Private Sector Risk and Financial Crises in Emerging Markets

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1 Financial Crises are not all alike

- Financial crises can be caused by bad government policy
  - Large literature on causes of sovereign default
  - Hypothesis: not all financial crises are caused by bad government policy
- Financial crises can be caused by interaction of risky investment and capital market imperfections
  - Crises originate in the private sector
  - Government policy can be good
  - East Asian crises in 1997-98

1.1 Central Question: Why do capital markets break down?

1. Why are rational creditors willing to lend amounts which are "too much" for agents to repay under some circumstances?

2. Why do creditors at times ration credit, creating sudden stops of capital flows, instead of just raising the interest rate?

3. Can financial market imperfections imply that a negative shock to risky investment creates widespread default?

Present a model to address these questions

1.2 Key Assumptions

- three-period model with investment decision in period 0
- investment is of fixed size, risky, and takes two periods to mature
- a fraction ρ $(1-\rho)$ of agents have high (low) productivity
  - ρ is stochastic and unknown in period 0
  - agents learn their identity when the investment project matures in period 2
- **insufficient funds** to finance investment, requiring external financing

- two credit market imperfections
  - costly state verification yields equilibrium with
    - debt finance with positive probability of default
    - debt backed by claims to a **fraction** of expected future output awarded by bankruptcy court
    - debt ceilings
  - moral hazard in the choice of investment projects with different maturities yields equilibrium with
    - maturity mismatch in loans and investment projects
- agents in emerging markets compared to industrial countries

1.3 Preview of Results

- in period 0, creditors offer initial one-period debt, up to a ceiling based on expected future output, to finance investment

- accurate news about productivity of the investment arrives in period 1
  - bad news reduces the debt ceiling (sudden stop of capital) and raises interest rate
    - if the debt ceiling is less than debt repayments on initial loans, all agents default
    - sudden stop of capital creates current account reversal
  - low productivity creates a recession

- loan characteristics in equilibrium
  - maturity mis-match – one-period debt finances two-period investment projects
  - debt ceilings and interest rates fluctuate with news
  - inability to roll over debt creates default

1.4 Quantitative Implications

Can reasonably-sized productivity shocks and capital market imperfections produce financial crises similar in magnitude to those observed?

- Aggregate economy has overlapping generations of agents with access to risky investment project and others without access

- Calibrate to match
  - Standard deviation of HP-filtered GDP for South Korea
  - Probability of financial crisis for non-Latin emerging market in investment boom 7-10% (Gourinchas et al 2001)
  - 20% of South Koreans have 38% of the income (Zin 2005)
- Crisis magnitudes similar to those observed
  - current account reversal
  - output and consumption collapse
  - interest rate increase

1.5 Closely Related Literature

- Mendoza and co-authors
  - productivity shocks interacted with collateral constraints cause financial crises
  - quantitative implications
  - collateral constraint imperfection cannot explain
    - debt finance over equity
    - maturity mismatch

- Literature on financial market imperfections
  - costly-state verification
    - Townsen (1979)
    - Bernanke Gertler (1989) and Bernanke Gertler Gilchrist (1996)
  - Atkeson (1991) moral hazard

2 Assumptions

2.1 General

- small open economy
  - single good with fixed world price
  - fixed world risk-free interest rate
  - risk-neutral foreign creditors

- unit mass of home agents
  - access to investment project of fixed size which exceeds endowment ($K > Y$)
  - investment is risky
    * ρ $(1 - \rho)$ agents will receive output in period 2 of HK (LK)
    * ρ is stochastic with bounded support and revealed in period 1
    * agents do not learn their own identity until period 2
    * $\rho^l H > L$

- three periods
  - Period 0 - planning period in which choose whether or not to invest to max utility

$$\int_{\rho^i}^{1} \left[\ln c_1 + \beta(\rho \ln c_{2h} + (1-\rho) \ln c_{2l})\right] f(\rho)\, d\rho.$$

  - Period 1 - agents learn ρ and receive $\lambda < \frac{1}{1+r}$ of expected period 2 output
  - Period 2 - investment matures, agents learn identity and receive idiosyncratic output

2.2 Financial Market Imperfections

- costly state-verification
  - creditors cannot observe output without payment of a verification fee
  - bankruptcy awards are a fraction $\eta < 1$ of output
  - optimal contract minimzes verification fees and is a debt contract
    - when agreed repayments $<$ η*output, agents repay and no need to verify
    - when agreed repayments $>$ η*output, agents do not repay, verification occurs, agents surrender bankruptcy awards

- moral hazard with respect to maturity of investment project
  - investment projects with maturities of one and two periods are available
  - to receive a loan, agents must provide credible evidence of investment, but not of investment maturity
  - if two-period loans were available, agents could finance the one-period project with a two period loan
    - there would be no output to support repayment when the debt contract matures
    - equilibrium does not allow two-period loans, yielding maturity mismatch

2.3 Government

- No government spending or debt
- No sovereign financial crisis
- In period 2, government redistributes income to achieve perfect risk-sharing across agents

Time Line

Period 0	**Period 1**	**Period 2**
invest	learn ρ and ceiling on D_1	realize output, agents learn identity
D_0	agents repay or default	creditors pay verification fees
	c_1	l-agents pay **min** $[\eta LK, (1+r_1)D_1]$
		h-agents pay **min**$[\eta HK, (1+r_1)D_1]$
		c_2

3 The Supply of Debt by Risk-Neutral International Creditors

- interest rates offered by international creditors conditional on level of debt
- debt ceilings.

3.1 Period 1 Debt (D_1)

- Aggregate uncertainty resolved with revelation of ρ
- Agents do not know their identity

3.1.1 Debt Ceiling $\left(\bar{D}_1\right)$

- Case in which agents want to borrow enough that $l-$agents always default in period 2.

- Simplify by assuming that the verification fee equals the bankruptcy awards, so creditors expect to receive no net payment from $l-$agents.

- Creditors offer debt up to the value of bankruptcy payments by $h-$agents to assure $h-$agents always repay

- Debt ceiling is

$$\bar{D}_1 = \frac{\eta H K}{1 + r_1}.$$

3.1.2 Interest Rate (r_1)

- Assume that debt can be pooled to yield a risk-free asset.

- Interest payments on debt by those who repay must equal payments on the same debt at the risk-free world interest rate.

$$\rho\,(1 + r_1)\,D_1 = (1 + r)\,D_1$$

- This implies

$$1 + r_1 = \frac{1 + r}{\rho} \text{ and } \bar{D}_1 = \frac{\rho\eta H K}{1 + r}$$

- A low ρ creates capital flight by reducing $\bar{D}_1$.

3.2 Period 0 Debt (D_0)

The interest rate and ceiling on D_0 depend on the decision to default on D_0

3.2.1 Default decision on D_0 made in period 1

- Penalty to default
  - Either creditors claim η of period-1 output at the cost of ω or
  - Creditors roll over debt, and receive at least $\eta\left(\rho H+\left(1-\rho\right)L\right)K-\varpi$ next period.
  - Creditors prefer to roll over debt since period-1 output is less than the present value of period-2 output

- Decision whether or not to default
  - Present value of debt repayments if repay

$$(1 + r_0) D_0 + \frac{(1 - \rho) \eta L K}{1 + r}$$

  - Present value of debt repayments if default

$$\frac{\eta (\rho H + (1 - \rho) L) K}{1 + r}$$

  - Default raises total resources if

$$\bar{D}_1 = \frac{\rho \eta H K}{1 + r} < (1 + r_0) D_0$$

    * low ρ creates a low debt ceiling – a sudden stop
    * such that cannot rollover debt payments with new debt

Critical value for ρ below which agents default $\left(\rho^d\right)$

Lemma 1 *Given a value for initial debt with interest,* $(1+r_0)\,D_0$*, there is a critical value of* $\rho=\rho^d$*, below which agents choose default and above which they choose repayment.*

Since $\rho<\rho^l$ is infeasible, define

$$\rho^d=\max\left[\frac{(1+r)\,(1+r_0)\,D_0}{\eta H K},\rho^l\right]. \tag{1}$$

When $\rho<\rho^d$, default raises resources and these resources are available in period 1 where they are needed to smooth consumption. When $\rho>\rho^d$, default reduces resources and the reduction comes in period 1.

Higher values of debt are riskier since they imply default for higher values of ρ.

Critical value for D_0 above which it is risky (D_{0R})

If D_0 is so low that $\rho^d = \rho^l$, agents will never default on D_0, implying that it is not risky. The critical value for D_0, above which it is risky and below which it is safe is

$$D_{0R} = \frac{\rho^l \eta H K}{(1+r)^2}.$$

Interest rate conditional on a value for D_0 (r_0)

Arbitrage relationship between debt to emerging market agents and risk-free debt

$$(1+r)\,D_0 = (1+r_0)\,D_0 \int_{\rho^d}^{1} f(\rho)\,d\rho + \int_{\rho^l}^{\rho^d} \left(\frac{\eta\,(HK-LK)}{1+r}\right) \rho f(\rho)\,d\rho \tag{2}$$

Solving (2) for $(1+r_0)\,D_0$ as a function of ρ^d yields

$$(1+r_0)\,D_0 = \frac{(1+r)\,D_0 - \int_{\rho^l}^{\rho^d} \left(\frac{\eta(HK-LK)}{1+r}\right) \rho f(\rho)\,d\rho}{\int_{\rho^d}^{1} f(\rho)\,d\rho} \tag{3}$$

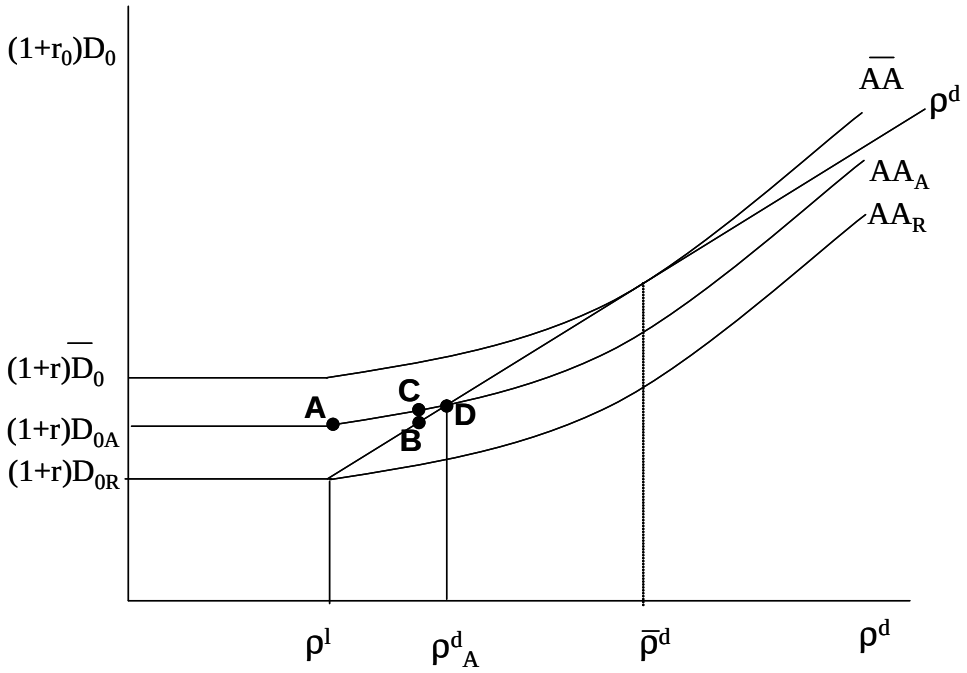

Figure 1: Financial Markets

r_0 and ρ^d are increasing in D_0

$\bar{D}_0$ is increasing in η

4 Budget Constraints

4.1 Period 0

$$Y + D_0 = K + B_0 \quad D_0 \leq \bar{D}_0 \quad B_0 \geq 0$$

Lemma 2 *A country for which the size of the investment project is large relative to an agent's endowment, $K - Y > \bar{D}_0$, does not have access to international financial markets. Access requires either stronger capital markets, modeled by a larger value for η which raises $\bar{D}_0$, or a larger endowment, Y.*

4.2 Period 1

Letting $\zeta = 1$ in the absence of default and zero otherwise

$$c_1 = \lambda \left[\rho H + (1-\rho) L - 1\right] K + \zeta \left[D_1 - (1+r_0) D_0\right] + (1+r) B_0 - B_1$$

4.3 Period 2

$$\begin{aligned} c_2 &= \rho \left\{\zeta_h \left[HK - (1+r_1) D_1\right] + (1-\zeta_h)(1-\eta) HK\right\} \\ &\quad + (1-\rho)(1-\eta) LK + (1+r) B_1 - \tau_2 \end{aligned}$$

5 First Order Conditions

$$\frac{1}{c_1} \geq \frac{\beta\rho\left(1+r_1\right)}{c_2} = \frac{\beta\left(1+r\right)}{c_2}$$

$$\left\{\int_{\rho^l}^{\rho^d}\left(\frac{1+r}{c_1\left(\rho\right)}\right)f\left(\rho\right)d\rho + \frac{1+r_0}{c_1\left(\rho^d\right)}f\left(\rho\right)\frac{\partial\rho^d}{\partial D_0}\right\} - \left\{\int_{\rho^d}^{1}\left(\frac{r_0-r}{c_1\left(\rho\right)}\right)f\left(\rho\right)d\rho\right\} \geq 0.$$

- Marginal benefit of additional debt – utility from additional consumption an agent receives in states for which debt is not repaid

- Marginal cost is the utility of the consumption reduction, due to the excess of the risk-adjusted interest rate above the risk-free rate, in states for which debt is repaid.

- For $D_0 < D_{0R}$, marginal costs and marginal benefits are both zero - if debt this low is sufficient to finance investment, then low debt can be an equilibrium, and it is risk free

- For $D_0 = D_{0R}$, $\frac{\partial \rho^d}{\partial D_0} > 0$, implying that marginal benefits of additional debt exceed marginal costs because they increase states in which debt is not repaid

- For $D_0 > D_{0R}$, marginal benefits exceed marginal costs and are rising at a faster rate in D_0 than marginal costs. Key to the rapid increase in marginal benefits is the effect of more debt on the value of ρ^d.

Lemma 3 *Under the assumption that agents coordinate on the safe equilibrium value for D_0 if it exists, then if $D_{0R} < K - Y$, equilibrium implies $D_0 = K - Y$. Alternatively, if $D_{0R} \geq K - Y$, then equilibrium requires $D_0 = \bar{D}_0$.*

Credit Clubs

Proposition 1 *Given parameters characterizing the inherent riskiness of the project, countries with high values for* $\frac{K-Y}{\eta K}$ *have no access to credit for financing profitable, risky projects; countries with lower values have access which is volatile; and countries with even lower values have safe, stable access.*

Debt Crises

Proposition 2 *In period 1, a value for* $\rho < \bar{\rho}^d$ *triggers a debt crisis in which all agents choose not to repay debt.*

6 Calibration

6.1 Macro model

- Overlapping generations of agents with access to risky, profitable projects
  - identical projects and agents ex ante
- Other agents with access to safe, less productive project

6.2 Standard parameters

- $r = 0.04$ and $\beta(1 + r) = 1$
- $\delta = 0.10$
- $K = 1$
- ρ is bounded normal

6.3 Calibration targets

- standard deviation of logarithm of HP-filtered real GDP for South Korea of 0.031

- 20% of agents have access to risky profitable projects, which give them 38% of the income

- probability of a banking crisis in non-Latin emerging markets experiencing investment boom between 7 and 10%

6.4 Inequality constraints

- Y and η must imply $D_{0R} < K - Y < \bar{D}_0$ so that agents must borrow to invest and debt is risky

- $\lambda < \frac{1}{1+r}$ so creditors prefer to roll over debt

- $D_1 > \eta LK$ and $\rho^l H < L$ implying $l-$agents always default in period 2

- the risky project is profitable enough so that expected utility from investment exceeds other options

6.5 Parameter values

- $L = 0.8$
- $H = 2.4$
- $\frac{Y}{K} = 0.569$
- $\eta = 0.35$
- $\lambda = 0.5$
- mean $\rho = 0.75$ and $\sigma_\rho = 0.115$

Table 1: Data for South Korea

	GDP	C	CA/GDP	r
1996	5.3	12.6	-4.2	12.11
1997	4.5	10.1	-1.3	16.97
1998	-7.7	-7.3	11.3	20.71

Table 2: Hypothetical Shock Sequence

	1995	1996	1997	1998
ρ	.829	.897	.603	.671
F(ρ)	.868	.975	.047	.201

Table 3: Model

	GDP	C	CA/GDP	r
1996	5.6	8.1	-1.2	11.32
1997	2.7	2.8	5.8	-
1998	-6.9	-7.3	2.8	30.85

7 Conclusions

- Financial crisis models are like mushrooms after a rain. Why do we need another?

- Because models in the dominant class, those with collateral constraints, fail to answer some fundamental questions.

- Alternative model class – costly state verification with moral hazard leading to maturity mismatch

- Fundamental questions
  - Why do emerging market agents use debt finance over equity finance?
  - Why do agents take on debt which is sometimes too much?
  - Why does debt used to finance investment exhibit maturity mismatch and why is the inability to roll over debt associated with default?
  - Why do creditors sometimes ration credit, creating a sudden stop, instead of just raising the interest rate?
  - Why are there different credit clubs with differing access to credit on different terms?

- Proposals for financial reform: objective is reduce probability of crises without substantially reducing access to profitable investment
  - Raise equity relative to debt finance
  - Raise long-term lending relative to short-term

Quantitative implications

- Reasonably sized productivity shocks can generate a financial crisis similar to that observed in Korea in 1997-98

- Not as good as a DSGE model with collateral constraints and many shocks in generating business cycle moments