Global Financial Systems
Chapter 12
Currency Crisis Models

Jon Danielsson London School of Economics
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To accompany
Global Financial Systems: Stability and Risk
http://www.globalfinancialsystems.org/
Published by Pearson 2013
Version 1.0, August 2013
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
$1^\text{st}$ 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.

\[ m_t \quad \log \text{domestic money supply} \]

\[ p_t \quad \log \text{price level in domestic country} \]

\[ i_t \quad \text{domestic interest rate} \]

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: \[ m_t = d_t + r_t \] (2)

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*
PPP and UIP

These are the no arbitrage conditions

\[ p_t = p_t^* + \log e_t \]
\[ i_t = i_t^* + E_{t-1} \Delta \log e_t = \log e_t - \log e_{t-1} \] (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:
  \[ \log \dot{e} = \mu = E_{t-1} \Delta \log e_t \]  
  \[ (9) \]
- And, given $r = 0$, (1) becomes:
  \[ d_t - \log \tilde{e}_t = -\alpha (E_{t-1} \Delta \log e_t) \]  
  \[ (10) \]
- Solving for the shadow exchange rate $\log \tilde{e}$:
  \[ \log \tilde{e}_t = \alpha \mu + d_t \]  
  \[ (11) \]
Exchange rate

$log \text{ exchange rate}, \ e$

$log \bar{e}$

time
Exchange rate

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

\[ \log \bar{e} \]

Shadow rate \( \tilde{e}_t \)
Exchange rate

log exchange rate, $e$

$\text{log } e$

Shadow rate $\tilde{e}_t$

Timing of attack

$T$
Exchange rate

log exchange rate, $e$

log $\bar{e}$

Shadow rate $\bar{e}_t$

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 \( T \), \( \log \tilde{e} = \log \bar{e} \):

\[ \log \bar{e} = \alpha \mu + d_0 + \mu T \quad (12) \]

• Solving for \( T \):

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

log money supply, $m$

- $m_T$
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
Inflation

1991 1993 1995 1997 1999 2001
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).
Desired exchange rate

- 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 $\text{Cost}(\Delta e)$
- The function $\text{Cost}(\Delta e)$ 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)

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

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

• The government aims to minimize the following loss function

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

• \( \psi(\hat{e} - \bar{e}) \) is the loss associated with overvaluation
• Focus on \( \hat{e} > \bar{e} \), government is only concerned with an overvaluation
• \( \eta \mathbb{E}(\Delta e) \) 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:
  \[
  L_1 = \{\psi(\hat{e} - \bar{e})\}^2
  \]

- In a rational expectations equilibrium, the government defends if:
  \[
  L_1 < Q
  \]
Two cases with two choices

Government is expected to abandon peg

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

$$L_2 = \{(\psi + \eta)(\hat{e} - \bar{e})\}^2$$

- Now the government chooses to devalue if:

$$L_2 > Q$$
Multiple equilibria

$\mathcal{L}$

$\hat{e}$
Multiple equilibria

\[ \mathcal{L} \]

\[ Q \]

\[ \bar{e} \]
Multiple equilibria

\[ \mathcal{L} \]

\[ Q \]

\[ \bar{e} \]

\[ \hat{e} \]

\[ \mathcal{L}_1 \]
Multiple equilibria
Multiple equilibria

\[ Q = \bar{e} \]

\[ \mathcal{L}_1 \]

\[ \mathcal{L}_2 \]

Defend

\[ \bar{e} \]
Multiple equilibria

\[ \mathcal{L} \]

\[ Q \]

Defend

Abandon

\[ \bar{e} \]

\[ L_1 \]

\[ L_2 \]

?
Intermediate fundamentals

- If $\hat{e}$ lies between A and B, that is if $L_1 < Q < L_2$, 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
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
  \[ x_i \leftrightarrow \{ \text{Attack, Refrain} \} \]
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

\[
\Pr (\text{peg fails}|x^*) (1 - t) + \Pr (\text{peg stays}|x^*) (-t) \\
= \Pr (\text{peg fails}|x^*) - t \\
= 0
\]
\begin{itemize}
  \item Peg fails iff $\theta < \theta^*$. So
  \[
  \Pr (\theta < \theta^* | x^*) = t
  \]
  \[
  \frac{\theta^* - (x^* - \varepsilon)}{2\varepsilon} = t \tag{Eq 2}
  \]
  \item Two equations in two unknowns - $\theta^*, x^*$. Solving,
  \[
  \theta^* = 1 - t
  \]
  \[
  x^* = 1 - t - \varepsilon (2t - 1)
  \]
  \item As $\varepsilon \to 0$, $x^* \to \theta^*$
\end{itemize}
Verification of solution

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

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

- 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:

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

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

• $\Rightarrow$ density function over the incidence of attack is \textit{uniform} over $[0, 1]$

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

• $\Rightarrow$ 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