Financial Fragility and the Exchange Rate Regime
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1 Introduction and Motivation

• International illiquidity
  – Country’s consolidated financial system has potential short-term obligations in foreign currency that exceed the amount of foreign currency it has access to on short notice

• Model in which short-term illiquidity
  – Generates positive social returns
  – Implies banks are subject to runs

• Financial fragility
• Third generation exchange rate crisis model
2 Economic Environment

2.1 Assumptions

- Small, open economy
- Three periods, indexed $t = 0, 1, 2$
- Large number of ex ante identical agents
- Each agent is born at $t = 0$ with $e > 0$ in endowment
• Agents choose how to invest their endowment
  
  – invest in long-term technology \((k)\)
    
    * returns \(r < 1\) in period 1
    
    * returns \(R > 1\) in period 2
  
  – invest short-term in world market \((b)\)
    
    * returns 1 in either period 1 or 2

• Price of consumption is fixed and normalized at one dollar
• At $t = 1$, each agent discovers his own type
  
  – agent is impatient and receives utility only from period 1 consumption with probability $\lambda$
  
  – agent is patient and receives utility from period 1 holdings of domestic currency (pesos) and from period 2 consumption with probability $1 - \lambda$
  
• Notation
  
  – consumption in period 1 if impatient is $x$
  
  – quantity of pesos acquired in period 1 is $M$
  
  – consumption in period 2 if patient is $y$
- $E_t$ is the peso price of consumption in period $t$, equivalently the exchange rate

- Expected utility of the representative agent

$$\lambda g(x) + (1 - \lambda) g\left(\chi\left(\frac{M}{E_2}\right) + y\right)$$

- $g$ is smooth, strictly increasing and concave and satisfies Inada conditions

- $\chi$ is smooth, strictly concave, satisfies

$$\chi(0) = 0 \quad \chi'(0) = \infty \quad \chi'(\tilde{m}) = 0,$$

* where $\tilde{m}$ is the satiation level of money
• Realization of each agent’s type is private information

• Domestic agents, including the central bank, can invest but not borrow abroad
3 Currency Board

- Under a currency board, the central bank holds one dollar for every peso in circulation
  - No possibility of exhausting the supply of reserves
  - No possibility of a generation one currency crisis
  - Model will have the possibility of bank runs

3.1 Autarky (no banks)

- Set exchange rate to unity and therefore \( E_2 = 1 \)
• Optimization problem

  – Agents choose long-term investment \((k)\) and investment in the world asset \((b)\) to maximize expected utility subject to

    * assets chosen in period 0 must be less than or equal to the endowment

      \[ k + b \leq e \]

    * if impatient, consumption in period 1 must be less than or equal to returns from short and long assets

      \[ x \leq b + rk \]
if patient, money in period 1 is bound by returns from short investment and liquidation of the long-term asset in period 1:

\[ M \leq b + rl \]

and consumption in period 2 is bound by money and the rate of return on the non-liquidated long-term asset:

\[ y \leq M + R(k - l) \]

inequality constraints:

\[ l \leq k \]

\[ k, b, x, y, M, l \geq 0 \]
• Equilibrium

  – Each agent faces idiosyncratic uncertainty

  – Distorts the allocation of assets from optimal and creates costly liquidation of long-term assets
3.2 Banking System

- Assumptions
  - Bank pools resources of the economy to maximize the welfare of the representative member
  - No aggregate uncertainty
    * Bank would like to allocate resources based on realization of type, but type is private information
    * Bank can observe each agent’s transactions with the domestic banking system
    * Includes commercial banks and central bank
Consumption and transactions with the world cannot be observed

Optimization problem for bank

- Maximize expected utility of representative agent

- Subject to
  
  * Assets choices in period 0 are constrained by endowment as before
    
    \[ k + b \leq e \]

  * Period 1: Pooled second and third constraint such that consumption by impatient plus money by patient constrained by short assets and returns on liquidated long assets
    
    \[ \lambda x + (1 - \lambda) M \leq b + rl \]
* Restriction on period 2 consumption allocated to patient agent

\[(1 - \lambda) y \leq (1 - \lambda) M + R(k - l)\]

* Truth-telling (incentive-compatibility) constraint to get patient agents to reveal their type

\[\chi(M) + y \geq x\]

- if patient agent reports honestly, receives \( M \) in the first period and \( y \) in the second

- if patient agent reports dishonestly, receives \( x \) units of consumption in first period, which she can exchange for \( x \) dollars to buy \( x \) units of consumption in period 2

* Impatient agents receive no utility if they misreport since get consumption only in second period
• Optimal values (denoted by tildes)
  
  – never liquidate long-term assets because no aggregate uncertainty and more profitable to hold amount of short-term assets needed to provide money and consumption and put rest of endowment in long-term asset
  
  – feasibility constraint

\[
R \left[ e - \lambda \tilde{x} - (1 - \lambda) \tilde{M} \right] + (1 - \lambda) \tilde{M} = (1 - \lambda) \tilde{y}
\]

* where

\[
b = \lambda \tilde{x} - (1 - \lambda) \tilde{M}
\]

\[
k = e - \lambda \tilde{x} - (1 - \lambda) \tilde{M}
\]

* implying that long rate of return multiplied by [endowment less consumption to patient agents less money to impatient] plus money to impatient equals consumption to patient
* solve for \( \tilde{y} \)

\[
\tilde{y} = \frac{R}{1 - \lambda} \left[ e - \lambda \tilde{x} - (1 - \lambda) \tilde{M} \right] + \tilde{M}
\]

* substitute into utility and maximize with respect to \( \tilde{x} \) and \( \tilde{M} \)

\[
\lambda g(\tilde{x}) + (1 - \lambda) g \left( \chi (\tilde{M}) + \frac{R}{1 - \lambda} \left[ e - \lambda \tilde{x} - (1 - \lambda) \tilde{M} \right] + \tilde{M} \right)
\]

\[
\cdot \tilde{x}
\]

\[
\lambda g'(\tilde{x}) - (1 - \lambda) g' \left( \chi (\tilde{M}) + \tilde{y} \right) \frac{R\lambda}{1 - \lambda} = 0
\]

\[
\frac{g'(\tilde{x})}{g' \left( \chi (\tilde{M}) + \tilde{y} \right)} = R
\]

requires tangency of the social indifference curve to the relative price
\( \tilde{M} \)

\[
(1 - \lambda) g' \left( \chi \left( \tilde{M} \right) + \tilde{y} \right) \left[ \chi' \left( \tilde{M} \right) - R + 1 \right] = 0
\]

- allocation of money to patient agents

\[
\chi' \left( \tilde{M} \right) = R - 1
\]

* marginal benefits of money to patient agents must equal opportunity cost to bank which is the difference between the return on the long-term asset and the short-term one
• Implementation of optimal values with demand deposits

  − Description

  * Each agent turns over dollar endowment to bank in period 0 as a demand deposit

  * in period 0, bank invests $b$ in short asset and $k$ in long asset

  * in period 1, bank sells dollars it receives from assets to central bank for pesos to satisfy withdrawals

  * agent is promised payments in periods 1 and 2, conditional on reported type

    · agent is entitled to withdraw either $x$ pesos in period 1
• or $\tilde{M}$ pesos in period 1 and $\tilde{y} - \tilde{M}$ pesos in period 2

• to buy consumption, the agent must go to the central bank to exchange pesos for dollars

– Sequential service constraints

* central bank and commercial banks attend the requests of depositors on a first-come first-serve basis

* if the bank exhausts its assets, it closes and disappears
– Period 1

* depositors visit the bank and withdraw $\tilde{x}$ or $\tilde{M}$ pesos, depending on type

* bank liquidates assets to satisfy demand for withdrawals and sells dollars to central bank for pesos

* depositors with $\tilde{x}$ pesos sell them to the central bank for dollars

  · central bank closes if it runs out of dollars
Period 2

- bank liquidates its remaining investments and pays \( \tilde{y} - \tilde{M} \) in pesos to patient agents

- bank gets pesos by selling dollars to the central bank

- patient agents sell their pesos to the central bank for dollars to buy world consumption
Honest equilibrium: Proposition 3.1

- Period 1
  * impatient depositors retire $\lambda\tilde{x}$ pesos and patient ones retire $(1 - \lambda)\tilde{M}$ pesos
  * bank sells dollars to the central bank to get the pesos agents demand
  * impatient agents take $\lambda\tilde{x}$ pesos to the central bank and exchange for dollars to buy consumption good
  * leaves the central bank with $(1 - \lambda)\tilde{M}$ dollars at the end of period 1
- Period 2

  * bank pays \((1 - \lambda)(\tilde{y} - \tilde{M})\) pesos to patient agents after liquidating remaining assets for dollars and selling dollars to central bank for pesos

  * patient agents take \((1 - \lambda)\tilde{y}\) pesos to central bank and exchange for dollars to buy world consumption good

  * central bank has no dollars remaining
• Equilibrium with a run if

\[ \tilde{x} > \tilde{b} + r \tilde{k} \]

such that assets needed to pay if all agents withdraw in period one exceed assets available from the short investment together with liquidation of the long investment

– if everyone claims to be impatient, the bank fails and those at the end of the line do not get their deposits

– the central bank closes after paying \( \tilde{b} + r \tilde{k} \) dollars, but no run since it has sufficient dollars

– if everyone is claiming to be impatient, then it is optimal for a particular agent to claim to be impatient because there will be nothing left in the future period
3.3 Summary

- Banking system with a currency board

- Can have run on banking system where bank fails

- No run on central bank since it has dollars in sufficient quantity to buy all pesos
4 Fixed Exchange Rate and Central Bank Credit

4.1 Case for fewer reserves

- dollar reserves do not bear interest and are therefore inefficient

- central bank has \((1 - \lambda) \tilde{M}\) reserves at the end of the first period
4.2 Social optimum

- maximize expected utility

\[ \lambda g(x) + (1 - \lambda) g(\chi(M) + y) \]

- subject to

\[ \lambda x \leq b \]

\[ (1 - \lambda) y \leq Rk \]

\[ x, y, M, k, b \geq 0 \]

- denote social optimum values with overbars
- assumption that pesos can be provided at zero costs

- at the social optimum, quantity of pesos will be at satiation level

\[ \chi' (\bar{M}) = 0 \]

- feasibility constraint adds two resource constraints and equates sum with endowment

\[ \lambda \bar{x} + \frac{(1 - \lambda) \bar{y}}{R} = b + k = e \]

- rewrite

\[ R\lambda \bar{x} + (1 - \lambda) \bar{y} = eR \]
- compare with feasibility constraint under currency board

\[ R\lambda \bar{x} + (1 - \lambda) \bar{y} + (1 - \lambda) \bar{M} (R - 1) = eR \]

* economy saves the opportunity cost of providing the pesos for the impatient agents

- substitute solution of feasibility constraint for \( \bar{x} \) into utility and maximize with respect to \( \bar{y} \)

\[ \lambda g \left( \frac{eR - (1 - \lambda) \bar{y}}{R\lambda} \right) + (1 - \lambda) g \left( \chi \left( \bar{M} \right) + \bar{y} \right) \]

- FO condition

\[ -g' (\bar{x}) \frac{1 - \lambda}{R} + (1 - \lambda) g' \left( \chi \left( \bar{M} \right) + \bar{y} \right) = 0 \]
− simplifying

\[
\frac{g'(\bar{x})}{g'\left(\chi(\bar{M}) + \bar{y}\right)} = R
\]

* requiring that social indifference curve be tangent to the relative price
4.3 Implementation of the social optimum

- Central bank makes interest-free loans to commercial banks in period 1 to be repaid in period 2

- Constraints become, where $h$ is commercial bank borrowing from central bank

\[
\lambda x + (1 - \lambda) M \leq b + h
\]

\[
(1 - \lambda) y \leq Rk + (1 - \lambda) M - h
\]

\[x, y, M, k, b \geq 0\]
• Incentive for the bank to make all investments long-term and borrow from the central bank for all period 1 withdrawals

  – add a reserve requirement

  \[ \lambda x \leq b \]

  – borrowing will be sufficient to supply period 1 demand for pesos to hold as money

  \[ \bar{h} = (1 - \lambda) \bar{M} \]
4.4 Implementation of the social optimum with demand deposits

- in period 0, agents surrender endowments to banks as deposits

- Central bank restricts credit to commercial banks to \((1 - \lambda) \tilde{M}\)

- In period 1, banks borrow \((1 - \lambda) \tilde{M}\) from the central bank and service withdrawals of \(\lambda \tilde{x}\) by liquidating \(\tilde{b}\)

- There is an honest equilibrium in which everyone reports true type and there are no bank runs on commercial or central bank
• There can be an equilibrium with bank runs if

\[ \bar{x} > \bar{b} + r \bar{k} \]

– all depositors claim to be impatient and the bank fails in period 1

– if everyone is withdrawing \( \bar{x} \), optimal for patient to withdraw \( \bar{x} \) too because if they withdraw only \( \bar{M} \), then cannot exchange the pesos for dollars at the central bank until next period when the central bank will have no remaining dollars

• Fixed exchange rates with the central bank serving as lender of last resort

  – in the event of a bank run, the central bank extends credit

  – possible because the central bank gains control of the long-term asset and liquidates it to provide credit
– the central bank runs out of reserves, creating an exchange rate crisis
4.5 Fundamental Problem

- Investment in world liquid asset is less than the implicit short-term liabilities of the banking system.

- Possible solutions
  - Narrow banking = strict reserve requirements
    * require that commercial banks hold enough short asset to meet any possible demand
      \[ b \geq x \]
    * prevents runs
* but forego higher return on long asset

- Tax banks in period 0 and return taxes lump-sum in period 1 if no run

* With taxes plus the bank’s own investment in short assets large enough, there are no runs

\[ b + \hat{T} = \hat{x} \]

* But taxes are invested in short-asset which has lower rate of return

- Flexible exchange rates

* Central bank sells dollars to depositors up to a maximum of \( \lambda x \)

* If more are demanded, there is a devaluation
* Assures that there will be dollars available in period 3 for patient agents, convincing them not to run