How U.S. Travel Restrictions on China Affected the Spread of COVID-19 in the United States

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How U.S. Travel Restrictions on China Affected the Spread of COVID-19 in the United States*

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Abstract

Early in the COVID-19 pandemic, President Trump imposed travel restrictions on the People's Republic of China (PRC) to slow its spread to the United States. We use the synthetic control method (SCM) under eight different specifications to see whether the travel restrictions slowed the domestic spread of COVID-19. In most specifications, the travel restriction had no effect on the number of COVID-19 cases in the United States. In two specifications, the travel restriction reduced the number of COVID-19 cases for up to 15 days after the ban was enacted. Regardless of the intervention date or how the spread of COVID-19 is measured, we find that the travel restrictions did not delay the prevalence of COVID-19 or did so by 15 days at most.

JEL Codes: I10, I18, J15

Key Words: Travel bans, immigration, COVID-19, SARS nCoV-19

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1 Introduction

On February 2, 2020, President Donald Trump banned the entry of all aliens who were physically present within the People's Republic of China (PRC) during the 14-day period preceding their entry or attempted entry into the United States with some exceptions for U.S. lawful permanent residents and those closely related to American citizens (White House, 2020). The U.S. travel ban was the earliest domestic nonpharmaceutical intervention to limit the spread of SARS-CoV-2 (COVID-19) in the United States. Peer-reviewed papers on the effect of international travel bans on the spread of COVID-19 find that they delay the spread by a few days up to 2-3 weeks. However, those papers rely entirely on epidemiological models of emigration restrictions from the epicenter of the outbreak in Hubei (Chinazzi et al., 2020; Wells et al., 2020), focus on travel restrictions imposed by other countries like Japan (Anzai et al., 2020), or on how domestic travel restrictions in the PRC affected the spread of COVID-19 among Chinese cities (Fang et al., 2020).

The U.S. travel ban on people who had been in the PRC in the two weeks prior to their attempted entry, which is a de facto ban on the entry of all Chinese residents, allows us to empirically estimate the extent to which the U.S. travel ban affected the spread of COVID-19 in the United States. Historically, travel restrictions to prevent the spread of pandemic influenzas have been similarly ineffective at halting or significantly delaying the spread of those diseases (WHO Writing Group, 2006). No papers have yet examined how U.S. travel restrictions affected the spread of COVID-19 in the United States.

2 Data and Empirical Strategy

This paper uses the synthetic control method (SCM) to estimate a counterfactual number of COVID-19 cases for the United States in the absence of the February 2, 2020 travel restriction (Abadie, 2019; Abadie et al., 2010, 2015; Abadie et al., 2003; McClelland et al., 2017). The number of COVID-19 cases is the outcome variable and the predictor variables are those that influence the number of COVID-19 cases. The SCM is used outside of laboratory settings to create a more comparable control group when such a control group does not exist. The SCM is particularly useful to examine how policy interventions affect countries. This method mitigates endogeneity by creating a counterfactual Synthetic United States based on the same pre-treatment predictor variables that affect the number of COVID-19 cases. The only difference between the Real United States and the Synthetic United States is the PRC travel restriction.

This new Synthetic United States is estimated using a weighted average of predictor variables in similar countries that did not institute a PRC travel restriction during the time studied. The weighted average of predictor variables is determined by matching countries that share similar observable characteristics with the United States on the predictor variables that influence the number of COVID-19 cases before the travel ban. Given a set of weights, the SCM estimates the impact of the travel restriction as the difference between the number of COVID-19 cases in the Real United States and the number of COVID-19 cases in the Synthetic United States after the travel ban was enacted.

To outline this procedure, let Y_i be the sample mean of an outcome of interest for country i. The estimated treatment effect τ_1 for the United States ($i = 1$) is estimated as a weighted average of $N + 1$ donor countries in the form:

$$\tau_1 = Y_1 - \sum_{i=2}^{N+1} w_i Y_i. \tag{1}$$

This procedure considers the weighting vector $W = [w_2, \ldots, w_{N+1}]'$ which assigns a weight w_i to control countries subject to non-negativity ($\{w_i \in [0, 1]; i = 2, \ldots, N + 1\}$) and additive ($w_2 + \cdots + w_{N+1} = 1$) constraints (Nowrasteh et al., 2019).

The intervention period is February 2, 2020. The pre-treatment period begins on January 22, 2020 and runs to February 1, 2020. The post-intervention period begins on February 3, 2020 and runs through March 9, 2020, right before other countries in the sample began to impose similar travel bans on China. The weighted average of the country-predictor variables in the pre-treatment period is the basis for the construction of the Synthetic United States. The average weight of the predictor variables for the Synthetic United States in the pre-treatment period is then drawn out into the post-treatment period. The values for the average weights of the predictor variables in the countries in the post-treatment period continue to form the basis of the Synthetic United States.

To test the robustness of our results, we also analyze specifications that use reasonable alternative options for the intervention period and the start of the pre-treatment period. First, we used specification in which we changed the intervention period to February 16, 2020 to account for the 14-day length of the travel ban. Second, we tested specifications in which we normalized the data for all countries such that the first day of the pre-treatment period was the first day when there was one case of COVID-19 in each country in the donor pool. This second change does not affect the SCM's validity as no other countries in the donor pool had a PRC travel ban. The outcome variable for half of the SCM specifications is the number of COVID-19 cases. The outcome variable for the other half of the SCM specifications is the number of COVID-19 cases per million Americans. In total, we ran eight SCM specifications.

A Synthetic United States must be estimated from comparable countries to avoid interpolation bias. Since the number of COVID-19 cases after the U.S. travel ban is the outcome of interest, we select a donor pool of countries with similar levels of economic development (OECD, 2020), that are in the Northern Hemisphere (Luo et al., 2020), and that did not impose a travel ban on China until after the end of the post-treatment period (IATA, 2020). Most countries in the donor pool imposed a limited travel ban on Chinese citizens from Hubei province in the PRC (Chinazzi et al., 2020). Those travel bans on Hubei do not contaminate our donor pool because the Chinese government already instituted emigration bans from Hubei, making travel restrictions on the entry of people from Hubei redundant. This narrowing leaves 14 countries that we include in our donor pool: Austria, Belgium, Canada, France, Germany, Ireland, Japan, South Korea, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and the United States.

The outcome variable for specifications 1-4 is the number of COVID-19 cases per day. The outcome variable for SCM specifications 5-8 is the daily number of COVID-19 cases per million residents. The predictor variables for each specification are the immigrant population, the total population, population density, the percent of the population that is elderly, the share of the population that is urban, the median age, real GDP per capita (PPP), the absolute latitude or distance from the equator, and number of immigrants from China, and the number of airports with direct flights to China. We remove total population as a predictor variable from specifications 5-8 because population is already controlled for by the outcome variable. These predictor variables are similar to those in other SCM research on the effect of state-level social distancing policy on the spread of COVID-19 (Friedson et al., 2020). We do not include lags of the outcome variables as predictor variables in any specification to avoid biasing our results (Kaul et al., 2018).

3 Results

Table 1 shows the goodness of fit measures and results for SCM specifications 1-4 where the outcome variable is the number of COVID-19 cases. The different specifications are identified in rows 1, 2, and 3. Rows 4, 5, and 6 are the goodness of fit measures. The Root Mean Square Predicted Error (RMSPE) measures the distance between the Real United States and the Synthetic United States during the pre-treatment period. For all specifications, the RMSPEs show a good pre-treatment fit. Rows 5 and 6 show how many countries and how many predictor variables comprise at least 5 percent of the Synthetic United States in each specification. Row 7 shows the number of countries used in each sample, which was lower for the 3rd and 4th specifications because 5 countries (Austria, Ireland, the Netherlands, Norway, and Switzerland) had so few early cases that there was an insufficient number of pre-and-post treatment days (25) for the SCM to work. Rows 8 and 9 show the results for each specification.

Tables 2, 3, and 4 describe the construction our Synthetic United States for specifications 1-4. Table 2 shows the donor country weights chosen for each specification. As another measure of fit, Table 3 shows the predictor variables' balance relative to the Real United States and their sample means. Table 4 shows the relative weight assigned to each predictor variable when creating the Synthetic United States.

Specifications 1-4 show a statistically insignificant difference in the number of COVID-19 cases between the Synthetic United States and the Real United States (Figure 1). Table 1, row 8 shows the average p-values during the post treatment period for each specification and they are all far too high to be statistically significant. The p-values measure the fraction of gaps from an in-place placebo test that is larger than the gap between Real United States and Synthetic United States (Figure 2). Pooling these placebo effects together therefore estimates the distribution of observed treatment effects in the sample. The p-value denotes the probability that the estimated treatment effect for the United States is larger than all other placebo effects for the other countries in the donor pool. The p-values are presented for each day and there are no days in any specification where there is a statistically significant gap.

The figures for specifications 3 and 4 appear to show a statistically significant divergence beginning around day 30, long after the intervention date in specification 3 and shortly after for specification 4 (Figure 1). However, both apparent divergences for the Synthetic United States are insignificantly different from the Real United States because there is substantial variation in the number of COVID-19 cases among the donor pool countries at that time. Figure 2 shows that there was no statistically significant divergence in specification 3 or 4. There is no statistically significant difference in the number of COVID-19 cases in the Real United States with a travel ban and the Synthetic United States without a travel ban.

Table 5 shows the goodness of fit measures and results for SCM specifications 5-8 where the outcome variable is the number of COVID-19 cases per million residents. Specifications 5 and 6 reveal statistically insignificant gaps in the post-treatment period. Specifications 7 and 8 show a statistically significant difference after the intervention (Figure 3). Table 6 shows the donor country weights chosen for each specification. Further measure of fit are shown in Tables 7 and 8. Table 7 shows the predictor variables' balance relative to the Real United States and their sample means. Table 8 shows the relative weight assigned to each predictor variable when creating the Synthetic United States.

Specification 7 offers the most convincing evidence that the PRC travel restriction reduced COVID-19 cases per million in the United States. The gap is statistically significant immediately after the intervention period and remains so until February 17th with p-values of zero (Figure 4). After February 17th, the gap becomes statistically insignificant.

The statistically significant gap in specification 8 is less convincing (Figure 4). Although the gap is also statistically significant in specification 8 for ten days, those ten days are scattered across the post-intervention period and not immediately following the beginning of the travel ban. Since these significant post-intervention gaps are not in an ordered proximity to the travel ban, we have less confidence that these effects are directly attributable to the travel ban itself and are more likely to be statistically spurious. We therefore have more confidence in our results from specification 7.

4 Discussion

If a U.S. restriction on travel from the original COVID-19 hotspot were to have a significant effect in delaying the spread of the disease, we would expect to see it in every specification that we ran. Thus, our findings imply that travel restrictions in response to COVID-19 are largely ineffective at containing its spread. We have confidence in specifications 1-7. The first six of those specification reveal no statistically significant divergence in the number of COVID-19 cases between the Real United States and the Synthetic United States. However, specification 7 does reveal a statistically significant gap for 15 days after the intervention. Specification 8 shows another divergence, but we don't have confidence in the results.

Specification 7 is the only specification that reliably shows a statistically significant divergence in the number of U.S. COVID-19 cases resulting from an American travel restriction on the PRC. Specification 7 has an outcome variable of the number of COVID-19 cases per million U.S. residents and an intervention date beginning on the first day of the travel restriction on February 2, 2020. The result from specification 7 is remarkably similar to another epidemiologically-modelled estimate of how a 90 percent reduction in travel from Mainland China, beginning on February 1st, would have affected the number COVID-19 cases internationally (Chinazzi et al., 2020). In our specification 7 and the modelled 90 percent travel reduction estimate, the delay was 15 days (Chinazzi et al., 2020). Specification 7 is the best case that the early American travel restriction on the PRC delayed the spread of COVID-19, but it is the outlier specification.

5 Conclusion

In six of the eight SCM specifications we ran, the U.S. ban on travel from the PRC had no effect on the spread of COVID-19 in the United States compared to a donor pool of comparable rich nations in the Northern Hemisphere without such a policy. These six results are robust under an in-place placebo test. We found statistically significant effects of the U.S. travel ban on the PRC in two specifications: seven and eight. Specification 7 was the most convincing while an unordered pattern of statistical significance for specification 8 indicates a statistically specious finding. In most of our specifications, the empirical evidence is that the U.S.-imposed travel ban on the PRC had no statistically significant effect on the timing, number, or rate of COVID-19 cases in the United States. In two specifications, the U.S.-imposed travel ban on China significantly delayed the timing, number, or rate of COVID-19 cases in the United States by 15 days at most. Regardless of how we define the intervention date, and regardless of whether the spread of COVID-19 is measured by the total number of cases or the number of cases per capita, we find that the prevalence of the disease was delayed at most 15 days. President Trump's February 2, 2020 ban on travel from China did little to nothing to slow the spread of COVID-19 in the United States.

References

Abadie, A. (2019). Using Synthetic Controls: Feasibility, Data Requirements, and Methodological Aspects. *Journal of Economic Literature (forthcoming)*. http://economics.mit.edu/files/17847

Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic control methods for comparative case studies: estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, *105*(490), 493–505. https://doi.org/10.1198/jasa.2009.ap08746

Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative politics and the synthetic control method. *American Journal of Political Science*, *59*(2), 495–510. https://doi.org/10.1111/ajps.12116

Abadie, A., & J., G. (2003). The economic costs of conflict: A case study of the Basque country. *American Economic Review*, *93*(1), 113–132. https://doi.org/10.1257/000282803321455188

Anzai, A., Kobayashi, T., Linton, N., Kinoshita, R., Hayashi, K., Suzuki, A., Yang, Y., Jung, S., Miyama, T., Akhmetzhanov, A., & Nishiura, H. (2020). Assessing the impact of reduced travel on exportation dynamics of novel coronavirus infection (COVID-19). *Journal of Clinical Medicine*, *9*(2), 601. https://doi.org/10.3390/jcm9020601

Chinazzi, M., Davis, J., Marco, A., Gioannini, C., Litvinova, M., Merler, S., Piontti, P., Mu, K., Rossi, L., Sun, K., Viboud, C., Xiong, X., Yu, H., Halloran, M., Longini Jr., I., & Vespignani, A. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*, *368*(6489), 395–400. https://doi.org/10.1126/science.aba9757

Fang, H., Wang, L., & Yang, Y. (2020, March). Human Mobility Restrictions and the Spread of the Novel Coronavirus (2019-nCoV) in China (Working Paper No. 26906). National Bureau of Economic Research. https://doi.org/10.3386/w26906

Friedson, A., McNichols, D., Sabia, J., & Dave, A. (2020, April). Did California's shelter-in-place order work? early coronavirus-related public health effects (Working Paper No. 26992). National Bureau of Economic Research. https://doi.org/10.3386/w26992

IATA. (2020). Coronavirus Outbreak – Update. Travel News. https://www.iatatravelcentre.com/international-travel-document-news/1580226297.htm

Kaul, A., Klößner, S., Pfeifer, G., & Schieler, M. (2018). Synthetic Control Methods: Never Use All Pre-Intervention Outcomes Together With Covariates (Working Paper No. 83790). Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/id/eprint/83790

Luo, W., Majumder, M. S., Liu, D., Poirier, C., Mandl, K. D., Lipsitch, M., & Santillana, M. (2020). The role of absolute humidity on transmission rates of the COVID-19 outbreak. *medRxiv*. https://doi.org/10.1101/2020.02.12.20022467

McClelland, R., & Gault, S. (2017). The synthetic control method as a tool to understand state policy. https://www.urban.org/research/publication/synthetic-control-method-tool-understand-state-policy

Nowrasteh, A., Forrester, A. C., & Blondin, C. (2019). How mass immigration affects countries with weak economic institutions: a natural experiment in Jordan. *The World Bank Economic Review*, *lhy032*. https://doi.org/10.1093/wber/lhy032

OECD. (2020). List of OECD Member Countries. https://www.oecd.org/about/document/list-oecd-member-countries.htm

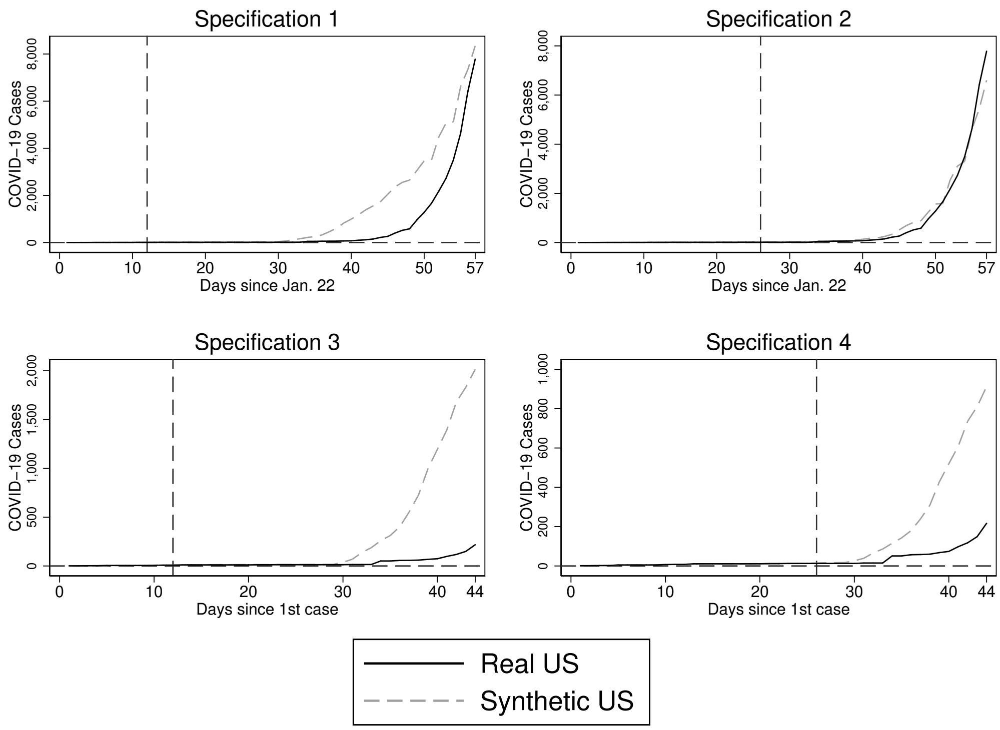
Wells, C., Sah, P., Moghadas, S., Pandey, A., Shoukat, A., Wang, Y., Wang, Z., Meyers, L., Singer, B., & Galvani, A. (2020). Impact of international travel and border control measures on the global spread of the novel 2019 coronavirus outbreak. *Proceedings of the National Academy of Science*, *117*(13), 7504–7509. https://doi.org/10.1073/pnas.2002616117

White House. (2020). Proclamation on Suspension of Entry as Immigrants and Nonimmigrants of Persons Who Pose A Risk of Transmitting 2019 Novel Coronavirus. https://www.whitehouse.gov/presidential-actions/proclamation-suspension-entry-immigrants-nonimmigrants-persons-pose-risk-transmitting-2019-novel-coronavirus/

WHO Writing Group. (2006). Nonpharmaceutical Interventions for Pandemic Influenza, International Measures. *Emerging Infectious Diseases*, *12*(1), 81–87. https://doi.org/10.3201/eid1201.051370

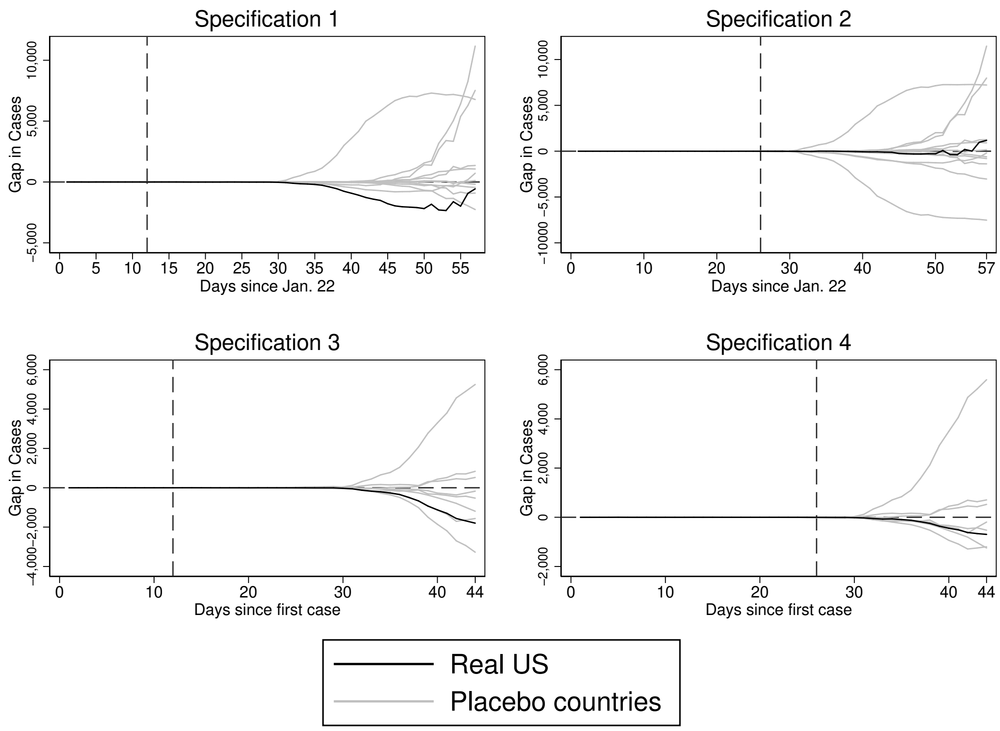
6 Figures

Figure 1. Goodness of Fit and Results for SCM Specifications 1-4



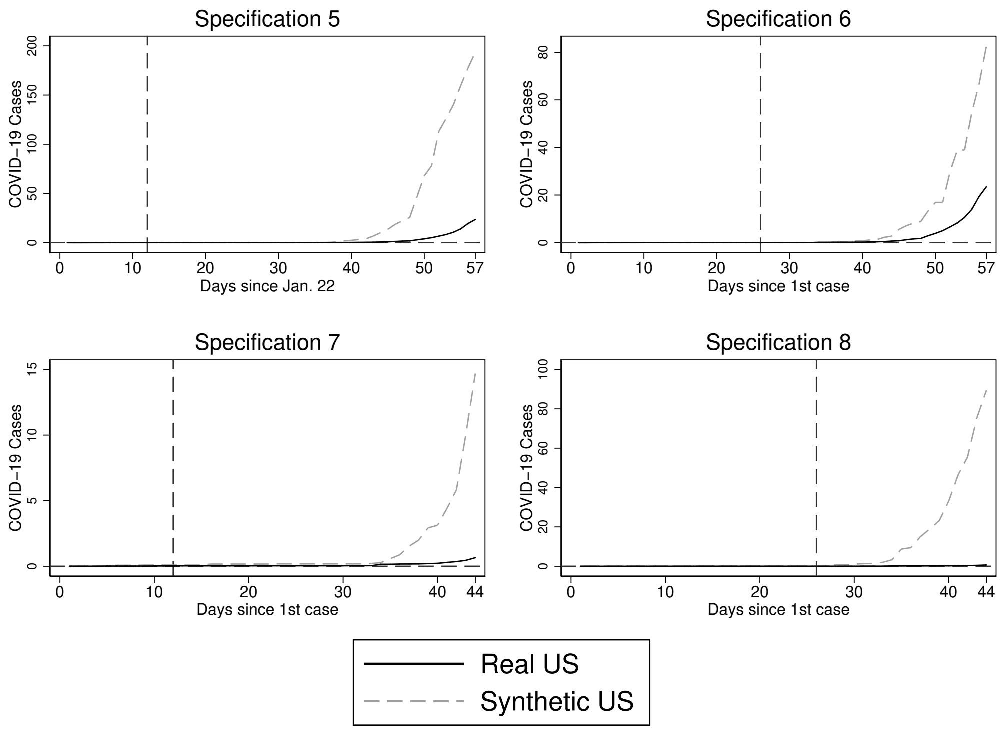
The daily number of COVID-19 cases in the Real United States and Synthetic United States for each specification before and after the travel restriction was imposed. The Real United States is represented by the dark line and the Synthetic United States by the dashed gray line. The intervention date is the vertical dashed line.

Figure 2. Placebo in Place Robustness Check for Specifications 1-4



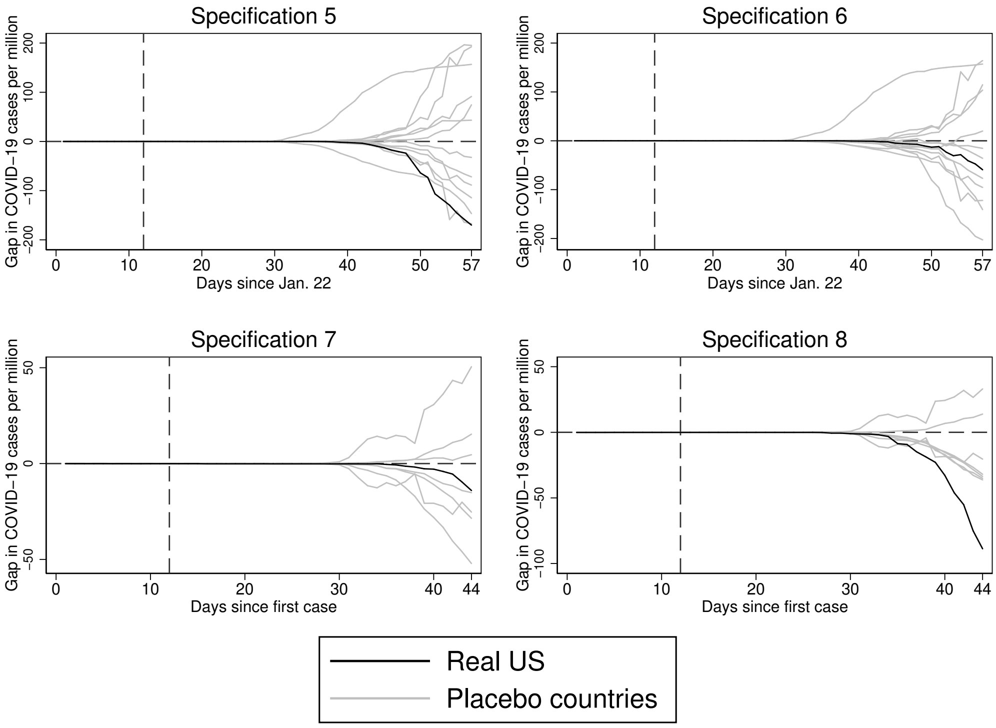
A graphical representation of the p-values showing that there is no statistically significant gap in the number of COVID-19 cases after the intervention date compared to the other countries in the donor pool for each specification. The Real United States is represented by the dark line and the donor pool countries by the light gray lines. The intervention date is the vertical dashed line.

Figure 3. SCM Results for Specification 5-8



The daily number of COVID-19 cases per million residents in the Real United States and Synthetic United States for each specification before and after the travel restriction was imposed. The Real United States is represented by the dark line and the Synthetic United States by the dashed gray line. The intervention date is the vertical dashed line.

Figure 4. Placebo in Place Robustness Check for Specifications 1-4



A graphical representation of the p-values showing that there is no statistically significant gap in the number of COVID-19 cases per million after the intervention date compared to the other countries in the donor pool for each specification. The Real United States is represented by the dark line and the donor pool countries by the light gray lines. The intervention date is the vertical dashed line.

7 Tables

Table 1. Goodness of Fit and Results for SCM Specifications 1-4

Rows 1, 2, and 3 describe the different specifications. Rows 4, 5, and 6 are the goodness of fit measures. The Root Mean Square Predicted Error (RMSPE) measures the distance between the Real United States and the Synthetic United States during the pre-treatment period. Rows 5 and 6 show how many countries and how many predictor variables comprise at least 5 percent of the Synthetic United States. Row 7 shows the number of countries used in each sample. Rows 8 and 9 show the results for each specification. Specification numbers are listed in parentheses in each column header.

	(1)	(2)	(3)	(4)
Intervention Date	2/2/2020	2/16/2020	2/2/2020	2/16/2020
Intervention Day Relative to 1/22/2020	12	26	12	26
Normalized Relative to 1st COVID-19 Case	No	No	Yes	Yes
RMSPE	0.89	1.53	0.73	0.69
Countries > 0.05	3	4	3	4
Predictor Variables > 0.05	6	5	9	9
Number of Countries in Donor Pool	13	13	8	8
Avg. Post Treatment $p-$value	0.20	0.56	0.44	0.56
Days When Post Treatment $p-$value < 0.05	1	0	0	0

Table 2. Country Donor Weights for Synthetic Control Specifications 1-4

Table presents estimated country donor weights for each synthetic control specification. The outcome variable for each specification is the cumulative number of COVID-19 cases. *NA* denotes that the country is not included in the donor pool. Each specification does not allow extrapolation, such that $w_i \in [0,1]$ and $\sum_i w_i = 1$. Specification numbers are listed in parentheses in each column header.

	Intervention Date:			
	2/2/2020		2/12/2020	
Country	(1)	(2)	(3)	(4)
Austria	0.000	0.000	NA	NA
Belgium	0.000	0.000	0.000	0.000
Canada	0.000	0.000	0.559	0.673
France	0.689	0.511	0.000	0.000
Germany	0.000	0.140	0.154	0.160
Ireland	0.000	0.160	NA	NA
Japan	0.074	0.189	0.000	0.068
Korea, Republic of	0.237	0.000	0.287	0.099
Netherlands	0.000	0.000	NA	NA
Norway	0.000	0.000	NA	NA
Sweden	0.000	0.000	0.000	0.000
Switzerland	0.000	0.000	NA	NA
United Kingdom	0.000	0.000	0.000	0.000

Table 3. Predictor Variable Balance for Synthetic Control Specifications 1-4

Table presents summary statistics for pre-treatment predictor variables for the Real United States, their corresponding pre-treatment sample means, and the weighted averages used to construct the Synthetic United States. The full donor pool (used in Specifications 1, 2, 5, and 6) consists of Austria, Belgium, Canada, France, Germany, Ireland, Japan, South Korea, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. The restricted donor pool (used in Specifications 3, 4, 7, and 8) omits Austria, Ireland, the Netherlands, Norway, and Switzerland due to limited pre-treatment case data. Specification numbers are listed in parentheses in each column header.

		Days Since 1/22			*Days Since 1st Case*		
Variable	Real US	Sample Mean	(1)	(2)	Sample Mean	(3)	(4)
Migrant Stock	50,661,149	7,544,758	6,203,433	6,703,282	10,800,000	6,806,327	7,743,792
Total Population	331,002,647	59,300,000	66,483,504	69,778,615	87,200,000	48,714,849	52,481,951
Pop. Density	36.00	206.08	233.00	172.00	218.01	191.00	117.00
Pop. 65+	17.00	19.29	20.00	21.00	19.96	18.00	19.00
% Pop. Urban	83.00	81.24	82.00	80.00	85.09	81.00	82.00
Median Age	38.00	42.22	43.00	43.00	42.56	43.00	43.00
Per Capita GDP (2011)	55,719.00	48,913.60	38,878.00	45,407.00	43,686.80	42,269.00	43,327.00
Abs. Latitude	38.00	49.76	43.00	46.00	48.31	52.00	55.00
Migrant Stock, China	2,899,267.00	404,314.00	288,570.00	229,140.00	612,996.80	582,907.00	599,200.00
Airport Connects. to China	58.00	30.29	53.00	34.00	45.11	53.00	36.00

Table 4. Predictor Variable Weights for Synthetic Control Specifications 1-4

Table presents variables weights used to construct the Synthetic United States. The full donor pool (used in Specifications 1 and 2) consists of Austria, Belgium, Canada, France, Germany, Ireland, Japan, South Korea, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. The restricted donor pool (used in Specifications 3 and 4) omits Austria, Ireland, the Netherlands, Norway, and Switzerland due to limited pre-treatment case data. Specification numbers are listed in parentheses in each column header.

	Days Since 1/22		*Days Since 1st Case*	
Variable	(1)	(2)	(3)	(4)
Migrant Stock	0.014	0.048	0.102	0.115
Total Population	0.099	0.167	0.083	0.130
Pop. Density	0.141	0.223	0.017	0.060
Pop. 65+	0.072	0.057	0.193	0.112
% Pop. Urban	0.103	0.263	0.097	0.023
Median Age	0.069	0.018	0.106	0.112
Per Capita GDP (2011)	0.019	0.127	0.096	0.104
Abs. Latitude	0.423	0.088	0.152	0.117
Migrant Stock, China	0.047	0.008	0.092	0.116
Airport Connects. to China	0.012	0.000	0.062	0.110

Table 5. Goodness of Fit and Results for Synthetic Control Specifications 5-8

Rows 1, 2, and 3 describe the different specifications. Rows 4, 5, and 6 are the goodness of fit measures. The Root Mean Square Predicted Error (RMSPE) measures the distance between the Real United States and the Synthetic United States during the pre-treatment period. Rows 5 and 6 show how many countries and how many predictor variables comprise at least 5 percent of the Synthetic United States. Row 7 shows the number of countries used in each sample. Rows 8 and 9 show the results for each specification. Specification numbers are listed in parentheses in each column header.

	(5)	(6)	(7)	(8)
Intervention Date	2/2/2020	2/16/2020	2/2/2020	2/16/2020
Intervention Day Relative to 1/22/2020	12	26	12	26
Normalized Relative to 1st COVID-19 Case	No	No	Yes	Yes
RMSPE	0.00	0.02	0.06	0.07
Countries > 0.05	6	3	1	2
Predictor Variables > 0.05	2	4	5	3
Number of Countries in Donor Pool	13	13	8	8
Avg. Post Treatment $p-$value	0.55	0.80	0.06	0.14
Days When Post Treatment $p-$value < 0.05	0	0	15	10

Table 6. Country Donor Weights for Synthetic Control Specifications 5-8

Table presents estimated country donor weights for each synthetic control specification. The outcome variable for each specification is the cumulative COVID-19 cases per million population. *NA* denotes that the country is not included in the donor pool. Each specification does not allow extrapolation, such that $w_i \in [0,1]$ and $\sum_i w_i = 1$ Specification numbers are listed in parentheses in each column header.

	Intervention Date:			
	2/2/2020		2/12/2020	
Country	(5)	(6)	(7)	(8)
Austria	0.000	0.000	NA	NA
Belgium	0.055	0.000	0.000	0.000
Canada	0.059	0.001	0.000	0.000
France	0.191	0.318	1.000	0.000
Germany	0.000	0.000	0.000	0.000
Ireland	0.061	0.579	NA	NA
Japan	0.000	0.000	0.000	0.000
Korea, Republic of	0.000	0.000	0.000	0.000
Netherlands	0.000	0.000	NA	NA
Norway	0.528	0.000	NA	NA
Sweden	0.000	0.000	0.000	0.927
Switzerland	0.000	0.000	NA	NA
United Kingdom	0.106	0.103	0.000	0.073

Table 7. Predictor Variable Balance for Synthetic Control Specifications 5-8

Table presents summary statistics for pre-treatment predictor variables for the Real United States, their corresponding pre-treatment sample means, and the weighted averages used to construct the Synthetic United States. The full donor pool (used in Specifications 1, 2, 5, and 6) consists of Austria, Belgium, Canada, France, Germany, Ireland, Japan, South Korea, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. The restricted donor pool (used in Specifications 3, 4, 7, and 8) omits Austria, Ireland, the Netherlands, Norway, and Switzerland due to limited pre-treatment case data. Specification numbers are listed in parentheses in each column header.

		Days Since 1/22			*Days Since 1st Case*		
Variable	Real US	Sample Mean	(5)	(6)	Sample Mean	(7)	(8)
Migrant Stock	50,661,149	7,544,758	3,692,196	4,124,952	10,800,000	8,334,875	2,556,134
Pop. Density	36.00	206.08	86.00	108.00	218.01	119.00	43.00
Pop. 65+	17.00	19.29	18.00	17.00	19.96	21.00	20.00
% Pop. Urban	83.00	81.24	82.00	71.00	85.09	81.00	88.00
Median Age	38.00	42.22	40.00	40.00	42.56	42.00	41.00
Per Capita GDP (2011)	55,719.00	48,913.60	55,696.00	57,822.00	43,686.80	39,556.00	47,192.00
Abs. Latitude	38.00	49.76	57.00	51.00	48.31	46.00	61.00
Migrant Stock, China	2,899,267.00	404,314.00	96,411.00	70,501.00	612,996.80	121,172.00	48,412.00
Airport Connects. to China	58.00	30.29	4.00	4.00	45.11	10.00	3.00

Table 8. Predictor Variable Balance for Synthetic Control Specifications 5-8

Table presents variables weights used to construct the Synthetic United States. The full donor pool (used in Specifications 5 and 6) consists of Austria, Belgium, Canada, France, Germany, Ireland, Japan, South Korea, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. The restricted donor pool (used in Specifications 7 and 8) omits Austria, Ireland, the Netherlands, Norway, and Switzerland due to limited pre-treatment case data. Specification numbers are listed in parentheses in each column header.

	Days Since 1/22		*Days Since 1st Case*	
Variable	(5)	(6)	(7)	(8)
Migrant Stock	0.003	0.006	0.102	0.023
Pop. Density	0.015	0.160	0.269	0.474
Pop. 65+	0.010	0.204	0.001	0.042
% Pop. Urban	0.186	0.018	0.008	0.001
Median Age	0.006	0.265	0.170	0.378
Per Capita GDP (2011)	0.777	0.272	0.007	0.061
Abs. Latitude	0.003	0.040	0.316	0.008
Migrant Stock, China	0.000	0.000	0.081	0.002
Airport Connects. to China	0.000	0.035	0.047	0.012

Online Appendix for: How U.S. Travel Restrictions on China Affected the Spread of COVID-19 in the United States

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A Data Appendix

A.1 COVID-19 Cases

Data on confirmed COVID-19 cases are from the COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. These data are compiled from a variety of sources, such as the World Health Organization (WHO) and other public health and media sources. The data provide the cumulative number of confirmed COVID-19 cases, deaths, and recoveries by day starting on Jan. 22, 2020. The raw data are available on GitHub here.

A.2 United Nations

The United Nations (UN) is our primary data source for population data, including demographic structure, urbanicity, population density, and international migration. We use three main data collections from the UN. First, we collect data on countries' age structure from the *World Population Prospects 2019* data files. These data include annual estimates of a country's population, broken down by age and sex. We subset these data to the 2020 estimates. Using the 2020 estimates, we identify the share of a country's population above the age of 65. These data also contain measures of population density, measured as persons per square kilometer, and the population's median age. These data are available here.

Next, we collect data on a country's urban population from the UN *World Urbanization Prospects 2018*. The UN urbanization data provide quinquennial estimates of the share of a country's population living in urban agglomerations spanning 1950-2050. We specifically use the 2020 estimates for each country. The data are available here.

Finally, we collect data on a country's foreign-born population from the UN *International Migrant Stock 2019* data. These data provide estimates of the number of international migrants for 2019 broken down by age, sex, and country of origin. For our analyses, we take the estimates of the total foreign-born stock and the foreign-born stock originating from China. The data are available here.

A.3 World Bank

We collect data on per capita income from the World Bank. These data provide the per capita Gross Domestic Product (GDP) by country, expressed in purchasing power parity (PPP) adjusted constant 2011 dollars. We use the most recent year of data available for 2018. These data are available here.

A.4 OpenFlights

Information on the number of flight connections to China are from OpenFlights and are available here. Unfortunately, the most recent data on connecting flights is from June 2014, since their provider of connecting flight information stopped updating their data at that time.

B Additional Tables

Table A1. Variable Descriptions and Sources

Table provides a listing of the outcome and predictor variables used in our analyses, including brief descriptions and their respective sources.

Variable	Description	Source
	Outcome Variables	
`confirmed`	Cumulative confirmed COVID-19 cases	Johns Hopkins
`confirmed_mill`	Cumulative confirmed COVID-19 cases per million	Johns Hopkins & authors' calculations
	Predictor Variables	
`un_migrant`	Total foreign born stock as of 2019	UN
`un_migrant_china`	Total foreign-born stock from China as of 2019	UN
`pop_total`	Total population as of 2020	UN
`pop_density`	Population density per sq. km. as of 2020	UN
`n_oldpop`	Total Population age 65+ as of 2020	UN
`pct_urban`	% of the population living in urban areas as of 2020	UN
`un_medage`	Median age of the population as of 2020	UN
`gdppc2011`	Per capita GDP in constant 2011 PPP-adjusted dollars as of 2018	World Bank
`abslat`	Absolute value of latitude	Source
`n_connects`	Number of airport connections with China as of 2014	OpenFlights.org