applications.

I use annual country-level panel data for the period 1970-1988. The ceasefire between Iran and Iraq was reached in 1988, ending a war that started in 1980. The treatment year is determined to be 1977, which is the start of revolutionary movements in Iran.[2]

Following the same method used by Farzanegan (2020) in analyzing the economic costs of the Iranian revolution and war, the synthetic Iran is constructed as a weighted average of potential control countries in the donor pool. The donor pool includes a sample of Middle East & North Africa (MENA) and Organization of the Petroleum Exporting Countries (OPEC) from 1970 to 1988. Using this sample helps to control for cultural, religious, geographical and economical similarities. [3] In the SCM approach, an outcome variable (life expectancy) should be comparable between the treated country (Iran) and its synthetic before the event (revolution and war with Iraq), conditional on the successful generation of such a synthetic Iran. In the latter case, a divergence between the factual Iran and its counterfactual after the treatment year suggests the causal impact of the revolution and war on the longevity of Iranians. For an unbiased estimation in SCM, it is important that countries in the donor pool do not have a similar experience of conflict and violence as in the case of Iran. For this reason, countries such as Iraq, Lebanon and Israel were excluded. After excluding countries with missing data, there are a total of nine countries (from the initial 20) as possible candidates to generate a counterfactual Iran[4]. For the outcome variable, I use an indicator of longevity from the World Bank (2020), which measures the number of years a newborn infant would live if prevailing patterns of mortality at the time of birth were to stay constant throughout the child's life. The following predictors of life expectancy are used to produce a counterfactual Iran before applying the joint treatment of Islamic revolution and war. The selection of predictors is based on earlier literature regarding determinants of longevity, the availability of data from all

[2] The results do not change if we select 1978 as the treatment year.
[3] The results are robust to an expanded worldwide sample.
[4] These are Algeria, Ecuador, Egypt, Gabon, Malta, Morocco, Saudi Arabia, Tunisia, and Venezuela.

countries in the donor group from 1970 to 1988 and their contribution in generating a counterfactual Iran before the treatment year (1970-1976) with high preciseness. The following are used as predictors and correlates of outcome in SCM: gross domestic product (GDP) per capita (2010 US$), gross capital formation (% GDP) and final consumption expenditure (% of GDP) (Pritchett and Summers 1996), population growth rate (Acemoglu and Johnson 2007), and urbanization (% of total population) (Dye, 2008). Furthermore, there is extensive literature on the positive association between education and health (e.g., Grossman and Kaestner 1997). Higher education is associated with higher income and wealth and more cognitive ability to manage health risk factors. Lleras-Muney (2005) also provides empirical evidence on the causal effect of education on health outcomes, focusing on adult mortality rates in the United States.[5] In a sample of MENA countries, Hamidi et al. (2018) find a significant positive effect of educational attainment on life expectancy, controlling for other factors. I use a human capital index from the Penn World Table, which is calculated based on years of schooling and returns on education (Feenstra, Inklaar and Timmer 2015). Finally, I control for the previous records of life expectancy in years 1976, 1974, 1972 and 1970 to help increase the goodness of fit of the counterfactual Iran with the factual Iran during the pre-revolution and war periods. The source of data for all variables (except for human capital) is the World Bank (2020).

The synthetic control method employs countries included in the donor pool which have not been exposed to the treatment (the Islamic revolution and war with Iraq), to build the counterfactual development of life expectancy for Iran in the post-treatment (i.e. revolution and war) period. This method considers that different countries from the donor pool share a different degree of similarity with Iran by using country weights ω_d for each country d in donor pool, assuming that these weights are between 0 and 1, i.e., $0 \leq \omega_d \leq 1$ and $\sum_{d=1}^{D} \omega_d = 1$. To

[5] Using OLS estimates, she shows that one more year of education in 1960 increased life expectancy at age 35 by as much as 1.7 years.

identify and generate the best possible counterfactual Iran from all possible mixture of countries in the donor sample, the SCM uses pre-treatment information of the outcome variable (life expectancy in this study) Y_t and additional predictor variables Z_t which are shown to be relevant explanatory variables for life expectancy (as explained earlier). Formally, the synthetic Iran is generated by selecting weights ω_d such that $Y_t - \sum_{d=1}^{D} \omega_d^* Y_{dt}$ and $Z_t - \sum_{d=1}^{D} \omega_d^* Z_{dt}$ are minimized for the years prior to the treatment, i.e., in this case, Iran's revolutionary period and the war with Iraq for t < 1977. In simple terms, the optimal synthetic Iran should not only have the same (or similar) life expectancy as Iran during the pre-revolution and war periods, but it should also have the same (or similar) values of the covariates. The treatment effect $\alpha_t$is calculated as $\alpha_t = Y_t - \sum_{d=1}^{D} \omega_d^* Y_{dt}$ for $t > 1977$.

The impact of the revolution and war on life expectancy is equal to the difference between the factual Iranian life expectancy and the estimated counterfactual life expectancy, over the period of 1978-1988, had the Iranian revolution and war not happened.

Results

Table 1 shows that the synthetic Iran is best generated by a weighted average of three countries, with Gabon (54%), Tunisia (30%) and Venezuela, RB (16%) having the highest weights. Table 2 shows the average values of the covariates for the factual Iran and the counterfactual Iran before 1977. The synthetic Iran closely reflects the pre-1977 performance of the life expectancy covariates of the factual Iran. The synthetic Iran is similar to factual Iran in terms of life expectancy before 1977, as well as in the associated shares of gross capital formation, final consumption (private and public) in total GDP, population growth rate, urban share of population, GDP per capita and human capital index.

In addition to data on factual Iran, the synthetic Iran, and their differences, in Table 2, I present an unweighted average of variables for countries with a weight > 0 (i.e., Gabon, Tunisia and Venezuela) during 1970–1976. The predicted outcome (life expectancy) in the pre-treatment period is similar between the factual Iran and the synthetic Iran (with optimally selected weights, as shown in Table 1). However, there is a significant gap between the outcome of the factual Iran and the *unweighted* average of life expectancy for countries with weight > 0. This shows the importance of using a synthetic control method for this analysis, which generates a counterfactual Iran by assigning the *optimum weights* to relevant countries.

Table 1. Country weight in synthetic Iran

Country	Weight
Algeria	0
Ecuador	0
Egypt	0
Gabon	0.539
Malta	0
Morocco	0
Saudi Arabia	0
Tunisia	0.304
Venezuela	0.157

Table 2. The means of predictors during the pre-treatment period (1970–1976)

	Factual Iran (1)	Synthetics Iran (2)	Unweighted average of variables for countries with weight >0 (3)	Difference (1-2)	Difference (1-3)
Life expectancy (years) (1976)	55.74	55.96	58.83	-0.21	-3.09
Life expectancy (years) (1974)	54.46	54.30	57.33	0.16	-2.87
Life expectancy (years) (1972)	52.56	52.60	55.77	-0.04	-3.21
Life expectancy (years) (1970)	50.86	50.86	54.14	0.00	-3.28
GDP per capita (US$)	8793.44	8886.10	9162.63	-92.66	-369.19
Population growth (%)	2.78	2.18	2.36	0.60	0.42
Urban population (% population)	43.93	46.39	52.90	-2.46	-8.98
Gross capital formation (% of GDP)	38.73	39.12	36.32	-0.38	2.42
Human capital index	1.14	1.23	1.28	-0.09	-0.14
Final consumption (% of GDP)	66.85	58.64	63.63	8.21	3.23

Figure 1 shows the life expectancy trajectory of the factual Iran and its synthetic for the 1970–1988 period. The synthetic Iran reproduces the life expectancy of the factual Iran during the entire pre-revolution period. The estimate of the effect of the revolution and war on the life expectancy in Iran is shown by the difference between the factual Iran and its synthetic (Figure 2 and Table 3).

The two lines diverge significantly after the collapse of Pahlavi monarchy and during the war with Iraq. While life expectancy falls in the factual Iran, longevity keeps its earlier path during the early the 1980s in the case of the synthetic Iran. The difference between the two series remains significant towards the end of the sample period. Therefore, the results imply a main negative effect of the revolution and war on life expectancy in Iran, which is a key metric for assessing the health of the population.

The accumulated years of life lost to the revolution and war for an average Iranian is 62 years.[6] From 1978 to 1988, the average annual years of life lost to the revolution and war for an Iranian was 5.8 years. The lowest average years of life lost was 2.1 (in 1978), while the highest was 8.2 (in 1983). The median years of life lost to the revolution and war during the treatment period was approximately 6.5 years. Table 4 shows the summary statistics regarding the life expectancy gap between Iran and its counterfactual from 1978 to 1988.

[6] Note that only statistically significant estimated years of life lost from 1979 to 1988 are considered for this calculation. In other words, although the estimated years of life lost between 1977 and 1978 (the revolutionary period) were -1 and -2.1, due to their statistical insignificance, they are excluded from the accumulated sum.

Table 3. Years of life lost to revolution and war in Iran

Year	Gap in years (Iran life expectancy-synthetic Iran life expectancy)	Iran life expectancy	Synthetic Iran life expectancy
1970	0.00	50.86	50.86
1971	-0.07	51.66	51.73
1972	-0.04	52.56	52.60
1973	0.06	53.51	53.46
1974	0.16	54.46	54.30
1975	0.13	55.27	55.13
1976	-0.21	55.74	55.96
1977	-0.95	55.83	56.78
1978	-2.08	55.51	57.59
1979	-3.52	54.88	58.40
1980	-5.08	54.11	59.19
1981	-6.52	53.45	59.97
1982	-7.60	53.13	60.73
1983	-8.16	53.29	61.45
1984	-8.14	54.00	62.13
1985	-7.54	55.21	62.76
1986	-6.47	56.85	63.32
1987	-5.12	58.68	63.81
1988	-3.70	60.53	64.23

Table 4. Summary statistics for the life expectancy gap between Iran and Synthetic Iran (1978-1988)

Mean of loss	-5.8 years
Median of loss	-6.5 years
Minimum loss	- 2.1 years
Maximum loss	- 8.2 years
Std. Dev.	2.06 years
Post -treatment period (1978-1988)	11 years

Figure 1. Factual and counterfactual Iran. Source: Author's own calculations.

It is also important to consider the uncertainty around the estimated years of life lost to the revolution and war in the SCM approach. To do this, I follow a methodology developed by Firpo and Possebom (2018) and Ferman, Pinto, and Possebom (2020) to gain more insight into the statistical significance of the estimated results. Ferman et al. (2020) proposed a uniform confidence set around the estimated effect by SCM, which contains all functions that are deviations from the estimated treatment effect by an additive and constant factor and are not rejected by the placebo test. Figure 2 shows the estimated life expectancy gap between the factual Iran and the counterfactual Iran with uniform confidence sets at 90% level (which is the highest level of confidence intervals given the sample size of 10). I observe that the negative effect of the joint treatment of revolution and war on the longevity of Iranians is statistically significant in all years between 1979 and 1988. Table 5 and Figure 2 show the estimated gap in life expectancy of the factual Iran and its counterfactual, in addition to the lower and upper bounds for these estimations. In the years when confidence sets do not include zero, I am 90% confident on the true negative effect of the revolution and war on the longevity of Iranians.

Table 5. Confidence sets for estimated years of life lost to revolution and war in Iran (1977–1988)

Year	Upper Bound (Best Scenario)	*Estimated Lost Years*	Lower Bound (Worst Scenario)
		Confidence sets (Uniform treatment)	
1977	1.4	*-1.0*	-3.4
1978	0.3	*-2.1*	-4.5
1979	-1.2	*-3.5*	-6.0
1980	-2.8	*-5.1*	-7.6
1981	-4.3	*-6.5*	-9.0
1982	-5.4	*-7.6*	-10.1
1983	-6.0	*-8.2*	-10.7
1984	-6.0	*-8.1*	-10.7
1985	-5.4	*-7.5*	-10.2
1986	-4.3	*-6.5*	-9.1
1987	-3.0	*-5.1*	-7.8
1988	-1.7	*-3.7*	-6.4

Estimated Lost Years is the factual Iran's life expectancy-synthetic Iran life expectancy. Calculations of confidence sets are based on the work of Firpo and Possebom (2018) and Ferman et al. (2020). The confidence interval is 90% (which is the highest possible level for the sample of 10 countries). The bounds not only rejects the null hypothesis of no effect (because the upper bounds of the confidence sets are –since 1979–below the zero function), but they also show that the joint health impact of the revolution and war is far from zero, suggesting relevant negative effects on human life.

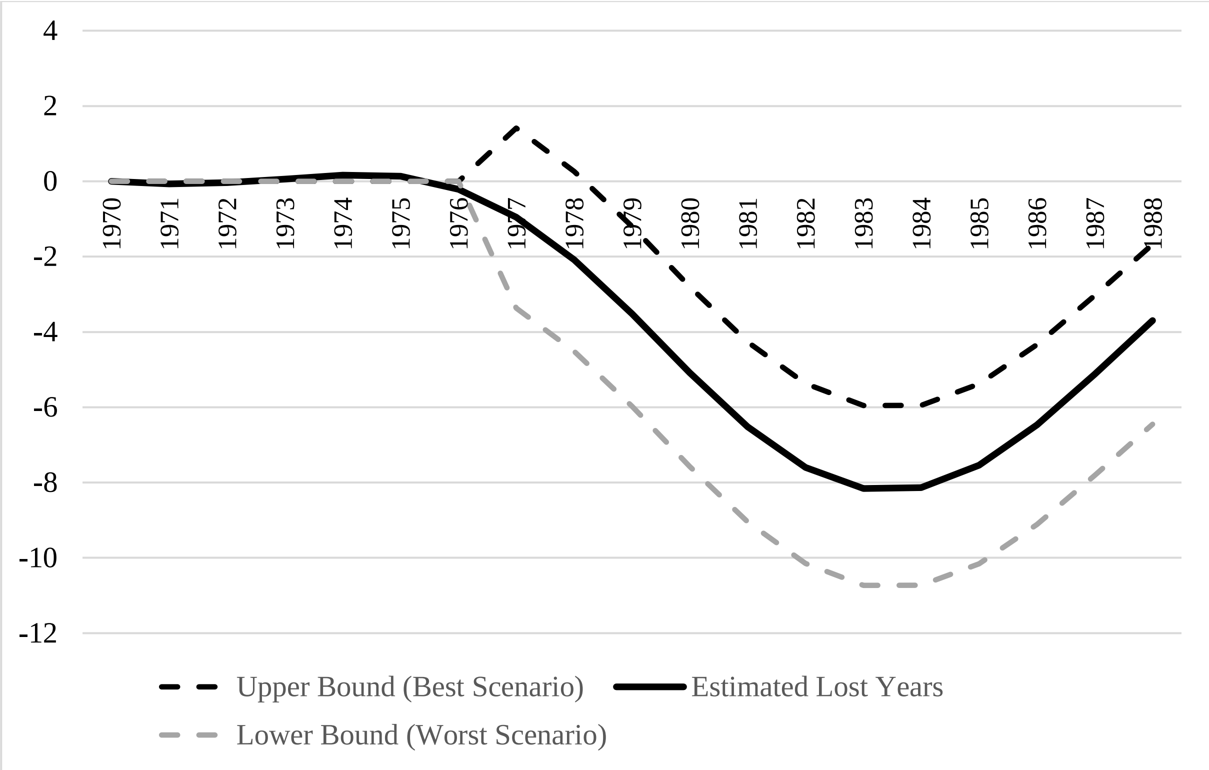

Figure 2. The life expectancy gap between the factual Iran and the synthetic Iran before and after the revolution (with uniform confidence sets). Source: Author's own calculations. Uniform confidence sets are based on Ferman, Pinto, and Possebom (2020). The confidence interval level is 100-(1/10 × 100) = 90%.

Inference Procedures and Sensitivity Analysis

In-Space Placebo Test

The approach suggested by Firpo and Possebom (2018) and Ferman et al. (2020) in using confidence intervals around the estimated effect from SCM provides good insight on the uncertainty around the estimated years of life lost to the revolution and war in Iran.

An alternative way to test the robustness of these estimations is through placebo or Falsification tests. They are also known as randomization inference tests in statistical fields (Bertrand, Duflo, and Mullainathan 2004). Placebo tests have a simple framework: if SCM is applied to other countries that were not under the treatment (revolution and war), then logically, a similar significant negative health outcome, should not be observed, as in the case of Iran. If a similar trajectory for other countries is observed, then the estimated effect for Iran cannot be associated with the post-revolution shock. The placebo tests are shown in Figure 3.

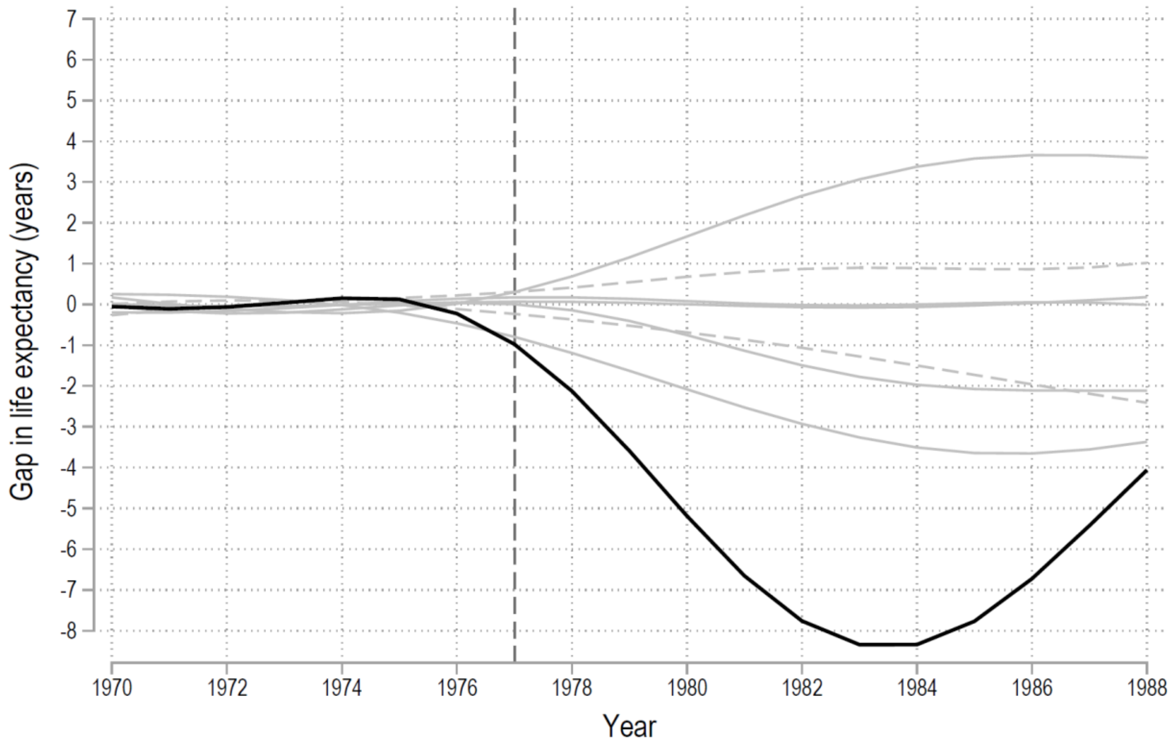

Figure 3. (in-space) Placebo Tests. Source: Author's own calculations.

The tests were applied to the other nine donor countries in 1977.[7] The thick black line shows the earlier estimated health effect for Iran. The other lines represent the gap between the life expectancy (in years) of each of the other countries and their related synthetic counterparts produced by SCM. From Figure 3, it is clear that Iran shows a significant drop in the post-1977 period. There is no other country in this sample which shows a similar negative health effect when subjected to this treatment.

[7] Two countries (Gabon and Malta) showed a poor pre-treatment goodness of fit and are dropped from Figure 3.

In addition to this visual check, I calculate a pseudo p-value based on the rank of the treatment unit's post/pre-root mean square prediction error (”RMSPE”) ratio compared to the untreated placebo units’ post/pre-RMSPE ratios (as in Abadie, Diamond, and Hainmueller, 2010). As the results in Table 6 show, the largest ratio of post-treatment RMSPE to pre-treatment RMSPE belongs to Iran (48.33). The inference procedures show a pseudo p-value of 1/10=0.10, meaning that there are no other placebo runs that outperform or equal the effect of Iran’s estimate when pre-intervention fit (RMSPE) is accounted for. The evidence for a causal health effect of the Iranian revolution and war is strong.

Table 6. Ratio between the post- and pre-intervention root mean squared prediction error (RMSPE)

Country	post/pre-RMSPE ratio
Algeria	18.76
Ecuador	2.30
Egypt	11.07
Gabon	1.53
Iran	48.33
Malta	0.92
Morocco	11.61
Saudi Arabia	0.61
Tunisia	4.96
Venezuela	19.05

Source: Author’s own calculations.

Change in Time Dimension (In-Time Placebo)

What will happen to the results produced by the synthetic control method if other years are selected as treatment shocks? To evaluate the reliability of the results, and in addition to “in-space placebo” test, I follow Abadie, Diamond, and Hainmueller 2012 and conduct an “in-time placebo” examination. I re-estimate the SCM model but change the treatment year from the beginning of the revolution in 1977 to two other periods. One is 1974, which did not have any specific major political or economic shocks in Iran, and the other is 1980, which was the start of the Iran-Iraq war. Is there a similar divergence between the life expectancy of the factual Iran and its synthetic even if other periods are used? Figure 4 displays the result of the "in-time placebo" study.

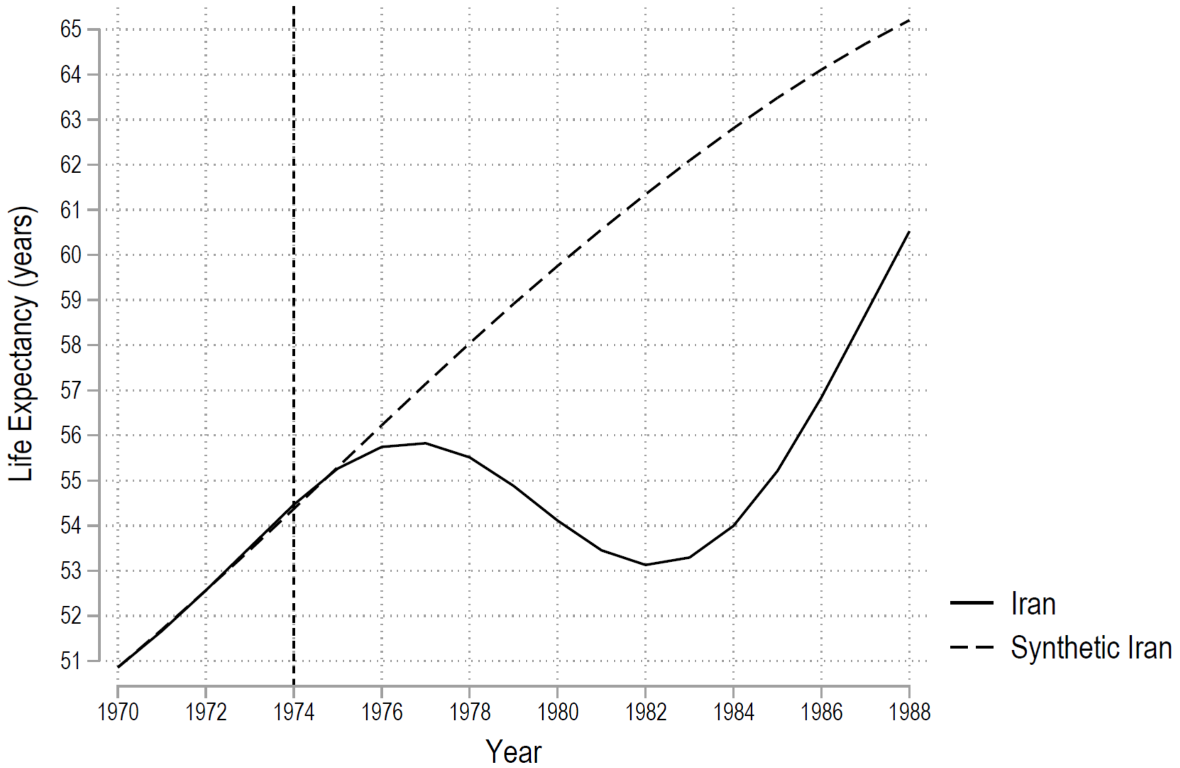

Figure 4. In-time placebo effect of 1974 life expectancy of the factual Iran vs. synthetic Iran. Source: Author's own calculations.

In Figure 4, there is no divergence between the actual life expectancy of the factual Iran and the synthetic Iran, and there is no effect estimated for 1974. This shows that the random selection of a year with no major political or economic events does not generate the effect which was observed from the real shock of the revolution and war.

How about assuming the beginning of war with Iraq as the possible year of shock? Is there a divergence between the factual Iran and its synthetic beginning in 1980? Re-estimating the synthetic analysis shows that the divergence between the factual Iran life expectancy and its synthetic began during the revolution (1977). In other words, the revolution and subsequent war with Iraq imposed a causal negative effect on the life expectancy of Iranians.

Figure 5. In-time placebo effect of 1980 life expectancy of the factual Iran vs. synthetic Iran. Source: Author's own calculations.

Leave-One-Out Synthetic Control

To what extent is the main result sensitive to the inclusion of a specific country in the donor pool? To elaborate this issue, I conduct a leave-one-out analysis where the most influential countries are iteratively excluded from the synthetic control sample. In each iteration, the number of countries in the donor pool is reduced by one and the model is re-estimated based on the adjusted synthetic sample.

In the first iteration, Gabon, which has the highest weight (see Table 1), is excluded, and the synthetic control method is run following this adjustment to the donor pool. After running SCM without Gabon, Tunisia received the highest unit weight in the donor sample.

In the next iteration, both Gabon and Tunisia are excluded. I am interested in synthetic controls with low prediction errors. Thus, I continue this process until the pre-intervention

RMSPE is more than twice of the main estimation. This happens after the second iteration (when excluding both Gabon and Tunisia, resulting in pre-intervention RMSPE of 0.2642, which is 2.2 times of the pre-intervention RMSPE of the main estimation at 0.1189).

Figure 6 illustrates the findings of *Leave-One-Out Synthetic Control* analysis. The synthetic control results are robust to the exclusion of dominant countries from the donor pool, ensuring the reliability of the initial findings.

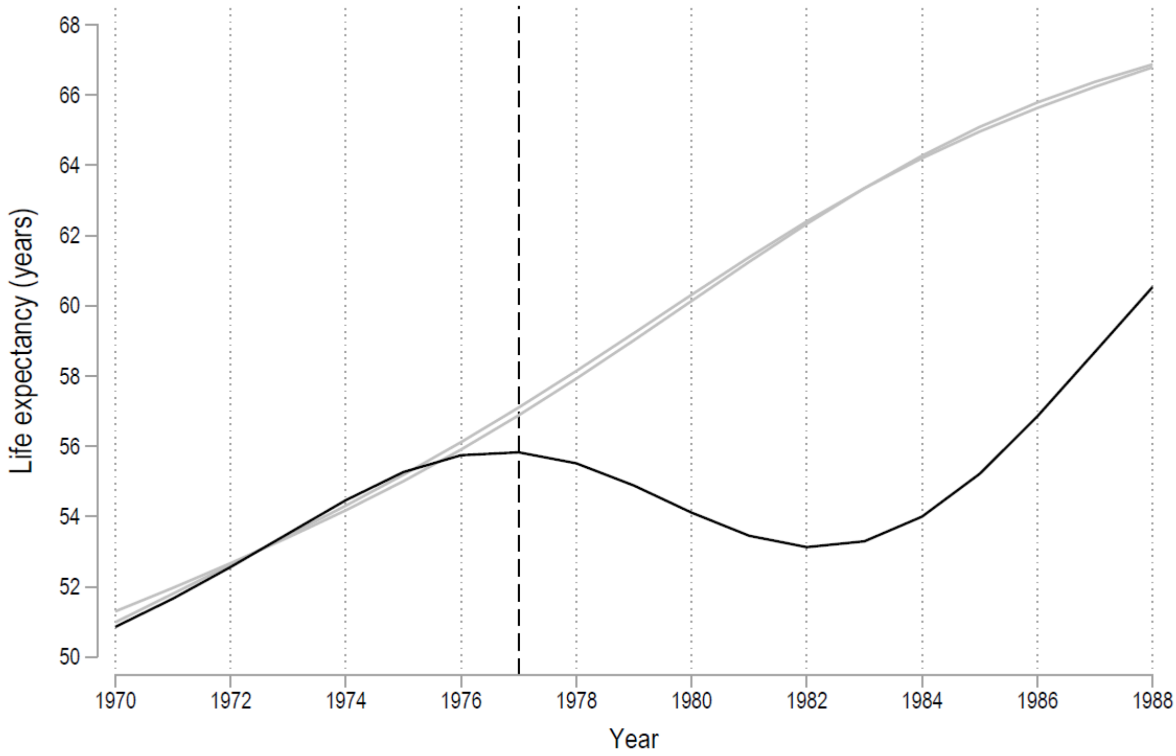

Figure 6. Sensitivity analysis

Note: Results from a leave-one-out analysis that iteratively reduces the donor pool by excluding the most important country from the synthetic control unit until the pre-intervention prediction errors are twice as large as in the main analysis (n = 2 iterations). Source: Author's own calculations.

Conclusion

More than four decades ago, Iran experienced a series of momentous political events with substantial implications for its socio-economic development. The Islamic revolution, which started during 1977-78 and led to the collapse of monarchy system in Iran in 1979, as well as the subsequent war with Iraq (1980-88) imposed significant economic costs. Farzanegan (2020) examined the causal joint effect of the revolution and war on the economy of Iran and showed that the average income per capita lost to the revolution and war was approximately US$ 3000. While the economic costs of conflict and violence (with more focus on the war with Iraq) has been studied in the literature, the human and health consequences of these events are less investigated.

This study provides an answer to the question: what could have happened to the longevity of Iranians in the absence of the Islamic revolution and war with Iraq? Addressing this question is important given the significant body of evidence on the long-term positive development consequences of longer life expectancy. Earlier studies suggest that an increase in life expectancy leads to more economic growth directly and indirectly through different channels, such as higher incentives for investment in human capital (education), saving rates, labor force participation and productivity, and life sensitisation, among others.

I aim to find an answer on the causal effect of conflict and violence on the health of a nation. To do this, I employ a quasi-experimental approach based on the synthetic control method, estimating the years of life lost in Iran following the Islamic revolution and war with Iraq. I show that the trajectories of life expectancy of the factual Iran and its synthetic were similar before the shock of the revolution. However, it significantly deviated after.

The results show that an average Iranian lost an accumulated 62 years of life during the post-revolution period until the end of war with Iraq in 1988. The average annual years of life lost is approximately 6 years. In other words, in the absence of the revolution and war, an average Iranian’s life expectancy could be approximately 6 years longer.

I also consider the uncertainty around the estimated life expectancy gap between the factual Iran and its counterfactual after the revolution and calculate the 90% confidence intervals around the estimated gap. I observe that the negative effect of the joint treatment of the revolution and war on the longevity of Iranians is statistically significant in all years between 1979 and 1988. The highest negative effect on health is observed in 1983 with an estimated 8.2 years of life lost.

A change in regime and a destructive eight-year war with Iraq forced the state to allocate more scarce economic resources to the military, rationing key food and nutrition products and restricting trade. Post-revolution Iran also experienced a variety of economic sanctions imposed by the United States. The reduction of the quantity and quality of basic goods and services degraded the quality of life under the harsh political situation of the post-revolution period.

In addition to considering the uncertainty around the estimations, I also carried out the more traditional forms of sensitivity analysis for the synthetic control method. These tests included in-space and in-time placebo examinations as well as leave-one-out synthetic control. These additional robustness checks support the initial findings of a significant negative causal effect of revolution and war on the life expectancy of Iranians.

According to existing literature, the lost longevity has long-term negative impact on willingness to invest in human capital, public funding on education, cognitive development, saving rates, labor force productivity, fertility behavior of individuals, investment rates and economic growth. The political shock of the revolution that destabilized the government and the subsequent war with Iran not only destroyed the nation's physical infrastructure, but also came with sizable health costs.

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