Endogenous Debt Crises

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Objectives

- Provide a simple theoretical framework accounting for:
  - the fact that some emerging countries prudently manage their external debt
  - while others periodically fall into the trap of debt crises
- Infer a typology of crises:
  - exogenously-driven: unanticipated shock on the fundamentals
  - endogenous crises:
    - *self-enforcing* (the country rationally adopts a risky behavior)
    - *self-fulfilling* (the markets trigger a crisis that was avoidable)
- Estimate their relative prevalence in historical data

Typology of self-fulfilling debt crises

- Liquidity crises (Cole and Kehoe, 1996, 2000)
  - Essentially a coordination problem
  - Analog to bank runs
  - Can be avoided with a simple coordination device (Chamon, 2007)
- Snowball effect (Calvo, 1988)
  - High interest rates $\Rightarrow$ more debt $\Rightarrow$ default
  - Low interest rates $\Rightarrow$ less debt $\Rightarrow$ no default
  - Can be avoided if negotiation occurs on the amount due tomorrow rather than the amount lent today (Chamon, 2007)
  - More generally, impossible when no social cost of default (generalization of Cohen and Portes, 2004)

$\Rightarrow$ Self-fulfilling crises characterized as the outcome of an endogenous destruction of fundamentals by the crisis

Self-enforcing (or Panglossian) effect

- Tendency to overborrow today when risk of default is high tomorrow
- Explanation: you don't repay when you default, so why care?
- Similar to OLG models: risk premium = probability of death
  $\Rightarrow$ the two cancel out
- Technically: in the Euler equation, the derivative of expectation term w.r.t. debt is zero over the default set

Outline

Outline

1. The Model
   - Presentation
   - The two regimes
   - The risk of multiple equilibria
   - Generalization and reduced form
2. Empirical analysis
   - Dataset
   - Econometric model
   - Estimation technique and results
3. Conclusion

Outline

Model features (1/2)

- In the spirit of Eaton and Gersovitz (1981), Arellano (2008)
- Discrete time
- Sovereign country (with representative agent) produces and consumes
- Production is an exogenous stochastic stream (*i.i.d.* growth rate)
- Difference between production and consumption financed on international markets
  $\Rightarrow$ accumulation of a stock of external debt
- Debt is short-term and needs to be refinanced every year
- Debt repayments not contingent to the state of nature
- Discount rate δ supposed greater than $r - \gamma\bar{g}$ (γ is inter-temporal elasticity of substitution)
  $\Rightarrow$ the country has an inner tendency to borrow

Model features (2/2)

- The country can make the strategic decision to default
- Default implies financial autarky and cost on output
- Anticipating default, international markets may impose a (model-consistent) risk premium or ration the country
- Two differences with standard models:
  - negotiation occurs on the amount lent today rather than the amount due tomorrow
  - output cost of default has two components: a social loss, and a fraction grabbed by investors

A two-period model (1/3)

Country perspective

- Period 1:
  - Output Q_1 known
  - Country borrows L_1, for a future repayment D_2 (interest rate is $D_2/L_1 - 1$)
  - It consumes $C_1 = Q_1 + L_1$
- Period 2:
  - Output can take two values: $Q_2^+ > Q_2^-$ (resp. with probability $1 - p$ and p)
  - If country repays: $C_2 = Q_2 - D_2$
  - If it defaults: $C_2 = (1 - \lambda)\mu Q_2$
- Objective:

$$\max_{C_1, C_2} u(C_1) + \beta \mathbb{E}_1 u(C_2)$$

A two-period model (2/3)

Output cost of default

- In case of default:
  - Country gets $(1-\lambda)\mu Q_2$
  - Investors get $\lambda\mu Q_2$
  - Social loss is $(1-\mu)Q_2$
- The parameter μ measures the negative externality associated to a default. If $\mu = 1$, then default is efficient *ex post*.
- The parameter λ measures the ability of creditors to seize country ressources. If $\lambda = 0$, recovery for creditors is null.

A two-period model (3/3)

Investors perspective

- Investors risk neutral, subject to zero-profit condition.
- If repayment is expected (safe case):

$$L_1(1+r) = D_2^s$$

- If default is expected (unsafe case):

$$L_1(1+r) = (1-p)D_2^u + p\lambda\mu Q_2$$

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The safe case

- Repayment in period 2 occurs when:

$$D_2 \leq \kappa\, Q_2$$

where $\kappa = 1 - (1 - \lambda)\mu$

- In that case, the FOC is:

$$u'(Q_1+L_1) = \beta(1+r)\{(1-p)u'(Q_2^+ - L_1(1+r)) + p\, u'(Q_2^- - L_1(1+r))\}$$

- C_1 is increasing in Q_2^- $\Rightarrow$ prudent behavior

The unsafe case

- Occurs when $D_2 > \kappa\, Q_2$
- The FOC becomes:

$$u'(C_1) = \beta(1+r)u'(C_2^+)$$

- The risk premium and the probability of the bad state cancel each other
- If $\lambda > 0$, Q_2^- only plays a role in the supply curve for lending; if $\lambda = 0$, no role at all
- Panglossian/self-enforcing effect: country indifferent to the bad state of nature; tendency to rationally overborrow

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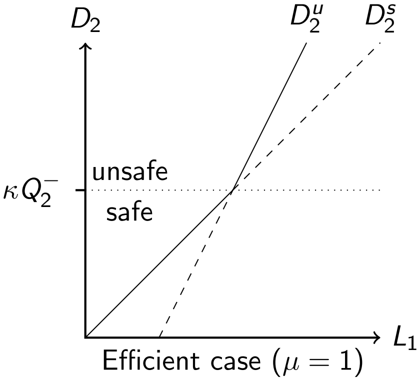
Characterization of multiple equilibria (1/2)

- Usually, the risk determines the interest rate
- But the reverse causation can also be at work (snowball effect)
- Possible when $D_2^s \leq \kappa\, Q_2^-$ and $D_2^u > \kappa\, Q_2$, *i.e.*

$$\kappa\, Q_2^- - p(1-\mu)Q_2^- < L_1(1+r) \leq \kappa\, Q_2^-$$

- Range of multiple equilibria smaller as μ get bigger; nil when $\mu = 1$ $\Rightarrow$ multiple equilibria disappear when fundamentals are immune to the crisis

Characterization of multiple equilibria (2/2)



Outline

Generalization to infinite horizon

- Insights of the two-period model still hold
- The impossibility of multiple equilibria needs a slightly stronger condition than $\mu = 1$ (we name it a *smooth default*)
- Panglossian effect now written as:

$$u'(C_t) = \beta(1+r)(1+\xi_{t+1|t})\mathbb{E}_t\left[u'(C_{t+1})\,|\mathscr{R}(D_{t+1}, Q_t)\right]$$

  where $\xi_{t+1|t} > 0$ reduces the propensity to borrow (nil for the *smooth default* case)
- The recovery of investors λ is supposed stochastic

Reduced form of debt dynamics

$$\hat{D}_{t+1} = a_1 + a_2\,\hat{D}_t - a_3\,g_{t+1}\hat{D}_t + a_4\,(g^+_{t+1|t} - \bar{g}) + \varepsilon^d_{t+1}$$

where

- ε^d_{t+1} is deviation from "desired" debt (Alesina and Tabllini 1990; Beetsma and Mavromatis 2014)
- $g^+_{t+1|t} - \bar{g}$ is the Panglossian effect: growth differential between repayment states and average state

The Panglossian term can be rewritten as $\pi_{t+1|t}\,(g^+_{t+1|t} - g^-_{t+1|t})$, with $\pi_{t+1|t}$ the probability of default and $g^+_{t+1|t} - g^-_{t+1|t}$ the growth differential between repayment states and default states

Outline

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Debt crises

Definition of Kraay & Nehru (2004)

For a given year, a country is considered to be in debt crisis if at least one of the following 3 conditions holds:

- it receives debt relief from the Paris Club (rescheduling and/or debt reduction)
- the sum of its principal and interest arrears is above 5% of outstanding debt stock
- it receives substantial balance of payments support from the IMF through a non-concessionnal Standby Arrangement (SBA) or Extended Fund Facility (EFF)
  Threshold: amount of support $>$ 50% of IMF quota

Episodes

- Having defined *years* of crisis (or no-crisis), we define *episodes* made of several consecutive years
- *Distress episodes*: at least 3 consecutive years of crisis, preceded by at least 3 years without crisis
- *Normal times episodes*: 5 consecutive years without crisis
- An episode is characterized by 4 informations:
    1. type: distress or normal
    2. country
    3. year of beginning
    4. length (in years)

Data sources

- World Bank's *Global Development Finance* for data on debt levels and payment arrears
- Paris Club website for information on debt reliefs
- IMF's *International Financial Statistics* for data on SBA/EFF commitments
- World Bank's *World Development Indicators* for general macroeconomic variables
- *Penn Word Tables* for data on Purchasing Power Parity (PPP) variables

Sample

- Country set:

	135	developing countries (World Bank definition)
−	38	with no access to private financial markets
=	97	countries in the sample

- Time span: 1970-2004
- Number of episodes obtained:
  - 70 distress episodes
  - 223 normal times episodes
- Average default episode length: 13.3 years
- Average GDP loss peak to through: 1.9%

Outline

Core equations

$$d_{it} = X^{d}_{i,t-1}\,\eta^{d} + g_{it}\,X^{d,g}_{i,t-1}\,\eta^{d,g} + \varepsilon^{d}_{it}$$

$$g_{it} = X^{g}_{i,t-1}\,\eta^{g} + \delta_{it}\,X^{g,\delta}_{i,t-1}\,\eta^{g,\delta} + \varepsilon^{g}_{it}$$

$$\delta_{it} = 1_{\{X^{\delta}_{i,t-1}\,\eta^{\delta} + d_{it}\,X^{\delta,d}_{i,t-1}\,\eta^{\delta,d} + \varepsilon^{\delta}_{it} > 0\}}$$

where:

- i country concerned by the episode
- t beginning year of the episode
- d_{it} debt-to-GDP ratio
- g_{it} growth rate
- δ_{it} dummy for debt crisis
- X vectors of exogenous variables
- η parameters
- ε exogenous shocks

Possibility of multiple equilibria

- Crisis explained by a probit equation where debt/GDP appears
- Debt/GDP explained by two linear predictors, the second of which is growth
- Growth itself gets a malus in case of crisis
  $\Rightarrow$ endogeneity of the fundamentals to the crisis
- Model not well-specified at this stage: circular dependency of the three endogenous variables
- For a given set of exogenous and a given draw of random shocks, one could have a crisis equilibrium and a no-crisis equilibrium
  $\Rightarrow$ possibility of self-fulfilling crises

Completion of the model specification

- *Solution*: add a *sunspot*, which determines the equilibrium when both are possible
- The sunspot is "on" with probability p
- For a given set of exogenous and a given draw of random shocks, three cases are possible:
    1. Only the no-crisis equilibrium is possible
    2. Only the crisis equilibrium is possible
       $\Rightarrow$ crisis driven by an exogenous shock
    3. Both crisis and no-crisis equilibrium are possible
       The crisis occurs if sunspot is "on" $\Rightarrow$ self-fulfilling crisis
- *A posteriori*, for a given observed crisis, it is possible to compute the probability that it was self-fulfilling rather than exogenously driven

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Estimation technique

- Maximum likelihood estimation, with randomization algorithm to deal with the non-global concavity of likelihood function
- Exogenous variables taken two years before beginning of episode
- Concerning parameter p ($=$ the probability of sunspot being "on"):
  - It is never statistically significant
  - Therefore we calibrate with sensible values
    - $p = 1$: markets panic-prone
    - $p = 0.5$: markets lose confidence half of the time

Measuring the Panglossian effect

- Constructed variable: $\pi_{t+1|t}\,(g^{+}_{t+1|t} - g^{-}_{t+1|t})$
- Probability of default computed with a first-stage Probit
- Growth gap approximated by the mean growth rate (accross the whole sample) above and below quantile π_{it}
- Generated regressor $\Rightarrow$ standard errors corrected by the Murphy and Topel (1985) method

Estimation results

Debt/GDP ratio dynamics			
η^d: Debt/GDP $(t-2)$	1.204*** (0.023)	1.205*** (0.023)	1.104*** (0.075)
η^d: Crisis prob $\times$ Growth gap $\hat{g}$ $(t/t-2)$			0.821** (0.262)
$\eta^{d,g}$: Debt/GDP $(t-2)$ $\times$ Growth (t)	-1.722*** (0.214)	-1.719*** (0.210)	-1.651*** (0.320)
Growth dynamics			
η^g: Log per capita PPP real GDP $(t-2)$	-0.023** (0.008)	-0.025** (0.008)	-0.023** (0.007)
η^g: Growth $(t-2)$	0.281** (0.101)	0.277** (0.101)	0.281** (0.086)
$\eta^{g,\delta}$: Debt crisis dummy (t)	-0.059*** (0.015)	-0.077*** (0.014)	-0.062*** (0.015)
Debt crisis determinants			
η^δ: Log per capita PPP real GDP (t-2)	-0.365** (0.132)	-0.426** (0.133)	-0.356** (0.135)
η^δ: US$ GDP / PPP GDP (t-2)	1.477** (0.535)	1.582** (0.530)	1.454** (0.525)
$\eta^{\delta,d}$: Debt/GDP (t)	2.883*** (0.456)	2.971*** (0.465)	2.815*** (0.429)
p: Sunspot Bernoulli parameter	1.0	0.5	1.0
Self-fulfilling probability	0.111	0.077	0.111
Self-enforcing probability			0.124

Robustness checks

- The Panglossian effect is not simply a proxy for the risk premium effect
- It is not either a proxy for “bad news,” which trigger an debt increase in a model of inter-temporal consumption smoothing (tested by introducing a measure of the business cycle)
- The following possible missing variables in growth equation (Moral-Benito, 2012) have been tested:
  - price of investment goods
  - distance to major world cities
  - political rights

For each crisis, probability that it was self-fulfilling

i.e., probability that it would have been avoided if confidence had been maintained

Country	Year	Crisis length	Probability
Jordan	1989	16	0.2%
Somalia	1981	24	1.4%
Rwanda	1994	11	1.4%
Congo, Rep.	1985	20	1.6%
⋮	⋮	⋮	⋮
Venezuela	1989	4	19.3%
Indonesia	1997	8	19.6%
El Salvador	1990	3	19.9%
Argentina	1983	13	20.3%

Computed for $p = 1$

Model simulation

Contribution of each shock to crises

Effect	Contribution
Market shock ($\varepsilon_{it}^{\delta}$)	55.8%
Debt shock (ε_{it}^{d})	15.2%
Panglossian effect	12.0%
Growth shock (ε_{it}^{g})	11.0%
Self-fulfilling effect (ζ_{it})	6.1%
Total	100.0%

Monte-Carlo simulations of the benchmark estimated model.
Results computed over 2,500 simulations of a 10-year duration and starting from a debt-to-GDP ratio of 60%.

Outline

Conclusion

- Two endogenous forces at work in debt crises:
  - self-enforcing / Panglossian effect
  - self-fulfilling effect
- Categories that are empirically relevant: taken together, they explain between 1/4 and 1/5 of crises
- However, the majority of crises are of an exogenous nature (earthquake model)
- Policy implications:
  - Promote the usage of state contingent debt (solution to the exogenously driven case)
  - Debate about debt restructuring (solution to the self-fulfilling case) less important than finding more innovative sources of financing