Global Financial Systems
Chapter 12
Currency Crisis Models

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Book and slides

- The tables and graphs are the same as in the book
- See the book for references to original data sources
- Updated versions of the slides can be downloaded from the book web page

www.globalfinancialsystems.org
1st Generation (1G) Currency Crisis Model
1G models

- Collapse of Bretton Woods in 1971 leads to an increase in the number of currency crises
- 1G models developed to explain crises of the late 70s and 80s. Continuing relevance
- The basic assumption is that a currency crisis stems from monetary or fiscal policy that is incompatible with a fixed exchange rate regime
- We study a simplified version of Flood and Garber (1984) who drew upon Krugman (1979)
- Specifically follow the implementation in Obstfeld and Rogoff (1996)
Money market equilibrium

There is a small open economy which employs a fixed exchange rate.

\[ m_t \quad \text{log domestic money supply} \]
\[ p_t \quad \text{log price level in domestic country} \]
\[ i_t \quad \text{domestic interest rate} \]

The real demand for money is a negative function of the domestic interest rate.

\[ m_t - p_t = -\alpha i_t \quad (1) \]

This gives the equilibrium condition in the money market.
## Central bank balance sheet

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net domestic currency bonds</td>
<td>Currency</td>
</tr>
<tr>
<td>Net foreign currency bonds</td>
<td>Required reserves</td>
</tr>
<tr>
<td>Net foreign currency reserves</td>
<td>Net worth</td>
</tr>
<tr>
<td>Gold</td>
<td></td>
</tr>
</tbody>
</table>

Simplified: \[ m_t = d_t + r_t \]  

Where

- \( d_t \) log domestic credit
- \( r_t \) log foreign exchange reserves
Money creation

- The government runs *persistent deficits*
- Which are financed by *money creation*

\[ \dot{d} = \mu \quad (3) \]

- Domestic credit is changing at a rate of \( \mu \)
- \( \mu \) is assumed to be *constant and strictly positive*
These are the no arbitrage conditions

\[ p_t = p_t^* + \log e_t \]  \hspace{1cm} (4)

\[ i_t = i_t^* + E_{t-1} \Delta \log e_t = \log e_t - \log e_{t-1} \]  \hspace{1cm} (5)

\[ \log e_t \]  log spot exchange rate (domestic/foreign)
**Currency peg**

- The exchange rate is fixed and equal to $\log \bar{e}$
- Substituting (2), (4), (5) into (1) leads to:

  $$r_t + d_t - p_t^* - \log \bar{e} = -\alpha(i_t^* + E_{t-1} \Delta \log e_t)$$  

  (6)

- By assumption, $\log \bar{e}$ is constant, $p_t^*$ and $i_t^*$ normalized to zero:

  $$\dot{r} + \dot{d} = 0$$  

  (7)

- From (3), we can write:

  $$d_t = d_0 + \mu t$$  

  (8)

- We assume that the government will support the fixed rate as long as its net reserves remain positive
Shadow exchange rate

• The *shadow exchange rate* is the rate that would prevail if the currency were allowed to *float*, denoted $\log \tilde{e}$

• Note:

$$\log \hat{e} = \mu = E_{t-1} \Delta \log e_t \quad (9)$$

• And, given $r = 0$, (1) becomes:

$$d_t - \log \tilde{e}_t = -\alpha(E_{t-1} \Delta \log e_t) \quad (10)$$

• Solving for the shadow exchange rate $\log \tilde{e}$:

$$\log \tilde{e}_t = \alpha \mu + d_t \quad (11)$$
Exchange rate

\[ \log \text{exchange rate, } e \]

\[ \log \bar{e} \]
Exchange rate

log exchange rate, $e$

log $\bar{e}$

Shadow rate $\tilde{e}_t$
Exchange rate

log exchange rate, $e$

log $\bar{e}$

Shadow rate $\tilde{e}_t$

Timing of attack $T$
Exchange rate

log exchange rate, $e$

log $\bar{e}$

Shadow rate $\tilde{e}_t$

actual exchange rate

$T$

time
Timing of attack

- A speculative attack happens *before* the CB exhausts its reserves.
- Otherwise, there would be a perfectly anticipated rise in the exchange rate, implying an infinite rate of capital gain, and therefore an arbitrage opportunity.
- Therefore, speculators will buy all the reserves *before*.
• The attack takes place when

\[ \log \tilde{e}_T = \log \bar{e} \]

• Speculators do not attack after, because at any such point there would be a discrete jump in the exchange rates implying *infinite profits*

• Speculators do not attack before because if they did, the currency would *appreciate* to the shadow rate resulting in a negative return.
Solving for time of attack

- Recall (8):
  \[ d_t = d_0 + \mu t \]

- Substitute for \( d_t \) in (11), and noting that at \( T \),
  \[ \log \tilde{e} = \log \bar{e} \]  
  \[ \log \bar{e} = \alpha \mu + d_0 + \mu T \]  
  (12)

- Solving for \( T \):
  \[ T = \frac{\log \bar{e} - d_0 - \alpha \mu}{\mu} \]  
  (13)
Money supply

log money supply, $m$

$log \text{ money supply, } m$

$T$
Summary

- Currency crises originate from domestic policies that are incompatible with a fixed exchange rate regime
- Not caused by speculators’ irrationality
- Timing of speculative attack is predictable
- There will be inflation after the peg is abandoned
- Model is reliant on strong assumptions, e.g. UIP, PPP and perfect foresight
Argentina
Argentina — Background

• Argentina was one of the richest countries until the middle of the last century, now on par with or below poorest countries in EU
• Experienced currency crises, hyperinflation, sovereign default in the second half of last century
• *High inflation rate* persisted until the early 90s
• In 1991 the government adopted a *currency board* at *parity* to the dollar
• Prices *stabilize* quickly and inflation is brought down rapidly
The peso depreciation

1st generation models

Argentina

Copeland 2G model

ERM

Global games

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Global Financial Systems © 2021 Jon Danielsson, page 22 of 76
**Inflation**

- 1st generation models
- Argentina
- Copeland 2G model
- ERM
- Global games

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>0%</td>
</tr>
<tr>
<td>1993</td>
<td>0%</td>
</tr>
<tr>
<td>1995</td>
<td>0%</td>
</tr>
<tr>
<td>1997</td>
<td>0%</td>
</tr>
<tr>
<td>1999</td>
<td>0%</td>
</tr>
<tr>
<td>2001</td>
<td>0%</td>
</tr>
</tbody>
</table>
The 90s

- With low inflation, Argentina saw *strong growth* in the 90s
- Persistent *budget deficits* and *fiscal problems* continued but were masked by the strong growth performance
- In the late 90s, Asia, Russia and Brazil were all hit by a crisis and reacted with a *devaluation* of their currencies
- At the same time the dollar *appreciated* strongly
- Making the Argentinean peso look *overvalued*
The crisis

• Debt as a ratio of GDP increased even in boom times
• *Growth* unsustainable
• Argentina plunges into recession in 1999 driven by *loss of export competitiveness* due to the overvalued peso
• The government facing an election responds by *increasing fiscal spending* (*AKA fiscal stimulus*)
• *Fiscal federalism* — regions borrow, center does now know or can’t control
• Recent echoes in e.g. Spain and China
• As growth stalls, the government resorts to expansionary fiscal policy causing the debt ratio to surge
• Investors get nervous and start pulling out capital
• As capital outflows increase, the government finds it difficult to service its debt
• Devaluation not an option due to the currency board
• Large part of the debt is denominated in dollars
• Government continues with expansionary fiscal policy, heading for disaster (Does this ring a bell?)
In late 2000 Argentina is unable to pay back its maturing debt and needs to ask the IMF for a loan.

IMF lends $17 billion but the situation does not improve.

The government is unwilling to reign in fiscal spending.

The IMF *withholds* a further loan in 2001 causing the government to default on $65 billion of its debt.

The currency board is *abandoned* a few weeks later.

The peso depreciates from parity to the dollar to a rate of 3.4:1.
Reasons

• Vulnerable to external shocks because fiscal policy *incompatible* with a fixed exchange rate regime

• The dollar peg *eliminated* monetary policy as an option and put strong *restrictions* on fiscal policy to keep debt sufficiently low to avoid an overvaluation of the peso

• Prudent fiscal policy was also important to maintain the *credibility* of the currency board (stimulus)

• The government never got its finances under control and when faced with a crisis, responded with an expansionary fiscal policy

• The fiscal policy of expansion was the result of political institutions pushing to commit more fiscal resources than they had
Classical 1G story

• Everybody knew it was unsustainable
• Government used up all reserves
• Markets anticipated drop
• Capital controls
• ADR market classic example of how agents bypass restrictions
Can the 1G model be applied to the current crisis?

- Original model was about gold, and basic intuition applies to many situations
- While the 1G currency model does not apply to most currency crisis
  - it has parallels with what is going on in Europe
  - for example Greece
- How can the model be applied here?
Copeland 2G Model
Multiple equilibria

- An attack can be *self–fulfilling* and independent of monetary policies
- What determines whether a currency will be attacked is *market sentiment*
- The success of attacks then becomes a *self–fulfilling* event
- We now look at a model by Copeland (2000)
Fixed rate $\bar{e}$

Government may wish to devalue

Reduce unemployment

Reduce CA deficit

Reduce foreign debt

These policies are summed up in $\hat{e}$, the desired exchange rate, which the government would choose were it not committed to the peg.
Cost of devaluation — high cost if peg is abandoned

- Political pain
- Loss of *credibility* of monetary authority
- International investors may demand *higher yields* in future
- This cost is summed up in the indicator function Cost(Δe)
- The function Cost(Δe) takes *two values*

\[
\text{Cost}(\Delta e) = \begin{cases} 
0 & \text{for } \Delta e = 0 \\
Q & \text{for } \Delta e > 0 
\end{cases}
\]

- A high level of Q makes it more costly and therefore less likely for the government to devalue
Cost of defense (UIP)

- Peg more costly to defend when a devaluation is expected
- Expectation leads to a rise in domestic interest rate
- Adverse impact on economy

\[ i = i^* + \mathbb{E}\left(\frac{\Delta e}{e}\right) \]
Government loss function

- The government aims to minimize the following loss function

\[ L = \{\psi(\hat{e} - \bar{e}) + \eta E(\Delta e)\}^2 + \text{Cost}(\Delta e) \quad \psi, \eta > 0 \]

- \( \psi(\hat{e} - \bar{e}) \) is the loss associated with overvaluation
- Focus on \( \hat{e} > \bar{e} \), government is only concerned with an overvaluation
- \( \eta E(\Delta e) \) is the loss associated with defending the peg with increasing interest rates
Two cases with two choices

Government is expected to defend

• \( E(\Delta e) = 0 \) the cost of defending is:

\[
\mathcal{L}_1 = \{\psi(\hat{e} - \bar{e})\}^2
\]

• In a rational expectations equilibrium, the government defends if:

\[
\mathcal{L}_1 < Q
\]
Two cases with two choices

Government is expected to abandon peg

- Government expected allow depreciation to \( \hat{e} \), the cost of defending becomes:

\[
\mathcal{L}_2 = \{(\psi + \eta)(\hat{e} - \bar{e})\}^2
\]

- Now the government chooses to devalue if:

\[
\mathcal{L}_2 > Q
\]
Multiple equilibria

$\mathcal{L}$

$\hat{e}$
Multiple equilibria
Multiple equilibria
Multiple equilibria

\[ L \]

\[ Q \]

\[ e \]

\[ L_1 \]

\[ L_2 \]

\[ e = \bar{e} \]

\[ A \]

\[ B \]
Multiple equilibria
Multiple equilibria
Intermediate fundamentals

• If \( \hat{e} \) lies between A and B, that is if \( \mathcal{L}_1 < Q < \mathcal{L}_2 \), there are **multiple equilibria**, the government finds it:
  • optimal to defend if the market expects the peg to be defended
  • optimal to abandon if the market expects the peg to be abandoned
• A speculative attack in these regions would be *self–fulfilling*
• Attack can succeed without any reference to the fundamentals
Self–fulfilling attack

Stable peg

Belief of stable peg

Hold

Depreciation

Belief of imminent attack

Sell
Fundamentals

• However, fundamentals are not completely irrelevant
• They determine the gap between \( \hat{e} \) and \( \bar{e} \), which determines how easy the government finds it to defend
• The difference between \( \hat{e} \) and \( \bar{e} \) determines also the slope of the loss function
• Fundamentals also affect the abandonment cost \( Q \)
• The higher \( Q \), the costlier it is for the government to devalue and the less likely that it will do so
The relevance of 2G models

- Existence of multiple equilibria has been questioned
- Consequence of common knowledge of fundamentals
- And common knowledge of actions in equilibrium
- Moreover, no convincing theory of shifts between equilibria
- Empirically, attacks occur mostly when fundamentals have already deteriorated
ERM Crisis 1992–1993
ERM System

- Part of the European Monetary System, precursor of the euro
- Essentially a target zone exchange rate regime
- The European Currency Unit (ECU), an artificial unit of account, was created
- Exchange rates for each currency against the ECU were established
- The system allowed a fluctuation band of ±2.25% around this central rate
- Member countries had to intervene to ensure their currencies stayed within the band
Dominant role of Germany

- Effectively, the bands were maintained against the *most stable currency*, the Deutschmark (*DM*), which became the unofficial *reserve currency*

- The Bundesbank was *supposed* to lend DM to countries whose currencies came under depreciatory pressure

- Therefore, Germany was the only country with *discretion* over its own monetary policy
Reunification of Germany

- Amalgamation of a large rich economy with a smaller poorer economy
- Germany embarked on a massive *fiscal expansion* to transfer resources to the east
- East German marks were converted to DM at a rate of *1.8:1*
- The government deficit rose from 5% to 13.2%
- Bundesbank concerned about high inflation pursued a *contractionary* monetary policy, by raising interest rates
Adverse impacts

- High interest rates and *appreciation* of DM hurt other countries
- *UK* was in a recession, with unemployment levels over 10%
- Same was true of *Italy, Spain, Sweden*
- Those countries *couldn’t* use expansionary monetary policy or a weaker currency to stimulate their economy
- Speculators figured the system was not *sustainable*
Speculative attacks

- September 16, 1992 is nicknamed “Black Wednesday”
- In the morning, BoE raised rates from 10% to 12%, a few hours later, to 15% but could not stop the massive selling of pounds
- Eventual loss for the UK of £3.3 billion
- Sterling left the ERM that evening, followed by the Italian lira
- Eventually, on August 3, 1993, the size of the bands were widened from ±2.25% to ±15%
- Basically a free float
2G explanation

- Market sentiment gradually turned and was casting doubt whether governments would stay firmly committed to the ERM
- Governments were *weighting* the costs involved in staying in the ERM (loss of monetary independence) against the benefits (monetary union)
- Investors started to believe that the costs for some governments in the ERM had become too high and they were no longer committed to the peg
- Countries with the *weakest fundamentals* were the first to be attacked and the first to abandon the ERM
Parallels with today

1. Devalue
   • The countries that devalued/left were in a recession
   • Devaluation helped them to recover
   • Is that needed today?

2. Be stable
   • Currency crises and devaluations and inflation costly
   • Stability valuable
   • Hence common currency
Global Games
Global games models

- Speculators have an uncertain signal about the fundamentals
- This delivers unique equilibria
Setup

net benefit to government of holding peg

\[ B(\theta, \ell) \]

- \( \theta \) is underlying strength of economy
- \( \ell \) is proportion of speculators who attack
- For concreteness,
  \[ B(\theta, \ell) = \theta - \ell \]
- So, peg abandoned if and only if
  \[ \theta < \ell \]
Survival of regime

- When $\theta < 0$, peg *fails irrespective* of speculators’ actions
- When $\theta \geq 1$, peg *survives irrespective* of speculators’ actions
- When $0 < \theta \leq 1$, the peg is “ripe for attack”
- Peg is abandoned if and only if
  \[ \theta < \ell \]
- i.e. a *sufficiently large* speculative attack is launched
Speculators’ choices

• Speculators, indexed by $[0, 1]$
• Two actions: *attack*, *refrain*
• Payoff to refrain is zero
• Cost of attack is $t$, but profit from collapse of peg is 1
• So, payoff to attack depends on
  • state $\theta$
  • proportion $\ell$ of creditors who attack

\[ v(\theta, \ell) = \begin{cases} 
1 - t & \text{if } \ell > \theta \\
-t & \text{if } \ell \leq \theta 
\end{cases} \]

• Coordination problem when $\theta \in (0, 1)$
Fundamental signal

- $\theta$ uniformly distributed
- Noisy signal
  \[ x_i = \theta + s_i \]
  $s_i$ uniformly distributed over $[-\varepsilon, \varepsilon]$
- Posterior distribution over $\theta$ conditional on $x_i$ is uniform over
  \[ [x_i - \varepsilon, x_i + \varepsilon] \]
- Strategies
  \[ x_i \mapsto \{ \text{Attack, Refrain} \} \]
Solution

- Solving for unique equilibrium in switching strategies around $x^*$
  - Failure point $\theta^*$ depends on switching point $x^*$
  - Switching point $x^*$ depends on failure point $\theta^*$
• Failure point $\theta^*$ solves $\theta = \ell$.

• If all follow $x^*$-switching, $\ell$ is the proportion whose signal is below $x^*$ when the true state is $\theta^*$

$$\ell = \frac{x^* - (\theta^* - \varepsilon)}{2\varepsilon}$$

• So, $\theta^* = \ell$ if and only if

$$\theta^* = \frac{x^* - (\theta^* - \varepsilon)}{2\varepsilon} \quad \text{(Eq 1)}$$
At switching point $x^*$, a speculator is indifferent between attack and refrain

$$
\Pr(\text{peg fails}|x^*)(1 - t) + \Pr(\text{peg stays}|x^*)(-t) = \Pr(\text{peg fails}|x^*) - t
$$

$$
= 0
$$
• Peg fails iff $\theta < \theta^*$. So

$$\Pr(\theta < \theta^* | x^*) = t$$

$$\frac{\theta^* - (x^* - \varepsilon)}{2\varepsilon} = t \quad \text{(Eq 2)}$$

• Two equations in two unknowns - $\theta^*, x^*$. Solving,

$$\theta^* = 1 - t$$

$$x^* = 1 - t - \varepsilon (2t - 1)$$

• As $\varepsilon \rightarrow 0$, $x^* \rightarrow \theta^*$
Verification of solution

- When $x_i < x^*$, speculator wants to attack.
- When $x_i > x^*$, speculator wants to refrain.
- Say $x_i < x^*$.

\[
\Pr \left( \text{peg fails} \mid x_i \right) = \frac{\theta^* - (x_i - \varepsilon)}{2\varepsilon} > \frac{\theta^* - (x^* - \varepsilon)}{2\varepsilon} = \Pr \left( \text{peg fails} \mid x^* \right)
\]

- And conversely for when $x_i > x^*$
- Switching strategy around $x^*$ is equilibrium.
- In fact, it’s the unique equilibrium.
Dimensions of debate

- Multiple equilibria
- Externalities, inefficiencies
- Sudden, precipitous changes
- Outcome correlated with fundamentals
Strategic/fundamental uncertainty

• Distinction between *fundamental uncertainty* and *strategic uncertainty*

• In equilibrium of currency attack model,

\[
\theta^* = 1 - t \\
x^* = 1 - t - \varepsilon (2t - 1)
\]

• As \(\varepsilon \to 0\), \(x^* \to \theta^*\).

• Fundamental uncertainty disappears as \(\varepsilon \to 0\). However, there is still uniqueness of equilibrium (difference between \(\varepsilon = 0\) and limit as \(\varepsilon \to 0\))

• Why?
What happens to strategic uncertainty as \( \varepsilon \to 0 \)?

- Consider the following question

  **Question.** My signal is exactly \( x^* \). What is the probability that proportion \( \ell \) or less of the speculators are attacking the currency?

- The answer to this question is important, since the fact that I am indifferent between attacking and not attacking is due to uncertainty about the incidence of attack

- My reasoning must take account of:
  - My uncertainty over true state \( \theta \)
  - My uncertainty over incidence of attack
Two steps to answer the question

- Step 1. If the true state $\theta$ is higher than some benchmark level $\hat{\theta}$, then the proportion of speculators receiving signal lower than $x^*$ is $\ell$ or less. This benchmark state $\hat{\theta}$ satisfies:

$$x^* - \left( \frac{\hat{\theta} - \varepsilon}{2\varepsilon} \right) = \ell$$

Or

$$\hat{\theta} = x^* + \varepsilon - 2\varepsilon\ell$$
• Step 2. So, the answer to the question is given by the probability that the true state is higher than $\hat{\theta}$, conditional on signal $x^*$. This is,

\[
\frac{(x^* + \varepsilon) - \hat{\theta}}{2\varepsilon} = \frac{(x^* + \varepsilon) - (x^* + \varepsilon - 2\varepsilon \ell)}{2\varepsilon} = \ell
\]
Incidence of attack

the proportion of speculators who attack

• The cumulative distribution function over the incidence of attack is the identity function

• ⇒ density function over the incidence of attack is *uniform* over \([0, 1]\)

• How is this answer affected by the size of the noise \(\varepsilon\)?
• Not at all!!

• ⇒ As \(\varepsilon \to 0\), the uncertainty concerning \(\theta\) dissipates, but the strategic uncertainty is as severe as ever
Transparency and disclosure

- What are the effects of more precise public information concerning $\theta$?
- Debate on transparency and disclosures hinges on this
- No universal answers
- When fundamentals are weak, greater public disclosure of $\theta$ increases probability of attack
  - strategic uncertainty dissipates - makes coordinated attack easier
  - fundamental uncertainty also dissipates - increases incentive for attack
Examples

“Constructive ambiguity”

- Thailand 1997
- Rescue of LTCM, 1998
- Lehman’s 2008
- Liquidity support in 2008
- LTRO
- Greece 2012
Disclosure strategies

• When fundamentals are strong, greater public disclosure of $\theta$ decreases probability of attack
  • strategic uncertainty dissipates - coordinated pull back from attack
  • fundamental uncertainty also dissipates - increases incentive to refrain from attack

Note: difference between ex ante decisions on disclosures and opportunistic disclosures