International Finance

Lecture VIII Sovereign Debt and Default: Facts and a Case Study (USG Chapter 13 + Caselli et al., 2022)

Geneva Graduate Institute

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Motivation

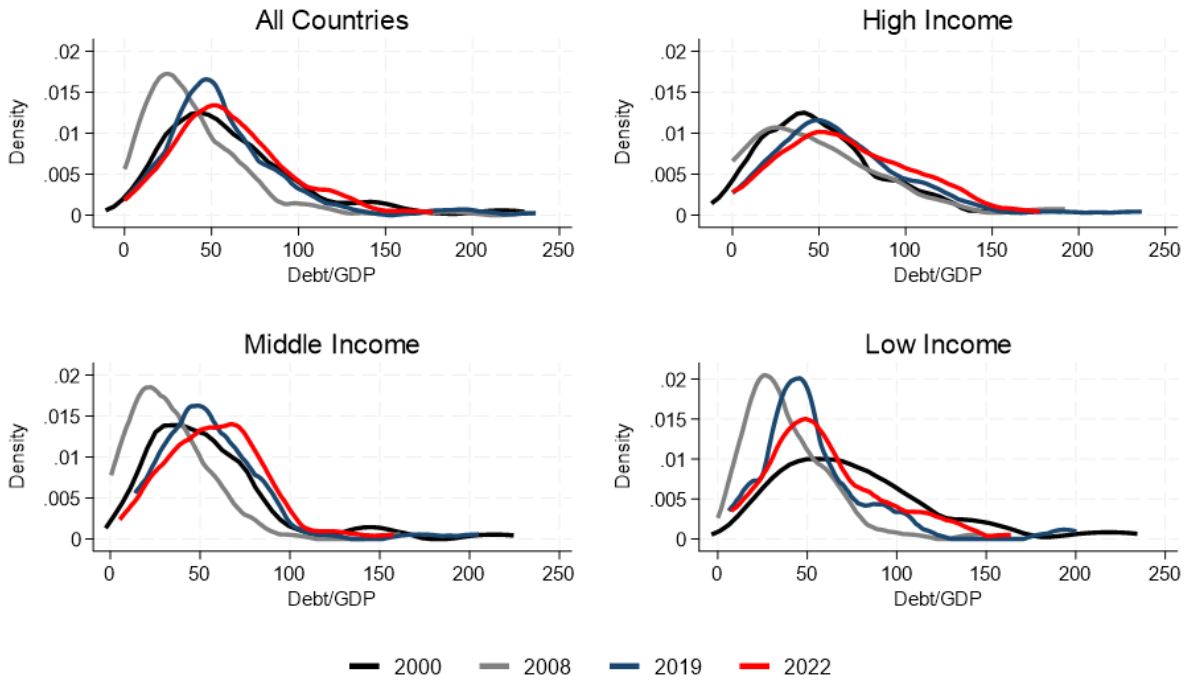
- We do observe a significant amount of borrowing and lending across nations.
- But why do countries pay their international debts?
- There is no supranational authority capable of enforcing international debt contracts.
- Defaulting on international financial contracts appears to have no legal consequences.
- Three reasons typically offered for why countries honor their debts:
  1. Economic sanctions
  2. Reputation
  3. Output costs
- In the next few classes:
  1. Empirical regularities about international lending, default, and costs of default.
  2. One case study
  3. Theoretical models of sovereign debt.
  4. Quantitative models of sovereign debt.
  5. Puzzles and way forward

Show me the data

Facts about Public Debt

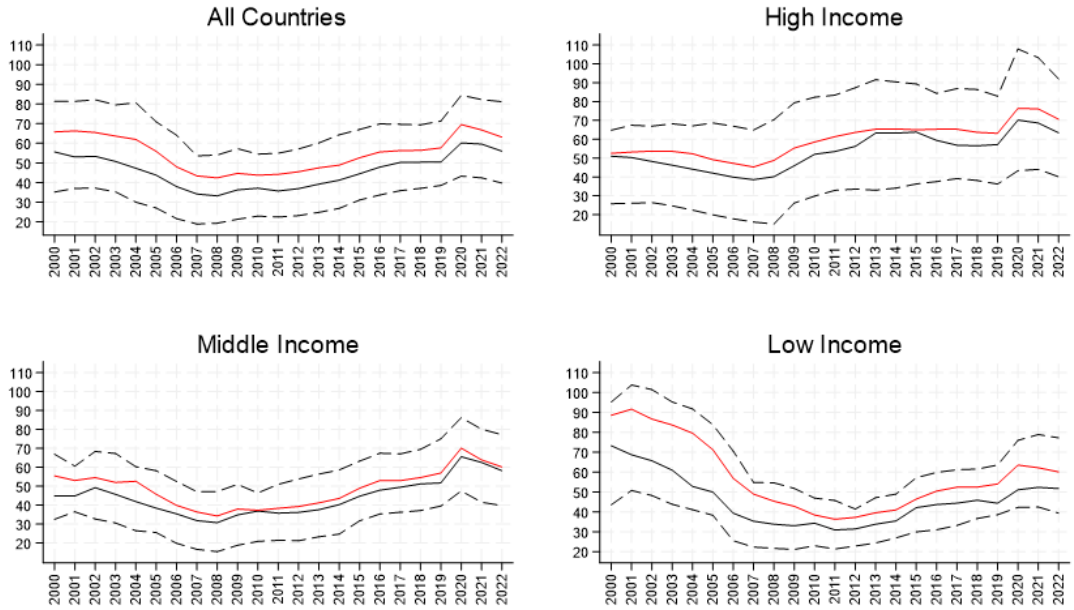
Facts about Public Debt: Levels

(distribution of Public Debt/GDP)



Facts about Public Debt: Levels

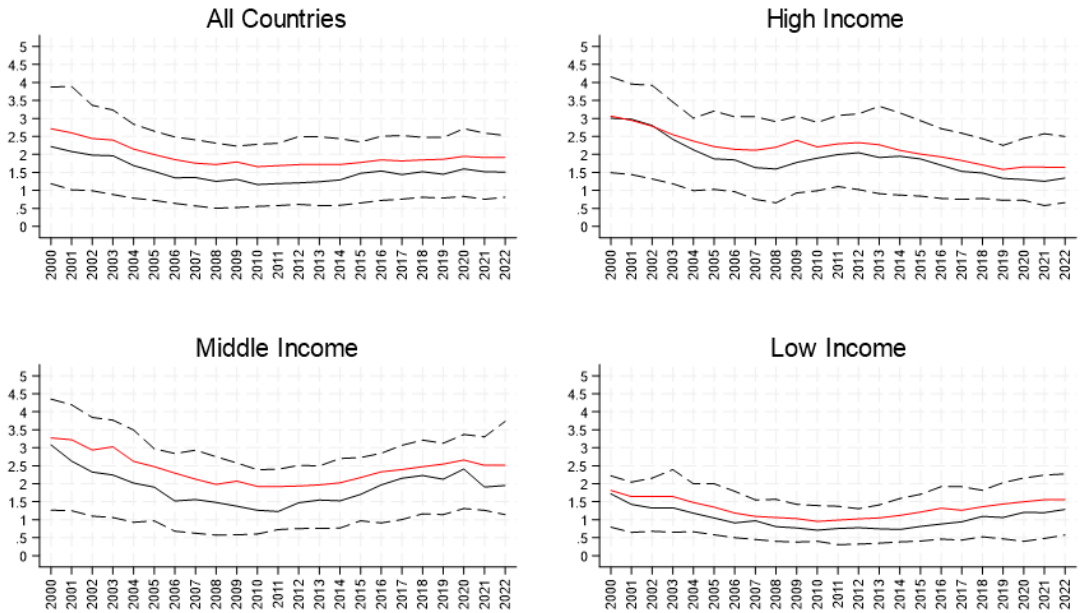
(evolution of Public Debt/GDP)



Mean, Median, & interquartile range

Facts about Public Debt: Levels

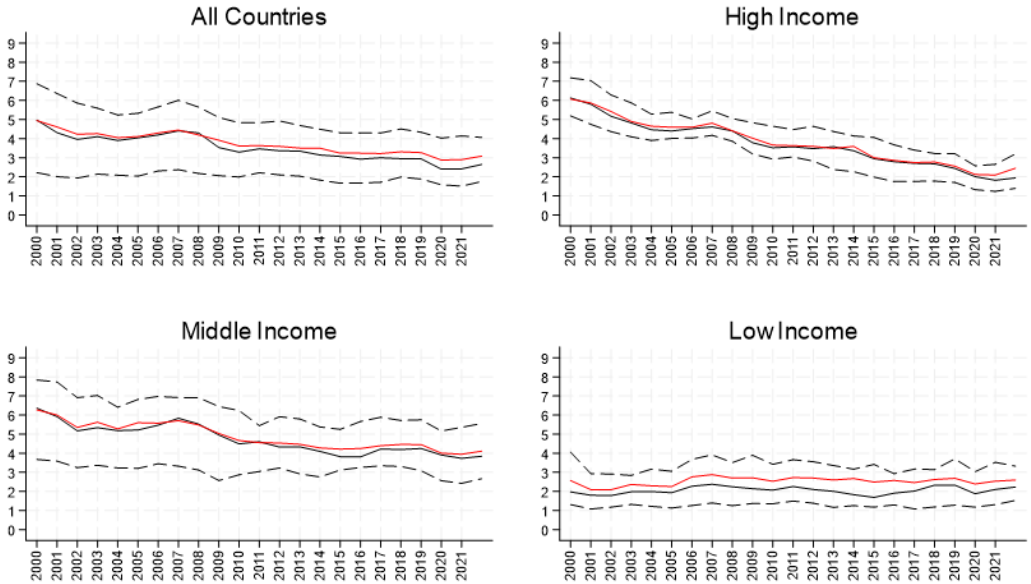
(Interest Expenses/GDP)



Mean, Median, & interquartile range

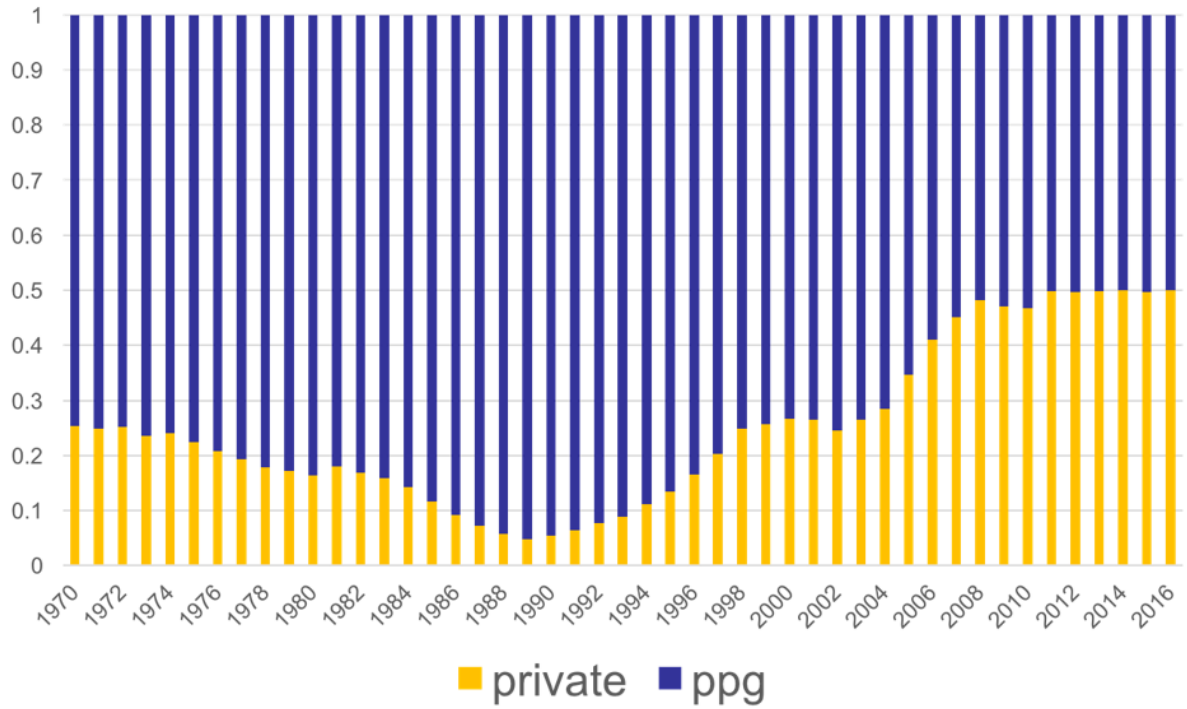
Facts about Public Debt: Levels

(Average interest rate)

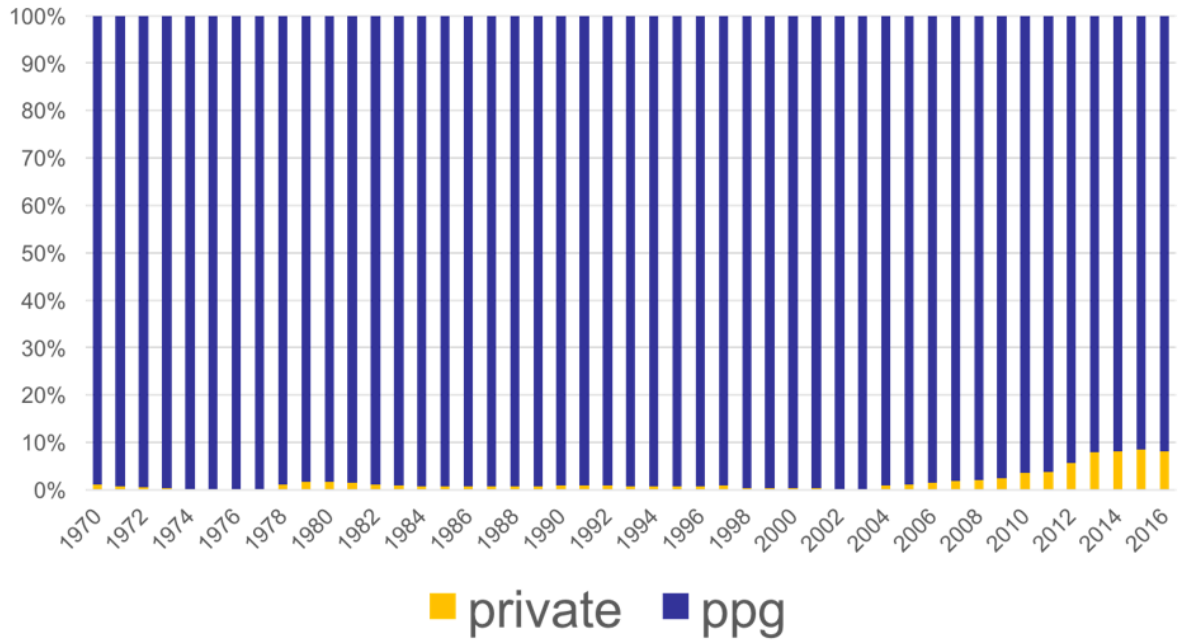


Mean, Median, & interquartile range

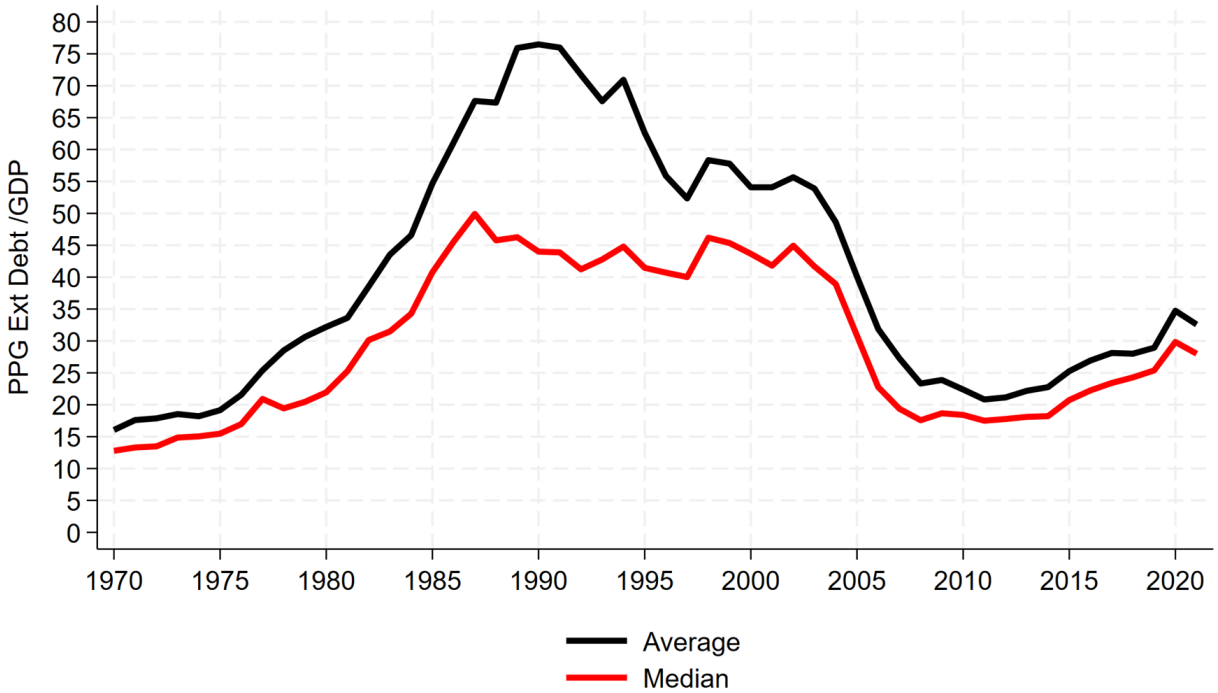
Facts about External Debt: Composition (EMDE)



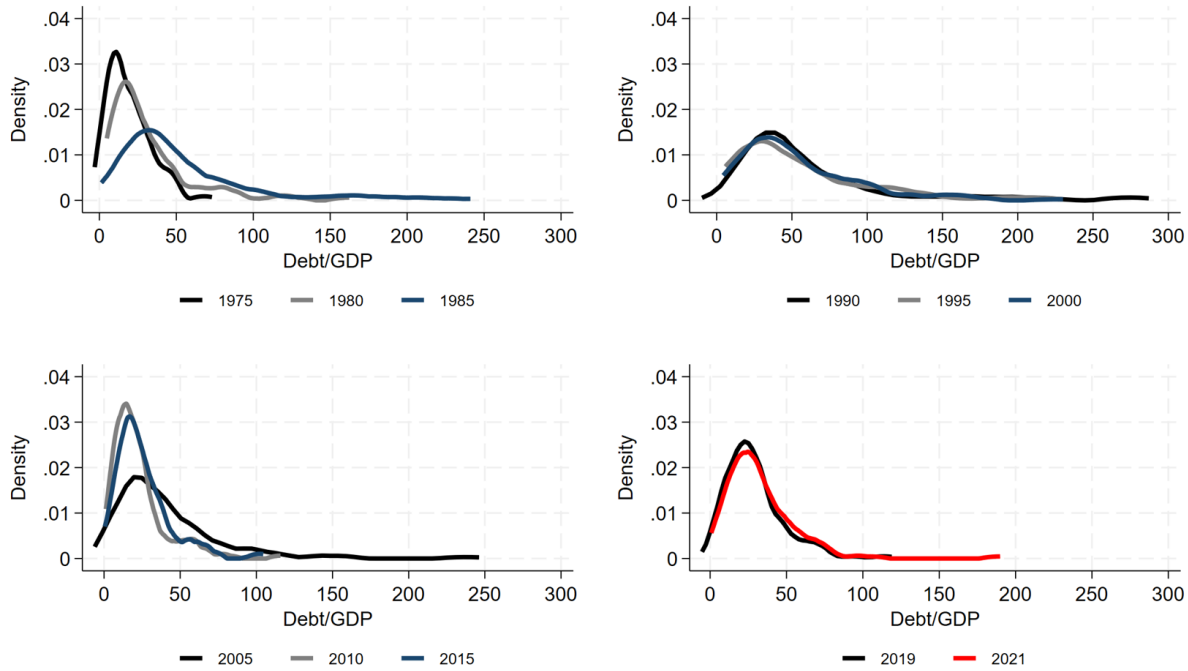
Facts about External Debt: Composition (LIC)



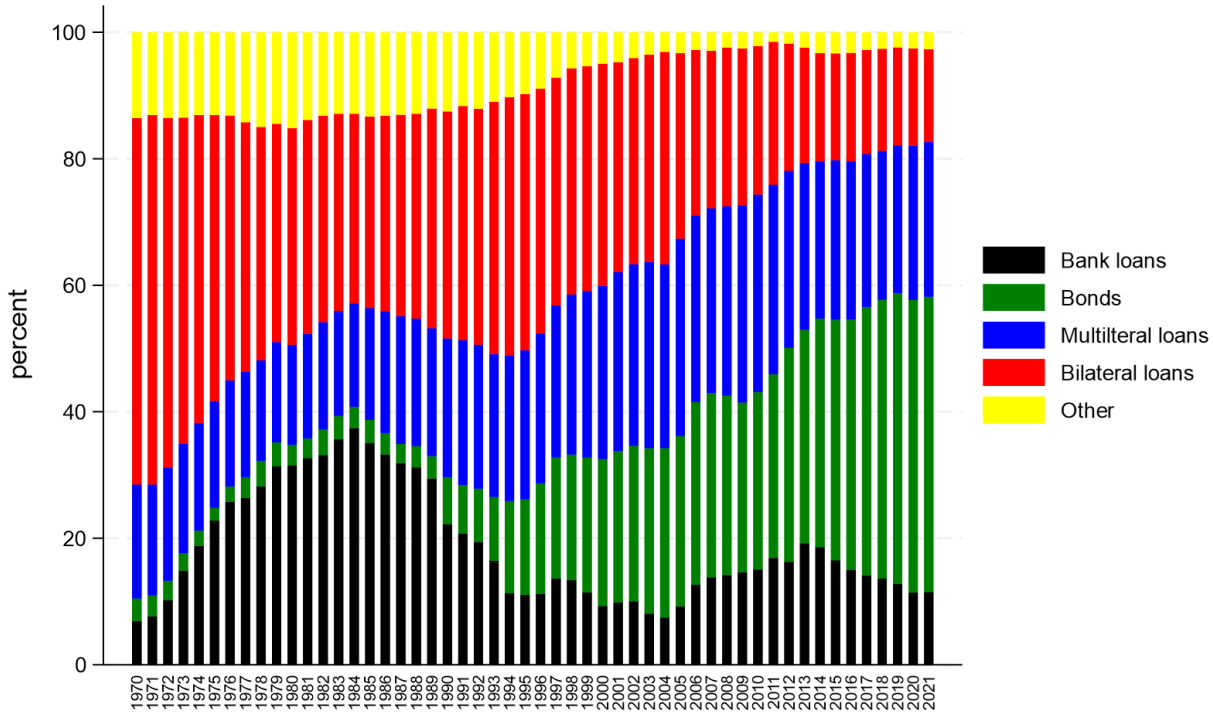
Facts about External Public Debt: Levels (EMDE)



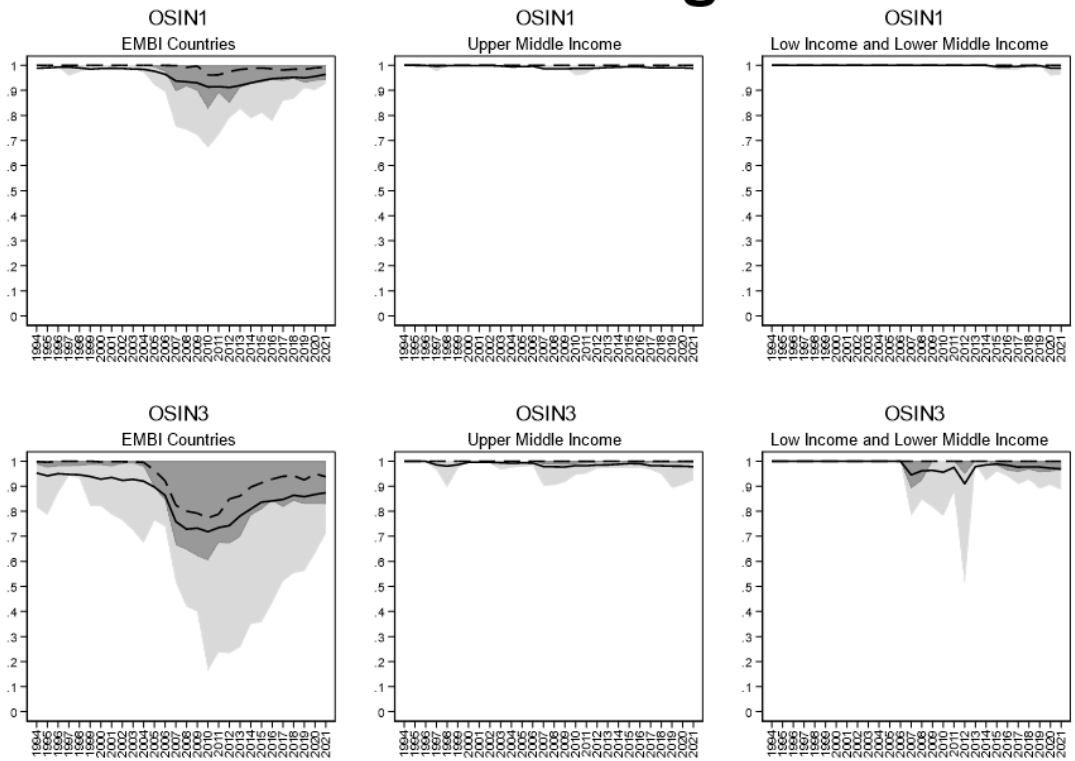
Facts about External Public Debt: Distribution (EMDE)



Facts about External Public Debt: Composition (EMDE)

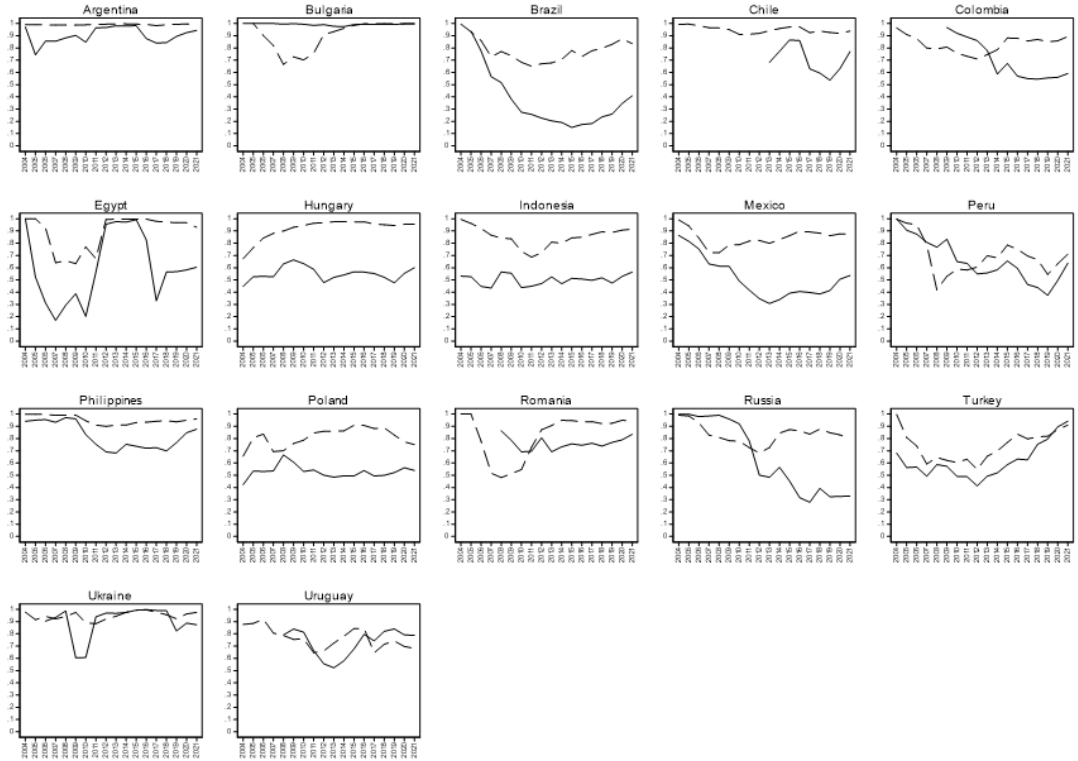


Facts about Debt: Original Sin



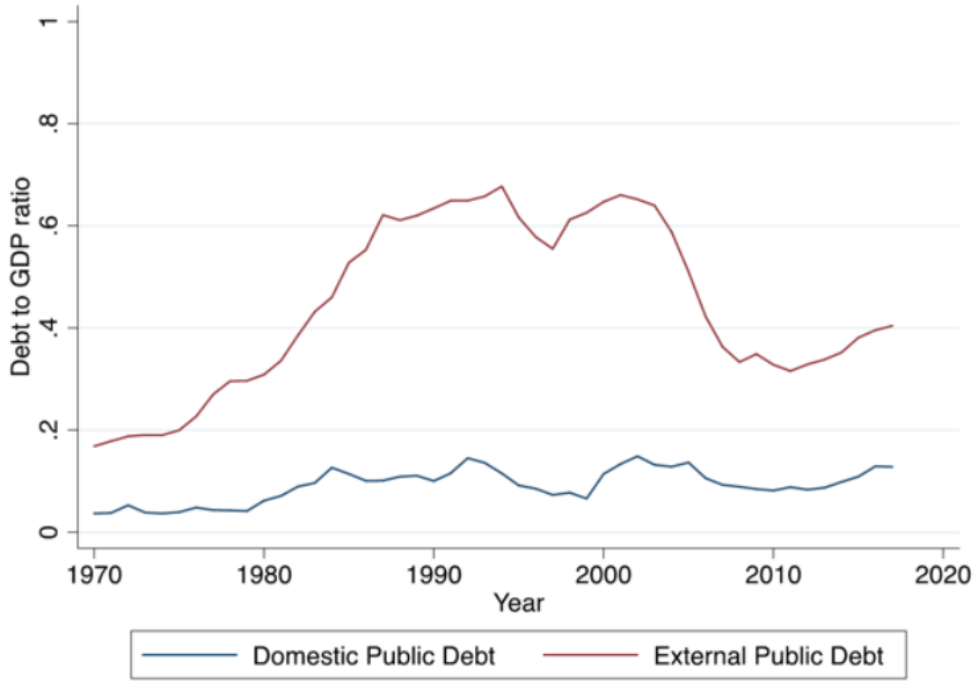
The dashed line is the cross-country median, the solid line is the cross-country mean, the dark shaded area shows the interquartile range, and the light shaded area shows the evolution of the bottom 10% of the distribution

Original Sin: Top Performers

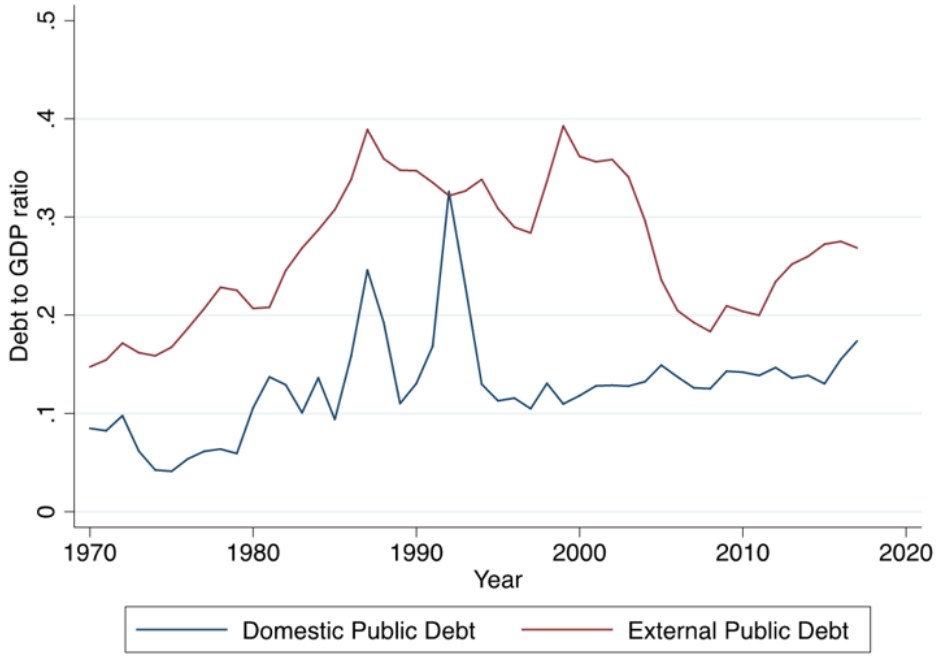


OSIN3 computed with BIS data (dashed black line) and the share of foreign currency debt for central government securities held by non-residents (solid black line) computed using Arslanalp and Tsuda data

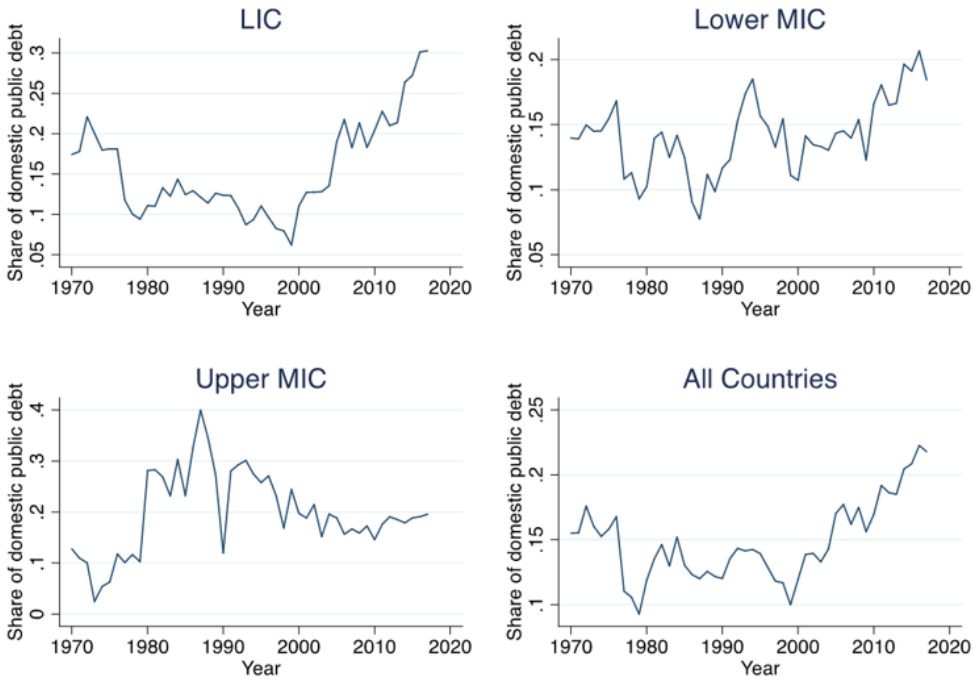
Facts about Public Debt: Composition (EMDE, simple average)



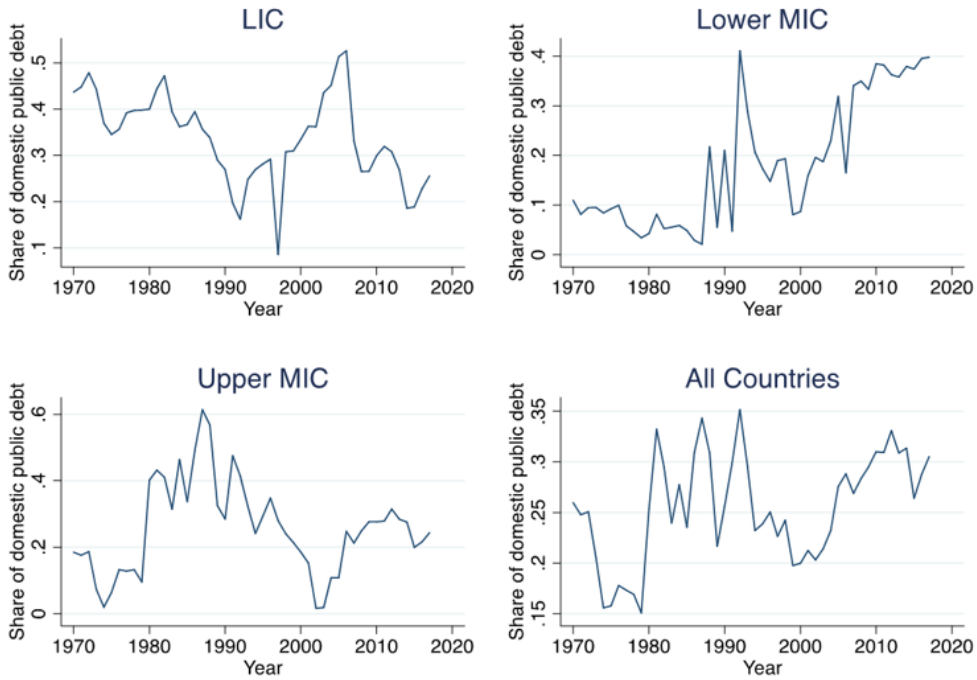
Facts about Public Debt: Composition (EMDE, weighted average)



Facts about Public Debt: Share of domestic public debt (EMDE, simple average)



Facts about Public Debt: Share of domestic public debt (EMDE, weighted average)



Section 13.1
Sovereign Default: Empirical Regularities

Note that the literature focuses on external debt and, in general, it makes no difference between external public and private debt

Empirical Definition of Default

- Much of the data on sovereign default is produced by credit rating agencies, especially Standard and Poor's (S&P).
- **Entrance To Default Status:** S&P defines default as the failure to meet a principal or interest payment on the due date. This includes situations in which the sovereign forces an exchange of old debt for new debt with less-favorable terms or converts debt into a different currency of less value.
- **Exit From Default Status:** S&P considers a country to have emerged from default when it resumes payments of interest and principal (including arrears), or after a debt settlement that leads the rating agency to conclude that no further near-term resolution of creditors' claims is likely.
- **There are serious problems with this binary definition of default**

Table 13.1 Frequency And Length of Sovereign Defaults: 1824-2014

Country	Number of Defaults 1824-2014	Probability of Default		Years in State of Default per Default Episode
		all years	years not in default	
Argentina	5	0.026	0.035	10
Brazil	7	0.037	0.047	6
Chile	3	0.016	0.020	14
Colombia	7	0.037	0.058	10
Egypt	2	0.010	0.012	11
Mexico	8	0.042	0.056	6
Philippines	1	0.005	0.006	32
Turkey	6	0.031	0.037	5
Venezuela	10	0.052	0.079	6
Mean	5.4	0.029	0.039	11

Note. The sample includes only emerging countries with at least one external-debt default or restructuring episode between 1824 and 1999. The 2014 selective default of Argentina with 1 percent of the holdout investors that did not enter the debt restructurings of 2005 and 2010 is not counted as a default event.

Observations

- 49 defaults in 9 countries over 191 years. $\Rightarrow$ average probability of default is 2.9% per year (once per 33 years).
- suppose we divide not by all years, but only by years not in default, then the average probability of default is 3.9% per year.
- When a country defaults it stays in default status on average for 11 years.

Has The Frequency and Length Of Default Changed Over Time?

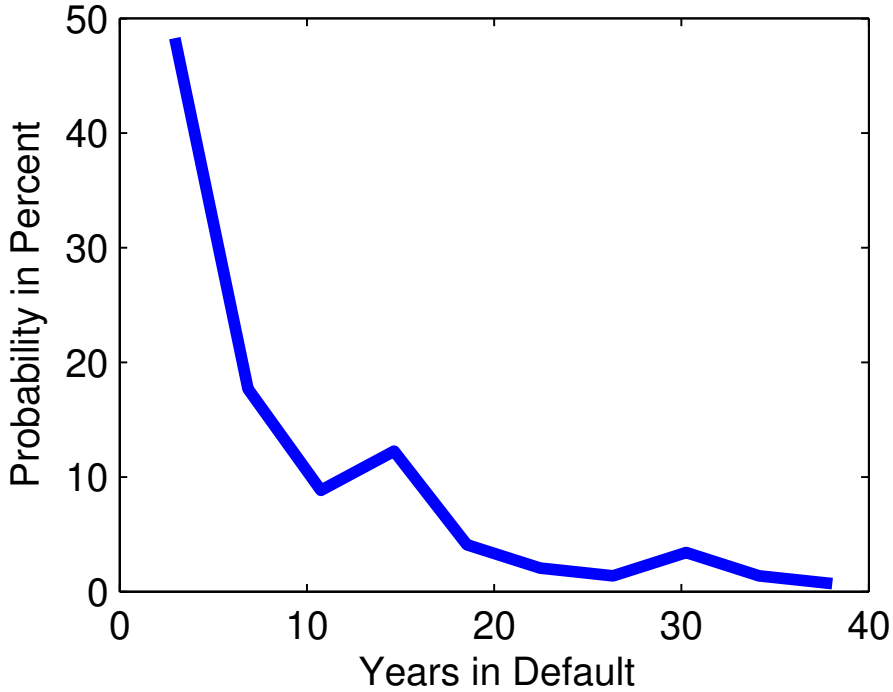
Table 13.2
1824-1999 Versus 1975-2014

Period	Probability of Default per year	Years in State of Default per Default Episode
1824-1999	0.029	11
1975-2014	0.040	8

Observation: Defaults have become more frequent but shorter. Important for calibrating default models.

Figure 13.1 Distribution Of The Length Of Default Episodes

1975-2014 sample: 147 defaults in 93 defaulting nations



Observations on figure:

1. Distribution of length of default is skewed (mean 8 years, median 5)
2. Distribution looks exponential $\Rightarrow$ not unreasonable to assume probability of re-access to credit markets constant over time as in most Eaton-Gersovitz-style models of default.

13.1.2 Haircuts: The Size of Defaults

- Most models of default assume that defaults are always on 100% of the debt.
- In reality, this is not the case.
- A haircut is the loss inflicted to creditors upon restructuring, measured as the decrease in the present value of current and future expected payments.
- Key conceptual issue: discount rate
- A number of studies estimate similar values of haircuts (Sturzenegger and Zettelmeyer, 2008; Cruces and Trebesch, 2013; Benjamin and Wright, 2008):
  - Average Haircut: 40%
  - Standard deviation of haircut: 22%.

Debt to GNP Ratio is Higher Than Usual Prior to Default

Table 13.3 Debt-to-GNP Ratios Among Defaulters: 1970-2000

Country	Average Debt-to-GNP Ratio	Debt-to-GNP Ratio in Year of Default
Argentina	37.1	54.4
Brazil	30.7	50.1
Chile	58.4	63.7
Colombia	33.6	
Egypt	70.6	112.0
Mexico	38.2	46.7
Philippines	55.2	70.6
Turkey	31.5	21.0
Venezuela	41.3	46.3
Average	44.1	58.1

Table 13.4 Interest Rate Spreads Among Defaulters: 1999-2013

	Average Country Spread	
Country	All Years	Years Not In Default
Argentina	15.8	7.43
Brazil	5.61	5.61
Chile	1.44	1.44
Colombia	3.70	3.70
Egypt	2.46	2.46
Mexico	3.47	3.47
Philippines	3.49	3.49
Turkey	4.10	4.10
Venezuela	9.24	9.23
Average	5.5	4.5

Notes: The sample includes only emerging countries with at least one external-debt default or restructuring episode between 1824 and 1999. Country spreads are measured using the EMBI Global index, produced by J.P. Morgan, and expressed in percent, and are averages through 2013, with varying starting dates as follows: Argentina 1994; Brazil 1995; Chile 2000; Colombia 1998; Egypt 2002; Mexico 1994; Philippines 1998; Turkey 1997; Venezuela 1994. Start and end dates of default episodes are taken from table 13.9 of USG (2017).

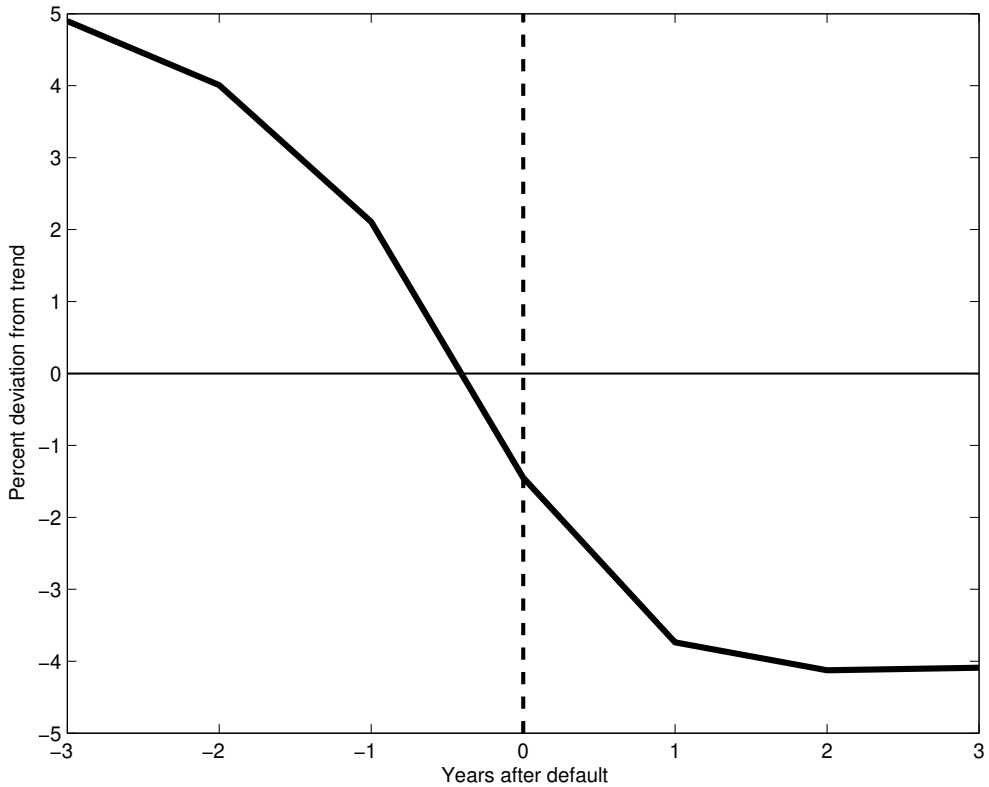
The Spread-Default-Frequency Differential is Positive After Correcting for the Sample-Mismatch Bias (Table 13.5)

	Sample for spread	Country Spread (percent)	Default Probability common	Default Probability 1824-2014
Argentina	1994-2013	7.43	6.7	3.5
Brazil	1995-2013	5.61	0	4.7
Chile	2000-2013	1.44	0	2.0
Colombia	1998-2013	3.70	0	5.8
Egypt	2002-2013	2.56	0	1.2
Mexico	1994-2013	3.47	0	5.6
Philippines	1998-2013	3.49	0	0.6
Turkey	1997-2013	4.10	0	3.7
Venezuela	1994-2013	9.23	13.3	7.9
Mean		4.5	2.2	3.9

* **The sample-mismatch bias:** Due to data limitations, spread samples are short, starting in the mid 1990s or later for most countries. By contrast, default data is much longer, starting at least in 1975 and going back almost two centuries for some countries. Computing spread default-frequency differentials using samples of different lengths yields quite different results than using samples spanning the same periods.
* With risk neutral lenders, spreads should equal default probability. With partial default, and risk neutral lenders, spreads should be smaller than default probabilities. Evidence of spreads in excess of default probability suggests risk aversion on the part of lenders.

Do Countries Default In Bad Time? Yes.

Figure 13.2 Output Around Default Episodes

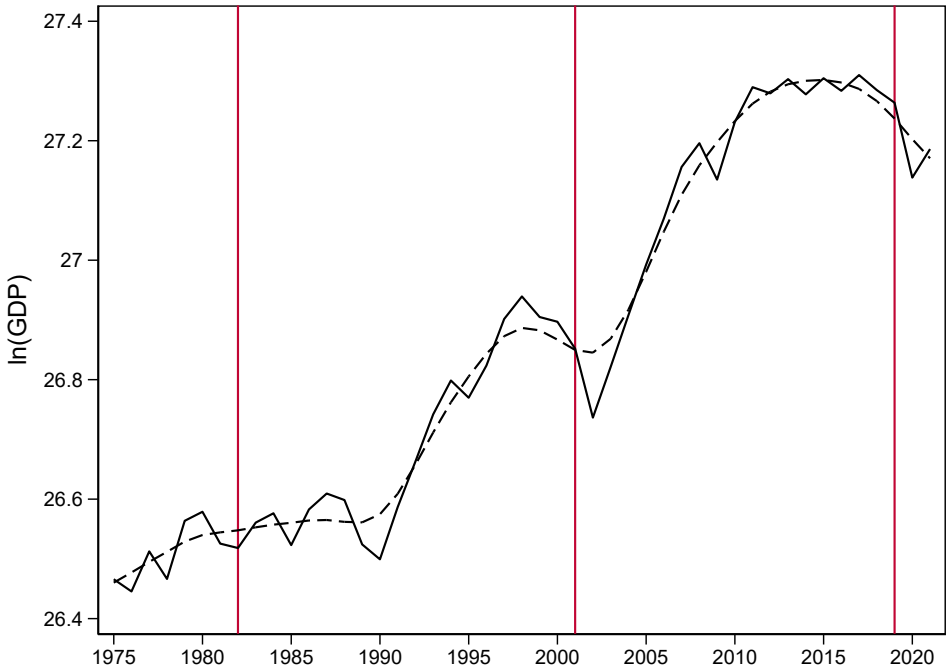


Note: Annual log-quadratically detrended real GDP per capita. The year of default is normalized to 0. Median over 105 default episodes between 1975 and 2014.

Observations

- Detrended output falls by 6.5 percent in the 3 years leading up to default.
- 75 percent of the default episodes are associated with a contraction in detrended output (i.e, a fall in detrended output between years -1 and 0).
- Relation to Tomz and Wright (2007): Also find that countries default in bad times, but claim that the evidence is weak. Why?
  * In the period of default output is only 1.5 percent below trend. Same true in current data set, but what about the 5% contraction in output between years -3 and -1?
  * Tomz and Wright find that in only 60 percent of the default episodes output is below trend. Same true in current data set. But if one asks how many countries are contracting at the time of default (i.e., displaying a fall in output), the answer is 75%.
  * Maybe it's all in HP
- Default comes at the end of a large contraction and the beginning of a growth (but not level) recovery as stressed by Levy-Yeyati and Panizza (2011).

Argentina: Actual GDP and HP filtered GDP (λ=6.25)



Source: Panizza (2022)

In "Why You Should Never Use the Hodrick-Prescott Filter," Hamilton concludes that the HP filter: *introduces spurious dynamic relations that are purely an artifact of the filter and have no basis in the true data-generating process, and there exists no plausible data-generating process for which common popular practice would provide an optimal decomposition into trend and*

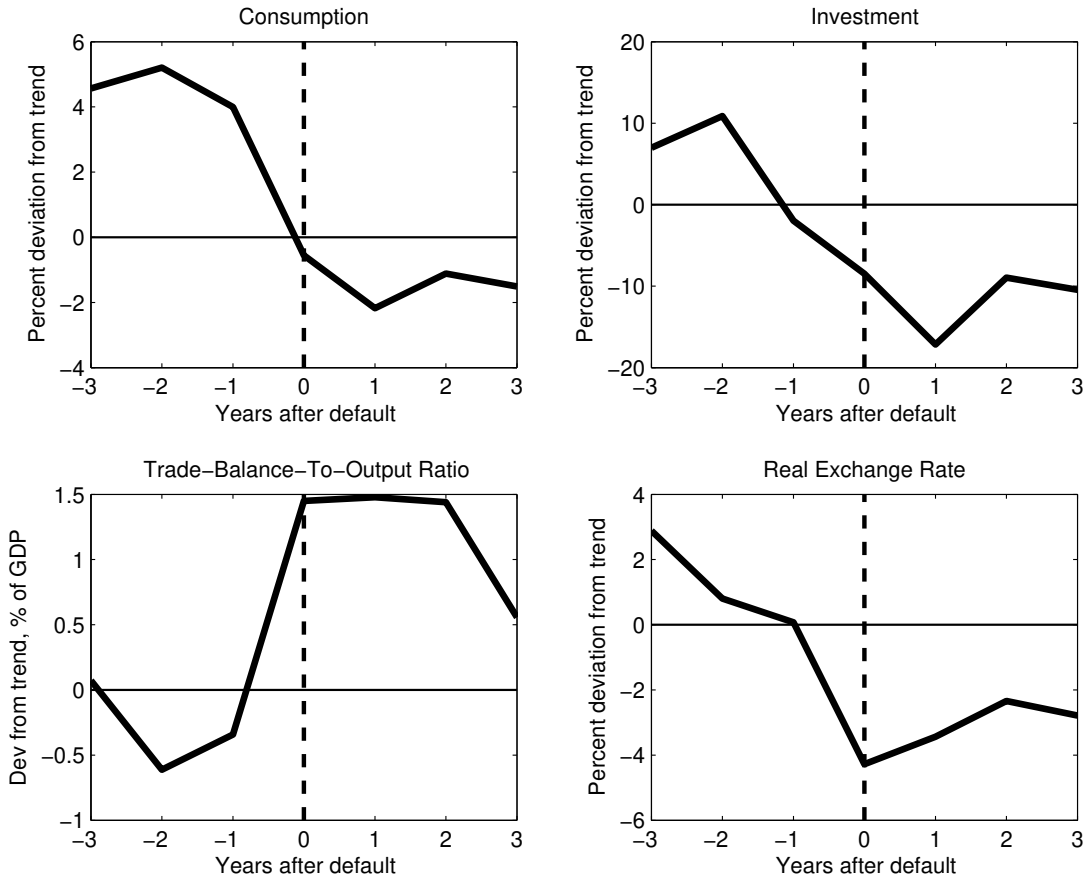
The role of alternative detrending techniques

	HP (λ=6.25)	HP (λ=400)	Ham. Trend	Log-lin. Trend	$g_t > \mu$	Tomz & Wright Hist.	Tomz & Wright Model
Good times defaults	35%	44%	19%	54%	20%	38.5%	14.1%
Average output gap (%)	-0.9%	-1.2%	-6.9%	0.2%	-4.5%	-1.6%	-7.4%
Median output gap (%)	-0.07%	-0.9%	-5.4%	1.3%	-2.7%		
St. dev. output gap	3.5%	7.7%	9.7%	14.3%	6.7%		
25th pctile of output gap	-2.2%	-4.8%	-10.6%	-6.2%	-6.2%		
75th pctile of output gap	1.3%	2.7%	-0.7%	7.7%	-0.9%		
Skewness	-0.47	-0.36	-1.56	-0.68	-1.78		
Number of episodes	79	79	79	79	79	169	

Source: Panizza (2022)

Other Macro Indicators Around Defaults support view that countries default in bad times

Figure 13.3 Consumption, investment, the trade balance, and the real exchange rate around default episodes



Observations

- Consumption contracts by as much as output in the run up to default (about 6 percent).
- The contraction of investment leading up to default is 3 times as large as that of output.
- The trade balance is below average up until the year of default. And in the year of default it experiences a reversal of about 2% of GDP.
- The real exchange rate depreciates significantly in the default year (by over 4%), and then begins to gradually appreciate.

Section 13.2
The Cost of Default: Empirical Evidence

What are possible costs of default?

1. Use of force?
2. Financial Exclusion? (Reputation)
3. Output Losses?
4. Reductions in trade?

The Drago Doctrine—No Use of Force

Photo Credit: Cristóbal Uribe, Buenos Aires, December 2015.

- The use of force by one country or a group of countries to collect debt from another country was not uncommon until the beginning of the twentieth century. (controversial)
- In 1902, an attempt by Great Britain, Germany, and Italy to collect the public debt of Venezuela by force prompted the Argentine jurist **Luis-María Drago**, who at the time was serving as minister of foreign affairs of Argentina, to articulate a doctrine stating that no public debt should be collected from a sovereign American state by armed force or through the occupation of American territory by a foreign power.
- **The Drago doctrine** was approved by the Hague Conference of 1907.

Exclusion Costs: Are Defaulters Excluded From Financial Markets? and For How Long?

Measure	Partial Reaccess (flows>0)	Full Reaccess (flows$>1\%$GDP)
Length of Default*	8	
Issuance of New Debt		
-Gelos, et al. (2011)*	4.7	
-Richmond and Dias (2009)**	5.7	8.4
-Adjusted Richmond and Dias*	13.7	16.4
-Cruces and Trebesch (2013)**	5.1	7.4
-Adjusted Cruces and Trebesch*	13.1	15.4
Average	9.8	15.9

Note. Reaccess is measured in years. after the beginning of default (*) or in years after the end of default (**). Averages are taken over single-star lines.

Observations

- Estimates of the average length of the exclusion period is important for the calibration of default models.
- The change in net external debt is an equilibrium outcome.
- Thus, if a country does not borrow, it could be due to lack of demand, and not necessarily to a supply restriction motivated by punishment.
- Thus, estimates of exclusion may carry an upward bias.

Determinants of the Exclusion Period

- Frequency of default is not a significant determinant of the length of exclusion (Gelos et al., 2011)
- Defaults that resolve quickly are associated with short exclusion periods (Gelos et al., 2011).
- Excusable defaults (such as those following a natural disaster) are associated with reduced exclusion periods (Richmond and Dias, 2009).
- Restructurings involving higher haircuts (i.e., higher losses to creditors) are associated with significantly longer periods of capital market exclusion (Cruces and Trebesch, 2013).
- In most theoretical models of default, the length of exclusion is assumed to be random and exogenous.

Output Cost of Default

- Theoretical default literature relies on assumption that default leads to output loss. What does the data show?
- Standard approach: Growth regressions augmented with default variables (see, for example, Chuan and Sturzenegger, 2005; Borensztein and Panizza, 2009; De Paoli, Hoggarth, and Saporta, 2006; and Levy Yeyati and Panizza, 2011).
- Alternative approaches: Esteves, Kenny, and Lennard (2021); Caselli, Faralli, Manasse and Panizza (2022); Farah-Yacoub, Graf von Luckner, Ramalho, and Reinhart (2022).

Default Dummies in Growth Regressions

Borensztein and Panizza (2009) estimate the equation

$$\text{Growth}_{it} = \alpha + \beta X_{it} + \gamma \text{Default}_{it} + \sum_{j=0}^{3} \delta_j \text{DefaultB}_{it-j}$$

where Growth_{it} is the growth rate of real per capital GDP in country i between years $t-1$ and t, X_{it} is a vector of standard controls in growth regressions (initial income, education, population, etc.), Default_{it} is a dummy taking the value 1 if country i is in default in year t and 0 otherwise, and DefaultB_{it} is a dummy taking the value 1 if country i enters default in year t.

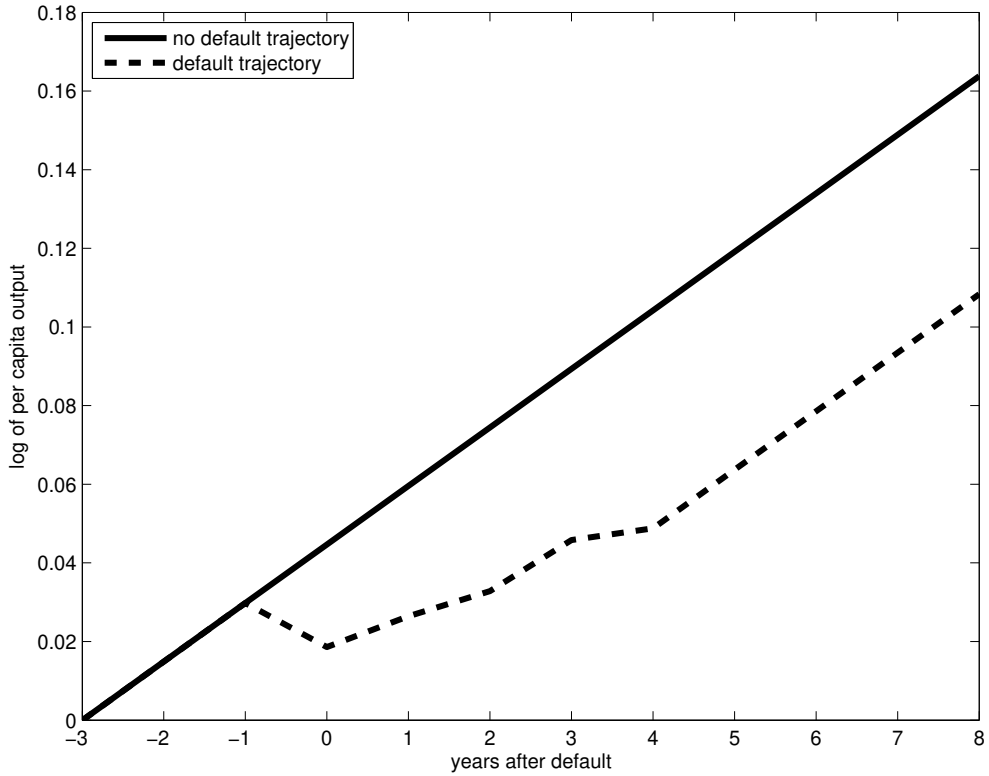
Estimation Results

Using annual data for 83 countries for the period 1972 to 2000, Borensztein and Panizza estimate

$$\begin{aligned} \text{Growth}_{it} &= \alpha + \beta X_{it} - 1.184\text{Default}_{it} \\ &\quad -1.388\text{DefaultB}_{it} + 0.481\text{DefaultB}_{it-1} \\ &\quad +0.337\text{DefaultB}_{it-2} + 0.994\text{DefaultB}_{it-3} \end{aligned}$$

with γ and δ_0 significant at confidence level of 5% or less.
This estimate implies that the beginning of a default is associated with a fall in the growth rate of 2.5 percentage points ($= \gamma + \delta_0$).
More importantly, default is associated with a permanent loss of output.
This is shown in the next figure, which displays a simulation of the log of output per capita implied by the regression equation (default occurs in period 0).

Simulated Path Of Output After A Default Implied By the Borensztein-Panizza Regression



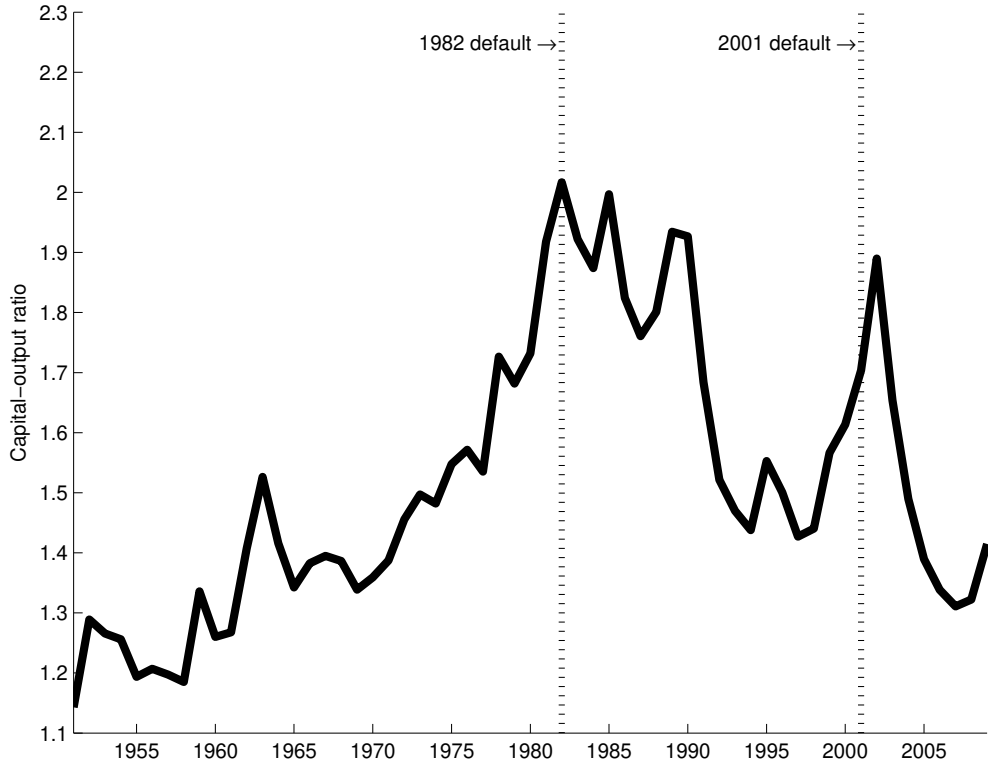
In producing the figure, long-run growth is set to 1.5%, and exclusion is set to 5 years (median from figure 13.1)

Observations on Default Dummies in Growth Regressions

- After an initial fall, growth gradually regains its long-run level.
- However, the level of output never recovers. It remains 5.5% below the no-default trajectory. Taken at face value, the cost of default is enormous.
- Reasons why the output loss estimate can be upwardly biased:
  - The regression doesn't include lags in the variable Default_{it} and may include insufficient lags in DefaultB_{it}. If they entered with positive signs, these extra lags could capture a catch-up effect.
  - **More importantly,** output growth and default are both endogenous variables.
  - Not clear what causes what. If default occurs during recessions, estimated effect of default may be negative even if in reality they are zero.

Output Cost Of Default: A Growth Accounting Approach (Zarazaga, 2012)

Take a look at the behavior of the capital-output ratio around the Argentine defaults of 1982 and 2001:



Observation: Both defaults are associated with a fall in the capital-output ratio. What does this imply for output per worker?

Default and Growth Accounting (continued)

- Let the production function be $y_t = k_t^{0.4} h_t^{0.6} \Rightarrow y_t/h_t = (k_t/y_t)^{2/3}$
- In the 2002 default, k_t/y_t fell from 1.9 to 1.35 in 2007.
- Therefore, Percent change in y_t/h_t equals: $\left[\left(\frac{1.9}{1.35}\right)^{2/3} - 1\right] \times 100 = 26\%$.
- This means that, on average, output was 13% (=26%/2) lower every year between 2002 and 2007. Large output cost of default!
- **Usual cautionary note:** This calculation assumes that all of the change in k_t/y_t is due to default.
- But causality may go the other way as well.
- To the extent that this is the case, the 13% output loss must be interpreted as an upper bound of the cost of default.

Trade Costs of Default

- **Hypothesis:** Countries honor their debts, among other things, to avoid trade sanctions.
- Rose (2005) sets out to test this hypothesis by estimating the following gravity model augmented with default variables:

$$\ln T_{ijt} = \beta_0 + \beta X_{ijt} + \sum_{m=0}^{M} \phi_m ACRED_{ijt-m} + \epsilon_{ijt}$$

- **Definitions:** T_{ijt} = real value of trade between countries i and j in year t; X_{ijt} = usual gravity variables; $ACRED_{ijt} = 1$ if one country is a restructuring debtor and the other a negotiating creditor (the affected creditor), 0 otherwise.
- **Sample:** 1948-1997 annual, 217 countries.
- **Finding:** $\sum_{m=0}^{15} \phi_m = -1.12$. Thus, the cumulative cost of default is over one year of trade over 16 years. It looks like the trade costs of default are enormous.
- But is it sanctions or general economic stress around default episodes? Keep reading...

Does Default Disrupt Int'l Trade So Much?

- Martínez and Sandleris (2011) estimate the following variant of Rose's gravity model:

$$\ln T_{ijt} = \beta_0 + \beta X_{ijt} + \sum_{m=0}^{M} \phi_m ACRED_{ijt-m} + \sum_{m=0}^{M} \gamma_m DEBTOR_{ijt-m} + \epsilon_{ijt},$$

- **Definition:** $DEBTOR_{ijt} = 1$ if either country is a restructuring debtor, 0 otherwise.
- **Finding:** $\sum_{m=0}^{15} \phi_m = 0.01$ and $\sum_{m=0}^{15} \gamma_m = -0.41$.
- **Implication:** It might not be trade sanctions to defaulters, but general economic stress around default episodes.
- But if default is punished with collective trade sanctions, not just sanctions by the affected creditors, the variable $DEBTOR_{ijt}$ may not pick up just economic distress, but also the effect of collective punishment.

Controlling for Collective Sanctions

- To control for collective sanctions, Martínez and Sandleris (2011) estimate the following equation

$$\ln T_{ijt} = \beta_0 + \beta X_{ijt} + \sum_{m=0}^{M} \phi_m CRED_{ijt-m} + \sum_{m=0}^{M} \gamma_m DEBTOR_{ijt-m} + \epsilon_{ijt}$$

- **Definition:** $CRED_{ijt} = 1$ if one country is a renegotiating debtor and the other is a (not necessarily renegotiating) creditor.
- **Finding:** $\sum_{m=0}^{M} \phi_m$ positive at horizons 0, 5, and 10, and negative at horizons 15 or longer.
- **Interpretation:** No sanction effect, unless creditors have very long memories (at least 15 years) and are willing or have reasons to delay punishment.

Martínez and Sandleris III:

$$\ln T_{ijt} = \beta_0 + \beta X_{ijt} + \sum_{m=0}^{M} \phi_m ACRED_{ijt-m} + \sum_{m=0}^{M} \xi_m NACRED_{ijt-m} + \sum_{m=0}^{M} \gamma_m NOTCRED_{ijt-m} + \epsilon_{ijt}.$$

- **Definitions:** $NACRED_{ijt} = 1$ if one country is a renegotiating debtor and the other a nonrenegotiating creditor, 0 otherwise. $NOTCRED_{ijt} = 1$ if one country is a renegotiating debtor and the other is not a creditor.
- **Finding:** $\sum_{m=0}^{M} \xi_m < 0$, but $\sum_{m=0}^{M} \phi_m > 0$ at horizons 0, 5, 10, and negative only at horizon 15.
- **Interpretation:** Again, no sanction effect, unless creditors have very long memories (at least 15 years) and are willing or have reasons to delay punishment.

Case Study: Colombia in the 1980s

The Benefits of Repaying

Francesca Caselli, Matilde Faralli, Paolo Manasse, and Ugo Panizza

Outline

- Objective of the Paper
- The Latin American debt crisis
  - The three phases of the Latin American debt crisis
  - Colombia
- Colombia's default probability
- Counterfactual analysis
- Reputation
- Conclusions

Objective of the Paper

Estimating the **benefits of repaying** when everybody else defaults

- Large literature that tries to estimate the costs of defaults
  - **On GDP growth:** Sturzenegger (2004), Borensztein and Panizza (2009), De Paoli, Hoggarth, and Saporta (2009), Jorra (2011), Levy Yeyati and Panizza (2011), Asonuma and Trebesch (2016), Reinhart and Trebesch (2016), Asonuma, Chamon, Erce, and Sasahara (2019), Esteves, Kelly, and Lennard (2021)
  - **On reputation:** Ozler (1993), Eichengreen and Portes (1986), Jorgensen and Sachs (1989), Flandreau and Zumer (2004), Borensztein and Panizza (2009), Gelos, Sahay, and Sandleris (2011), Tomz (2012), Cruces and Trebesch (2013), Catao and Mano (2017)
  - **On trade:** Rose (2005), Martinez and Sandleris (2011), Borensztein and Panizza (2010)
- Colombia is the only large Latin American country which is normally deemed as not having defaulted in the 1980s
- We use archival research and econometric techniques to study what happened

Objective of the Paper

Estimating the **benefits of repaying** when everybody else defaults

> *To fulfill one's contracted obligations is extremely honorable, but to do so when everyone is defaulting and in times of crisis is a thousand times more valuable.*
>
> Alberto Hueyo (Minister of Finance of Argentina, 1932-33)

> *Maintaining the role of "good debtor" and being an exceptional case in Latin America and in most of the developing world will improve Colombia's future market access.*
>
> Luis Jorge Garay (Colombia's Chief Debt Negotiator in the 1980s)

Inspiration: Bluto's Big Speech

The Latin American debt crisis

- The "Mexican Weekend"

  On August 13, 1982, after closing the country's foreign exchange market, Mexican finance minister Jesùs Silva Herzog traveled to Washington to inform the Fund and the Treasury that Mexico was no longer able to service its $86 billion of external debt

- Mexico was soon followed by Argentina, Brazil, Chile, Ecuador, and several other countries in Africa, Asia, and Europe
  * 26 countries "defaulted" between 1982 and 1983 and other 29 in the rest of the 1980s
  * Latin America and the Caribbean was the most severely affected region. Out of the region's 23 countries with more than one million inhabitants, 22 "defaulted" between 1980 and 1989
  * Note the quotation marks

The three phases of the crisis

- **Phase 1 (1982-85):** it's just a liquidity problem!
  - * Fiscal adjustment and coordinated reprofiling of principal repayments
  - → Concerted lending at relatively high rates and large upfront cash commissions
  - * Increase in borrowing costs and in the PV of external debt
- **Phase 2 (1985-89):** Baker Plan and "New Money"
  - * New disbursement from the World Bank and RDBs
  - * Softer financial conditions and lower cost of credit
  - * First hint that debt relief might be needed:
    The reality of the marketplace may well have to be taken into account by the banks to ensure the success of future financing packages and the maintenance of solidarity among the financial community (Jacques de Larosière, 1987)

The three phases of the crisis

- **Phase 3 (1989-98):** The Brady Plan
  - → Announced by US Treasury Secretary Nicholas Brady in March 1989
  - → It focused on debt reduction with direct financial support from the official sector
  - → It envisioned a transformation of defaulted bank loans into collateralized bonds
  - → Over 1990-1998, 11 countries implemented Brady exchanges

Colombia 1

- In the run-up to the crisis, Colombia's macro and fiscal indicators were slightly better than those of the median country in LAC, but Colombia was never the best performer
  - → Rapid deterioration of Colombia's economic situation in the first half of the 1980s
  - → Net capital inflows collapsed in 1982; Colombia was unable to access the international capital market
  - → At the end of 1982, the government declared a 5-day state of economic emergency
  - → During the 1983 Article IV, the authorities expressed concerns that if reserves dropped by more than $1 billion there could be widespread market panic (reserves dropped by $1.6 billion)

Macro indicators in the run-up to the LA debt crisis

Ext. debt/GDP 1981		P. Bal./GDP 1978-81		CAC/GDP 1978-81		Real growth 1978-81		Inflation 1978-81		Spread (bps) 1981	
GTM	15.2	BRA	5.31	T & T	3.1	PAR	10.33	ELS	4.14	VEN	57
T & T	15.8	CHL	4.19	VEN	0.61	MEX	8.77	HTI	4.67	MEX	62
PAR	19.6	MEX	2.16	ELS	0.55	CHL	7.38	GTM	8.18	COL	66
URY	19.86	PER	0.39	ARG	-0.2	PAN	6.74	DOM	8.32	CHL	70
COL	24.24	ARG	-0.12	COL	-0.8	HTI	5.05	HON	8.6	ECU	70
MEX	30.89	COL	-0.88	GTM	-4.12	ECU	5.02	PAN	10.13	ARG	80
BRA	32.42	HON	-1.3	HTI	-4.55	COL	4.96	JAM	12.81	URY	93
DOM	34.01	DOM	-1.35	MEX	-4.58	URY	4.7	T & T	15.3	CRI	93
ELS	36.55	BOL	-9.27	ECU	-5.65	T & T	4.39	PAR	15.85	PAN	125
ECU	36.93			JAM	-6.29	HON	4.31	VEN	17.5	BRA	205
PER	42.17			PAR	-6.32	BRA	3.93	CRI	19.2	BOL	222
HON	46.51			BOL	-6.46	GTM	3.44	COL	22.8		
ARG	46.6			DOM	-6.85	PER	2.7	NIC	23.1		
CHL	50.44			HON	-7.24	CRI	2.34	BOL	23.9		
BOL	65.3			BRA	-7.32	BOL	1.1	CHL	36.0		
JAM	83.42			CHL	-8.17	JAM	0.63	URY	51.1		
PAN	88.8			NIC	-9.57	ARG	-0.45	PER	67.9		
NIC	107.6			CRI	-13.45	VEN	-0.75	BRA	72.3		
CRI	146.5			PAN	-23.24	ELS	-2.66	ARG	130		
Mean	48.85		-0.4		-5.76		3.3		28.15		104
Med	36.74		-0.5		-5.97		4.31		17.5		86
σ	33.99		4.07		5.71		3.97		30.23		55
					Colombia minus regional average						
Difference	-25.9		-0.53		5.25		1.74		-5.59		-41.45
	(35.3)		(4.54)		(5.85)		(4.15)		(31.75)		(58.65)

Source: IMF (1987)

Colombia 2

- By mid-1984, Colombia was unable to service its external debt
- However, rather than suspending its payments, it negotiated with its foreign creditors a series of arrangements that would refinance the majority of payments coming due over 1985-94
  - → 4 arrangements: the "Jumbo" arrangement of 1985 ($1 billion); the "Concorde" arrangement of 1987 ($1 billion); the "Challenger" arrangement of 1989 ($1.5 billion), and the "Hercules" arrangement of 1991 ($1.8 billion)
  - → Participation in these exchanges was not fully voluntary
  - → While the Colombian authorities strove to maintain their reputation of "good debtor" in the international capital market, Colombian loans traded in the secondary market at a deep discount

Secondary market prices of syndicated loans

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Argentina	66	35	21	13	21	32	43		
Brazil	75	46	40	22					
Chile	67	61	57	59	73.3	90	90	90	95
Colombia	84	63	58	64	64	75	75	85	90
Ecuador	65	37	13	14	19.8	22	28	52	
Mexico	56	50	43	36					
Panama	67	35	20	12	13	21	29	53	53
Peru	18	7	5	6	4	11	19	67	56
Venezuela	74	57	41	34					

Source: Klingen, Weder di Mauro, and Zettelmeyer (2013)

Colombia's debt renegotiations

Date and Name	Amount	Disbursement	Grace Period	Spread	Maturity	Notes
Apr. 1985, Jumbo	$1billion	$515mill. planned for 1985 $485mill. planned for 1986, but all disbursed in 1986	3.4y	LIBOR+150 bps for the first 4y, LIBOR+138 bps for the next 6y. Effective average cost: LIBOR+1.93	8.4y	Quarterly disbursements conditional on IMF monitoring
Jan. 1988, Concorde	$1billion (corresponding to 70% of payments due to banks in 1987-88)	Planned for 1987-88, but only signed & disbursed in 1988	5.0y	LIBOR+93 bps (15/16). Effective average cost: LIBOR+1.42	10y	Authorities had to share copies of Article IV reports with creditors
Jun. 1989, Challenger	Syndicate Loan of $1.47bill. and facility of $185mill.	1989-90 (1st disbursement October 1989)	6y for the SL & 5y for the fac.	LIBOR+87 bps for the SL and LIBOR+93 bps for the fac.. Effective average cost: LIBOR+1.11	12y for the SL & 10y for the fac.	
Dec. 1990, Hercules	Syndicate Loan of $1.575bil. & facility of $200mill. (90% of principal payments coming due over 1991-94)	1991-94	6.2y	LIBOR+100 bps for the SL & LIBOR+150 bps for the fac.. Effective average cost: LIBOR+1.24	12.6 y	

Source: IMF Article IV 1988, 1989, 1991, and garay (1991)

Colombia 3

Colombia external debt strategy has been to achieve a return to normal access to international capital markets. Consistent with this strategy, the authorities have avoided a formal debt rescheduling and have tried to maintain the exposure of commercial banks and multilateral institutions to Colombia that roughly match amortizations payment as they fall due.
(IMF, 1989 pages 39-41)

Colombia 4

The Colombian authorities were disappointed by the fact that their efforts to act as good debtor did not grant them a better treatment.

> *in accordance with its exceptional status of good debtor country, the international financial system should have given Colombia a more favorable treatment, rewarding Colombia by differentiating it from other countries with payment problems would have set a clear precedent (page 18)....the commercial banks should be criticized for not having given better recognition to a good debtor in the midst of a generalized debt crisis (page 29)*
> *(Garay, 1991)*

Colombia's special treatment

- Colombia did not want an IMF program
- Private creditors' "advisory" committees requested that Colombia should be subject to a form of IMF "enhanced" surveillance in which the Fund would certify and monitor Colombia's adjustment program
- Colombian authorities wanted to have the Fund's Executive Board's and not just the staff's 'seal of approval' without the stigma that might be associated with a formal stand-by arrangement (Boughton 2001, P. 413)
- Directors did not like it
- Until the last minute, the Colombian authorities doubted that the Board would approve this unusual arrangement (Junguito, 1985)
- But...

Colombia's special treatment

For cases such that of Colombia, when the Board was asked to make a judgment about an arrangement that had no precise precedent, Mr Dallara said, the Fund ought to develop new techniques only with considerable caution and with awareness of potential risks and benefits. Appropriately, the Fund has never been called an excessively innovative institution, but it had devoted great care and caution in examining the Colombian economy, and the benefits outnumbered the risks... Under the circumstances it was appropriate for the Fund to accept and perform the proposed monitoring role.
(Minutes of the Executive IMF Board Meeting, July 26, 1985)

Colombia's special treatment

- Reasons for this special treatment
  - → Cooperation on drug traffic control
  - → Geopolitics (the US was losing friends in Latin America)
  - → Strong relationship with the Fed.
    - * Paul Volcker, wanted to make the point that the US was not using a one-size-fits-all approach towards Latin America's debt problems.
    - * The Colombian authorities' determination to be a "good debtor" made Colombia a good candidate for a more favorable treatment
    - * (In July 1986, Paul Volcker received the Cruz de Boyaca, one of the highest honors granted by Colombia)

Colombia's default probability

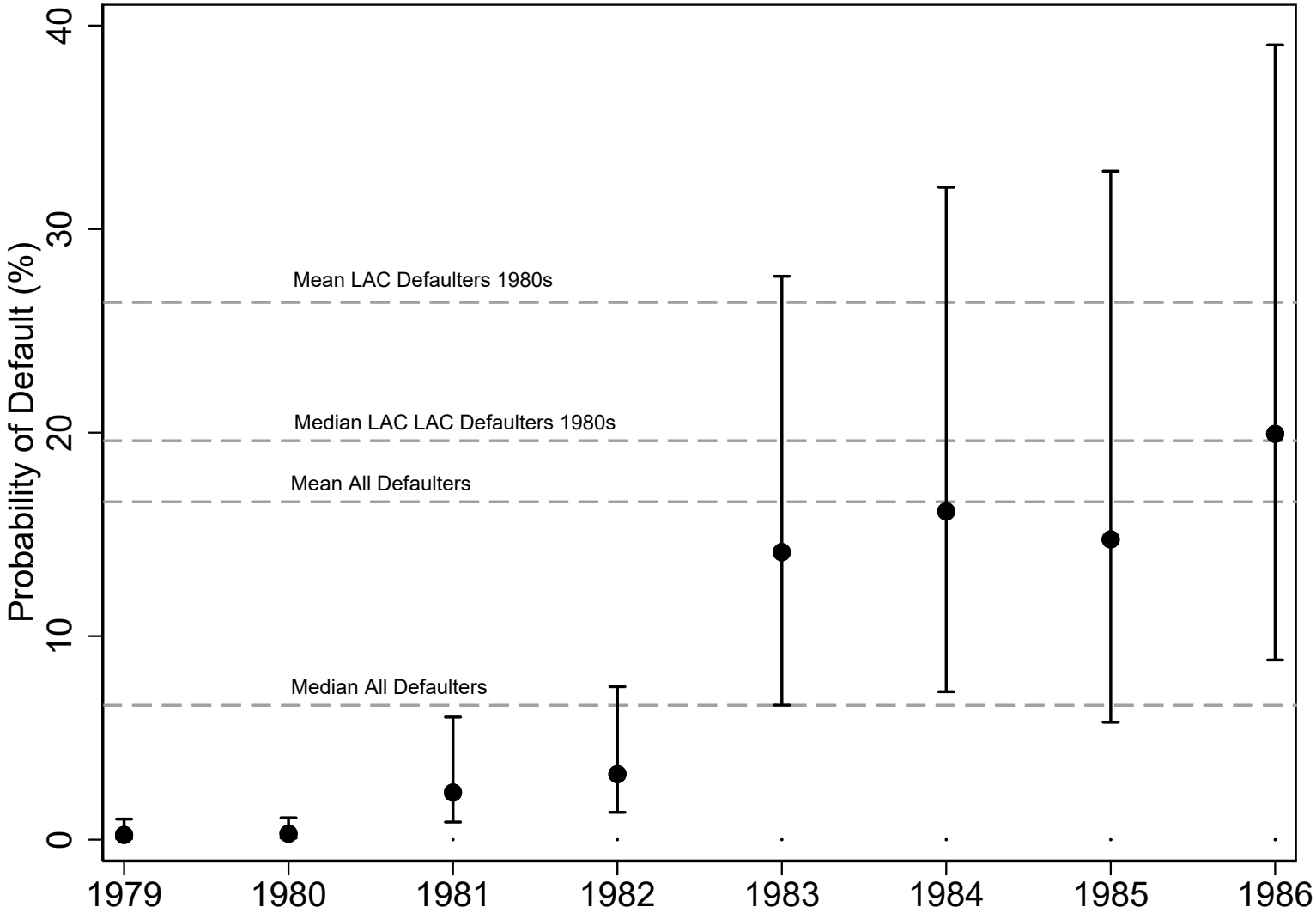
- Archival research shows that Colombia's fundamentals were similar to those of the Latin American countries that defaulted
- We test whether in the 1980s Colombia's default probability was different from that of other Latin American countries
- We proceed in two steps.
  1. We use LASSO-logit to select a parsimonious set of variables which are good predictors of the probability of default

     Our data cover 87 countries over the period 1976-2017 and include 77 defaults.

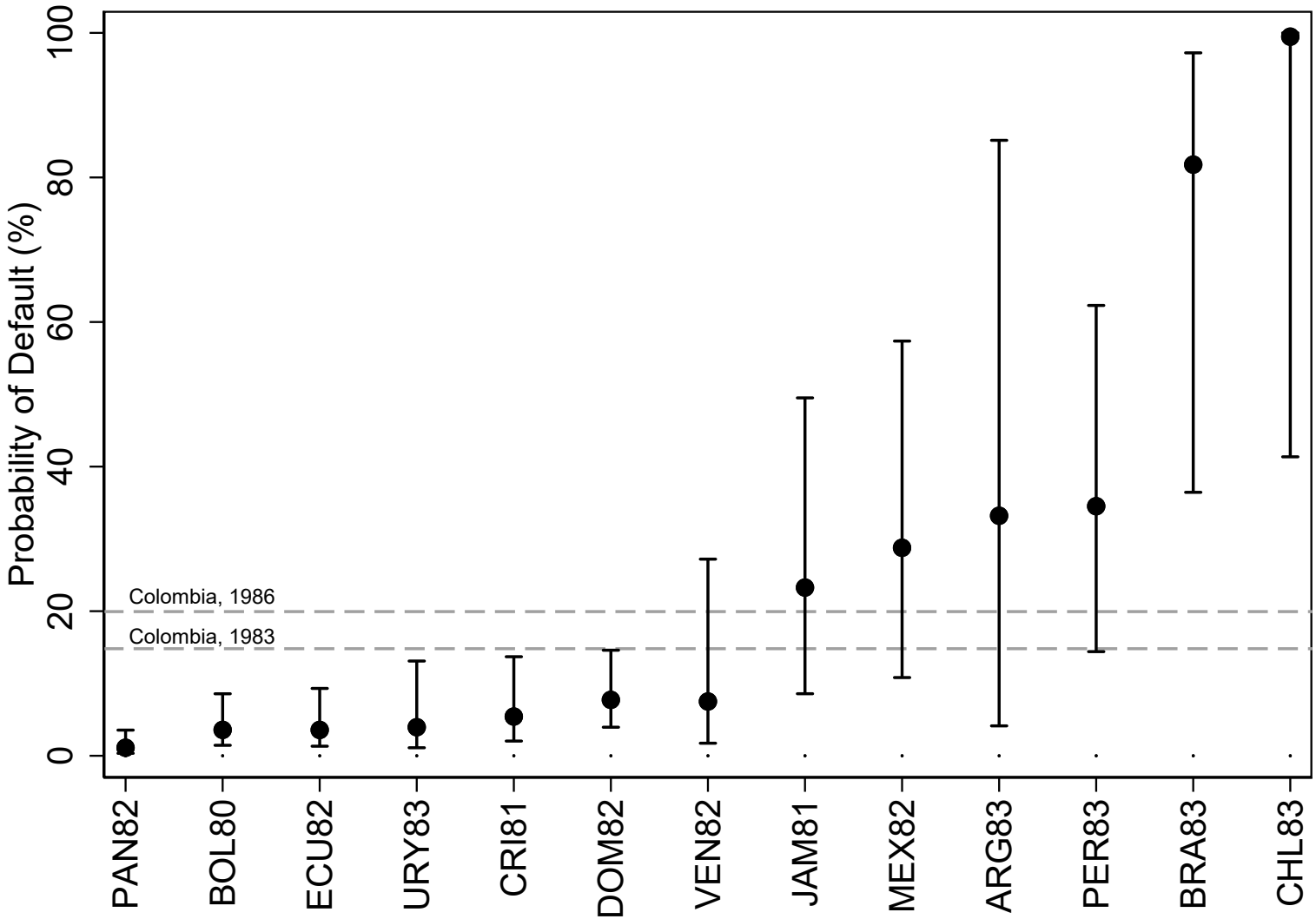
     Data on default are from Asonuma and Trebesch

     When a country has several consecutive restructurings,we only keep the first episode
  2. We estimate a model with the selected variables to predict Colombia's default probability and compare it with the probability of default of LAC countries when they actually defaulted

Colombia's default probability vis-à-vis LAC



LAC default probability vis-à-vis Colombia



Counterfactual Analysis

- We study whether Colombia enjoyed short-run benefits by not defaulting in the 1980s
- We build a counterfactual with the synthetic control method (SCM) (Abadie and Gardeazabal, 2003) and the synthetic difference-in-differences method (SDID) (Arkhangelsky, Athey, Hirshberg, Imbens, and Wager, 2020))
- SDID is a generalization of the standard SCM which further improves identification by accounting for unobservable time-invariant factors and common shocks

SCM: Variables

- We build counterfactuals for real GDP, inflation, exports, and imports
  - We choose 1981 as treatment date as it precedes the beginning of the Latin American crisis in 1982
  - We exclude Bolivia and Jamaica from the donor pool as they defaulted before 1981
  - We estimate the effect of non–defaulting up to 1985 to limit the possibility that other shocks might confound the SCM estimates
  - As a baseline and to avoid to 'cherry-picking' the set of predictors in the SCM, we choose to match the pre-treatment outcomes of interest on their lagged values only, with no additional controls (Doudchenko and Imbens, 2016 and Ferman, Pinto, and Possebom, 2020)

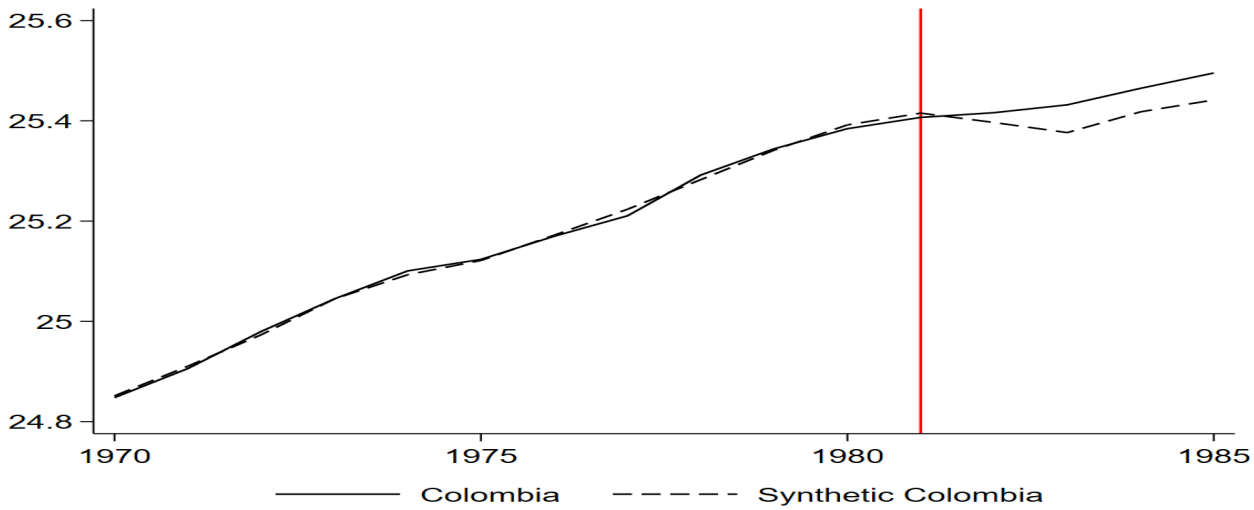
SCM: Fit

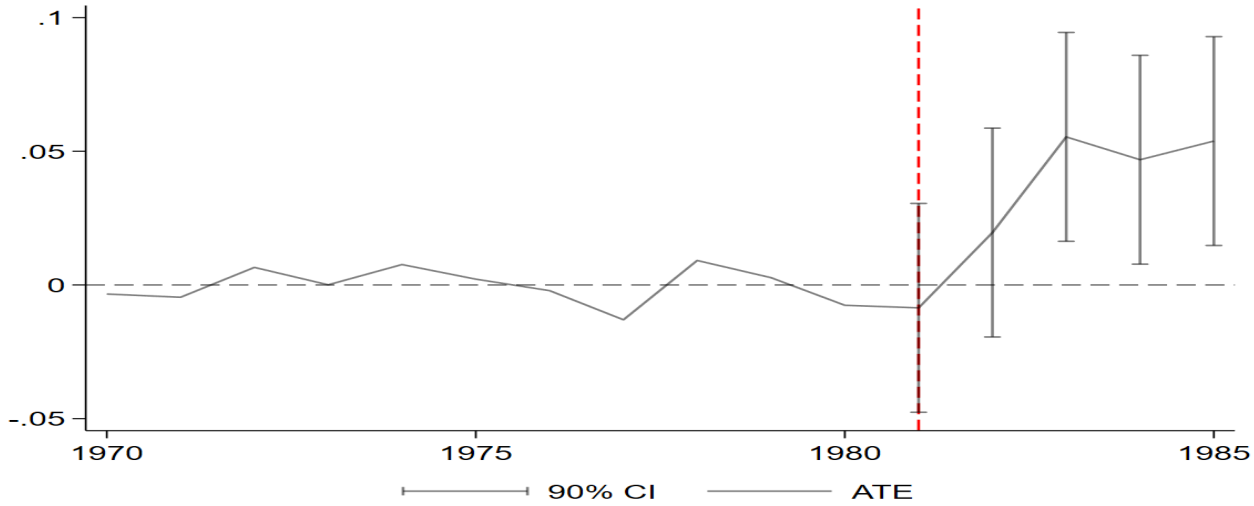
- Depending on the variable considered, different countries carry higher weights in the construction of the counterfactual
- We assess goodness of fit with the ratio of the pre-treatment RMSPE and the RMSPE obtained with a model with zero fit defined as in Adhikari and Alm (2016)
  - If the $RMSPE_j$ is 0, then the ratio index is equal to zero, indicating a perfect fit.
  - A ratio index equal to 1 suggests that the $RMSPE_j$ is identical to the zero fit model
  - We find that the ratio to the benchmark *RMSPE* is close to zero across all models
  - This suggests that our synthetic control performs well in approximating the pre-treatment dynamics of the variables considered

Country weights and goodness of fit

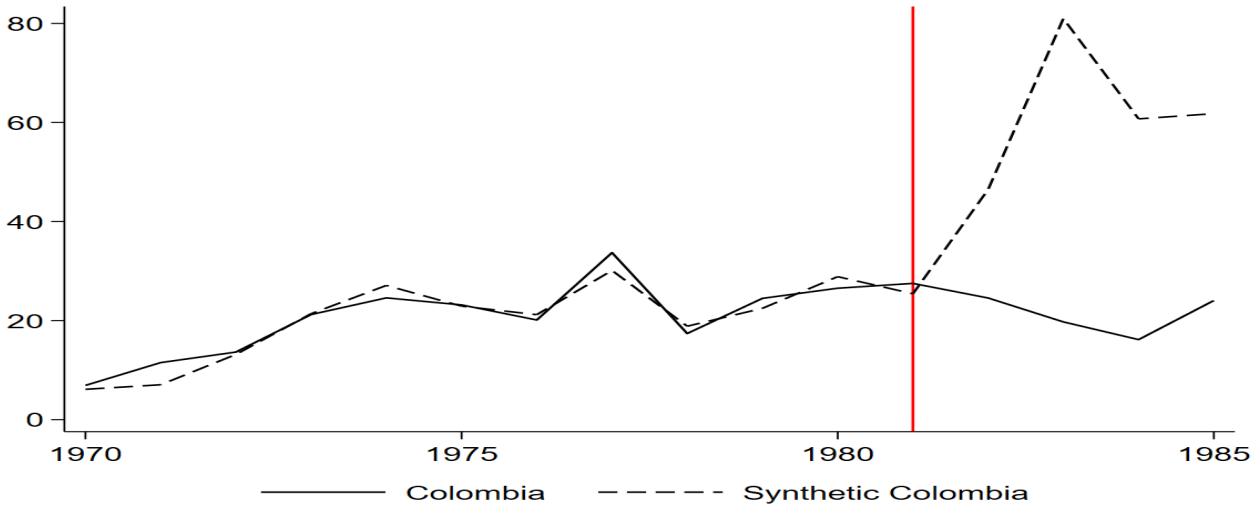
	Log of GDP	Inflation	Log of Export	Log of Import
ARG	0.038	0.008	0.000	0.000
BRA	0.126	0.000	0.149	0.000
CHL	0.036	0.000	0.000	0.278
CRI	0.231	0.000	0.482	0.000
DOM	0.000	0.181	0.000	0.000
ECU	0.000	0.000	0.004	0.000
MEX	0.276	0.711	0.365	0.032
PAN	0.138	0.000	0.000	0.391
PER	0.000	0.000	0.000	0.000
URY	0.000	0.099	0.000	0.169
VEN	0.155	0.000	0.000	0.130
Pre-treat. RMSPE	0.006	2.194	0.094	0.058
Ratio to bench. RMSPE	0.000	0.013	0.003	0.004

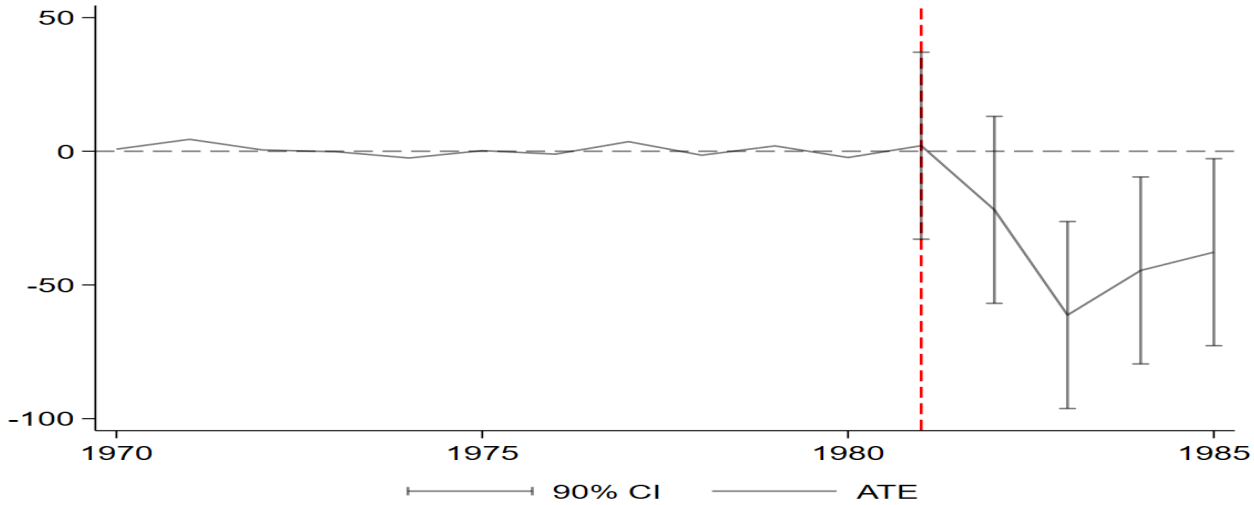
SCM: Log of real GDP



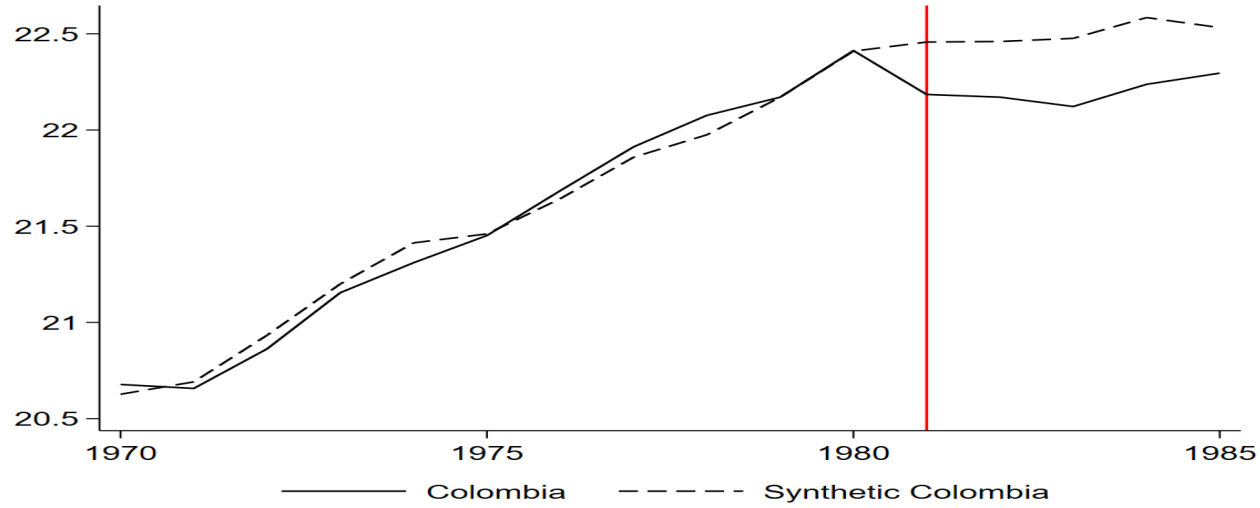


SCM: Inflation

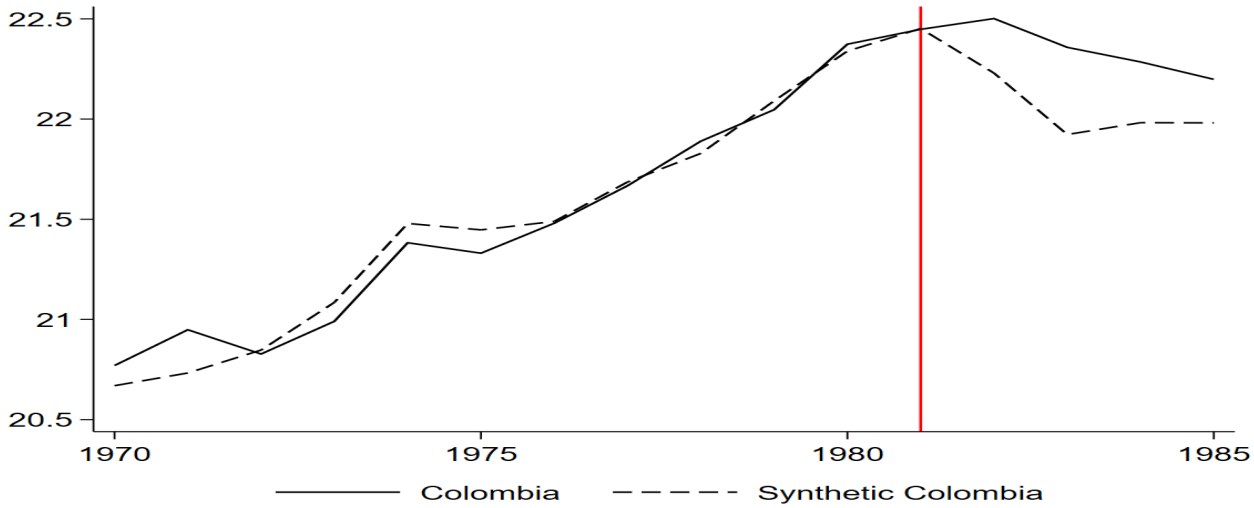


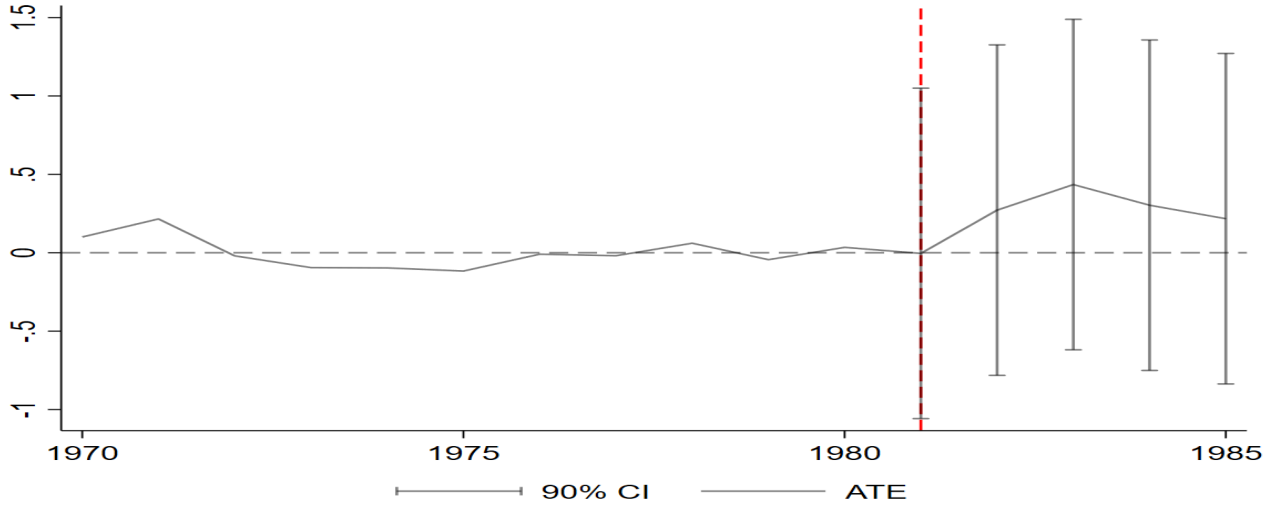


SCM: Log of real exports



SCM: Log of real imports

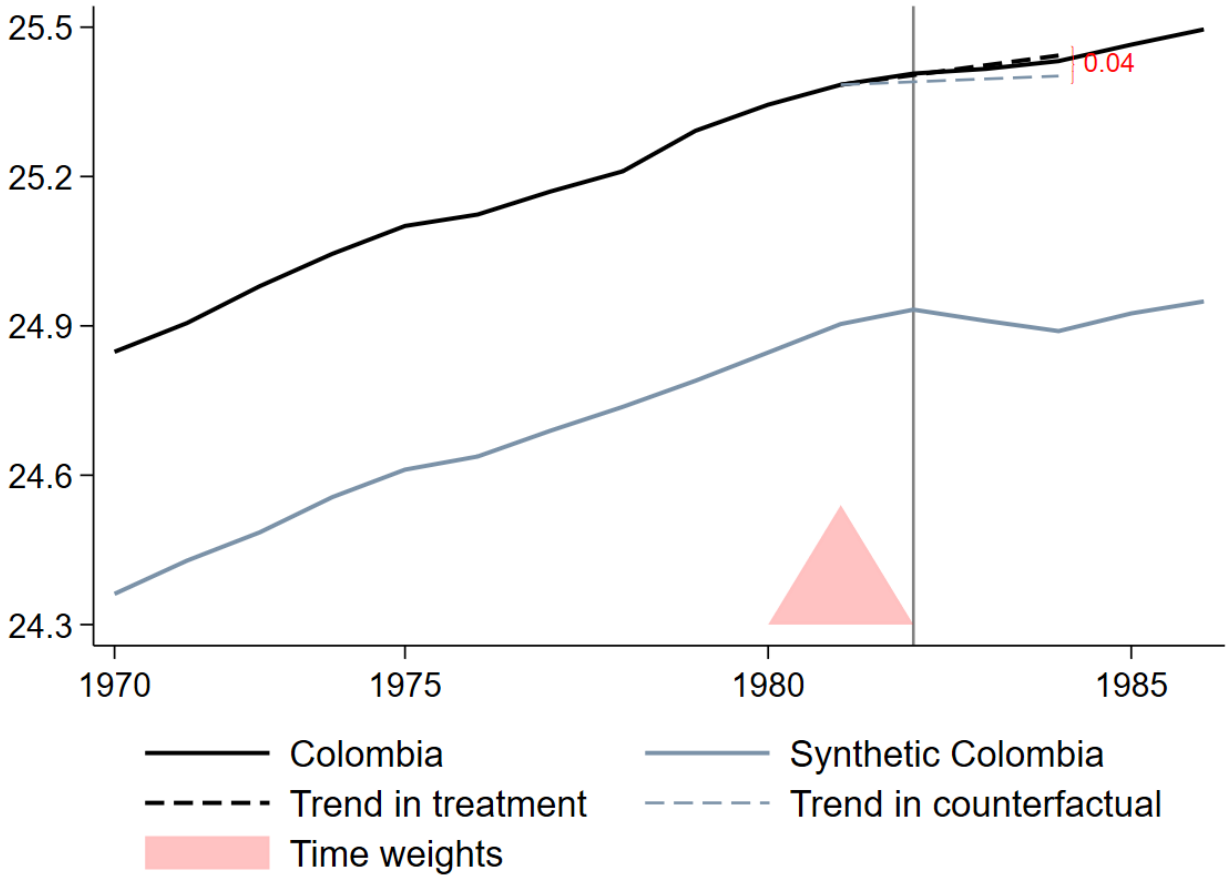




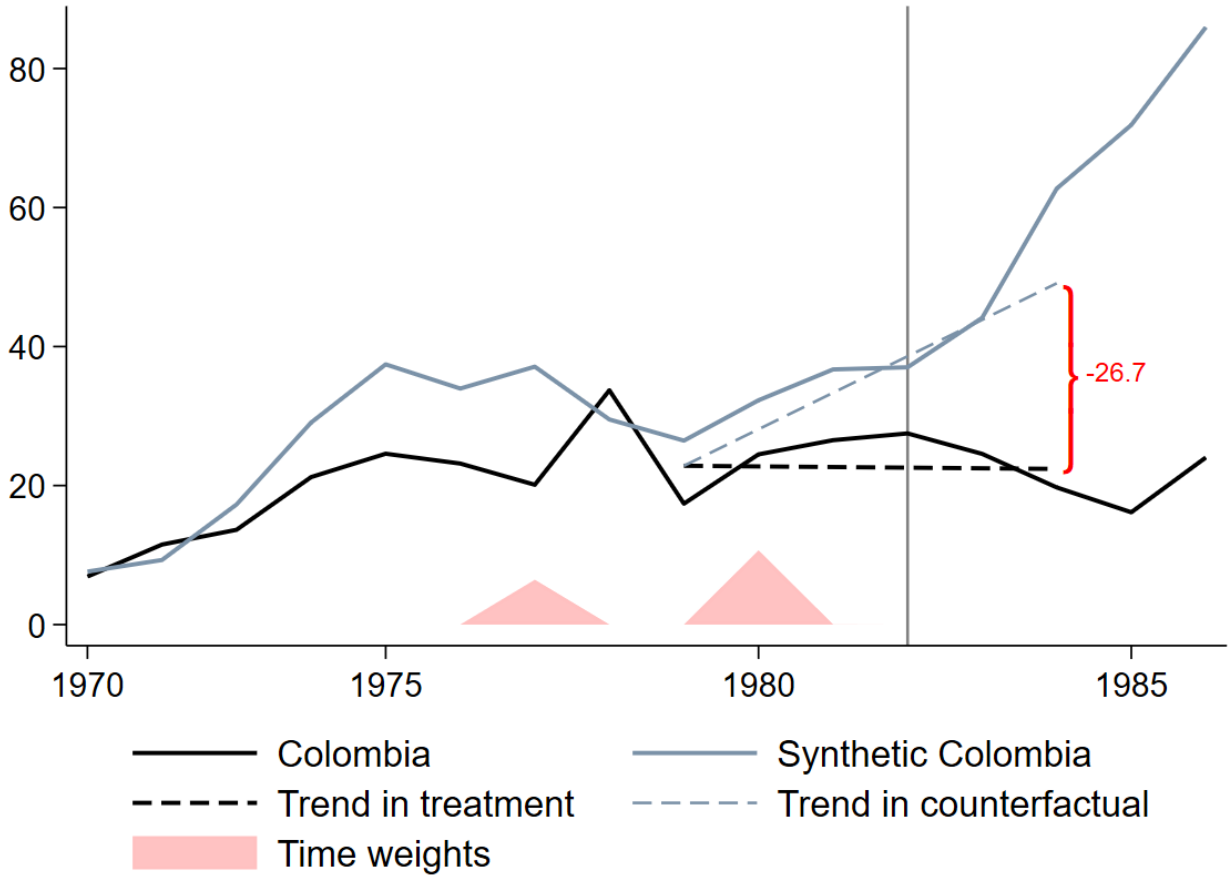
SDID

- Given that SDID includes fixed effects, the actual and counterfactual series are not supposed to overlap in the pre-treatment period
- The figures includes four lines
  1. The actual value of the variable of interest (the solid black line)
  2. The synthetic control (the solid blue line)
  3. The actual trend (the dashed black line)
  4. The counterfactual trend (the dashed blue line)
- The red brackets show the treatment effect which is given by the distance between the actual trend and the trend that we would have observed if Colombia had defaulted
- The triangles describe the time weights λ_t

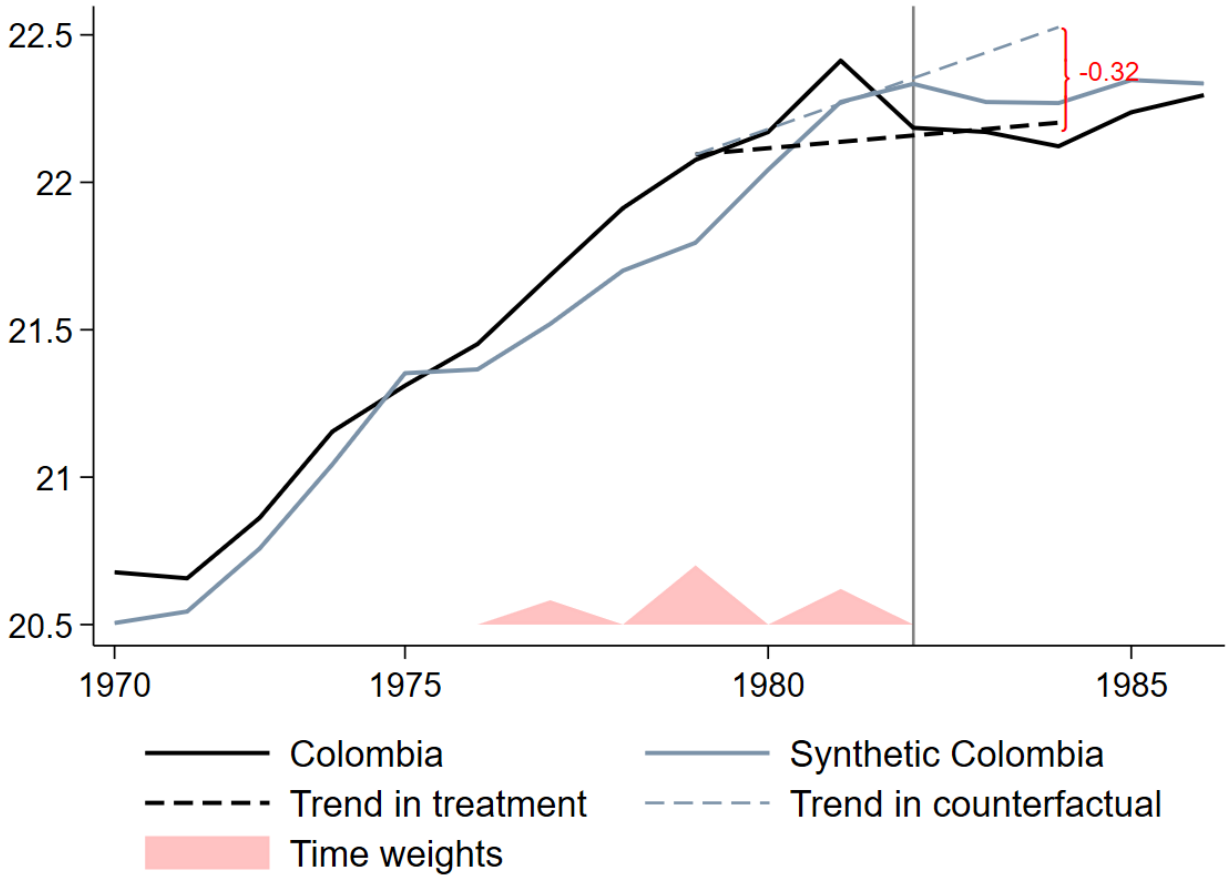
SDID: Log of real GDP



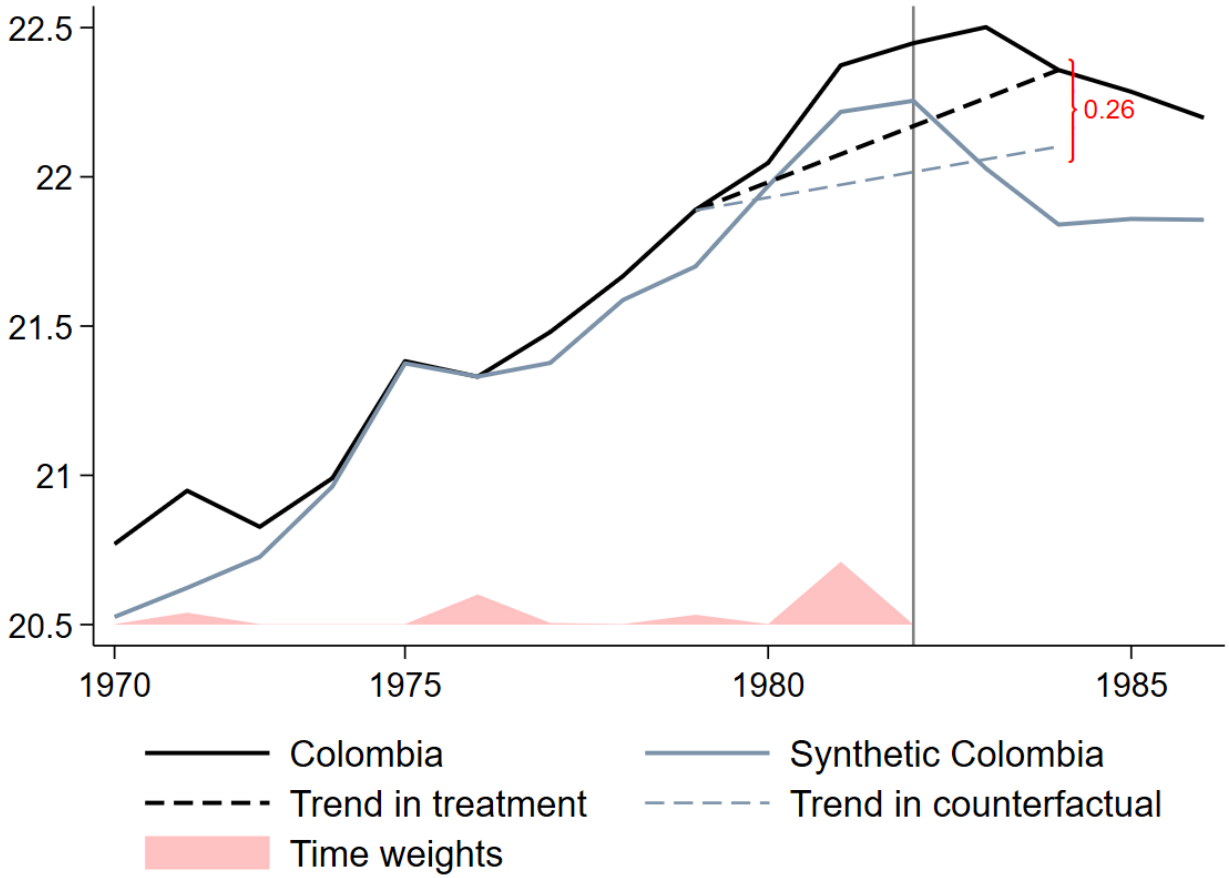
SDID: Inflation



SDID: Log of real exports



SDID: Log of real imports



Reputation

- Sovereign debt models in the tradition of Eaton and Gerosvitz assume that reputation is the main driver of willingness to repay
- The results of the empirical literature that tests for these reputational effects are mixed
- The Colombian authorities in the 1980s thought that defaulting would have had large reputational effects (Garay, 1989)
  - → Cline (1995) suggests that Colombia's strategy paid off: its first credit rating in 1993 was investment grade by S&P and only one notch below investment grade by Moody's
  - → However, Chile received higher credit ratings and Mexico was rated just one notch below Colombia
  - → Primary market yields of Colombian unenhanced international bonds issued in the first half of the 1990s were close to those of Mexico and Uruguay and higher than Chilean yields

Foreign currency credit ratings for Latin American sovereigns

	1993		1994		1995	
	Moody's	S&P	Moody's	S&P	Moody's	S&P
Argentina	B1	BB-	B1	BB-	B1	BB-
Brazil	B2	NR	B2	NR	B1	B
Chile	**Baa3**	**BBB**	**Baa2**	**BBB+**	**Baa1**	**BBB+**
Colombia	Ba1	**BBB-**	Ba1	**BBB-**	Ba1	**BBB-**
Mexico	Ba2	BB+	Ba2	BB+	Ba2	BB
Trinidad and Tobago	Ba2		Ba2		Ba2	
Uruguay			Ba1	BB+	Ba1	BB+
Venezuela	Ba1	BB	Ba2	BB-	Ba2	B+

Source: IMF (1993), Table 9 and IMF (1995b), Table 6. Investment grade issuers in bold

Spreads at launch for unenhanced USD international bonds issued by Latin American sovereigns

	1991	1992	1993	1994
Argentina	375	324	301	250
Chile	150	150		
Colombia			215	153
Mexico	201	215	208	
Uruguay		275	228	158
Venezuela	235		386	

Source: IMF (1995a), Table A6 and IMF (1995b), Table A8

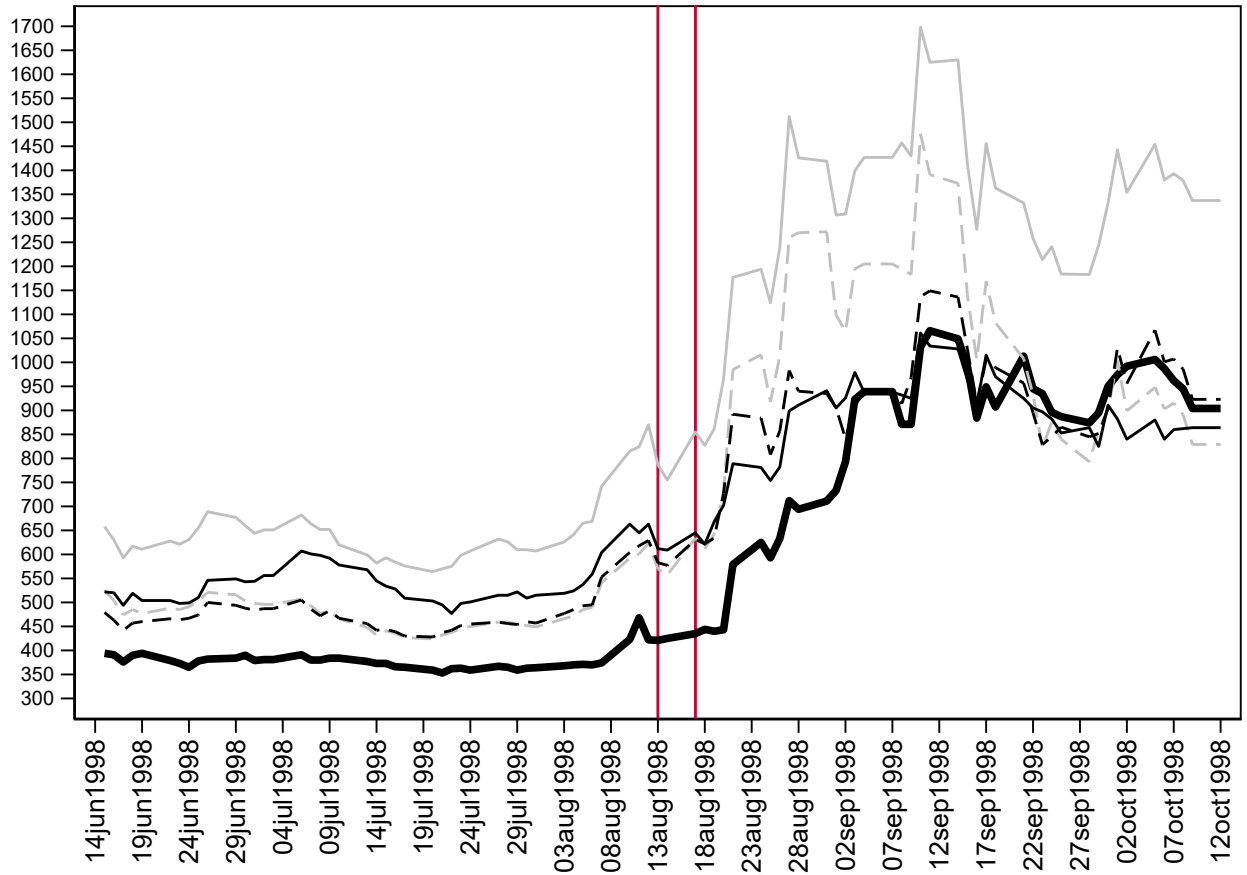
A test of long-run reputation

- Endogeneity: Differences in ratings and yields may be associated with unobservable differences in fundamentals
- Event study aimed at testing if long-term reputational effects are at play during a crisis period, when they should matter the most
- Sudden stop which followed the Russian default of August 1998
  - → In the early 1990s, several Latin American countries started experiencing large capital inflows (short-lived reversal in the aftermath of the "Tequila" and Asian crises)
  - → By mid-1998 about one-quarter of total investment (6% of GDP) of the LAC7 was financed by foreign capital (Calvo and Talvi, 2005).
  - → The Russian default put an abrupt end to these flows
  - → Flows to the LAC7 fell from $100 billion over the period 97Q3-98Q2 to $37billion in 98Q3-99Q2
  - → Average sovereign yield spreads tripled

A test of long-run reputation

- The fact that the crisis occurred in a country that represented less than 1% of global output and that had no significant economic ties with Latin America allows us to treat this event as an exogenous financial shock from the point of view of Latin American countries (Calvo 2004)
- There are two dates that mark the explosion of the Russian crisis
  - → Thursday August 13, 1998 (Crash of the Russian stock market)
  - → Monday August 17, 1998 (The decision of the Russian authorities to devalue the ruble, default on the domestic debt, and declare a moratorium on payments to foreign creditors)

Latin EMBI spreads around the Russian default



Note: Argentina: dashed grey line; Brazil: solid grey line; Colombia: thick black line; Mexico: dashed black line; Peru: thin solid black line. The figure does not include Chile because it was not part of the EMBI in 1998.

Event study: Details

- We regress daily changes in Colombian EMBI spreads (S_{C_t}) on daily changes in "market" spreads (S_{M_t}) over an estimation window that precedes the event:

$$\Delta S_{C_t} = \alpha + \beta \Delta S_{M_t} + \epsilon_t \tag{1}$$

  - In the baseline, we use a 90-day estimation window ending 4 days before the event (robust to using 60 and 120-day windows)
  - We close the estimation window on August 9 (results are robust to ending the estimation window on August 13) and build the baseline event window around August 17
  - The "market" spread is the first principal factor of changes in Argentinean, Brazilian, Mexican, and Peruvian spreads (robust to using the first and second principal factors of all seven LAC countries included in the EMBI in 1998)

Event study: Details

- Use the estimates of Eq. (1) to predict changes in spreads during the event window. Excess ("abnormal") changes in spreads are out-of-sample forecast error
  - The excess change in spread is $A\Delta S = \Delta S_{C_t} - \hat{\alpha} - \hat{\beta}\Delta S_{M_t}$.
- Denoting the length of the event window as W, the accumulated change in excess spreads is:

$$CA\Delta S = \sum_{i=1}^{W} A\Delta S_i \tag{2}$$

- A **positive** value of $CA\Delta S$ indicates that the country is doing **worse** than predicted by the "market."
  - The average daily excess spread is defined as $\frac{CA\Delta S}{W}$ with variance $\frac{\sigma^2_{A\Delta S}}{W}$ ($\sigma^2_{A\Delta S}$ is the variance of abnormal spreads during the estimation window). The t statistic for the average accumulated excess spreads is given by $\frac{CA\Delta S}{\sigma_{A\Delta S}\sqrt{W}}$.

Colombian abnormal spreads after the Russian default

	(1)	(2)	(3)	(4)	(5)	(6)
			6-day event window			
Av. Abn. Spr.	6.43**	9.13***	8.69***	9.98***	5.56**	1.83
	(2.38)	(3.89)	(3.61)	(4.52)	(2.39)	(0.79)
			12-day event window			
Av. Abn. Spr.	8.40***	10.57***	10.23***	11.21***	9.23***	7.45***
	(6.20)	(9.01)	(8.51)	(10.16)	(7.94)	(6.44)
			Estimation Window			
N. Days	90	90	120	60	90	90
Ending on	Aug. 9	Aug. 13	Aug. 9	Aug. 9	Aug. 9	Aug. 9
N. of fact.	1	1	1	1	1	2
Countries for Market spreads	ARG, BRA, MEX, PER				ARG, BRA, MEX, PER PAN, PER, VEN	

Abnormal returns t-test in parenthesis, ** statistically significant at 5% confidence level, *** statistically significant at 1% confidence level

Conclusions

- Novel approach to address a classic question in international finance: why do countries repay their debts in the absence of strong enforcement of creditors' rights?
- Rather than asking what are the costs of default, we study the benefits of repaying at time of widespread sovereign default
- In terms of economic fundamentals, Colombia in the early 1980s was similar its neighboring defaulting countries
- Archival research points to the fact that main differences were political in nature
- The case of Colombia turns out to be more complicated than what it is usually thought
- Our results support the view that default episodes should not be treated as binary events (Meyer, Reinhart, and Trebesch, 2019) and that more research is needed in order to understand the short and long-term economic effects of different debt rescheduling strategies

Technical stuff: LASSO

- We start with 22 candidate measures of solvency, liquidity, domestic and external volatility, macroeconomic performance, and political and institutional quality (see Manasse, Schimmelpfennig, and Roubini, 2003, Manasse and Roubini, 2009, and Fioramanti, 2008).
- LASSO is a variable selection algorithm commonly used in machine learning (Park and Casella, 2008; Tibshirani, 1996).
- The LASSO-logit estimator is defined as:

$$\beta^L =_\beta \sum_{i=1}^{N} [y_i X_i \beta - ln(1 + e^{X_i \beta})] - \lambda \sum_{j=1}^{p} |\beta_j|$$

- β^L is the vector of parameters to be estimated, y is the dependent variable, $\mathbf{X}$ is a matrix of controls, and $\lambda|\beta|$ is a penalty scalar to the maximization problem.

Technical stuff: LASSO

- The penalty helps selecting a parsimonious specification of the model by assigning a zero coefficient to the redundant components of $\mathbf{X}$.
- The hyper-parameter λ determines the size of the penalty.
  - Setting $\lambda = 0$ is equivalent to estimating a simple logit model (no variable is excluded from the model) and setting $\lambda = \infty$ forces all coefficients to zero
  - A standard technique for choosing λ is k-fold cross-validation. We use a standard 5-fold cross-validation
  - The cross-validation procedure determines an optimal value of $\lambda = 0.356$ and the LASSO estimator selects 17 variables
- After selecting λ, the routine implements a logistic LASSO for variable selection and then it computes a logit estimation retaining only the selected variable to predict the probability of observing an episode of sovereign default

Technical stuff: SCM

- SCM is a data-driven procedure that allows building counterfactual outcomes for observational units that are subject to a treatment (Abadie and Gardeazabal, 2003).
- Unlike a standard difference-in-difference estimation that considers a simple average of the control units, the SCM relies on a weighted average of the control observations (Athey and Imbens, 2017).
- For a given value of the non-default indicator $ND_j \in \{0, 1\}$ and values of an outcome $Y_{i,t}$, we define potential outcomes $Y_{j,t}(ND_j)$ as follows:

$$Y_{j,t}(ND_j) = \begin{cases} Y_{j,t}(0) & \text{if } ND_j = 0 \\ Y_{j,t}(1) & \text{if } ND_j = 1 \end{cases}$$

Technical stuff: SCM

- While we do not observe Colombia in both states, SCM builds a counterfactual for Colombia, i.e. the outcome of interest in the absence of the ND_j treatment.
- It finds the weighted average of all potential comparison units which best mimics the treated outcome during the pre-treatment period based on the idea that a combination of units that were not subject to the treatment (donor pool) may approximate the characteristics of the treated unit significantly better than any control unit alone.

Technical stuff: SCM

- Given a vector of weights $\vec{W} = (w_2, ..., w_{n+1})$, the synthetic control estimators of $Y_{1,t}(0)$ and the average treatment effect $\tau_{1,t}$ are defined as:

$$\hat{Y}_{1,t}(0) = \sum_{j=2}^{j+1} w_j Y_{j,t}$$

and

$$\hat{\tau}_{1,t} = Y_{1,t}(1) - \hat{Y}_{1,t}(0)$$

- For inference on the synthetic control estimates, we follow Firpo and Possebom (2018) who propose a placebo test-based approach to compute confidence intervals based on the permutation test framework of Imbens and Rubin (2015). This method extends and formalizes the procedure suggested by Abadie, Diamond, and Hainmueller (2010) and Abadie, Diamond, and Hainmueller (2015).

Technical stuff: SCM

- First, we run permutations (placebos) by re-assigning the treatment to one of the control countries in each iteration. We proceed as if each of the countries in the donor pool did not default
- Second, for each $j \neq 1$ country, we compute a test statistic that corresponds to the ratio of the mean squared prediction errors (RMSPE) as:

$$RMSPE_j = \frac{\sum_{t=T_{0+1}}^{T} (Y_{j,t} - \hat{Y}_{j,t}(0))^2)/(T - T_0)}{\sum_{t=0}^{T_0} (Y_{j,t} - \hat{Y}_{j,t}(0))^2/T_0}$$

- Where T_0 is the time of the treatment. This is the ratio of the post-treatment to the pre-treatment mean squared prediction errors.
- Finally, we invert the test statistic given by the $RMSPE_j$ to compute the confidence sets.

Technical stuff: SDID

- The standard synthetic control estimator does not allow controlling for unobserved heterogeneity through the inclusion of country and time fixed effects
- The synthetic difference-in-difference (SDID) estimator combines synthetic control and difference-in-differences (Arkhangelsky, Athey, Hirshberg, Imbens, and Wager, 2020)
  - Like SCM, SDID stregthens the plausibility of the parallel trend assumption by re-weighting and matching pre-treatment trends. Like DID, it allows controlling for country and time fixed effects
  - SDID provides a double-robustness property to the estimator because it employs fixed effects in modelling the outcome variables and also applies weights to the control units. As long as one of these two balancing approaches is effective, SDID produces unbiased estimates

Technical stuff: SDID

- Weights for the control units $\hat{\omega}_j$ are first estimated to match pre-treatment trends in the outcome of the treated unit. Time weights $\hat{\lambda}_t$ are also estimated to achieve balance in pre-treatment time periods ($\hat{\lambda}_t = 0$ in the SCM).

$$\left(\hat{\tau}^{sdid}, \hat{\mu}, \hat{\alpha}, \hat{\beta}\right) =_{\tau,\mu,\alpha,\beta} \left\{ \sum_{j=1}^{N} \sum_{t=1}^{T} \left(Y_{j,t} - \mu - \alpha_j - \beta_t - ND_j\tau_{1,t}\right)^2 \hat{\omega}_j \hat{\lambda}_t \right\}$$

- Unit weights are included to ensure that the average outcome for the treated unit is parallel to the average outcome for the control units. As the difference between treated and controls varies over time in the pre-treatment period, time weights adjust for the pre-treatment difference that is predictive of the outcomes in the post-treated period.