PRINCETON UNIVERSITY
Economics Department
Bendheim Center for Finance

**FINANCIAL CRISES
ECO 575 (Part II)**

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Section 4: Currency Crises

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(All materials available on my website:
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1. Introduction

During the period 1945-1971

- Banking crises were virtually eliminated.

- Currency crises did occur when government economic policies were inconsistent with fixed exchange rates.

The fact that currency crises during this period were the result of government mismanagement led to a very different philosophy than the literature on banking crises. Governments were viewed as the problem. In contrast in the banking crisis literature they were viewed as the solution.

Section 4.2 develops models that were developed to explain pure currency crises of the type that were observed in the period 1945-1971 and subsequently where government policy is inconsistent with a fixed exchange rate.

There are two generations of currency crisis model:

First generation:

Designed to explain currency crises such as Mexico 1973-82, e.g. Krugman (1979)

Shows how a fixed exchange rate plus expansionary pre-crisis fundamentals leads to a currency crisis

Second generation:
Designed to show how speculative attacks such as those in Europe in the early 1990's can occur, e.g. Obstfeld (1996)

Shows how a conditional government policy can lead to multiple equilibria – one without a speculative attack and one with a speculative attack

But what determines which equilibrium occurs?

Morris and Shin (1998) show how a lack of common knowledge can lead to uniqueness of equilibrium.

A survey of currency crises is contained in Flood and Marion (1998). See also Jeanne (2000) for a nice theoretical summary.

Both before and after 1945-1971, banking crises have been common. Often currency crises and banking crises occur together.

Kaminsky and Reinhart (1999) have investigated the relationship between currency crises and banking crises, which they term "twin crises"

- In the 1970's when financial systems were highly regulated currency crises were not accompanied by banking crises

- After the financial liberalizations that occurred in the 1980's currency crises and banking crises have become intertwined

- The usual sequence is that banking sector problems are followed by a currency crisis and this further exacerbates the banking crisis

Kaminsky and Reinhart find that the twin crises are related to weak economic fundamentals. Crises when fundamentals are sound are rare.

Section 4.3 considers models of twin crises.

- Given Kaminsky and Reinhart's finding that twin crises tend to occur when fundamentals are weak it would seem that the fundamental based or business cycle view has some applicability here.

Section 4.3 therefore starts with a fundamental based analysis, or in the terminology of the previous section, a business cycle view of banking crises and currency crises that extends the banking crisis model of Allen and Gale (1998).

- It develops a version of the model from Allen and Gale (2000) with an international bond market and considers the relationship between banking and currency crises

- Initially a closed economy is considered as a benchmark and international finance is incorporated subsequently

There are also examples of twin crises where it is difficult to identify changes in fundamentals. The model of Chang and Velasco (2000) also develops a model of twin crises but this is based on a multiple equilibrium analysis.

2. Macroeconomic Policies and Exchange Rates

2.1 First Generation Models

Salant and Henderson (1978) analyzed how the price of gold is determined when governments may intervene.

The Standard Hotelling Analysis

Competitive firms with zero extraction costs extract gold

There is a known fixed stock the firms are extracting

Consumers have a downward sloping demand curve each period that depends on the price of gold. There is a "choke" price P^c above which demand is zero.

In equilibrium the price of gold $P(t)$ must increase at the rate of interest. Otherwise the firms extracting the gold would be able to change their production decisions to increase the present value of extracting the gold.
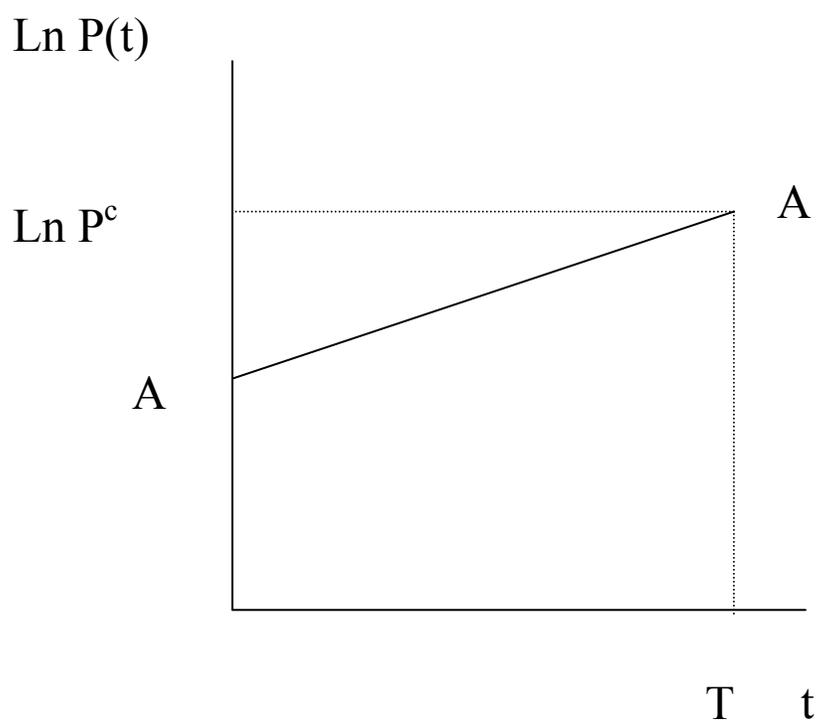
The terminal conditions are that

$$S(T) = 0$$

$$P(T) = P^c$$

where T is the final date such that the supply is just exhausted given the demand curve of consumers and $P(t)$. These terminal conditions tie down $P(0)$ and the price path.

$$P(t) = P(0)e^{rt}$$

Taking natural logs we get

$$Ln\ P(t) = Ln\ P(0) + rt$$

Ln P(t)

Ln P^c

A

A

T   t

This is how the simplest theory predicts prices will adjust. Salant and Henderson pointed out that in practice prices did not behave like this. In the 1970's they had risen and then collapsed risen and collapsed several times.

They developed a theory based on the uncertain possibility of government auctions of gold.

In this case there is a possibility that the supply of gold will be increased randomly in which case the price will fall and will follow the new path reflecting the increase in supply.

The line BB below shows how the price moves now assuming no sale takes place. It rises at a faster rate than AA to compensate for the possibility the price will fall.

Ln P(t)

B

Ln P^c .... A

A

B

T   t
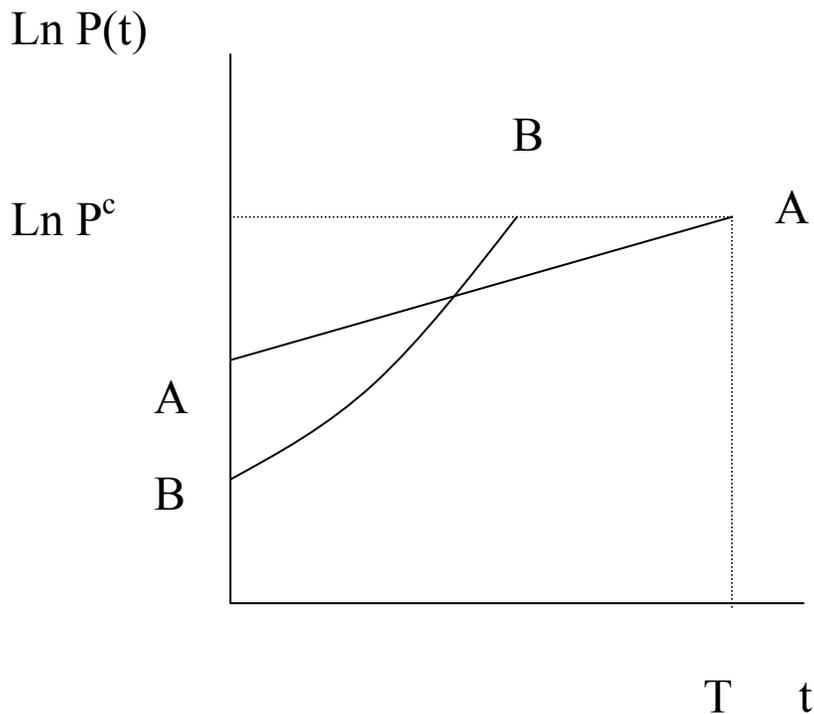
Finally, the curve CC shows what it would fall to if the government announced its auction and the supply increased. In other words it is the line representing the new P(0) given the new supply which is the sum of the current supply and the amount to be auctioned.
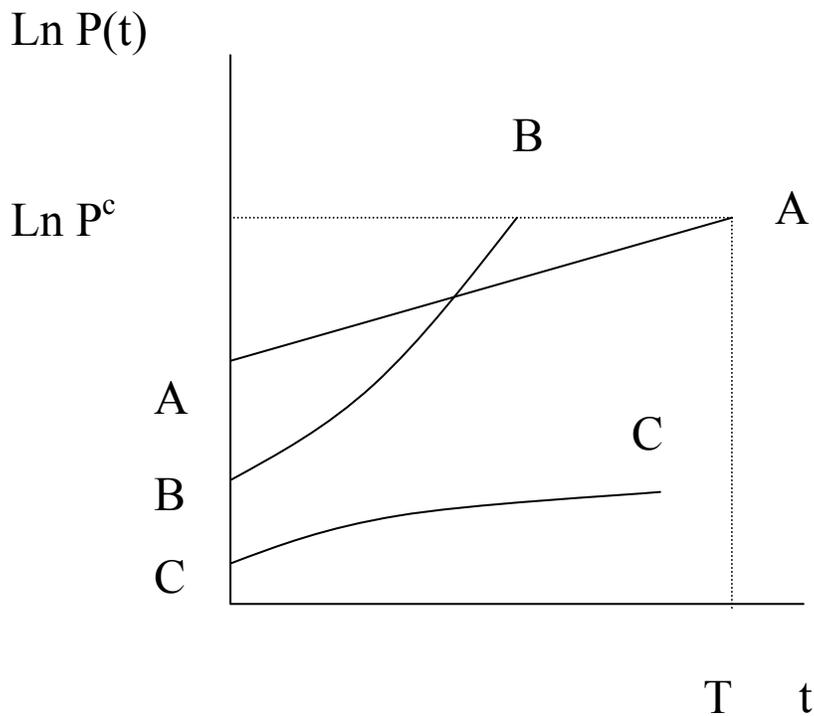
This theory can then explain the pattern of gold price drops and so forth that were observed in the 1970's. Salant and Henderson document that they occurred when announcements of gold sales were made.

For our purpose the more interesting part of the analysis is what happens if there is a price peg.

Suppose the government announces they will peg the price at P^* and there is no private supply. They can use their reserves to do this. However, if gold demand is positive at the pegged price (i.e. it is below P^c) they will eventually run out and the price will rise to P^c.

Ln P(t)

Ln P^c

P^*

T   t
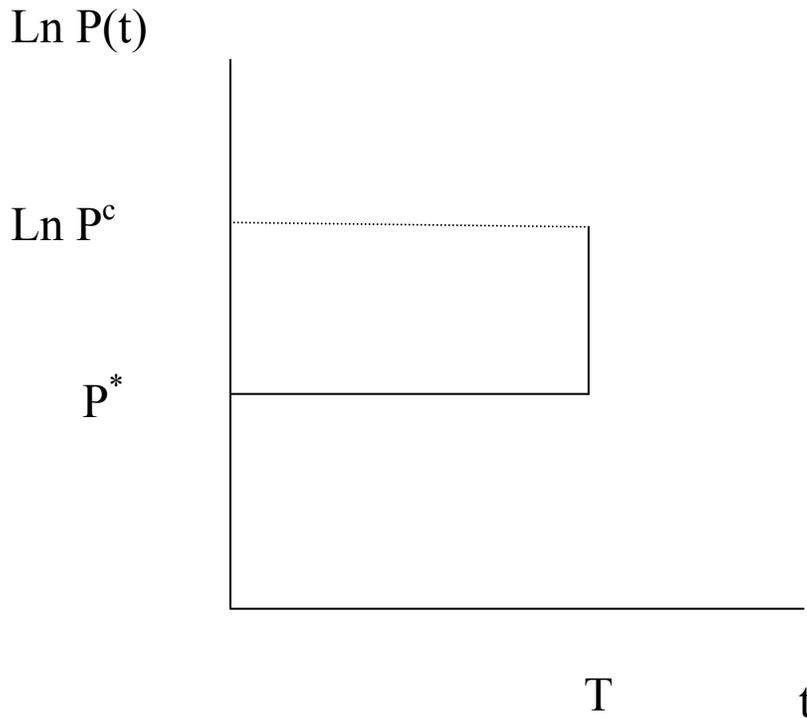
The price path shown can't be an equilibrium. Just before the government ran out of supplies of gold it would obviously pay to buy some gold and hold it. When the price jumped to P^c it would be possible to make a speculative profit.

The price must start rising before T. In fact the only price path that is an equilibrium is shown below.

Ln P(t)

Ln P^c

P

T'

t
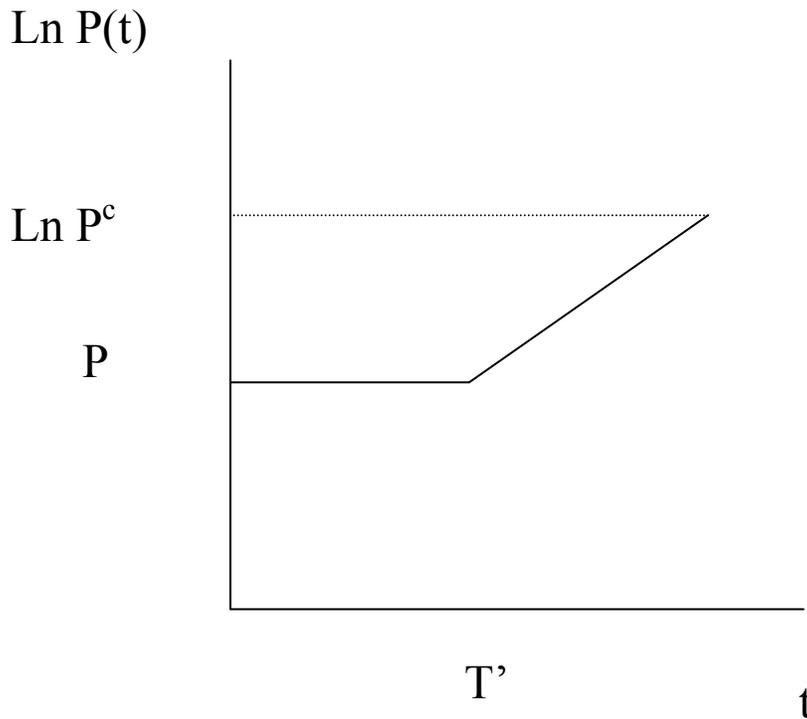
At time T' there is a speculative attack. All the government's gold reserves are depleted by speculators. Then the speculators supply the gold to the market at the market price.

T' is quite predictable. It is precisely the time such that if an attack takes place the price will rise at the rate of interest and exhaust demand when it hits P^c.

Krugman's model

Krugman (1979) realized that this analysis could be applied to currency crises. He developed a simple macroeconomic model.

There is a single consumption good. This is produced in the country and overseas.

There is purchasing power parity.

Units are chosen so that the price of the consumption good in foreign currency is 1

The domestic price of consumption is P units of domestic currency

$$P = S$$

where S is the exchange rate.
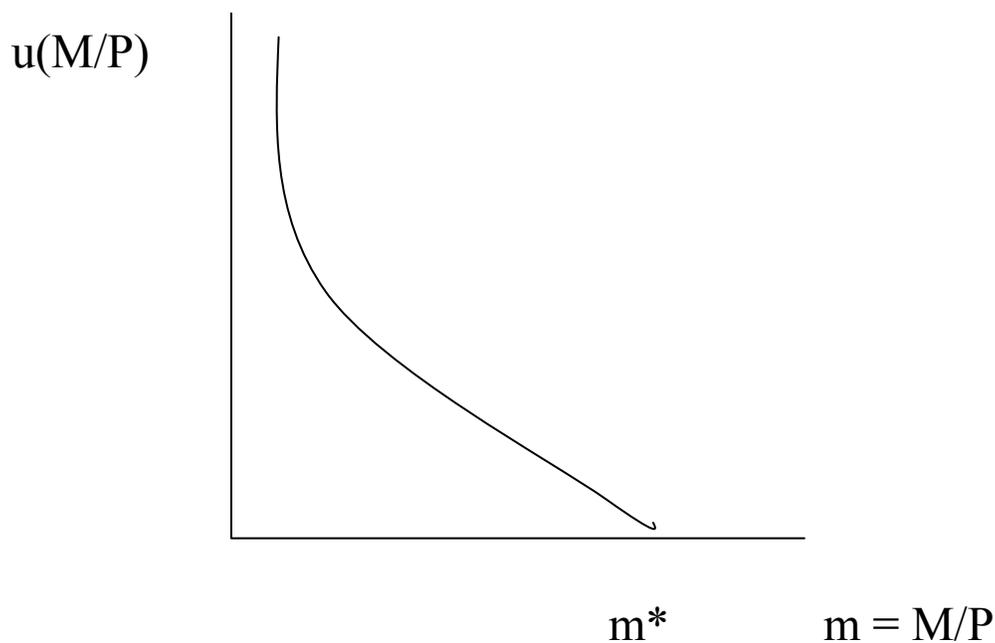
Individuals have two assets:

- Domestic money M with real value M/P

- Foreign currency F

Hence their wealth is

$$W = \frac{M}{P} + F$$

For simplicity, we assume domestic residents are the only people who hold domestic currency.

The reason they hold domestic currency is that it provides them with transaction services which are equivalent to a rate of return u(M/P).

u(M/P)

m*   m = M/P

Beyond the intercept m* they receive no extra services on the margin from holding money.

The government spends G.

The taxes the government raises are T.

It is assumed there is a government deficit so that

$$G > T$$

It is also assumed that the government cannot borrow or is unwilling to borrow what is required to cover the deficit.

How then can the government cover the government deficit?

- It can increase M and raise P so that there is inflation and hence an "inflation tax".

- Because of the inflation the exchange rate s goes up.

Similarly to the price of gold growing over time, there is an exchange rate over time such that the inflation tax is just enough to cover the government deficit.

S(t)

t
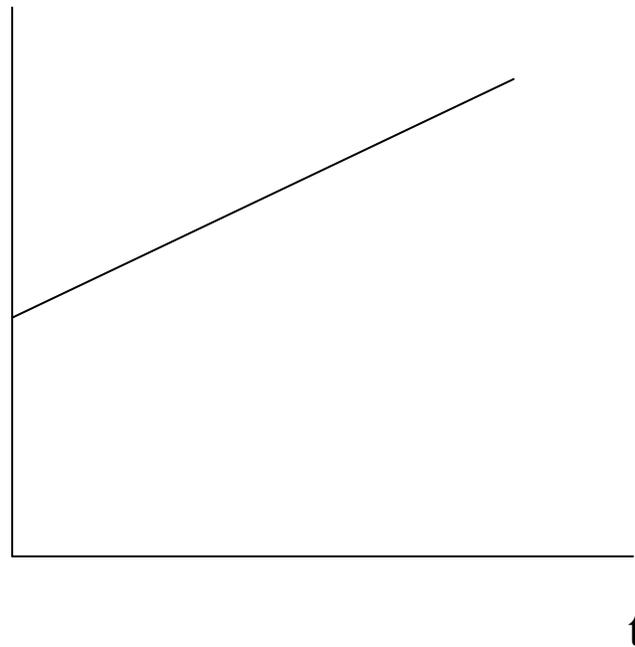
This gives the "shadow exchange rate" (see Flood and Garber (1984)) through time.

- Individuals adjust their portfolios so the real amount of money that they have equates the marginal rate of transaction services to the rate of depreciation.

- This makes them indifferent on the margin to holding foreign currency with zero rate of return and domestic currency that is depreciating.

Pegging the Exchange Rate

Now suppose the government uses its foreign exchange reserves to peg the exchange rate at some level.

- Just as in the case of gold it will need to continuously supply reserves to the market.

- The government is effectively covering its deficit from its foreign exchange reserves.

While the exchange rate is pegged there is no depreciation relative to the foreign currency.

- Therefore residents will hold enough domestic money so that the marginal transaction services are zero.

- Their money holdings will be equal to or above m*.

Eventually the government will run out of reserves.

- The exchange rate will revert to the "shadow exchange rate" as the government has to cover its deficit through an inflation tax.

- This will require a portfolio adjustment where domestic residents switch from domestic currency to foreign currency in order to equate the marginal transaction services with the rate of inflation.

Suppose this portfolio adjustment takes place at the date reserves run out. The exchange rate must jump when the large supply of domestic currency is sold.

S(t)

T   t
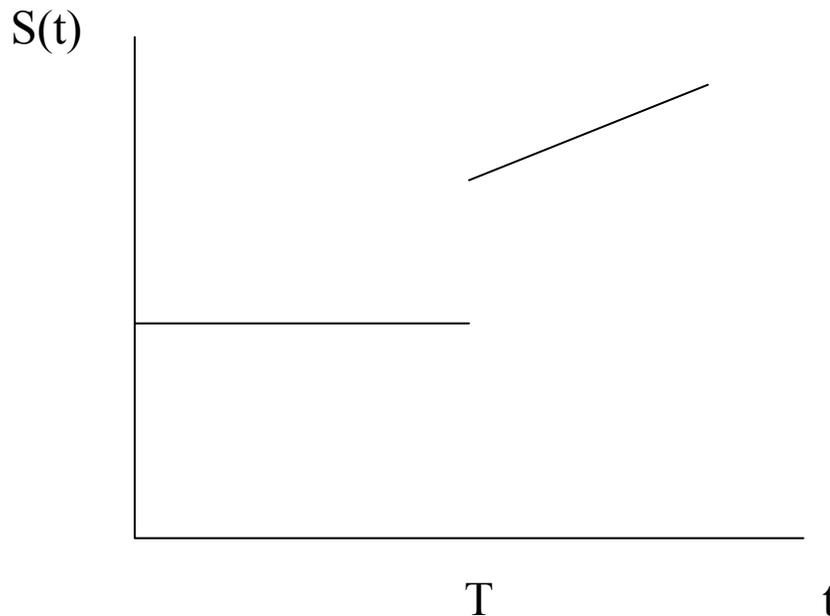
However, this can't be an equilibrium as it would clearly be better to do the portfolio adjustment just before date T when the price of foreign currency is lower.

In equilibrium there will be some date T' when the aggregate foreign reserves are just equal to aggregate portfolio adjustment.

- At date T' there will be a speculative attack on the government's reserves.

- The reserves will be instantaneously depleted and the exchange rate will start to change as the government covers its deficit with the inflation tax.

S(t)

T'   t
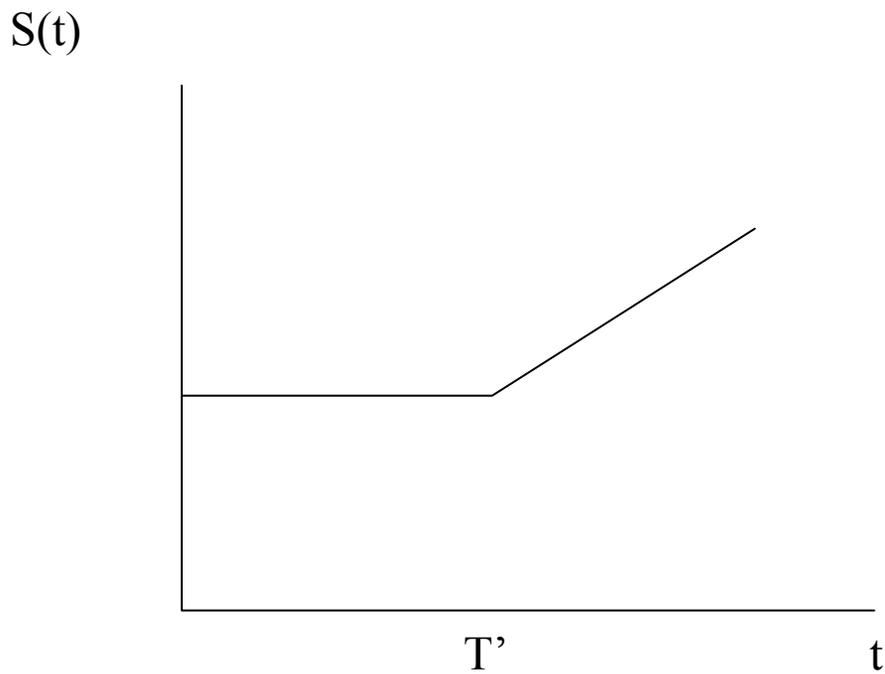
Just as with pegging the gold price there is a rational and predictable run on reserves that depletes them entirely and then the exchange rate resumes its change.

This was an important development in terms of understanding why currency crises occur when governments are running deficits.

However, there were a number of issues that arose

- The timing of exchange rate crises appears to be very unpredictable.

- When they do occur there are often jumps in exchange rates.

- The government's actions are taken as exogenous but aren't they concerned about running persistent deficits?

- In the ERM crisis in 1992 when the pound and the lira dropped out of the exchange rate mechanism it seemed difficult to explain what had happened in terms of first generation models.

- This lead to the development of second generation models.

2.2 Second Generation Models

The basic point in second generation models is that the extent to which the government is prepared to fight the speculators is endogenous. This can lead to multiple equilibria.

Obstfeld (1996) gives the following simple example to illustrate the point.

There are three agents

- A government that sells reserves to fix it currency's exchange rate.

- Two private holders of domestic currency who can continue to hold it or who can sell it to the government for foreign currency.

Each trader has reserves of 6.

Transactions costs of trading are 1.

If the government runs out of reserves it is forced to devalue by 50 percent.

The High Reserve Game: Government Reserves = 20

		Trader 2	
		Hold	Sell
Trader 1	Hold	0, 0	0, -1
	Sell	-1, 0	-1, -1

Here there is no devaluation because the government doesn't run out of reserves. Hence if either trader sells they simply bear the transaction costs.

The unique equilibrium is (0, 0).

<u>The Low Reserve Game: Government Reserves = 6</u>

		Trader 2	
		Hold	Sell
Trader 1	Hold	0, 0	0, 2
	Sell	2, 0	½, ½

Here either trader can force the government to run out of reserves.

If one trader sells then there is devaluation by 50 percent because reserves run out. The speculator selling makes a gross profit of

$$0.5 \text{ x } 6 = 3$$

After transaction costs of 1 the net profit is

$$3 - 1 = 2$$

If both sell they each get half of the reserves and so the net profit is

$$0.5 \text{ x } 0.5 \text{ x } 6 - 1 = \text{½}$$

The unique equilibrium is (½, ½)

<u>The Intermediate Reserve Game: Government Reserves =</u>
<u>10</u>

		Trader 2	
		Hold	Sell
Trader 1	Hold	0, 0	0, -1
	Sell	-1, 0	3/2, 3/2

Here a single trader cannot force the government to run out of reserves. Both traders need to sell for a devaluation to occur.

If one trader sells then they simply lose the transactions costs and have a payoff of -1.

If both sell there is devaluation by 50 percent because reserves run out. Each speculator receives half of the reserves and so the net profit is

$$0.5 \text{ x } 0.5 \text{ x } 10 - 1 = 3/2$$

There are two equilibria.

- (0, 0)

- (3/2, 3/2)

The key issue then becomes which equilibrium occurs? One way of proceeding is to use the Morris and Shin (1998) equilibrium selection methodology

Other more complicated models can be built which consider government trade-offs of unemployment versus inflation that endogenize whether it is desirable to fight the speculators (see Obstfeld (1994) and (1996)).

We will consider the equilibrium selection mechanism next.

2.3 The Morris-Shin Equilibrium Selection Mechanism in Second Generation Currency Crisis Models

The second generation currency crisis models such as Obstfeld (1996) incorporate a government objective with costs and benefits to maintaining a currency peg.

- To maintain a peg it may be necessary to spend reserves and raise interest rates to high levels. This may have a very damaging effect in terms of low investment, corporate bankruptcy, falling asset prices, stress on financial intermediaries and unemployment.

- At some point the costs will outweigh the perceived benefits and the peg will be abandoned.

The costs will depend on the number of speculators that join in the attack on the currency. This raises the possibility of multiple equilibria as the simple example above illustrated.

- If speculators attack the costs outweigh the benefits and the peg is abandoned.

- If speculators don't attack the costs are lower than the benefits and the peg survives.

The critical issue is then what determines which equilibrium occurs. Sunspots provide one answer. Morris and Shin's(1998) contribution was to show that lack of common knowledge could be used.

The Model

The state of the economy is characterized by the fundamentals θ

θ is uniformly distributed on $[0, 1]$

The floating exchange rate that would occur in the absence of government intervention is $f(\theta)$ where $f'(\theta) > 0$.

The government's objective is to peg the exchange rate at e* where

$$e^* \geq f(\theta) \text{ for all } \theta$$

Government:

Depending on the cost and benefits it will choose to defend or not defend the peg

- Value from maintaining the peg at e* is v

- Cost of defending the peg is $c(\alpha, \theta)$ where α is the proportion of speculators attacking in state θ where $c_\alpha > 0$ and $c_\theta < 0$.

    Payoff to defending the peg $= v - c(\alpha, \theta)$

    Payoff to abandoning the peg $= 0$

The following assumptions are made about $c(\alpha,\theta)$ and v

c(α, θ)

c(1, θ)

v

c(0, θ)

0   θ_L 1 θ
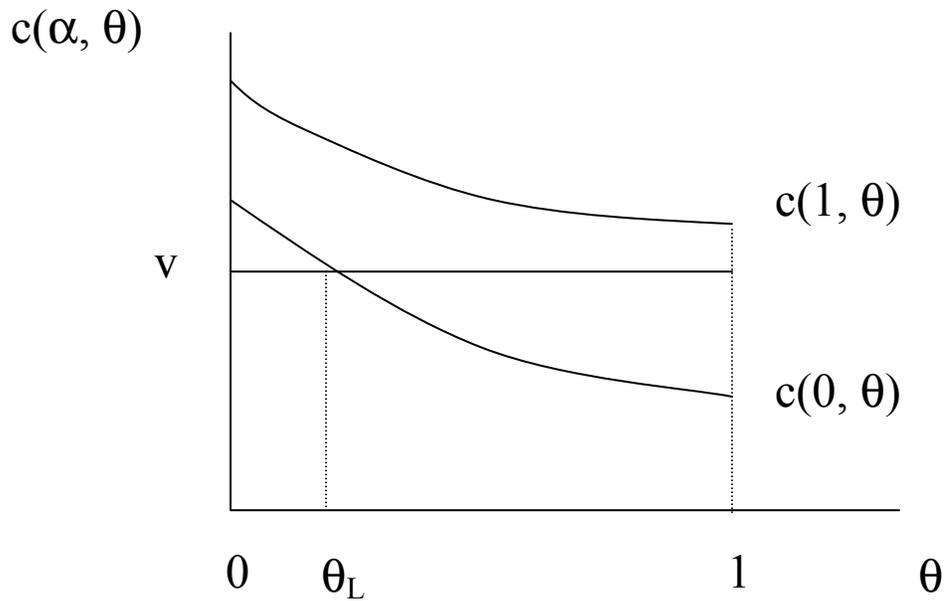
c(0, 0) > 0

c(1, 1) > 0

Note that for $\theta < \theta_L$ it is not worth defending the exchange rate since $v < c(\alpha, \theta)$ and the peg is unstable.

Speculators:

Two actions are available to them

- Attack by short selling 1 unit of the currency for transaction cost t
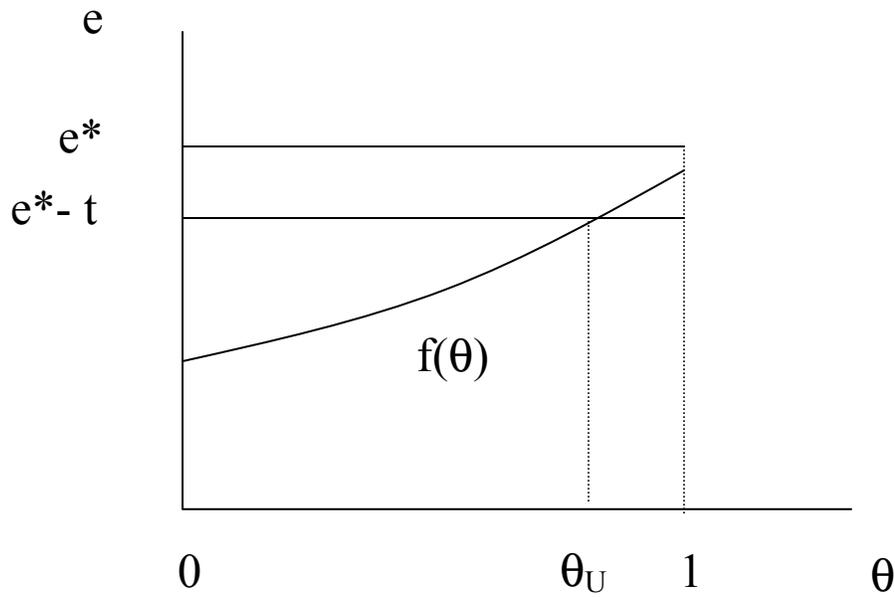
    If peg abandoned payoff = e^* - $f(\theta)$ – t

    If peg not abandoned payoff = - t

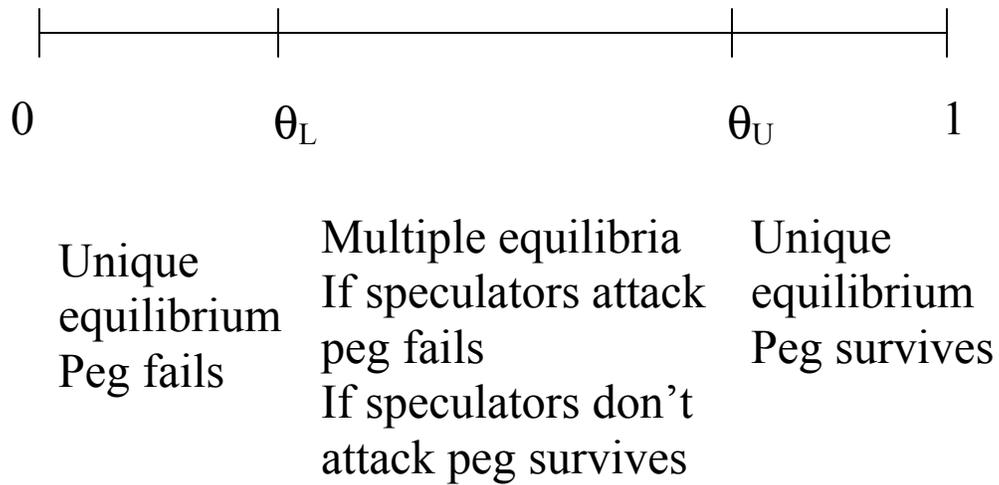- Do nothing

    Payoff = 0

The assumptions about the relationship between the fundamental and profitability of attack are:

$$e* - f(1) < t$$

Note that for $\theta > \theta_U$ it is not worth the speculators attacking the currency so the peg is stable.

When θ is common knowledge the relationship between θ and equilibrium is:

├──────────┼──────────────────┼──────────┤		
0	θ_L	θ_U	1

Unique
equilibrium
Peg fails

Multiple equilibria
If speculators attack
peg fails
If speculators don't
attack peg survives

Unique
equilibrium
Peg survives

Similarly to the model of banking crises considered in Section 3, if there is not common knowledge about θ there will be a unique equilibrium.

The Government's Response to an Attack

Whether or not an attack succeeds or fails depends on how many speculators are involved in the attack.

If we vary α from 0 to 1 then $c(\alpha,\theta)$ moves up and we find the critical level of α for each θ denoted $a(\theta)$ such that an attack succeeds if $\alpha > a(\theta)$ and fails otherwise.

$c(\alpha, \theta)$

$c(1, \theta)$

v

$c(a(\theta'), \theta')$

$c(0, \theta)$

0   θ_L θ' 1 θ
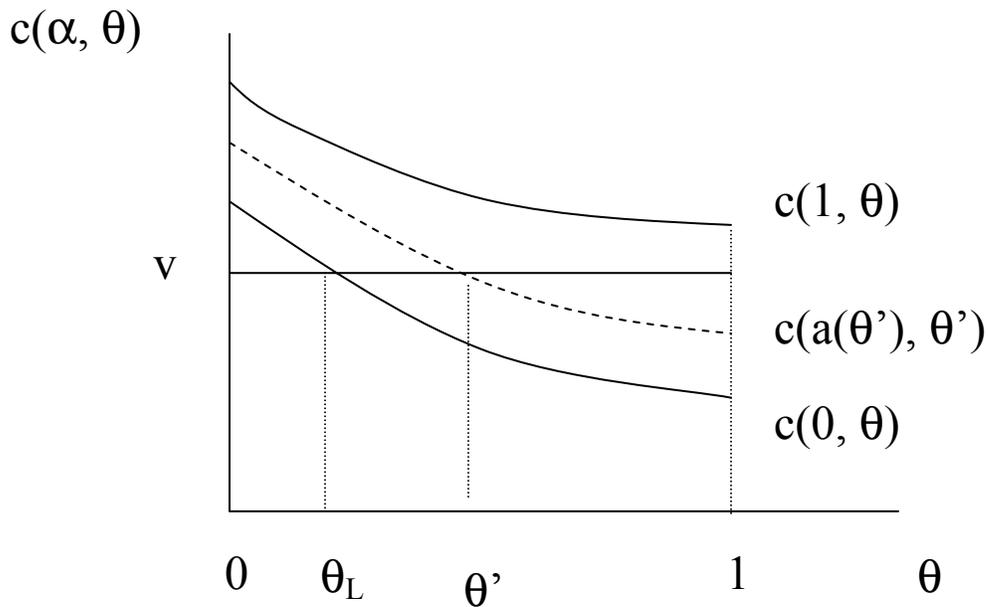
This gives the relation between a(θ) and θ.

a(θ)

1

a(θ)

0   1   θ
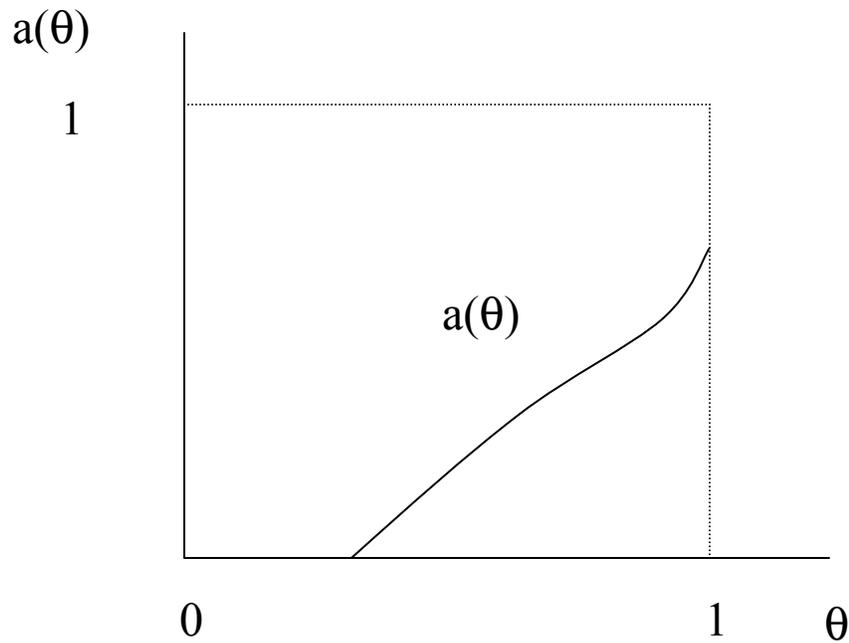
Once the government realizes that α > a(θ) they will abandon the peg. Otherwise they will persevere and defend it.

The problem for speculators is to find out whether or not the number attacking is above a(θ) or not.

Lack of Common Knowledge and Uniqueness of Equilibrium

Suppose that a drawing of θ is made and this determines the fundamental of the economy.

Each speculator receives a signal x that is uniformly distributed on $[\theta - \varepsilon, \theta + \varepsilon]$.

Morris and Shin are able to show the following.

Result 1: There is a unique value of θ* such that for θ < θ* the unique equilibrium is that the speculators attack and the government abandons the peg and for θ > θ* there is a unique equilibrium where the speculators don't attack and the peg survives.

To see what is going on consider what happens if speculators follow the strategy

- Attack if $x < x^*$

- Don't attack if $x \geq x^*$

Consider what happens if θ is around x^*. This is the interesting case since otherwise there will be an attack for sure if $\theta < x^* - \varepsilon$ and no attack for sure if $\theta > x^* - \varepsilon$.

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————————|————————|———|———|————————
        θ-ε       θ   x*  θ+ε
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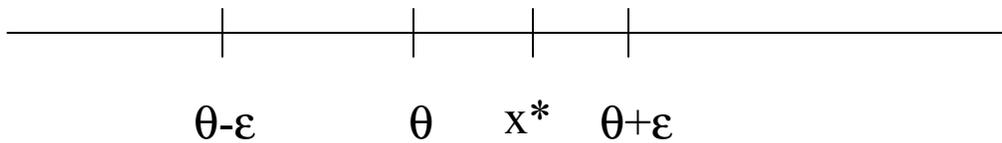
Since x is uniformly distributed on $[\theta - \varepsilon, \theta + \varepsilon]$

Proportion that attacks $s(\theta) = \dfrac{1}{2} + \dfrac{x^* - \theta}{2\varepsilon}$

The key issue is whether s is above or below a(θ):

a(θ)

1

s(θ)

a(θ)

0   x*-ε θ* x*+ε 1 θ
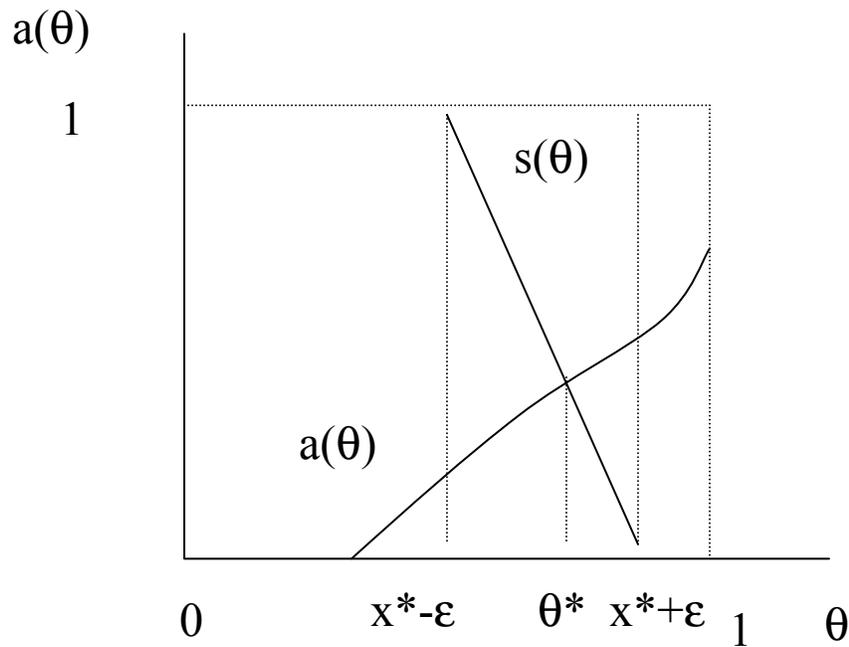
So if θ is below θ* there is an attack and the government abandons the peg. Otherwise the attack is unsuccessful and the government keeps the peg.

Result 2: In the limit as ε tends to zero θ* is given by the unique solution to

$$f(\theta^*) = e^* - 2t$$
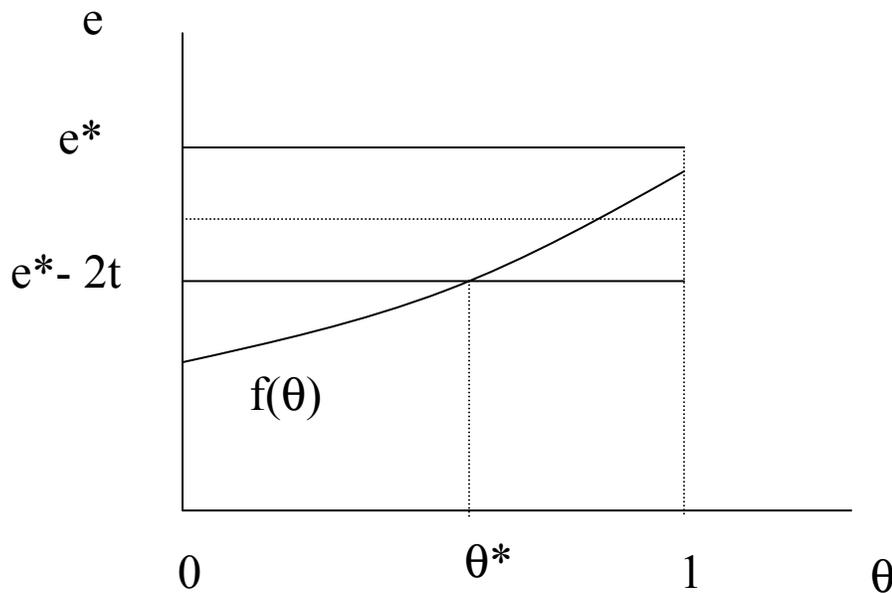
To see why the result holds consider the decision of a marginal speculator who receives the signal x = θ*

Since ε is small the speculator knows that the true θ is close to θ*. She attaches a 50% probability of the attack being successful and a 50% probability it is unsuccessful.

Expected payoff $= 0.5(e^* - f(\theta^*)) - t$

Since the person is the marginal speculator putting this to 0 gives the equation above.

The Morris and Shin paper was an important contribution because it again provided a theory about equilibrium selection. Whether this is the correct theory or not is another issue which has not been fully addressed yet.

3. Models of Twin Crises

As we saw in Section 2 and the introduction to this section, before 1945 and after 1971 there have been many occasions when there have been twin crises where currency and banking crises occurred together.

Kaminsky and Reinhart (1999) have investigated twin crises

- In the 1970's when financial systems were highly regulated currency crises were not accompanied by banking crises

- After the financial liberalizations that occurred in the 1980's currency crises and banking crises have become intertwined

- The usual sequence is that banking sector problems are followed by a currency crisis and this further exacerbates the banking crisis

Kaminsky and Reinhart find that the twin crises are related to weak economic fundamentals. Crises when fundamentals are sound are rare.

- Given Kaminsky and Reinhart's finding that twin crises tend to occur when fundamentals are weak it would seem that the fundamental based or business cycle view has some applicability here. We consider the model in Allen and Gale (2000) next.

3.1 Optimal Risk Sharing

Three dates $t = 0, 1, 2$

Single consumption good at each date

$$t = 0 \qquad\qquad 1 \qquad\qquad 2$$
$$|\underline{\qquad\qquad\qquad}|\underline{\qquad\qquad\qquad}|$$
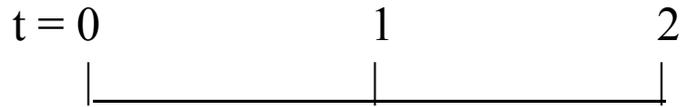
Safe asset: $1 \longrightarrow 1 \longrightarrow 1$
(storage)

Risky asset: $x \longrightarrow rh(x)$

The random return r has a cumulative density function $F(r)$ and density function $f(r)$ with support $[r_0, r_1]$ where $0 \le r_0 < r_1 < \infty$.

$h(x)$ is a decreasing returns to scale production function $(h'>0; h''<0)$

Leading economic   Observed at date 1:
indicator: perfect signal of r
                            (usually non-contractible)

Consumers:

    Ex ante identical   Non-contractible
    (measure 2)   type discovered:
                  Early   Late
                  (measure 1) (measure 1)
                  consume c_1 consume c_2

Type is non-observable to outsiders so late consumers can always mimic early consumers

This implies there is a "missing market" since liquidity shocks cannot be insured

Individuals can invest in the safe asset so that late consumers can withdraw at date 1 and consume at date 2

Utility function:

$$U(c_1, c_2) = u(c_1) + u(c_2) \quad \text{with } u' > 0; u'' < 0$$

Initial assumption as benchmark: r can be contracted upon

Each consumer's initial date 0 endowment of consumption goods is 1 so the aggregate endowment is 2

x is holding of risky asset
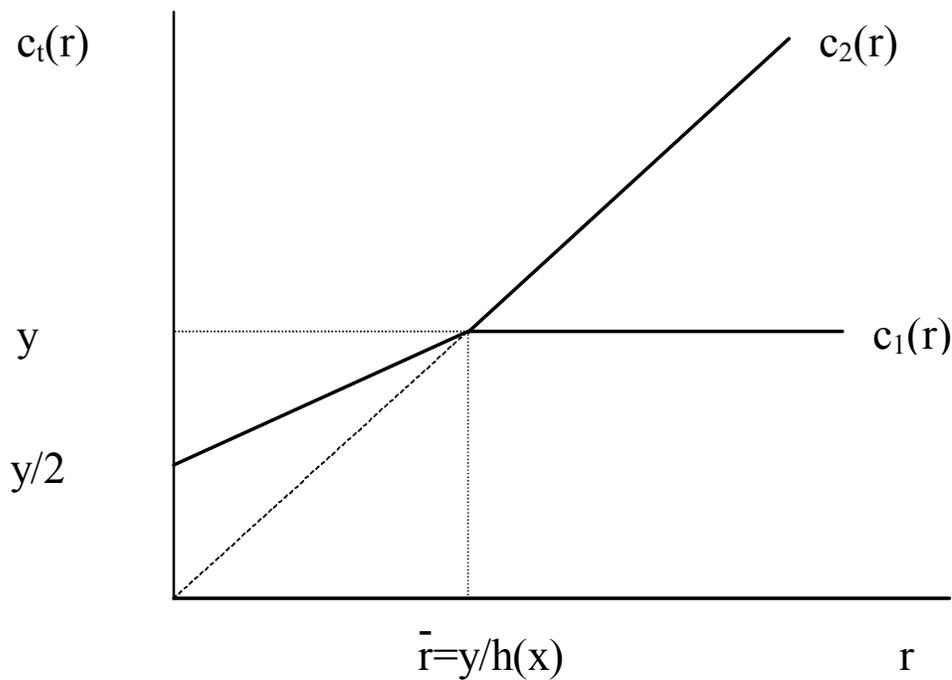
y " " " safe "

Optimal contract is $c_1(r)$, $c_2(r)$

Optimal risk sharing problem:

$$\max E[u(c_1(r)) + u(c_2(r))]$$
$$\text{s.t.}$$
$$x + y \leq 2$$
$$c_1(r) \leq y$$
$$c_2(r) \leq rh(x) + y - c_1(r)$$
$$c_1(r) \leq c_2(r)$$

Result 1: Characterization of optimal contract (assuming interior solution x, y > 0):

The optimal x and y are such that:

$$E[u'(c_1(r))] = E[ru'(c_2(r))]$$
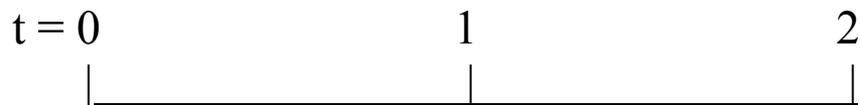
Implementing the incentive-efficient allocation:

- Equity markets cannot implement the first best allocation because of missing market for insurance against liquidity shocks

- Banks can potentially overcome the problem of the missing market

3.3 Banking
3.3.1 Real contracts

Contracts are in real terms and cannot be contingent on r

In the absence of a run

$t = 0$	1	2

Each consumer deposits 1 and bank invests in portfolio (x, y)

Early consumers withdraw d_1 $(d_1 \leq y)$

Late consumers withdraw d_2 $(d_2 \geq d_1)$

The problem comes when r is so low that the bank cannot afford to pay its depositors the promised amount. In particular, if late consumers think they will receive less than early consumers'd_1 there will be a *run* at date 1 and the bank will go *bankrupt*.

Bankruptcy rules:

- All assets must be liquidated and the proceeds distributed pro rata to claimants.

Liquidation proceeds:

- When risky asset is liquidated at date 1 the proceeds are $\gamma r h(x)$

- There are no liquidation costs for the safe asset or the risky asset at date 2

γ is sufficiently small that it is never worthwhile for the planner to liquidate the risky asset at date 1

Free entry into the banking industry and a continuum of banks with measure 1 implies banks offer contracts that maximize depositors' ex ante expected utility

Since there are no liquidation costs at date 2 the bank will set d_2 sufficiently high that the consumers withdrawing then receive everything that is left over

Let r^* be the critical value of r such that a run occurs:

$$c_2(r) = r^* h(x) + y - d_1 = d_1$$

or

$$r^* = \frac{2d_1 - y}{h(x)}$$

Representative bank's optimization

$$\max E[u(c_1(r)) + u(c_2(r))]$$

s.t.

$$x + y \leq 2$$

$$c_1(r) = d_1 \quad \text{for } r \geq r^*$$

$$c_2(r) = rh(x) + y - d_1 \text{ for } r \geq r^*$$

$$c_1(r) = c_2(r) = \frac{y + \gamma rh(x)}{2} \text{ for } r < r^*$$
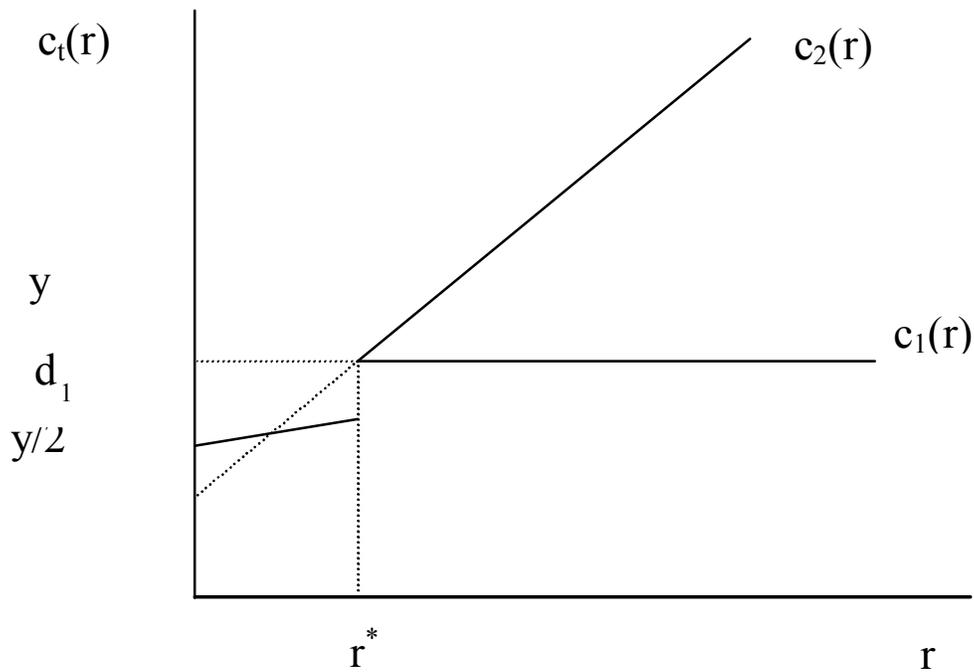
In addition to the direct costs of liquidation there is a distortion since the bank reduces its investment in the risky asset

Result 2: When deposit contracts are specified in real terms, the costly liquidation associated with a banking system leads to an allocation that yields depositors a lower ex ante expected utility than in the first-best allocation.

3.3.2 Optimal Monetary Policy

Suppose deposit contracts promise a fixed *nominal* return and there is a central bank

- The central bank can ensure banks can meet their commitments when the leading economic indicator shows that r will be low by setting the price level high and making the output from the storage technology valuable in nominal terms

- This ensures the deposits of the early consumers can be paid and the bank will have enough assets to make it worthwhile for late consumers not to withdraw

Result 3: If the central bank chooses the appropriate price level and banks use nominal contracts, there are no banking crises and the first-best allocation can be implemented as an equilibrium.

$p_1(r) = p_2(r)$
   $= p(r)$

1

$\bar{r}$ r
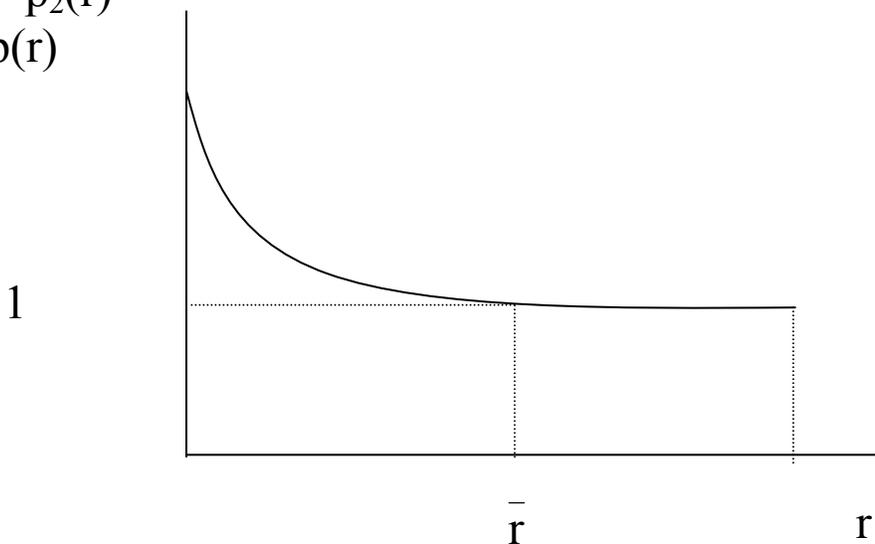
3.4 International Finance

Initially suppose there is a short-term international bond market – a long-term market is considered later

$$t = 0 \qquad\qquad 1 \qquad\qquad 2$$

$$|\!\!\rule[0.5ex]{4cm}{0.4pt}\!\!|\!\!\rule[0.5ex]{4cm}{0.4pt}\!\!|$$

International $1 \longrightarrow \rho \longrightarrow \rho^2$
bond market
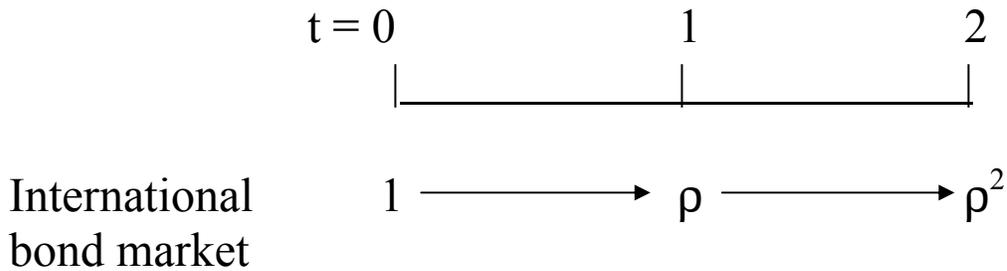
To ensure an interior solution: $E[r]h'(0) > \rho^2$

Country is small so bond market is *risk neutral*

Now y represents investment in the international bond market, i.e., it is a foreign currency investment

Individuals have access to the international bond market just as they had access to the storage technology previously

3.4.1 Optimal Risk Sharing

Suppose r can be contracted on and let $I(r)$ be the transfer from the international market. The planner's problem is:

$$\max E[u(c_1(r)) + u(c_2(r))]$$

s.t.

$$x + y \leq 2$$

$$c_1(r) + c_2(r)/\rho \leq rh(x)/\rho + \rho y + I(r)$$

$$\int_0^\infty I(r) = 0$$

$$\rho c_1(r) \leq c_2(r)$$

Solution is such that

- Full insurance is provided so early and late consumers bear no risk and receive the expected returns from the bank's portfolio

- The allocation between early and late consumers depends on the form of the utility function and involves $\rho c_1(r) = c_2(r)$ if the incentive constraint binds and $\rho c_1(r) < c_2(r)$ otherwise

- Production efficiency: $\quad E[r]h'(x) = \rho^2$

In practice such fully state contingent contracts are not possible. We consider what happens when there is an international debt market. Two cases are considered

- Debt is denominated in *domestic currency*

- Debt is denominated in *foreign currency*

For ease of exposition we focus below on the case where the incentive constraint binds.

3.4.2 Domestic Currency Debt

Suppose that a short-term international bond market denominated in domestic currency exists at dates 0 and 1.

- In the date 0 market uncertainty has not been resolved and the bond issue price reflects this.

- At date 1 uncertainty has been resolved so we can simply write everything in present value terms using ρ as the discount rate.

```
0                    1                    2
|_____|_____|

Borrow qB          Repay B
                   Borrow L/ρ          Repay L
```

Date 0 budget constraint: $x + y \leq 2 + qB$

No arbitrage condition: $p_1(r) = \rho p_2(r) \equiv p(r)$

Date 1 budget constraint:

$$c_1(r) + \frac{c_2(r)}{\rho} + \frac{B}{p(r)} = \frac{rh(x)}{\rho} + \rho y$$

Depositors have access to the international bond market so instead of $c_1(r) \leq c_2(r)$ the incentive constraint becomes

$$\rho c_1(r) \leq c_2(r)$$

Substituting the budget constraints and $c_1(r) = D/p(r)$ the incentive constraint becomes

$$p(r) \geq \frac{2D + B}{rh(x)/\rho + \rho y} = \frac{2D + B}{rh(x)/\rho + \rho(2 - x + qB)}$$

If r is large enough that this constraint is satisfied the bank is solvent and there is no need to liquidate the assets at date 1 but if it is not then the bank must liquidate and

$$c_1(r) = c_2(r)/\rho = \frac{D}{2D + B}(\gamma rh(x) + y)$$

In the closed economy the central bank sets the price level so that crises and the associated costly liquidation were avoided. In the open economy the counterpart is that the central bank sets the exchange rate $1/p(r)$ so that there is no banking crisis.

To see how equilibrium is analyzed consider the following situation and remember that we are focussing on the case where the incentive constraint binds.

- All banks choose D, $\bar{B}$, x and y.

- The central bank sets the exchange rate

$$\frac{1}{p(r)} = \frac{rh(x)/\rho + \rho(2 - x + q\bar{B})}{2D + \bar{B}}$$

and there are no banking crises.

Can a bank improve its depositors' welfare by changing its choice from D, $\bar{B}$, x and y? Suppose that in addition to $\bar{B}$ and y it adopts the following strategy (work in foreign currency):

$$
\begin{array}{lcc}
 & 0 & 1 \\
\text{Issue domestic currency bond:} & +q \longrightarrow & -1/p(r) \\
\text{Invest in foreign currency assets:} & -q \longrightarrow & \rho q \\
\text{Net payoff in foreign currency:} & & \rho q - 1/p(r)
\end{array}
$$

Since the bond is **fairly priced** to reflect exchange rate risk the expected payoff to this strategy is zero.
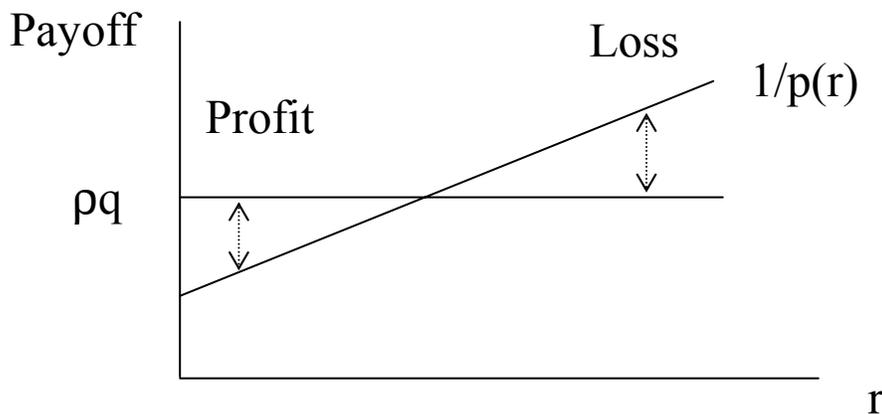
- The strategy effectively transfers resources from high return states to low return states for late consumers which allows depositors' welfare to be improved

The fact that each bank would like to borrow more than other banks indicates existence of equilibrium may be problematical. We therefore analyze a "pseudo-equilibrium" with a constraint $\overline{B}$ on borrowing. As $\overline{B} \to \infty$

$$\frac{1}{p(r)} = \frac{rh(x)/\rho + \rho(2 - x + q\overline{B})}{2D + \overline{B}} \to \rho q$$
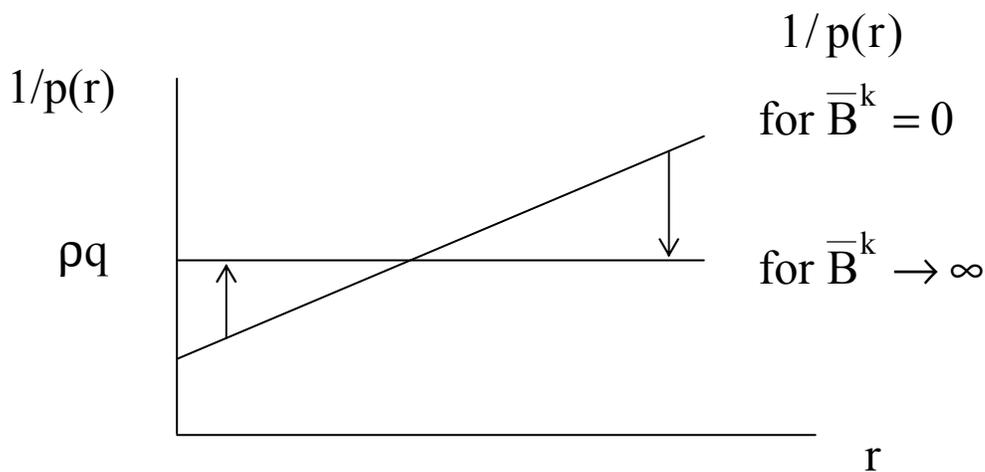
- As each bank borrows more and invests it in safe international bonds its portfolio becomes dominated by these assets. Domestic investors "own" a smaller proportion of the portfolio and bear less risk and foreign lenders "own" a larger proportion of the portfolio and bear more. Because the portfolio is becoming larger the risk of the domestic assets becomes relatively small and the exchange rate can fluctuate less.

Result 4: In the limit as $\overline{B} \to \infty$ all risk is eliminated for depositors and the allocation is optimal.

Comment: The form of the equilibrium is consistent with the observation that foreign exchange transactions and international financial flows are so large.

So far we have focussed on short-term debt but it turns out introducing long-term debt makes little difference.

Result 5: Because uncertainty is resolved at date 1 and short-term debt can be rolled over there is no difference between short and long-term debt except the cost. When the yield curve is flat or upward sloping, short-term debt is strictly preferred to long-term debt.

3.5 Foreign Currency Debt

- When foreign debt is denominated in terms of domestic currency there is a temptation for governments to inflate and expropriate the foreign lenders.

- For developed countries with sophisticated political institutions this will not be an issue.

- For emerging economies this possibility may be quite likely in which case an "inflation premium" will be charged. This may make borrowing in domestic currency expensive.

- The inflation premium can be avoided by denominating the international debt in foreign currency rather than domestic currency.

- However, if the foreign debt is denominated in foreign currency the benefits that a central bank and international bond market can bring are reduced.

  - The central bank may no longer be able to prevent financial crises and inefficient liquidation of assets

  - It may not be possible to share risk with the international bond market

3.5.1 The Dollarized Economy

- Deposit contracts and foreign debt in foreign currency (i.e. real) terms.

- In the event that r is low and commitments to depositors and foreign lenders cannot be met, there is bankruptcy and costly liquidation. As in Section 3 there is *equal priority* for all claimants.

Result 6: The optimal policy for the representative bank is to borrow an infinite amount in the international bond market and invest the proceeds in the international bond market. This eliminates risk for depositors when there is bankruptcy so that early consumers always obtain the same consumption level.

The key to understanding this result is that the offsetting long and short positions affect the outcome in bankruptcy.

- All parties get a share of assets equal to their nominal claim relative to total nominal claims.

- In the limit the risky domestic assets are negligible relative to the total portfolio so depositors obtain a fixed amount and the international bond market bears the risk.

3.5.2 Foreign-Currency Loans and Domestic-Currency Deposits

Suppose there is a central bank, deposits are in domestic currency and foreign debt is in foreign currency.

- Consider the polar case of foreign creditor priority where in the event of bankruptcy foreign creditors have a right to the whole liquidation value

The representative bank borrows qb in foreign currency at date 0 invests it in bonds to obtain ρqb at date 1 and repays b. Assuming the incentive constraint binds

$$c_1(r) = c_2(r)/\rho = \frac{1}{2}[rh(x)/\rho + \rho(2-x) + (\rho q - 1)b]$$

If there is an interior solution in the sense that x < 2, then when $r^* < r_0$, $\rho q = 1$ and the level of b is irrelevant. If $r^* \geq r_0$ then $\rho q < 1$ and borrowing is not worthwhile.

- There is no costly liquidation. However, there is no risk sharing with international bond market at date 0. Whether this is better than the dollarized economy will depend on parameters.

Other bankruptcy priorities can be similarly analyzed. The problem is that in the event of default there must be some division of output between foreign lenders and domestic depositors. This will usually be determined by some kind of bargaining. There is a whole range of possibilities.

3.6 Policy Implications

- Krugman (1998) and Fischer (1999) have argued the IMF should act as an international lender of last resort by analogy with the widespread acceptance of the need for domestic lenders of last resort.

- Friedman (1998), Schultz (1998) and Schwartz (1998) have argued that the IMF distorts markets when it intervenes.

- Chari and Kehoe (1999) have suggested that the role of the IMF should be limited to cases where there is a clear collective action problem. They argue that liquidity has been adequately provided by the U.S. Fed and other major central banks in times of crisis so the IMF has no role to play here. They do suggest it has a role as an international bankruptcy court and in other technical ways such as provision of information.

Our model provides a framework for thinking about these issues. In some situations it seems that an international organization has little role to play. In others, however, it may be able to prevent the costly liquidation and contagion associated with financial crises and improve the allocation of resources.

Case 1: Flexible Exchange rates and Foreign Debt in Domestic Currency

This was the case discussed in Section 4 and is the one applicable to the advanced industrial economies. The incentive efficient allocation can be implemented. Here no intervention by an international organization such as the IMF is needed.

Case 2: Foreign Borrowing Denominated in Foreign Currency

Many governments particularly in emerging economies are unable to borrow in domestic currency because of inflation concerns and must instead borrow in dollars as discussed in Section 5. In this case a whole range of possible arrangements exists. Banking crises with inefficient liquidation can occur. There may also be severe problems of *contagion* in this kind of situation. The IMF can have an important role to play in such circumstances.

3.7 Other models of twin crises

Chang and Velasco (2000a,b) have also developed a model of twin crises.

- Their model is based on Diamond and Dybvig (1983)

- They introduce money as an argument in the utility function and a central bank controls the ratio of currency to consumption

- Banking and currency crises are "sunspot phenomena"

- Different exchange rate regimes correspond to different rules for regulating the currency-consumption ratio

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