Seigniorage and Sovereign Default: The Response of Emerging Markets to COVID-19[1]

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[1]The views do not necessarily reflect official positions of the Federal Reserve Bank of St. Louis, the Federal Reserve System, or the Board of Governors.

Motivation

Inflation, exchange-rates and fiscal deficits play key roles in sovereign debt crises.

However, models of sovereign default typically abstract from domestic fiscal and monetary policies (implicitly assume lump-sum taxes)

Eaton and Gersovitz (1981); Aguiar and Gopinath (2006); Arellano (2008)

We provide a link between domestic policies and sovereign debt.

Domestic policies & sovereign default

We extend the standard sovereign default model to include distortionary taxes, fiat money and an equilibrium nominal exchange rate.

Government expenditure can be financed with taxes, money and external debt.

These extensions imply that

- Seigniorage is actively used to finance government expenditures
- There is a **time-consistency** problem in debt choice
- Both results are absent with lump-sum taxes

Quantitative Results

Consistent with the empirical evidence, a deterioration of the terms-of-trade leads to

- An increase in sovereign-default risk and inflation
- A reduction in growth

An unexpected shock resembling the COVID-19 pandemic generates

- Increased fiscal deficit: slight declines in tax rates and a significant drop in revenue.
- Distress in sovereign debt markets
- A large depreciation and an increase in inflation

MODEL

Setup

Small open economy tradable-nontradable model (TNT as in Uribe and Schmitt-Grohé, 2017, §8) with production, money and sovereign default.

There are three private goods and one public good:

1. Non-tradable good, consumed (c^N) and produced (y^N) domestically.
2. Tradable imported good, consumed (c^T) domestically but not produced.
3. Tradable export good, produced to be exported (y^T), but not consumed domestically.
4. Public good (g), transformed one-to-one from non-tradable output.

Preferences and Technology

Agents are endowed with 1 unit of time: $h + \ell = 1$.

Preferences are represented by

$$U(c^N, c^T, \ell, g) = u(c^N, c^T) + v(\ell) + \vartheta(g).$$

Hours worked h are transformed into non-tradable output, y^N and export goods, y^T according to the technology

$$F(y^N, y^T) - h \leq 0$$

where F is strictly increasing, strictly convex and homogeneous of degree 1.

Introducing Money

Households exchange non-tradable and imported goods, as well as domestic currency.

Money supply grows at the endogenous rate μ: $M' = (1+\mu)M$.

Domestic prices in pesos are given by: P^N (non-tradable) and W (wages). The nominal exchange rate E is defined as pesos per dollar.

Normalize by M for stationarity: $p^N \equiv P^N/M$; $w = W/M$; and $e \equiv E/M$.

The dollar price of imports is normalized to 1; the dollar price of exports is p^T, which then also stands for the terms of trade.

Cash-in-advance (CIA) constraint for non-tradable goods: $p^N c^N \leq m$, where m denotes (nomalized) individual money holdings.

Government budget constraint

Government expenditure consists of public good g and (exogenous) transfers γ.

To finance its expenditure, the government may:

- tax labor income wh at rate τ
- increase the money supply at rate μ
- issue debt in international credit markets

One-period discount bonds B denominated in foreign currency and sold at price q.

Government budget constraint **(GBC)** in (normalized) units of domestic currency is

$$p^N(g+\gamma) + eB = \tau wh + \mu + eqB'$$

Balance of Payments

- The balance of payments **(BoP)**, expressed in foreign currency, is

$$p^T y^T - c^T = B - qB'$$

- Combining BoP with GBC:

$$\underbrace{\tau wh - p^N(g+\gamma)}_{\text{primary surplus}} + \underbrace{\mu}_{\text{seigniorage}} = e\underbrace{(p^T y^T - c^T)}_{\text{trade balance}}$$

Firm optimization

A representative firm maximizes profits solving

$$\max_{y^N, y^T, h} \; p^N y^N + e p^T y^T - wh$$

subject to $F(y^N, y^T) - h \leq 0$.

The FOCs imply expressions w and e:

$$\begin{aligned} w &= \frac{p^N}{F_N} \\ e &= \frac{p^N}{p^T} \frac{F_T}{F_N} \end{aligned}$$

Household problem

The strategy is to solve for an equilibrium given the government policies.

Household takes as given the aggregate state, which contains

- aggregate debt (B)
- the government default decision ($\mathcal{I}$)
- shocks (s)

The household budget (HB) constraint is

$$p^N c^N + ec^T + m'(1+\mu) \leq (1-\tau)wh + m + p^N \gamma$$

Given individual state m and aggregate state $(B, \mathcal{I}, s)$, the problem of the household is

$$V(m, B, \mathcal{I}, s) = \max_{(c^N, c^T, m', h)} u(c^N, c^T) + v(1-h) + \beta \mathbb{E}\left[V(m', B', \mathcal{I}', s') | B, \mathcal{I}, s\right]$$

subject to the CIA and HB constraints, and the aggregate laws of motion.

Household problem's key equations

The equation characterizing the choice of hours worked is

$$\frac{(1-\tau)wu_T}{e} = v_\ell$$

where the tax rate τ introduces a **wedge** between the marginal utilities of consumption of imported goods and leisure.

The inter-temporal choice is characterized by

$$\frac{(1+\mu)u_T}{e} = \beta\mathbb{E}\left[\frac{u'_N}{p^{N\prime}}\middle| B, \mathcal{I}, s\right]$$

where money growth μ **distorts** the substitution between current imported consumption and future non-tradable consumption (current "credit-goods" vs future "cash-goods").

▸ Non-negativity constraint

Primal approach

Formulate the problem of the government as **selecting allocations and debt choices that are implementable in a monetary equilibrium.**

This approach means that we need to use the equilibrium conditions to **replace prices** (p^N, w, e) **and policies** (μ, τ) in the government budget constraint (GBC).

Add non-tradable resource constraint: $c^N + g = y^N$.

Repayment vs. Default

At the beginning of each period, government decides whether to default on its debt.

If government defaults, then debt is set to zero and country is excluded from international credit markets. Exclusion ends with probability δ.

Let $V^P(B, s)$ be the value of repaying; let $V^D(s)$ be the value of default.

Government decides between repaying (P) and defaulting (D):

$$\hat{\mathcal{V}}(B, s, \varepsilon^P, \varepsilon^D) = \max\{\underbrace{V^P(B, s) + \varepsilon^P}_{\text{Repayment value}}, \underbrace{V^D(s) + \varepsilon^D}_{\text{Default value}}\}$$

Shock ε^j is iid extreme value, with scaling parameter $\kappa > 0$.

Repayment

Given state (B, s) and expected future policies, the problem of the government in repayment is

$$V^P(B, s) \equiv \max_{(B', c^N, c^T, y^T, g)} u(c^N, c^T) + v(1 - F(c^N + g, y^T)) + \vartheta(g) + \beta \mathbb{E}[\mathcal{V}(B', s')|s]$$

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subject to

$$p^T y^T - c^T + Q(B', s)B' - B = 0$$

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subject to

$$\begin{aligned} p^T y^T - c^T + Q(B',s)B' - B &= 0 && (BoP) \\ u_T c^T - \gamma u_T p^T (F_N/F_T) - v_\ell F(c^N + g, y^T) + \beta\mathbb{E}\left[u'_N c^{N\prime}|P,s\right] &= 0 && (GBC) \end{aligned}$$

Default

Given state s, the problem of the government in default is

$$V^D(s) \equiv \max_{(c^N, c^T, y^T, g)} u(c^N, c^T) + v(1 - F(c^N + g, y^T)) + \vartheta(g) + \beta \mathbb{E}[\delta \mathcal{V}(0, s') + (1 - \delta) V^D(s') | s]$$

subject to

$$\begin{aligned} p^T y^T - c^T &= 0 \qquad (BoP) \\ u_T c^T - \gamma u_T p^T (F_N / F_T) - v_\ell F(c^N + g, y^T) + \beta \mathbb{E}[u'_N c^{N\prime} | D, s] &= 0 \qquad (GBC) \end{aligned}$$

Debt choice

Other FOCs

Let ξ and λ be the Lagrange multipliers of the BoP and GBC constraints in the repayment problem.

The **Generalized Euler Equation** (assuming u is separable) is

$$\mathbb{E}\Big\{\mathcal{P}(B',s')\Big[\underbrace{\frac{\xi}{1+r}-\beta\xi'}_{\text{smoothing+present-bias}}-\underbrace{\frac{\xi B'(1-\mathcal{P}(B',s'))\xi'}{\kappa(1+r)}}_{\text{default premium}}$$

$$+\underbrace{\lambda\beta[(u'_N+u'_{NN}\mathcal{C}^{N\prime})\mathcal{C}^{N\prime}_B-(u'_N\mathcal{C}^{N\prime}-\bar{u}'_N\bar{\mathcal{C}}^{N\prime})(1-\mathcal{P}(B',s'))(\xi'/\kappa)]}_{\text{time-consistency problem}}\Big]\Big|s\Big\}=0$$

The time-consistency problem

The time-consistency problem reinforces/mitigates present-bias in debt choice.

How does this channel work?

- Issuing more debt alters: (i) future fiscal and monetary policies in the repayment state; and (ii) future repayment probability.
- These anticipated changes alter households' current money holdings decisions.
- Change in money demand affects GBC in the current period.
- Sign of effect depends on income vs substitution effects in money demand.
- Future governments do not internalize this effect.

With *log* utility, time-consistency problem vanishes and the government simply trades off its smoothing + present-bias with the default risk-premium, as in standard models.

Equivalence with standard models

Standard Eaton-Gersovitz (EG) models assume (endogenous) lump-sum transfers.

EG-style models can be formulated similar to ours, but without the GBC (satisfied by transfers). Hence, optimal to set $\tau = 0$ and μ so that CIA constraint is slack.

The Generalized Euler Equation with endogenous lump-sum transfers becomes:

$$\mathbb{E}\Big\{\mathcal{P}(B', s')\Big[\underbrace{\frac{u_T}{1+r} - \beta u'_T}_{\text{smoothing+present-bias}} - \underbrace{\frac{u_T B'}{\kappa(1+r)}(1-\mathcal{P}(B', s'))u'_T}_{\text{default premium}}\Big|s\Big]\Big\} = 0$$

Differences with our GEE: (i) $u_T \neq \xi$; (ii) no time-consistency problem.

Without lump-sum taxes, there is no feasible monetary policy that decentralizes EG.

CALIBRATION

Functional forms

The period utility is

$$\alpha_N \frac{\left(c^N\right)^{1-\sigma^N}}{1-\sigma^N} + \alpha_T \frac{\left(c^T\right)^{1-\sigma^T}}{1-\sigma^T} + \alpha_H \frac{(1-h)^{1-\varphi}}{1-\varphi} + \alpha_G \log(g)$$

The function describing the labor requirement for production is

$$h = A^{-1}\left[\left(y^N\right)^{\rho} + \left(y^T\right)^{\rho}\right]^{1/\rho}$$

Productivity in default is

$$A^{def} = A - \underbrace{[\lambda_1 + \lambda_2 \times gap]}_{\text{default cost}}$$

where $\lambda_1 > 0$ is the intercept and $\lambda_2 > 0$ makes the default cost an increasing function of the output gap. see output gap approximation

Parameters set externally

Parameter	Description	Value	Basis
r	risk-free rate	0.03	Long-run average
φ	curvature leisure	1.50	Frisch elasticity
δ	re-enter probability	0.17	Exclusion duration
α_T	weight on c^T	1.00	Normalization
ρ	curvature prod. fcn.	1.50	See appendix
σ^T	curvature c^T	0.50	See appendix
σ^N	curvature c^N	0.50	See appendix

See robustness

Parameters set to match targets in steady state

Parameter	Value	Statistic	Target
A	1.475	Real GDP	1.000
β	0.821	Inflation	0.063
γ	0.122	Transfers/GDP	0.131
α^N	3.311	Exports/GDP	0.181
α^H	1.010	Employment/Population	0.589
α^G	0.581	Gov. Consumption/GDP	0.149
λ_1	0.109	Debt/GDP	0.290
κ	0.095	Default	0.010

See identification

$\lambda_2 = 0.06$ so that spreads increase by 300 basis points as a response to COVID-19.

Quantitative Evaluation:
The role of terms of trade shocks

Empirical Evidence and Model's Predictions

Drechsel and Tenreyro (2017) study the endogenous reaction of interest rate spreads to shocks in commodity prices in Argentina using a long time series

"A 10 percent deviation of commodity prices from their long-run mean can move Argentina's real interest spread by almost 2 percentage points."

They argue that using commodity prices is ideal because this variable is exogenous to the country.

We use shorter time series (1970-2018) but add more countries (Argentina, Brazil, Colombia, and Mexico) and explore the effect also on inflation and growth.

We did a similar exercise for shocks to the risk-free interest rate, r. See regression

Empirical Evidence and Model's Predictions on p^T shocks

Semi-elasticity: How much do spreads/inflation/growth increase (in percentage point) as commodity prices increase 10 percent?

Variable	EMBI		Inflation		Growth	
Data						
Terms of trade	-1.59		-3.65		0.22	
	(0.80)		(1.62)		(0.04)	
Commodity prices		-1.38		-3.03		0.33
		(0.61)		(3.47)		(0.05)

Empirical Evidence and Model's Predictions on p^T shocks

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Commodity prices		-1.38		-3.03		0.33
		(0.61)		(3.47)		(0.05)
Model						
p^T	{-1.18, -1.93}		{-2.35, -3.00}		{0.53, 0.52}	

Quantitative Exercise:
Disentangling the Effect of COVID-19

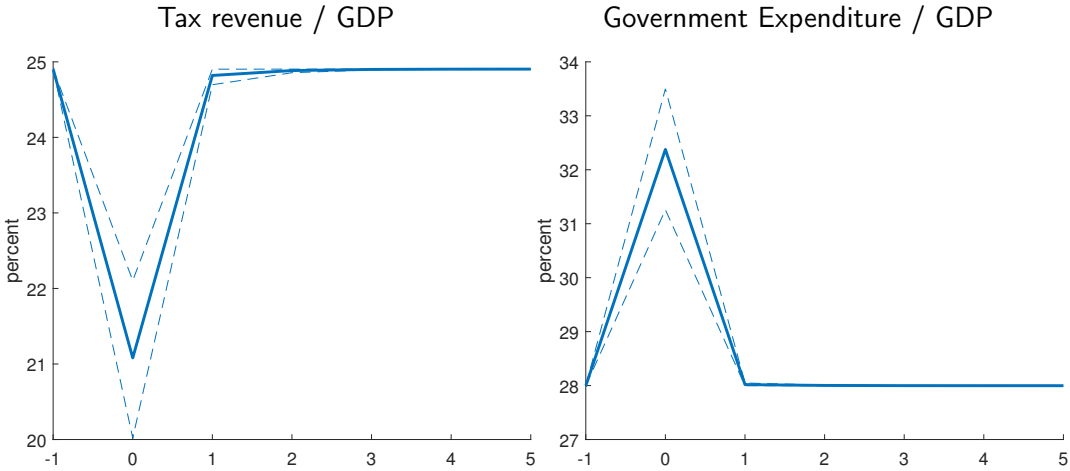
COVID-19 shock

COVID-19 shock is an "MIT shock" that combines shocks to productivity, disutility of labor, terms of trade and (exogenous) transfers:

1. Change TFP to get a drop in real GDP relative to trend of 8.1% (CEPAL and McKinsey).
2. Change labor disutility to get a drop on employment relative to trend of 5.7% (CEPAL and McKinsey).
3. Drop p^T by 17% as in the data (WEO-IMF Apr-2020).
4. Increase real transfers by 2.5 percentage points of GDP (Cavallo and Cai, 2020).

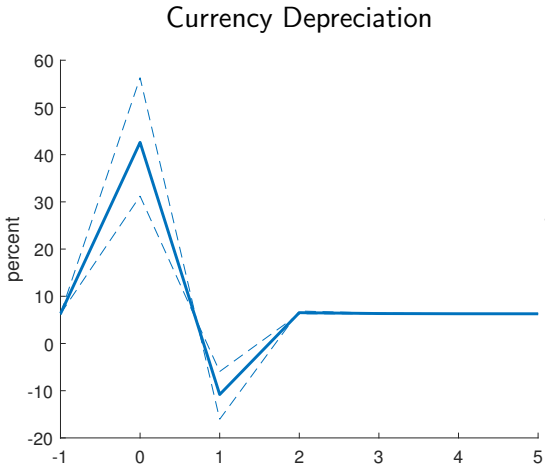
The shock persists with probability $\theta = 1/3$, to match the expected time until a vaccine is available of 1.5 years (NYT, April 20, 2020)

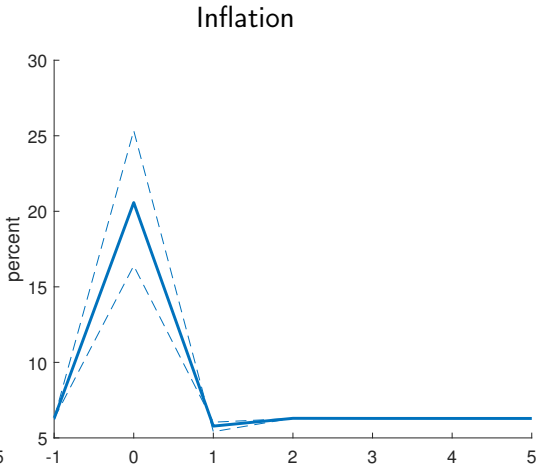
A crisis in government finances



Note: The solid blue line represents the response to the benchmark calibration of shocks. The dashed lines represent shocks that are 25% larger and smaller than the benchmark calibration

Significant Depreciation and increasing inflation





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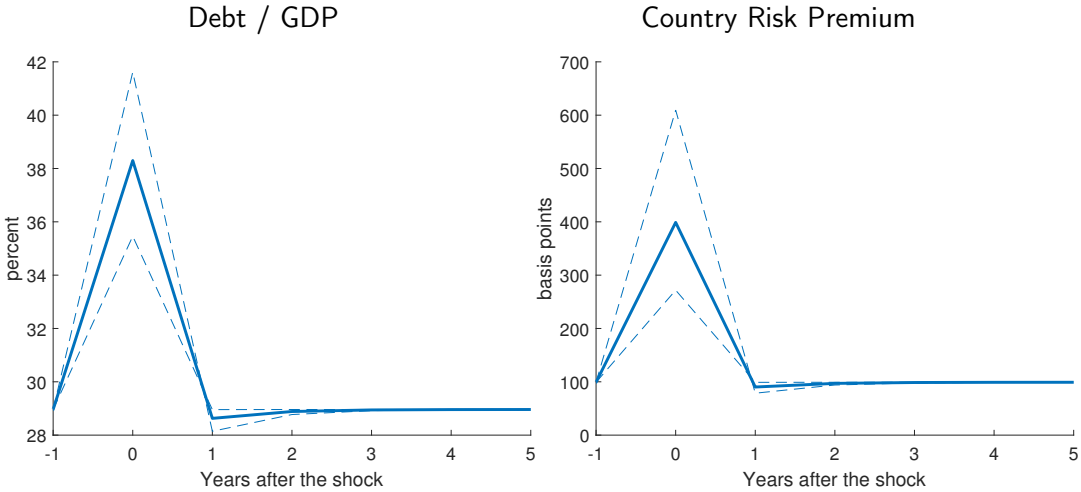
A debt crisis (?)



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Identifying the role of each component of the COVID-19 shock

The **TFP shock** is vital for the drop in GDP, and the **labor disutility shock** is essential for the declines in GDP and employment.

Both shocks contribute to the rise in inflation, but they do not account for much increase in debt/GDP.

The $\mathbf{p^T}$ **shock** implies a substantial depreciation and accounts for a significant part of the change in debt and spreads. However, it has a small effect on real variables.

Larger **transfers** contribute to higher inflation with little effect on other variables.

Higher persistence has a significant effect on the severity of the sovereign debt crisis without further affecting economic activity.

Identifying the role of the policy mix during COVID-19 shock

	Benchmark
μ money growth rate	0.20
τ tax rate	0.21
Δ Real GDP, percent	-8.10
Δ Employment, percent	-5.70
Δ Debt / GDP, pp	9.01
Δ Country risk premium, pp	3.00
Δ Expenditure, percent	6.40
Δ Revenue, percent	-9.79
Δ Inflation, pp	14.3
Δ Depreciation, pp	36.3

Identifying the role of the policy mix during COVID-19 shock

	Benchmark	Constant μ
μ money growth rate	0.20	0.06
τ tax rate	0.21	0.30
Δ Real GDP, percent	-8.10	-9.50
Δ Employment, percent	-5.70	-6.84
Δ Debt / GDP, pp	9.01	7.91
Δ Country risk premium, pp	3.00	2.89
Δ Expenditure, percent	6.40	5.02
Δ Revenue, percent	-9.79	5.35
Δ Inflation, pp	14.3	11.5
Δ Depreciation, pp	36.3	26.6

Note that even if monetary aggregates are kept constant, annual inflation would increase significantly by 11.5 pp. The terms of trade shock drives most of the inflation.

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Note that even if monetary aggregates are kept constant, annual inflation would increase significantly by 11.5 pp. The terms of trade shock drives most of the inflation.

Tighter monetary policy improves the fiscal outlook despite deepening the recession.

Identifying the role of the policy mix during COVID-19 shock

	Benchmark	Constant μ	Constant τ
μ money growth rate	0.20	0.06	0.15
τ tax rate	0.21	0.30	0.25
Δ Real GDP, percent	-8.10	-9.50	-8.67
Δ Employment, percent	-5.70	-6.84	-6.16
Δ Debt / GDP, pp	9.01	7.91	8.54
Δ Country risk premium, pp	3.00	2.89	2.95
Δ Expenditure, percent	6.40	5.02	6.48
Δ Revenue, percent	-9.79	5.35	-2.77
Δ Inflation, pp	14.3	11.5	13.5
Δ Depreciation, pp	36.3	26.6	32.8

Note that even if monetary aggregates are kept constant, annual inflation would increase significantly by 11.5 pp. The terms of trade shock drives most of the inflation.

Tighter monetary policy improves the fiscal outlook despite deepening the recession.

Similar effect of tighter fiscal policy although the effects are smaller.

Concluding remarks

Allowing for distortionary taxation in standard sovereign default models leads to the use of seigniorage to finance government expenditures.

This also introduces a time-consistency problem in debt choice.

The response of the model to terms of trade shocks is in line with empirical evidence.

The model generate policy responses to COVID-19 in line with some evidence of emerging markets.

APPENDIX

Related literature

Sovereign default: Eaton and Gersovitz (1981); Aguiar and Gopinath (2006); Arellano (2008).

Fiscal policy with risk of default: Mendoza and Oviedo (2006); Cuadra, Sánchez, and Sapriza (2010); Bianchi, Ottonello, and Presno (2019); Hatchondo, Roch, and Martinez (2012); Aguiar and Amador (2016); Anzoategui (2019).

Fiscal and monetary policies without commitment: Díaz-Giménez, Giovannetti, Marimón, and Teles (2008); Martin (2009, 2011).

Exchange rates/inflation: Na, Schmitt-Grohé, Uribe, and Yue (2018); Ottonello and Perez (2019); Arellano, Bai, and Mihalache (2019).

Emerging markets and COVID-19: Hevia and Neumeyer (2020), Arellano, Bai, and Mihalache (2020).

Extreme value shocks imply analytical expressions

Expectation of the value function with respect to the utility shocks:

$$\mathcal{V}(B,s) = \mathbb{E}[\hat{\mathcal{V}}(B,s,\varepsilon^P,\varepsilon^D) \mid \varepsilon] = \kappa \ln \left\{ \exp[V^P(B,s)/\kappa] + \exp[V^D(s)/\kappa] \right\}$$

Probability of repayment:

$$\mathcal{P}(B,s) = \frac{\exp[V^P(B,s)/\kappa]}{\exp[V^P(B,s)/\kappa] + \exp[V^D(s)/\kappa]}$$

Zero-expected profits by risk-neutral international lenders implies **debt prices**:

$$Q(B',s) = \frac{\mathbb{E}\left[\mathcal{P}(B',s')|s\right]}{1+r}$$

Formulating the government's problem

When the government repays, its policies are a function of the state (B, s): $\{\mathcal{B}, \mathcal{C}^N, \mathcal{C}^T, \mathcal{Y}^T, \mathcal{G}\}$.

When the government is in default, its policies are a function of the state s: $\{\bar{\mathcal{C}}^N, \bar{\mathcal{C}}^T, \bar{\mathcal{Y}}^T, \bar{\mathcal{G}}\}$.

These policy functions span continuation functions $V^P(B, s)$, $V^D(s)$ and $\mathcal{V}(B, s)$.

Government's problem is a best-response to anticipated policy functions.

A **Markov-perfect equilibrium** is a fixed-point in policy functions.

Non-negativity constraint

In a monetary equilibrium, the Lagrange multiplier of the CIA constraint must be non-negative. Hence,

$$u_N - \frac{u_T F_N p^T}{F_T} \geq 0$$

This non-negativity constraint (NNC) is a restriction in the government's problem. We assume and later verify that (NNC) is slack (i.e., CIA constraint in HH problem binds).

- When $\gamma = 0$ (zero transfers), (NNC) is slack iff $u_T + u_{TT} c^T > 0$.
- When $\gamma > 0$, $u_T + U_{TT} c^T > 0$ is sufficient but not necessary for NNC to be slack.

For positive inflation, (NNC) must be slack (CIA must bind); $\sigma_T < 1$ ensures this result.

Characterizing government behavior

First-order conditions with respect to c^N, c^T, y^T and g (assuming u is separable):

$$\begin{aligned} u_N - v_\ell F_N + \lambda(F_N \Phi - \gamma \Gamma_N) &= 0 \\ u_T - \xi + \lambda(u_T + u_{TT} c^T - \gamma \Gamma_T) &= 0 \\ -v_\ell F_T + \xi p^T + \lambda(F_T \Phi - \gamma \Gamma_y) &= 0 \\ -v_\ell F_N + \vartheta_g + \lambda(F_N \Phi - \gamma \Gamma_g) &= 0 \end{aligned}$$

where $\Gamma \equiv u_T p^T (F_N / F_T)$ and $\Phi \equiv -v_\ell + v_{\ell\ell} F(c^N + g, y^T)$. Implications:

$$\begin{aligned} u_N &= \vartheta_g \\ \lambda &= \frac{v_\ell F_N - u_N}{F_N \Phi - \gamma \Gamma_N} \\ \xi &= \frac{u_N F_T \Phi - v_\ell F_T \gamma \Gamma_N + (v_\ell F_N - u_N) \gamma \Gamma_y}{p^T (F_N \Phi - \gamma \Gamma_N)} \end{aligned}$$

Approximating the output gap

Note that the gap is exogenous and depends only on parameters. To compute this relation, we use a Taylor expansion,

$$gap = \sum_i \frac{\partial y^{US\$}}{\partial \mathrm{s}_i} \Delta \mathrm{s}_i, \tag{1}$$

where the sum is over all the exogenous state variables s_i, the derivative is the change in output measure in dollars with respect to each exogenous state variable s_i taken at the steady state (defined below) and $\Delta \mathrm{s}_i$ is the change in the exogenous state variable s_i with respect to its value in steady state. Thus, for example, if there are shocks to productivity A and the price of exports, p^T, the gap would be

$$gap = \frac{\partial y^{US\$}}{\partial A}(A' - A) + \frac{\partial y^{US\$}}{\partial p^T}(p^{T'} - p^T). \tag{2}$$

This specification allows the cost of default to depend on shocks to many variables in a parsimonious manner, since there are always only two parameters to calibrate, λ_1 and λ_2. The gap is measured in terms of output in foreign currency (dollars) since this captures the country's capacity to repay its debt. However, our approach is flexible and the gap could alternatively be specified using exports or real GDP.

Identification

Increase one target at a time by 10 percent and recalibrate the model.

Highlight the parameter with the largest percentage changes.

	Target increased by 10 percent							
	Default	Debt	G	Hours	Exports	Inflation	Transfers	GDP
κ	**9.38**	8.44	-11.01	55.16	7.52	8.10	-21.72	4.80
λ_1	-0.27	**-0.65**	0.45	-1.92	-0.59	-0.27	0.92	0.02
α_g	0.15	0.61	**12.85**	-6.64	-9.04	-0.65	5.66	4.89
α_H	0.05	0.18	-2.11	**-27.92**	-7.04	0.56	-1.74	4.88
α_N	0.15	0.62	1.44	-6.64	**-10.17**	-0.65	5.66	0.00
β	-0.06	-0.28	-2.52	7.13	2.36	**1.25**	-5.36	0.00
γ	0.00	0.00	0.00	0.00	-0.25	0.00	**10.00**	10.00
A	0.00	0.00	0.00	-9.09	-0.99	0.00	0.00	**10.00**

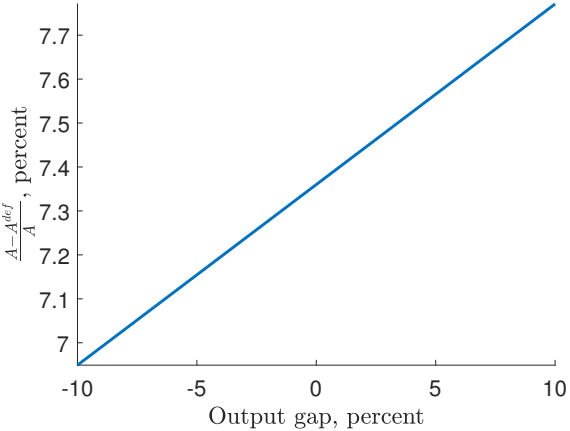
Empirical Evidence and Model's Predictions on r shocks

Semi-elasticity: How much do spreads/inflation/growth increase (in percentage point) as the risk-free rate increases 100 percent?

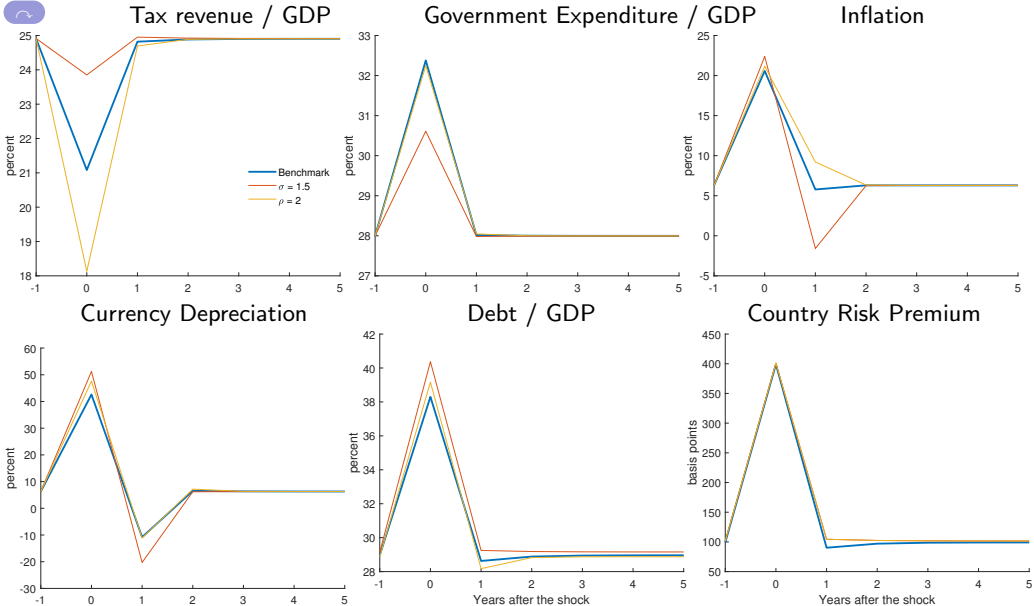
Variables	EMBI		Inflation		Growth	
Data						
Treasury rate	0.8		6.3		0.3	
	(0.2)		(3.1)		(0.2)	
UK real rate		1.1		6.6		-0.8
		(0.2)		(14.4)		(0.3)
Model						
r	{1.9, 3.4}		{3.9, 4.8}		{-0.1, -0.1}	

Default cost and the output gap

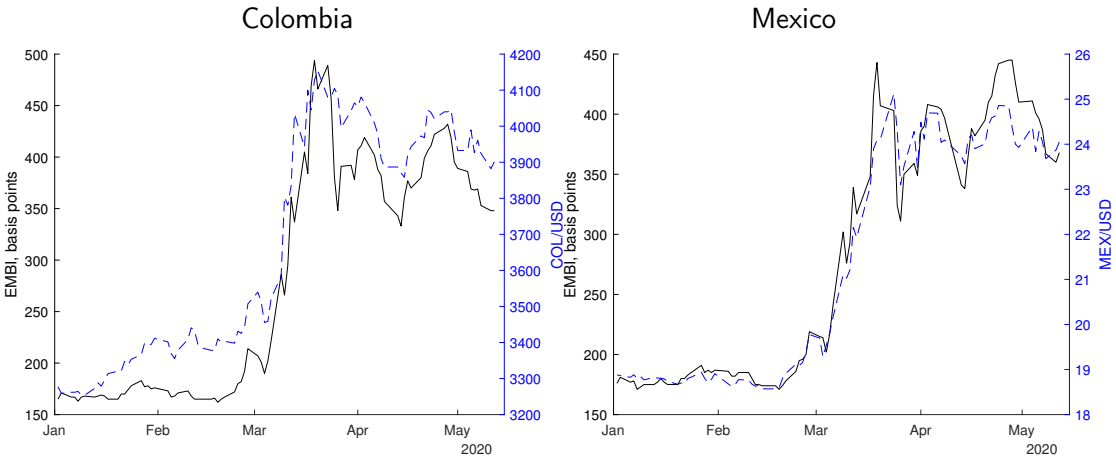
$\lambda_2 = 0.06$ so that spread increase by 300 basis points as a response to the COVID-19 shock.



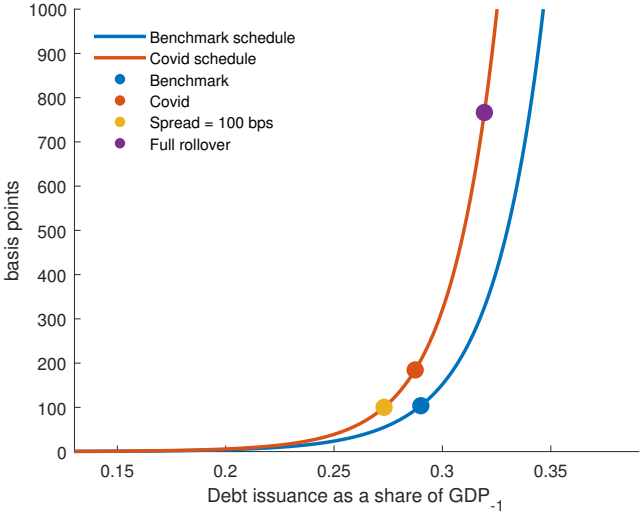
Robustness: σ and ρ



Impact of COVID-19 on country risk premium and exchange rates



Spreads at issuance, Debt, and the COVID-19 shock



Identifying the role of each component of the COVID-19 shock

Shocks to TFP and labor dis-utility

	All shocks	Only shocks to Prod.	Only shocks to Labor
Δ Real GDP, percent	-8.10	-2.94	-3.58
Δ Employment, percent	-5.70	-0.34	-3.64
Δ Debt / GDP, pp	9.01	0.97	1.19
Δ Country risk, pp	3.00	0.98	0.57
Δ Expenditure, percent	6.40	-0.88	-1.17
Δ Tax rate, pp	-3.82	-0.46	-1.27
Δ Inflation, pp	14.3	3.60	4.99
Δ Depreciation, pp	36.3	3.68	5.90

- The **TFP shock** is important for the drop in GDP.
- The **labor disutility shock** is important for the declines in GDP and employment.
- Both shocks contribute to the rise in inflation.
- These shocks do not account for much the increase in debt/GDP.

Identifying the role of each component of the COVID-19 shock

Shock to export prices and transfers

	All shocks	Only shocks to p^T	Transf
Δ Real GDP, percent	-8.10	-0.96	-0.74
Δ Employment, percent	-5.70	-0.77	-0.86
Δ Debt / GDP, pp	9.01	5.56	0.75
Δ Country risk, pp	3.00	**1.14**	0.00
Δ Expenditure, percent	6.40	0.11	8.48
Δ Tax rate, pp	-3.82	-0.98	-0.75
Δ Inflation, pp	14.3	1.89	2.13
Δ Depreciation, pp	36.3	17.1	3.94

- The $\mathbf{p^T}$ **shock** implies a large depreciation and accounts for a significant part of the change in debt and spreads.
- Small effect on real variables.
- Larger **transfers** contribute to higher inflation.

Decomposition: The role of persistence

We analyze a shock with "higher persistence" by increasing the probability that the COVID-19 state continues into the next period: $\Uparrow \theta$ from 0.33 to 0.5.

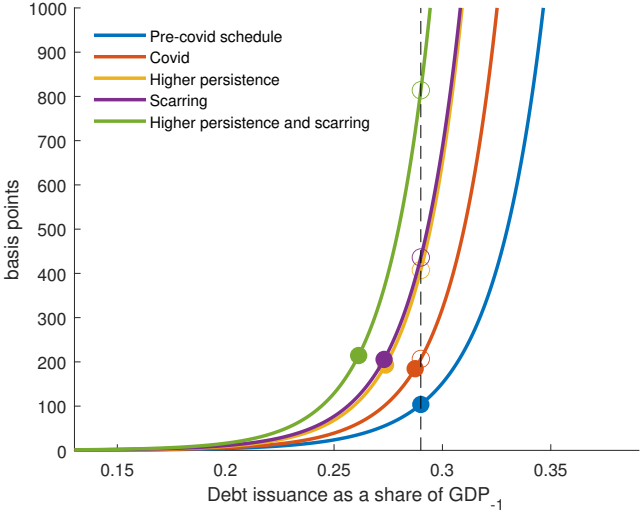
As more persistence can also take the form of **scarring** effects, we consider a shock in which all affected variables do not return to their original values; instead, 10% of the effect of COVID-19 shock remains indefinitely.

Decomposition: The role of persistence

	Benchmark	Higher persistence	Scarring	Higher persistence and scarring
θ, prob. COVID stays in t+1	0.33	0.50	0.33	0.50
η, share of COVID stays in the SS	0.00	0.00	0.10	0.10
Δ Real GDP, percent	-8.10	-8.28	-8.22	-8.34
Δ Employment, percent	-5.70	-6.09	-6.04	-6.38
Δ Debt / GDP, pp	9.01	8.27	8.23	7.53
Δ Country risk premium, pp	3.00	5.95	7.49	**13.04**
Δ Expenditure, percent	6.40	5.95	5.95	5.53
Δ Tax rate, pp	-3.82	-3.04	-3.04	-2.36
Δ Inflation, pp	14.29	17.06	17.08	19.71
Δ Depreciation, pp	36.31	43.46	43.63	50.40

- Higher duration of the shock and *scarring* effect have similar effects.
- Both have a significant effect on the severity of the sovereign debt crisis, without further affecting economic activity.

Spreads at issuance and the Persistence of COVID-19 shock



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