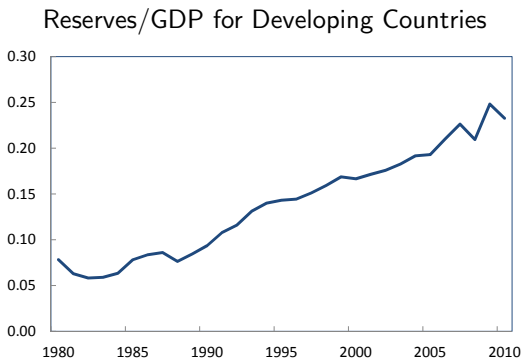


# Sudden Stops, Limited Enforcement and Optimal Reserves

Yun Jung Kim

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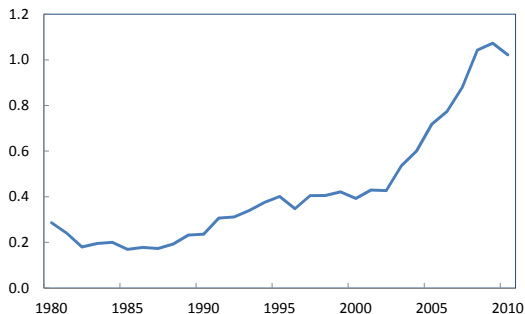
# Reserve Accumulation in Developing Countries



- There has been a dramatic increase in reserve accumulation by developing countries since the 1990s.

# Reserve Accumulation in Developing Countries

Reserves/External Debt for Developing Countries



- It is even more dramatic, compared with short-term external debt: Reserves/ST debt is over 2.
- Greenspan-Guidotti rule (most widely-used standard of reserve adequacy): full coverage of total short-term external debt.

# Accumulation of International Reserves

- Often explained by precautionary motive to insure against capital flow volatility.
- Can we quantify the level of reserves that can be justified as an insurance against capital flow volatility?
- Existing work
  - Takes as given the country's external debt, and solve for optimal insurance: Jeanne and Ranciere (2011), Aizenman and Lee (2005), Caballero and Panageas (2004), Lee (2004)
    - However, sovereign debt and reserves are jointly determined.
  - Treats reserve accumulation and less outstanding debt as substitutes: Durdu et al. (2009), Mendoza (2010)
    - Sovereign countries accumulate both external debt and reserves.

# External Debt and Reserves

- Need to analyze endogenous debt and reserve choices
  - Default risk is important for sovereign debt.
- With limited enforcement of sovereign debt, reserves tend to reduce sustainable debt levels.
  - Reduce the cost of exclusion after default, by providing insurance when the country has no access to international credit market.
  - Smooth by defaulting rather than having reserves
  - Alfaro and Kanczuk (2007) find that optimal reserves are close to zero.

# External Debt and Reserves

- To justify reserve accumulation, need additional benefit of reserves.
  - Bianchi et al. (2013) introduce long-duration bonds.
  - Consequence of policy to maintain external surpluses and undervalued exchange rates (Dooley et al. 2003).
  - Reserves are perceived as a tool to reduce the incidence of international crisis.
- Recent empirical literature emphasizes the role of reserves in preventing a sudden stop crisis, rather than being a buffer to absorb shock to capital flow volatility.
  - Garcia and Soto (2004), Bussiere and Mulder (1999), Calvo et. al. (2012), Cavallo and Frankel (2008).

# Probability of a Sudden Stop

- Probit Estimation of the Probability of a Sudden Stop, 1975-2005 (34 Emerging Market Countries)

	(1)	(2)	(3)
Debt/GDP	0.669*** (0.207)	0.154 (0.310)	0.017 (0.390)
Reserves/Debt	-0.457 (0.359)	-1.215** (0.542)	-1.436** (0.726)
REER Overvaluation	0.009*** (0.003)	0.009*** (0.003)	0.008** (0.004)
KA Openness	0.052 (0.049)	0.012 (0.065)	-0.024 (0.085)
Country Effects	No	Yes	Yes
Year Effects	No	No	Yes
Observations	831	629	607

# This Paper

- Quantify the level of reserves that can be justified as an insurance against sudden stops,
  - Taking default risk into consideration - opportunity costs of reserves are also endogenously determined in the model.
  - Also incorporating endogenous sudden stop risk.
- Intertemporal optimization problem of the government in a small open economy that has willingness-to-pay problem and is also hit by “sudden stops.”
  - Default: Willingness-to-pay crisis, mainly driven by the ratio of total debt to GDP ratio.
  - SS: Liquidity crisis, mainly driven by external factors, but incidence can be reduced by accumulating reserves.



# Benefits and Costs of Reserves

- Benefits of reserves:
  - Allow the country to smooth consumption in crises
  - Lower the probability of a sudden stop.
- Costs of reserves:
  - Yield a lower return than the interest rate on external liabilities.
  - Reduce sustainable debt levels (increases default premium).
- Quantitative question!

# Model

- A small open endowment economy that borrows funds from competitive risk-neutral foreign creditors.
- Subject to sudden stop shocks. In a sudden stop, the country cannot borrow and suffer income loss. The probability of a sudden stop  $P_S$  depends on reserves/debt. Exits sudden stop with probability  $\theta^S$
- May choose to default on its external debt. If defaults, the country is excluded from international credit markets and suffer income loss. It regains access with probability  $\theta$ .
- The country can use reserves as buffer to smooth consumption even when it cannot issue new debt.

# Model

- Timing: Learns income and sudden stop shocks, decides whether to default on its debt, then chooses levels of borrowing and reserves.

- Default/Repayment decision:

$$W(B, A, y, s) = \max_{d \in \{0,1\}} \{ (1-d)W^R(B, A, y, s) + dW^D(A, y, s) \}$$

- Value of repayment:

$$W^R(B, A, y, s) = \max_{B', A'} u(c) + \beta E_{y', s' | y, s} [W(B', A', y', s')]$$

$$\text{where } c = (1 - s\lambda^s)y - B + A + (1 - s)qB' - \frac{A'}{(1+r)}.$$

$s \in \{0, 1\}$ .  $s = 1$  denotes a sudden stop.

# Model

- The continuation value for the normal period ( $s = 0$ ) and for a sudden stop ( $s = 1$ ) can be written, respectively, as

$$s = 0 : \int_{y'} [(1 - p'_s(A'/B'))W(B', A', y', 0) + p'_s(A'/B')W(B', A', y', 1)] f(y', y) dy'$$

$$s = 1 : \int_{y'} [\theta^s W(0, A', y', 0) + (1 - \theta^s)W(0, A', y', 1)] f(y', y) dy'$$

where  $p'_s(A'/B')$  is the next period's probability of a sudden stop which is decreasing in  $(A'/B')$ , and  $\theta^s$  is the probability of exiting a sudden stop episode.

# Model

- The value of default is

$$W^D(A, y, s) = \max_{A'} u \left( (1 - \lambda^d)(1 - s\lambda^s)y + A - \frac{A'}{(1+r)} \right) + \beta E_{y', s' | y, s} [\theta W(0, A', y', s') + (1 - \theta) W^D(A', y', s')]$$

where  $\theta$  is the probability of exiting default penalty phase.

- The continuation values

$$s = 0 : \int_{y'} \{ \theta W(0, A', y', 0) + (1 - \theta) W^D(A', y', 0) \} f(y', y) dy'$$

$$s = 1 : \int_{y'} \{ \theta [\theta^s W(0, A', y', 0) + (1 - \theta^s) W(0, A', y', 1)] + (1 - \theta) [\theta^s W^D(A', y', 0) + (1 - \theta^s) W^D(A', y', 1)] \} f(y', y) dy'$$

# Foreign Lenders' Problem

- The bond price schedule is given by

$$\begin{aligned}
 q(B', A', y, 0) &= \frac{E_{y', s' | y, s}(1 - D(B', A', y', s'))}{1 + r} \\
 &= \frac{\int_{y'} [(1 - p'_s(A'/B'))(1 - D(B', A', y', 0)) + p'_s(A'/B')(1 - D(B', A', y', 1))] f(y', y) dy'}{1 + r}
 \end{aligned}$$

# Calibration

- Preferences:  $u(c) = \frac{c^{1-s}-1}{1-s}$ , Endowment:  $\ln(y_t) = \rho \ln(y_{t-1}) + \varepsilon_t$ ,  $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ .
- $p_s(A/B) = \Phi(m - \omega(A/B))$ , where  $\Phi(\cdot)$  is the cdf of the standard normal distribution: Jeanne and Ranciere (2011)
- Parameters:

Risk aversion ( $s$ )	2	Literature
Discount factor ( $\beta$ )	0.95	Assumption
Income autocorrelation coefficient ( $\rho$ )	0.945	Argentina data
Standard deviation of innovations ( $\sigma$ )	0.025	Argentina data
Risk-free rate ( $r$ )	0.00	Assumption
Income loss in crises ( $\lambda, \lambda^s$ )	0.10	Output drop 10%
Probability of Reentry ( $\theta, \theta^s$ )	0.10	Avg. exclusion 2.5 years
Probability of entering a sudden stop ( $p_s$ )		
$m$	-1.8	$Prob(SS Reserve = 0) = 12.9\%$
$\omega$	0.2	$Prob(SS) = 7.4\%$

# Simulation Results

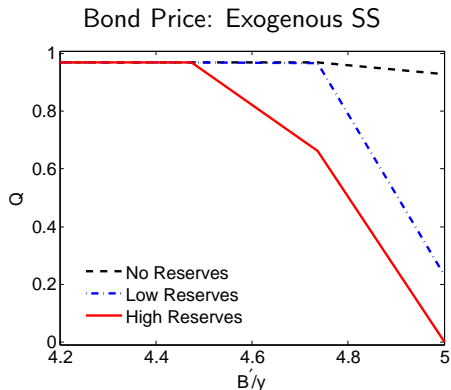
- Comparison of Statistics

	No Reserves		Reserves	
	No SS	No SS	Exogenous SS	Endogenous SS
mean(B/y)	50.15	49.81	36.32	26.20
mean(A/y)	-	0.00	1.74	24.01
prob(default)	0.00	0.00	1.41	0.00
prob(SS)	-	-	7.41	7.40

- Exogenous SS: smooth by defaulting rather than having reserves.
- When the sudden stop probability depends on reserves, benefit of holding reserves outweighs cost.
  - With plausible calibration, it is possible to generate reserve level which is close to the levels observed in the data: 34 Emerging Market Countries in 2010: Mean A/Y: 23%, Mean A/B: 1.02%

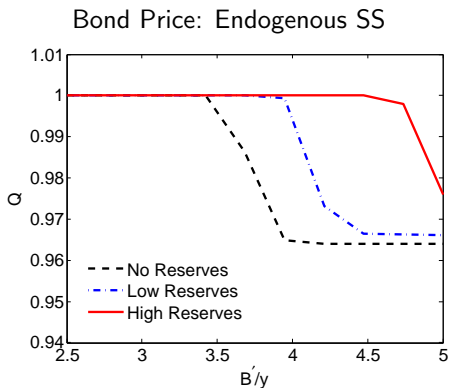


# Reserve and Debt Sustainability



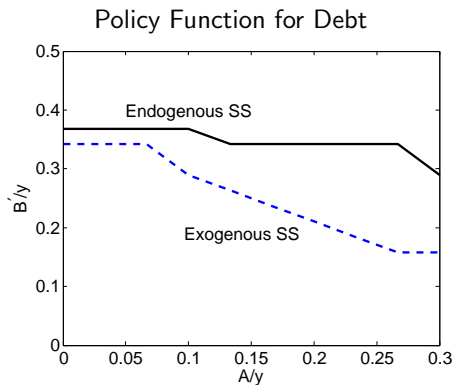
- Reserves make default less costly, thus default is chosen more often when the level of reserves is high.
- Reserves reduce debt sustainability.

# Reserve and Debt Sustainability



- When the sudden stop probability depends on reserves, debt sustainability sometimes even increases with reserves: Reserves reduce the probability of a sudden stop in which default is chosen more often than normal times.

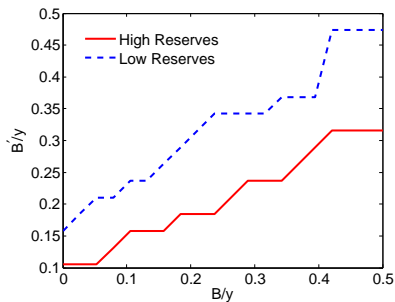
# Debt Choice Comparison



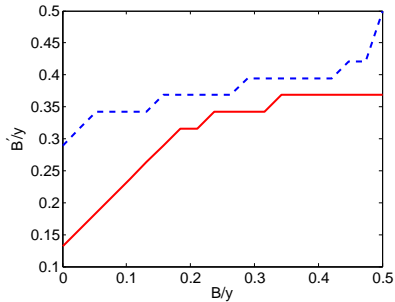
- Next period debt drops as reserves increase.
- It falls more rapidly in the exogenous SS case.

# Debt Choice Comparison

## Policy Function for Debt



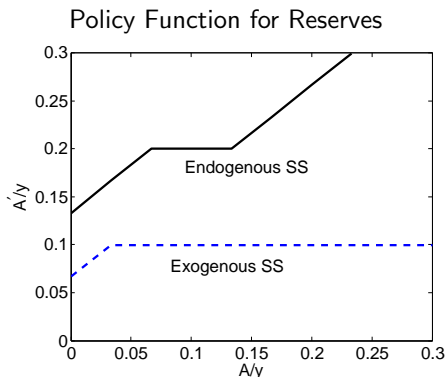
(a) Exogenous SS



(b) Endogenous SS

- Holding reserves reduces the next period debt levels.
- Difference is larger for the exogenous SS case.

# Reserve Choice Comparison



- The optimal level of reserves is higher when the sudden stop probability depends on reserves.

## Role of Default

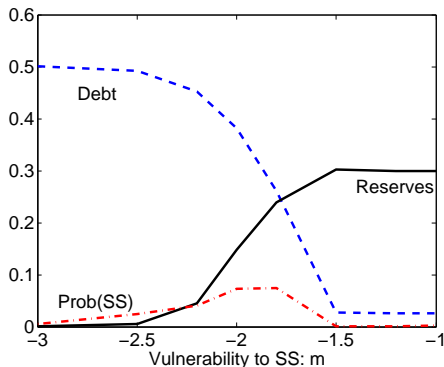
- Simulation Results with No Default Option

	No Default		Default Possible	
	Exogenous SS	Endogenous SS	Exogenous SS	Endogenous SS
mean(B/y)	30.01	0.00	36.32	26.20
mean(A/y)	0.00	3.36	1.74	24.01
prob(SS)	7.67	0.00	7.41	7.40

- Without limited enforcement, debt and reserves are substitutes. Only NFA position matters.
- Financing reserves by borrowing is more costly when default option is not available.
- With additional benefit of reserves in reducing the SS probability, the country reduces debt down to zero in no-default case.

# Sensitivity Analysis: Vulnerability to Sudden Stop

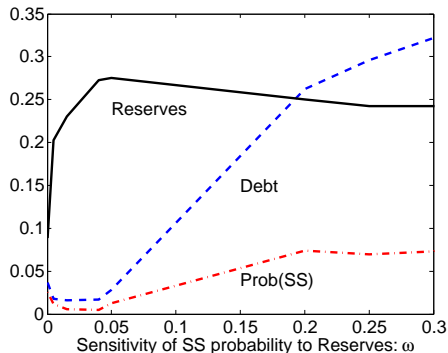
Optimal Reserves, Optimal Debt and SS probability



- More vulnerable countries tend to accumulate more reserves and less debt.

# Sensitivity Analysis: Effectiveness of reserve in reducing SS

Optimal Reserves, Optimal Debt and SS probability

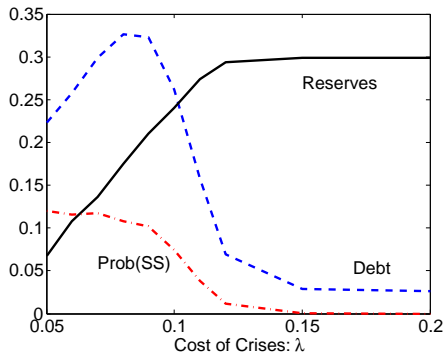


- Optimal reserves increase with  $\omega$ . The relationship is not monotonic, as a low probability of sudden stop can be achieved with less reserves for higher  $\omega$ .



# Sensitivity Analysis: Cost of Crises

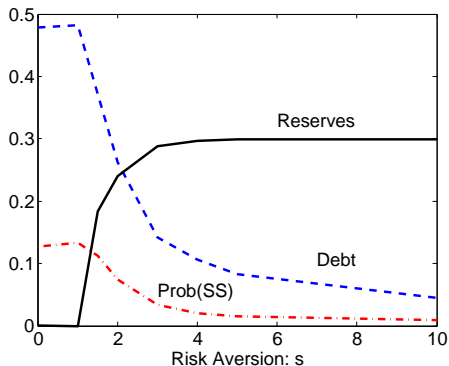
Optimal Reserves, Optimal Debt and SS probability



- The level of optimal reserves increases as output loss in crises becomes more severe.

# Sensitivity Analysis: Risk Aversion

Optimal Reserves, Optimal Debt and SS probability



- The level of optimal reserves increases as risk aversion increases, with milder impact for  $s$  larger than 3

# Model vs. Data

- Average reserves/GDP ratio is 23.3% in 2010 for 34 emerging market countries: Mostly in line with the model
- It is 35.5% in Asia. Seems excessive?
  - 42.5% in Malaysia, 52.6% in Thailand, 28.7% in Korea, 48.2% in China
- Hard to be justified even considering high output cost of the Asian Crisis in the late 1990s
  - Malaysia: 17%, Thailand: 17%, Korea: 14%
- There must be other reasons.

## Summary and Extensions

- A quantitative model with limited enforcement and sudden stop can generate levels of reserves and debt recently observed in data.
- Extension: Micro-foundation about sudden stop probability
  - Endogenize creditors' problems and explain sudden stops
- Extension: Private borrowing and reserves
  - It is often the private sector who has short-term foreign liabilities and who needs insurance. The government often steps in when a crisis is near or after a crisis occurs.
  - Dominguez (2011) shows, empirically, countries with higher private-sector liabilities hold greater reserves. However, the interplay between private external debt and government reserves has never been explored theoretically.
- Dynamic context