UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Administración y Economía

The Effects of the 1994-1995 Mexican Sudden Stop: A Synthetic Control Case Study

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AGRADECIMIENTOS

Para mi familia, especialmente para mi hermano.

RESUMEN

En este trabajo, estudio como una Parada Súbita de Entrada de Capital afecta a una economía con mercados emergentes. Con ese fin, utilizo datos de tipo panel de la plataforma OCDE Stats desde el primer trimestre de 1986 al cuarto trimestre de 2006. Identifique que México tiene 5 Paradas Súbita de Entrada de Capital con la metodología de Arrellano y Mendoza (2003). Después, me concentro en la Parada Súbita de Entrada de Capital Mexicana de 1994-1995 y genero un versión sintética de México. Encontré que el efecto causal de la Parada Súbita de Entrada de Capital de México de1994-1995 ocasionó una recesión del -13.51% en la economía Mexicana que duro 13 trimestres. Finalmente use una prueba de placebos y encontré que el nivel de significancia de esta contracción es del 7.69%.

Palabras clave: *Parada Súbita de Entrada de Capital, Synthetic Control Method, economias con mercados emergnetes, caso de estudios comparativos, prueba de efecto placebo.*

ABSTRACT

I study how Sudden Stops affect an emerging market economy. I use a data panel from the OCDE Stats platform from the first quarter of 1986 to the fourth quarter of 2006. I identify that Mexico have five Sudden Stops using the methodology of Arrellano and Mendoza (2003). Then, I focus on the 1994-1995 Sudden Stop to create a synthetic version of Mexico that replicates the behavior of the Mexican GDP. I find that the 1994-1995 Sudden Stop caused a recession of -13.51% in the Mexican economy that lasted for thirteen periods. Finally, I use a placebo effect test to find that the level of significance of this contraction is 7.69%.

Key words: *Sudden Stop, Synthetic Control Method, emerging market economies, comparative case studies, placebo effect test*

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1. INTRODUCTION

From the last quarter of 1994 to the first quarter of 1995, Mexico experienced a Sudden Stop Episode. Throughout 1995, its gross domestic product declined 6.2%, the level of prices increased by 35%, and unemployment climbed to 7.5%. These economic consequences show the importance of being aware of how Sudden Stops Episodes affect a country. Considering this idea, how much of the observed output contraction could be explained by the Sudden Stop?

To answer this question, I use the 1986-2006 data available for 13 countries from the OECD Stats. To study the impact of the 1994-1995 Sudden Stop in the Mexican economy, I construct an Event Study to compare the average behavior of the main macroeconomic variables when a Sudden Stop occurs. Then, I apply the Synthetic Control Method to estimate the behavior of a Synthetic Mexico that does not experience the 1994-1995 Sudden Stop. Finally, I use this approximation to calculate the gap that this estimate has with its real version.

I contribute to the literature on measuring Sudden Stops in the following way. By applying the Synthetic Control Method, I show that the causal effect of the 1994-1995 Sudden Stop on the Mexican economy is a recession of -13.51% that lasts 13 quarters. Moreover, I apply a placebo effect test to find that the level of significance of this contraction is of 7.69%.

Literature on the effects of Sudden Stops begins after the 1990 South Asian and Russian Crisis (Caballero & Panageas, 2005). Calvo and Reinhart (1999) and Calvo (2018) describe the mechanisms and implications of Sudden Stops. They are characterized by a sudden loss of access to international markets, a large reversal of the current account deficit, a collapse of domestic production and aggregate demand, and sharp corrections in asset prices and in the prices of non-traded goods relative to traded goods. Kiyotaki-Moore (1997), Caballero and Krishnamurthy (2001), and Arrellano and Mendoza (2002), among others, have implemented different methodologies to model this type of phenomenon.

Nevertheless, there is limited literature on measuring the real impact and the probability of a country suffering this episode in a comparative case study. Hutchison, M. M., Noy, I., and Wang, L. (2010) use a simple Regression Model to show the financial cost of Sudden Stops in output losses. On the other hand, Bordo, M. D., Cavallo, A. F., and Meissner, C. M. (2010) use a Probit Model to find the probability of suffering a Sudden Stop increases when there is a high level of debt in a foreign currency. Their results are in line with the findings of Arrellano and Mendoza (2002).

This paper is organized as follows Section 2 presents the Synthetic Control Method. Section 3 I describe the Data. Section 4 states the results, and Section 5 prompts the conclusions and brings up further considerations to study the real effects of Sudden Stops.

2. SYNTHETIC CONTROL METHOD

According to Abadie (2014), the Synthetic Control Method is a statistical tool that estimates the impact of an event in a single unit. To construct the estimate of the 1994-1995 Sudden Stop, I begin considering a total of $J+1$ countries and a total period T. The time before the Sudden Stop is from $t=1$ to $t=T_0$. While from $t=T_o+1$ to $t=T$ is the time when the Sudden Stop has passed. The variable of interest before the Sudden Stop for any country j at time t is

y_{jt}^{n}, and when the Sudden Stop passes is y_{jt}^{s}. In addition, the difference between y_{jt}^{s} and y_{jt}^{n} at any time *t* is the following:

$$D_{jt}\alpha_{jt} = y_{jt}^{s} - y_{jt}^{n} , \qquad (1)$$

where D_{jt} is a dummy variable that takes the value of 1 if $t>T_o$ or 0 if $t \leq T_o$. Finally, the only country expose to the Sudden Stop is Mexico so $j=1$, and for $t>T_o$ I express (1) as:

$$\alpha_{1t} = y_{1t}^{s} - y_{1t}^{n} . \qquad (2)$$

In *(2),* I consider the estimate of y_{1t}^{n} that I represent by the following model:

$$y_{1t}^{n} = d_t + \boldsymbol{O_t} \sum_{j=2}^{J+1} w_j^{*} \boldsymbol{Z}_j + \boldsymbol{L_t} \sum_{j=2}^{J+1} w_j^{*} \boldsymbol{U}_j + \sum_{j=2}^{J+1} w_j^{*} \boldsymbol{e}_{tj} , \qquad (3)$$

where d_t is a common unknown factor; Z_j is a vector of *rx1* of covariates; O_t is a *1xr* vector of unknown parameters; L_t is a *1xF* vector of unobserved common factors; U_j is an Fxt vector of unknown factor loadings. The error term e_{tj} is the transitory shock at the country level with zero means. The expression $\sum_{j=2}^{J+1} w_j^{*}$ is the weighted average of control countries that belong to a $\boldsymbol{W^*}=(w_{2*}, w_{3*,..,}w_{j+1*})$ vector and that is obtained by the following optimization process:

Minimize:

$$\boldsymbol{W^*}=(w_{2*}, w_{3*,..,}w_{j+1*})$$

Subject to:

$$\sum_{j=2}^{J+1} w_j^* y_{1j} \ = \ y_{11},$$

$$\sum_{j=2}^{J+1} w_j^* y_{2j} \ = \ y_{21},$$

$$.$$

$$. \qquad (4)$$

$$.$$

$$\sum_{j=2}^{J+1} w_j^* y_{T_o j} \ = \ y_{T_o 1},$$

$$\sum_{j=2}^{J+1} w_j^* \boldsymbol{Z}_J \ = \ \boldsymbol{Z}_1,$$

$$w_j* \geq 0 \qquad \forall\, j=2,3,.,.,J+1,$$

and

$$\sum_{2}^{J+1} (w_j^*) = 1.$$

So making use of (4) I express (3):

$$y_{1t}{}^{n} = \sum_{j=2}^{J+1} w_j^* \boldsymbol{y}_{jt}, \qquad (5)$$

plugging (5) into (2) I derive to the treatment estimate for α_{1t}:

$$\hat{a}_{1t} = y_{1t}{}^{s} - \sum_{j=2}^{J+1} w_j^* \boldsymbol{y}_{jt}. \qquad (6)$$

Finally, following Abadice and Gareazabal (2003) and Abadie, Diamond, and Hainmueller (2010), I apply a comparative case study placebo test to define the statistical strength of the estimate in (6).

3. DATA DESCRIPTION

The data I use for identifying the total number of Sudden Stops, the Event Analysis, and the RBC Second Moments Table is from the first quarter of 1986 to the last quarter of 2006. All data is from Mexico, and the variable of interest is the Current Account as a percentage of its GDP. There are other key variables such as productivity, consumption, private investment, the natural logarithm of its historical gross domestic product, government expenditure, inflation, exports, imports, consumer price index, production, unemployment rate, and capital expenditure.

For creating the Synthetic version of Mexico's natural logarithm of its historical GDP, the data is from the first quarter of 1986 to the last quarter of 1998. The variables I use are the same variables I use for the Event Analysis and the RBC Second Moments Table. But from a total of 12 countries found that have not experienced similar Sudden Stop Episodes prior 1994-1995. Finally, all the data comes from the OECD Stats Data Set.

4. RESULTS

I identify the number of Sudden Stops that Mexico experiences by applying the methodology of Arellano and Mendoza (2002). *Figure 1* exhibits the cyclical component of the Current Account as a percentage of its GDP obtain by the Hodrick-Prescott filter. It point out that from the last quarter of 1994 to the first quarter of 1995 there is a turning point. This difference corresponds to the change that the current account suffered because of the 1994-1995 Sudden Stop.

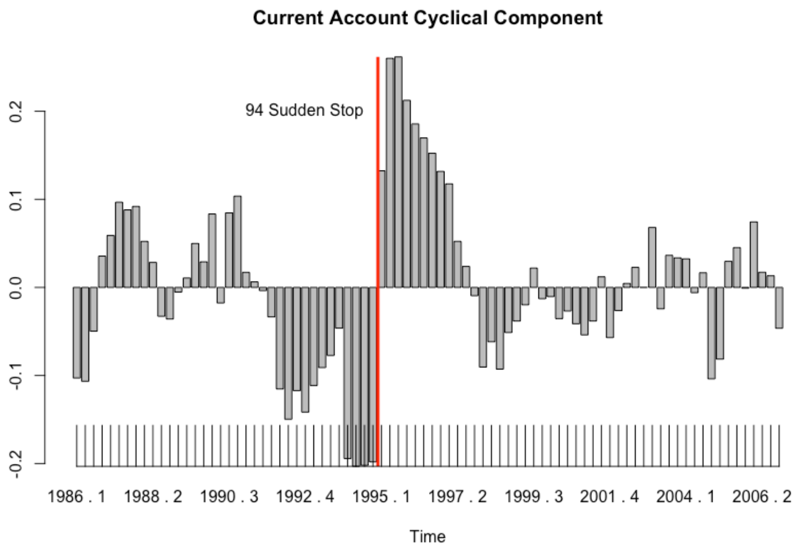


Figure 1: Cyclical Component of the Current Account as a Percentage of its GDP

Figure 2 is a visual representation of the first differences of the Current Account cyclical component frequency distribution and the values that correspond to the 95th percentile. It highlights with a red vertical line the value that corresponds to the 95th percentile of the distribution, which is equal to .0842. Likewise, the outlier value corresponds to the 1994-1995 Sudden Stop Episode and is cross with a blue vertical line. Finally, it exhibits that Mexico have a total of 5 Sudden Stops.

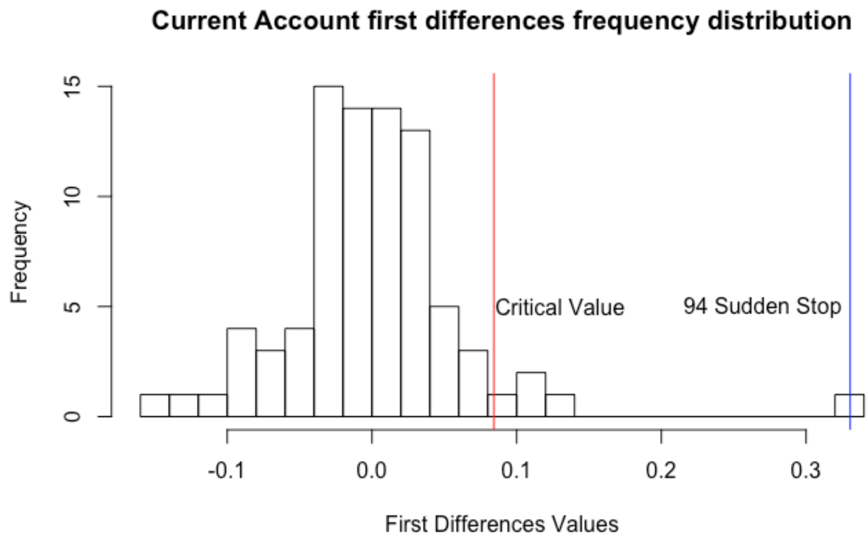


Figure 2: Frequency Distribution of the First Differences taken to the cycle of the Current Account.

Figure 3 displays the cyclical component of productivity, consumption, investment, the natural logarithm of the historical GDP, and government expenditure obtain by the Hodrick-Prescot Filter. It exhibits that all variables experience a substantial topple from the fourth quarter of 1994 to the first quarter of 1996. Finally, in this time frame, the two most affected accounts are consumption and the natural logarithm of its historical GDP.

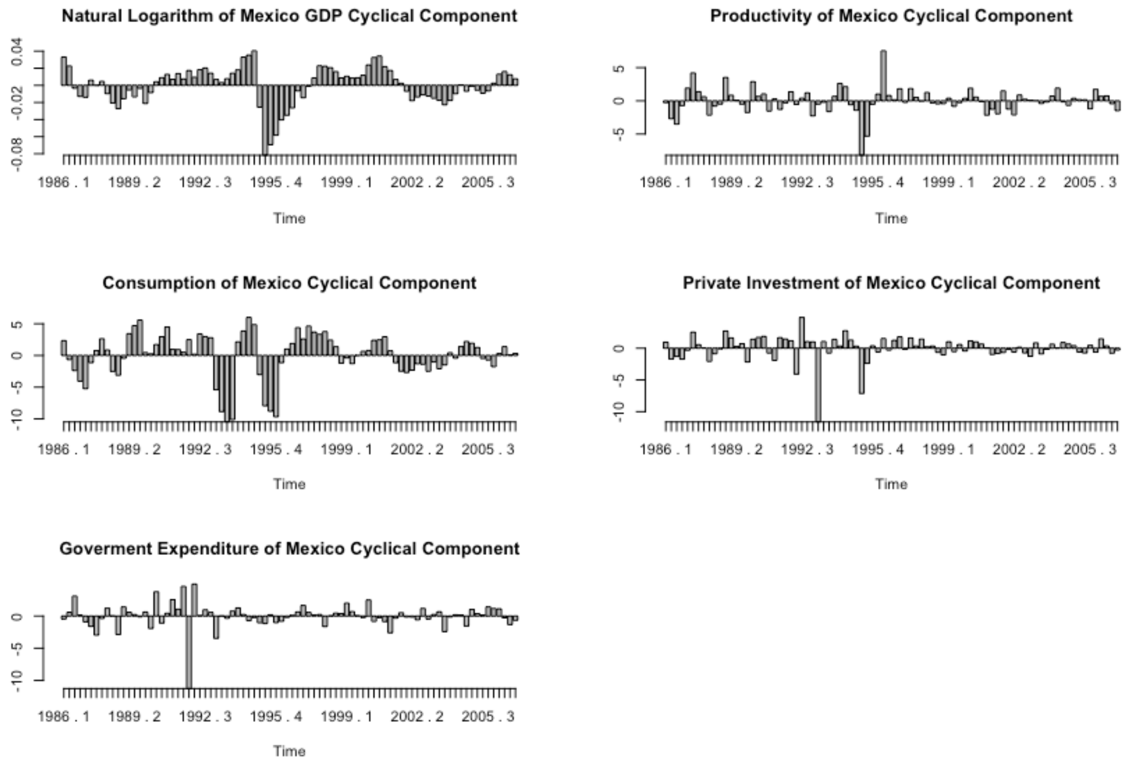


Figure 3: Cyclical Components of the Natural Logarithm of the historical GDP, Productivity, Consumption, Private Investment & Gov. Expenditure

Figure 4 and Table 1 show the Event Study for two periods before and five periods after the occurrence of a Sudden Stop. Due to the Sudden Stop, GDP, Consumption, Gov. Expenditure, Investment, and Productivity, experience a negative change of -.024, -2.50, -.600, -2.01, -2.60 pp. On the other hand, the Current Account is the only variable that experiences a positive change of .108 percent. They also exhibit that after five periods, the only negative variable is the natural logarithm of its historical GDP.

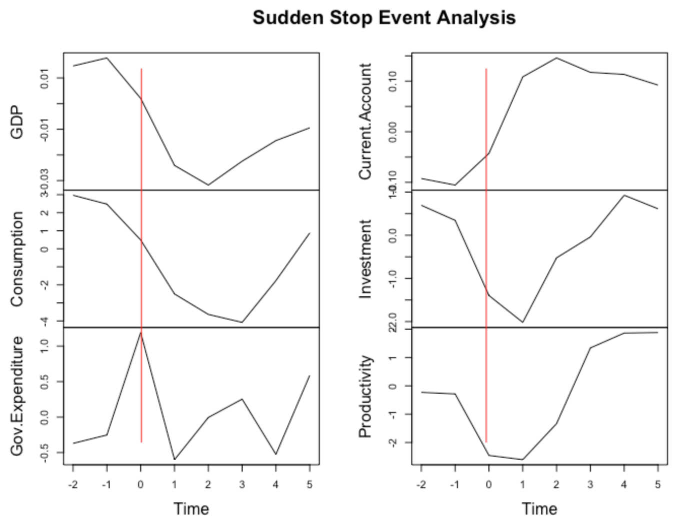


Figure 4: Sudden Stop Event Study

Table 1: Sudden Stop Event Study.

period	GDP	Consumption	Gov.Expenditure	Current Account	Investment	Productivity
-2	0.015	2.967	-0.371	-0.092	0.694	-0.229
-1	0.018	2.475	-0.253	-0.105	0.345	-0.287
0	0.002	0.487	1.191	-0.043	-1.396	-2.456
1	-0.024	-2.504	-0.601	0.108	-2.019	-2.606
2	-0.032	-3.639	-0.006	0.146	-0.524	-1.332
3	-0.022	-4.080	0.253	0.117	-0.039	1.338
4	-0.014	-1.762	-0.525	0.113	0.926	1.862
5	-0.009	0.880	0.589	0.092	0.613	1.880

According to Arellano & Mendoza (2003), countries that show a volatile Real Business Cycle tend to suffer from Sudden Stops. *Table 2* presents the Real Business Cycle Second Moments table of the Mexican Economy. It exhibits that Mexico has a volatile Real Business Cycle that correlates with the Current Account. Also, in column 2, all variables have relative volatility greater than one. Finally, column 3 displays that the Current Account and the GDP have a strong negative correlation.

Table 2: Real Business Cycle Second Moments Table

	Volatility	Relative Volatility to GDP	Correlation to GDP
GDP	0.02	1.00	1.00
CONSUMPTION	3.53	1.17	0.52
PRODUCTIVITY	1.92	88.37	0.081
EXPORTATION'S	15.18	699.21	-0.003
IMPORTATIONS	14.13	650.57	0.29
CURRENT ACCOUNT	0.09	4.36	-0.79
INFLATION	4.18	192.54	-0.28
UNEMPLOYMENT	0.63	28.94	-0.84
EXCHANGE RATE	0.65	30.04	-0.18
GOVERNMENT SPENDING	1.90	87.43	0.20
CPI	9.02	415.34	0.59
CAPITAL	4.86	223.80	0.14

To measure the causal effects of the 1994-95 Sudden Stop, I apply the Synthetic Control Method to generate a synthetic version of Mexico that replicates the behavior of the Mexican economy if the 1994-95 Sudden Stop did not occur.

Table 3 compares the mean values Mexico has with its synthetic version. According to Abadie et al. 2010, the variables that reflect a substantial difference are controls that do not predict the outcome variable, while variables that result with slight variations predict the outcome variable. It exhibits that inflation is a variable that does not foretell the natural logarithm of its historical GDP. Also, it shows that Consumer Price Index, Importations, and Private Investment are variables that predict the natural logarithm of Mexico´s historical GDP. Finally, consumption, productivity, and government expenditure are variables that are in between these two categories.

Table 3: Natural Logarithm of the Mexican Economy Predictor Means

	Treated	Synthetic	Sample Mean
Inflation	4.40	1.25	0.66
Exports	19.22	11.13	12.23
Imports	9.47	9.12	12.27
Productivity	-0.65	1.72	1.31
CPI	14.11	14.13	13.46
Government Expenditure	0.25	-0.04	0.34
Special Control	Treated	Synthetic	Sample Mean
Private Expenditure	0.84	0.87	0.61
Exports	17.24	9.91	9.85
Unemployment	2.94	6.71	6.51
Inflation	4.96	1.07	0.55
Productivity	0.99	0.85	0.61
Consumption	2.52	3.32	2.34
Capital	1.70	0.43	0.55

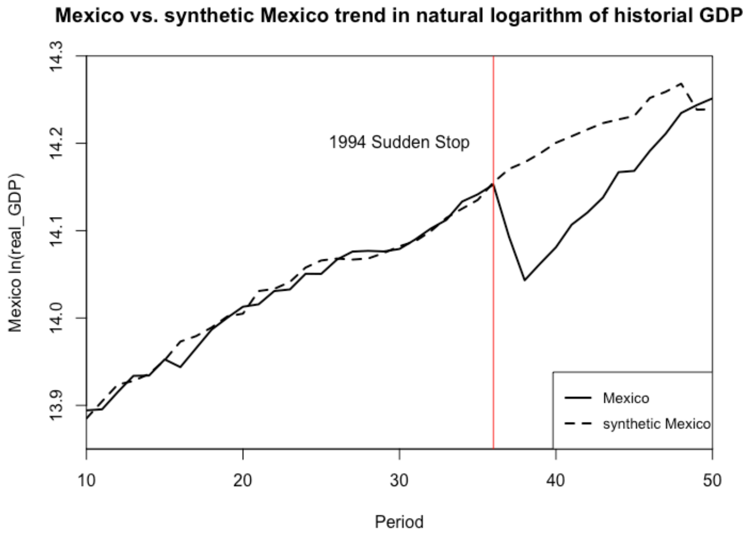
Table 4 shows the optimal weights for the synthetic control method. The first column shows the weights before the fourth quarter of 1994. It displays that the synthetic Mexico is a compound of Korea and Italy with respective weights of .36 and .64.

Table 4: State weights in the synthetic Mexico

weights	unit names	unit numbers
0.00	Australia	1
0.00	Finland	10
0.00	France	11
0.00	Germany	12
0.64	Italy	18
0.00	Japan	19
0.36	Korea	20
0.00	Netherlands	25
0.00	New Zealand	26
0.00	Norway	27
0.00	Sweden	33
0.00	United Kingdom	36

Figure 5 represents the trajectory of the natural logarithm of the Mexican gross domestic product with a black line and its synthetic version with the dotted line. The time ranges for this figure go from the third quarter of 1988 (period 10) to the third quarter of 1998 (period 50). It exhibits that once the 1994 Sudden Stop occurs, both lines diverge, and

the synthetic version continues growing at approximately the same rate as before. Meanwhile, Mexico experiences a sharp decline until the third quarter of 1998 (period 49).



.
Figure 5: Trend in the natural logarithm of the historical GDP: Mexico vs. Synthetic

Figure 6 shows the difference between the Natural logarithm of historical GDP gaps between Mexico and the Synthetic version. The preeminent variation is in the second quarter of 1995 with a corresponding magnitude of -13.51 percent. While the average difference, for periods 36 to 49, is -7.75 percent.

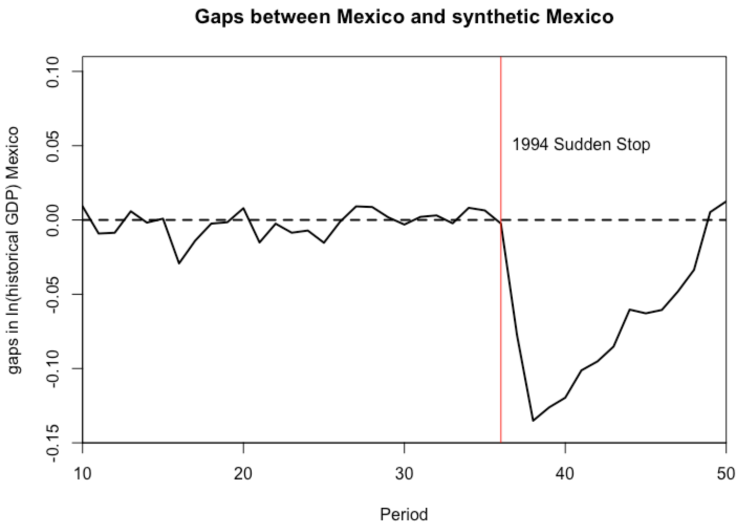


Figure 6: Natural logarithm of historical GDP gaps between Mexico and Synthetic

To evaluate the strength of the results, I propose: how often I will obtain a Sudden Stop if I select a random country in the data pool. If the results of these tests generate gaps of similar magnitude as the one for Mexico, then the 1994-95 Sudden Stop does not provide significant evidence of the negative effect. On the other hand, if the gap is significantly large, then the test supplies substantial evidence that the 1994-95 Sudden Stop affected Mexico.

Figure 7 shows the placebo test to a sub-set of countries that form the donor pool. The gray line represents the estimated gaps for the controls in the donor pool, and the black line is the estimated gap for Mexico. It exhibits that the synthetic version of Mexico is below the other grey lines.

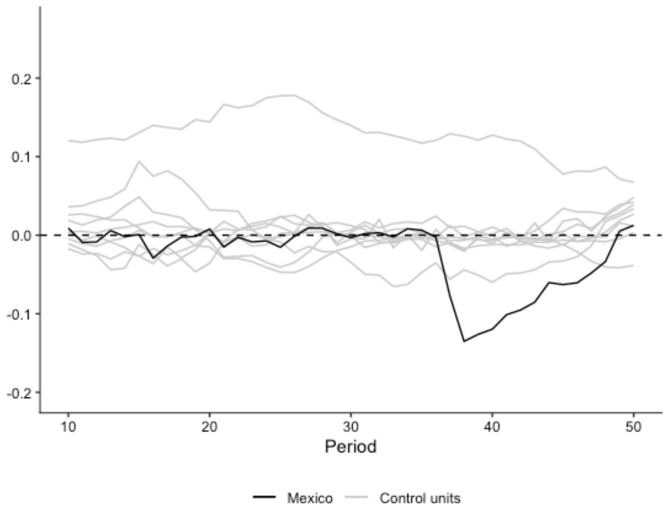


Figure 7. Natural logarithm of historical GDP gap in Mexico and placebo gaps in 10 control states

Figure 8 shows the second placebo test apply to countries that provide an accurate fit before the Sudden Stop. This test corroborates the findings of Abadie, Diamond, and Hansmueller (2010), who say that countries that provide a poor fit before the intervention period should be excluded. An example of a country that provides a poor fit is Italy because of its pre-intervention MSPE that is 12 times higher the one of Mexico. Finally, it shows that before the 1994-1995 Sudden Stop, there are only lines that do not diverge substantially from the cero gap line.

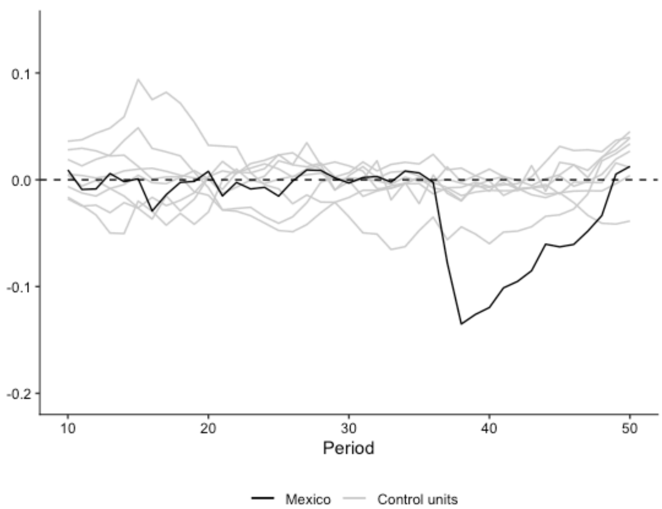


Figure 8. Natural logarithm of historical GDP gaps in Mexico and placebo gaps in 9 controls.

Concerning the finding of Abadie, Diamond, and Hansmueller (2010), another method to determine if the results are congruent is if the pre-intervention MSPE values of Mexico and the average donor pool are minor in both cases. In addition, the MSPE post/pre ratio of Mexico has to be among the highest of its distribution.

Tables 5 shows the MSPE values and ratios of the 1994-1995 Sudden Stop. It displays that Mexico and the average of all countries have a low pre-intervention MSPE of .00162 and .042.

Table 5: MSPE Values and Ratios of pre and post the 1994 Sudden Stop

COUNTRY	MSPE Pre 1994 SS	MSPE Post 1994 SS	MSPE RATIOS
Austria	0.0005	0.0003	0.5025
Finland	0.0018	0.0017	0.9110
France	0.0000	0.0001	1.6168
Germany	0.0003	0.0001	0.2369
Italy	0.0205	0.0107	0.5233
Japan	0.1491	0.1601	1.0735
Korea	0.0315	0.0508	1.6150
Netherlands	0.0001	0.0001	1.5520
New Zealand	0.3072	0.2263	0.7365
Norway	0.0008	0.0004	0.4685
Sweeden	0.0002	0.0005	2.1275
United Kingdom	0.0005	0.0005	0.8949
Mexico	0.0016	0.0069	4.2072

Figure 9 is a visual representation of the MSPE post/pre ratio for each of the countries. It shows that the relationship that corresponds to Mexico is the highest and equal to 4.5.

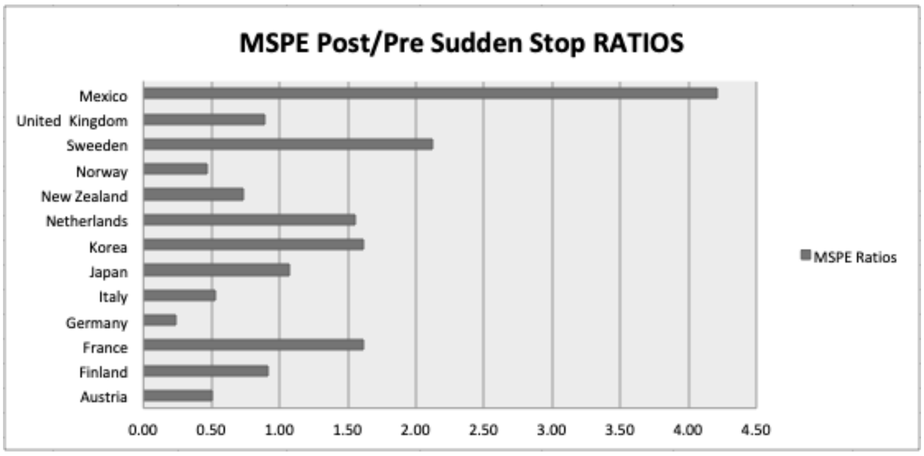


Figure 9. post/pre - Sudden Stop MSPE for each country.

Finally, *Figure 10* is the frequency distribution of all the post/pre MSPE ratios. It shows that no country presents a higher MSPE post/pre-relationship than Mexico has. Meaning that the estimated gap of Mexico is significant at a 07.69 percent.

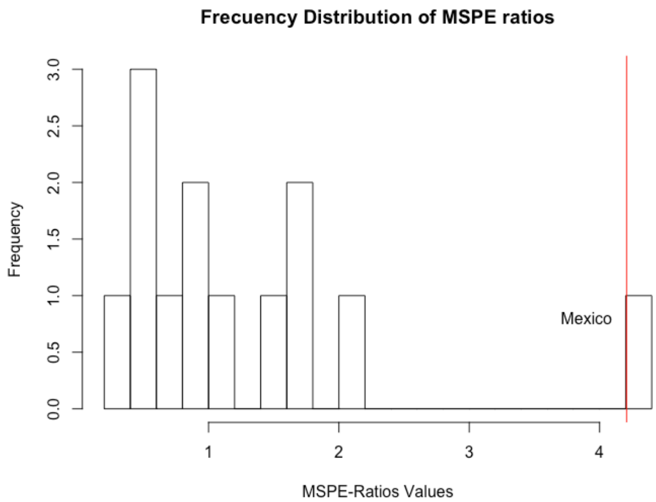


Figure 10. post/pre-Sudden Stop MSPE

5. CONCLUSION

Throughout this work, I testified that Sudden Stops Episodes impact emerging market economies by using the natural logarithm of Mexico GDP to measure total output. To achieve this, I used the data available from 37 countries taken from the OECD Stats (1986-2006), one of the most important macroeconomic data platforms to the present. This data allowed me to measure the recession from Sudden Stop.

My empirical strategy relies on the methodology proposed by Abadie, Diamond and, Hainmueller (2010) that consists of applying the Synthetic Control Method. My main contribution to the existing literature is by employing a different methodology to measure the causal effects of a Sudden Stops. This addition allowed me to improve my estimates on the recessions that come from Sudden Stops. It also allowed me to compare the behavior of a country that has not experienced a Sudden Stop with one that has.

I found that Mexico has experienced 5 Sudden Stops, and the one that occurred during 1994-1995 caused a recession of -13.51% in the natural logarithm of the Mexican historical GDP. Finally, I found that this contraction lasted for thirteen quarters with a 7.69 percent level of significance.

The main limitation of my work was that implementing the Synthetic Control Method could only be done to the natural logarithm of the Mexican Gross Domestic Product. Therefore, considering other macroeconomic variables, it would achieve a deeper comprehension of the Sudden Stop effects. In conclusion, the main findings of this work are that it measures the consequences of the Mexican 1994-1995 Sudden Stop in its historical Gross Domestic Product.

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APENDIX A: IDENTIFICATION OF A SUDDEN STOP AND CONSTRUCTION OF THE EVENT STUDY.

The effect of a Sudden Stop is measure in a total of *K* variables. Each of the *K* variables I observe at a time *t=1,2,3,.,.,.,T*. y_{kt} is the outcome of the variable of interest *k* at a given time *t*. For simplicity, the variable that identifies a Sudden Stop Episode is *K=1*. Thus, a variable y_{1t} is require to obtain a measurement of its mean. According to Arrellano and Mendoza (2002), extracting its HP-Cycle does this, as the following expression suggest:

$$f: \mathbb{R}^T \longrightarrow \mathbb{R}^T$$

$$f(\mathbf{y_{1t}}) = HP\text{-}CYCLE(y_{1t}),$$

Thus the outcome of this transformation is a new variable $\widehat{y_{1t}}$, and it represents the cyclical component of y_{1t}.

Furthermore, I want to calculate the first difference of its sample mean ($\widehat{\Delta y_{1t}}$), as it is express:

$$\widehat{\Delta y_{1t}} = \widehat{\Delta y_{1t}} - \Delta\widehat{y_{1t-1}},$$

Following Arrellano and Mendoza (2002), the next part is to identify the subset of times that a sudden stop occurs. The subset ($T^* \in T$) determines the values that correspond to the 95th percentile of the $\widehat{\Delta y_{1t}}$.

To obtain all the corresponding periods ($t_i^* \in T^*$), an *i* index will count and identify the total amount of Sudden Stops that occurs. Also, it gives the corresponding order of appearance of a Sudden Stop. Finally, it has a range from 1 to *U*. Where *U* is equal to the total amount of Sudden Stops that occurs by the following:

for $t = 1, \ldots, T$,

If $\widehat{\Delta y_{1t}}$ $\geq$ *Percentile95* *then there is an occurrence of a Sudden Stop and* $t_i^*=t$,

Once I test for every element in T if the previous condition holds. Then I identify all $t_i^*=t$ episodes when a Sudden Stop occurs. Doing such the vector $\mathbf{T}^* \in \mathbb{R}^U$ contains all of those t_i^* values, so $\mathbf{T}^* = \langle t_1^*, \ldots, t_U^* \rangle$.

To determine, ES_{ko} as the average effect of a Sudden Stop in the cyclical component of a given *k* variable at the moment that it occurs (i.e., $\mathbf{T}^*=(t_1^*,..,.t_U^*)$) at $\mathbf{T}^*$ is the following:

$$ES_{ko} = \frac{1}{U}\sum_{i=1}^{U} \hat{y}_{k=1t_i^*},$$

Thus, if I calculate the value that corresponds to the variable *k* in the event study when the moment is equal to -1 is the following:

$$ES_{K-1} = \frac{1}{U}\sum_{i=1}^{U} \hat{y}_{kt_i^*-1},$$

Finally, I generalize the previous expression to obtain the value of the event study to a particular variable *k* for any *n* moments:

$$ES_{Kn} = \frac{1}{U}\sum_{i=1}^{U} \hat{y}_{kt_i^*+n},$$

One last recall is that *n* is restrict to the following domain: $min(\boldsymbol{T})-min(\boldsymbol{T^*}) \leq n \leq max(\boldsymbol{T})-max(\boldsymbol{T^*})$. That for the example is: $1-t_1^* \leq n \leq T-tu^*$.