

Lectures on Credit, Banking, and Monetary Policy

Steve Williamson
Federal Reserve Bank of St. Louis

March 2015

- Basic Model
- Unsecured Credit
- Money
- Secured Credit
- Open Market Operations and Banking

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What is New Monetarism?

- Shares some ideas with Old Monetarism, but departs from Friedman's ideas in important ways.

Key principles:

- To understand monetary policy, monetary and financial arrangements need to be modeled explicitly, starting with the basic frictions - Lucas critique argument.
- No one model is an all-purpose vehicle for analyzing issues in monetary economics and monetary policy, but some models are better than others.
- Financial intermediation matters - for example, for determining the effects of “quantitative easing.”
- The whole spectrum of assets is important – for thinking about monetary policy for example. It's not useful to draw a line separating “monetary” assets from “non-monetary” assets.

- Basic structure is a version of Lagos-Wright (2005).
- $t = 0, 1, 2, 3, \dots$
- Two subperiods, CM (centralized market) and DM (decentralized market).
- Population: Continuum of *buyers*, continuum of *sellers*, each with unit mass.
- Buyers:

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(x_t) - H_t]$$

- Sellers:

$$E_0 \sum_{t=0}^{\infty} \beta^t [-h_t + X_t]$$

- $0 < \beta < 1$, $u' > 0$, $u'' < 0$, $u(0) = 0$, $u'(0) = \infty$.
- $u'(x^*) = 1$; $x^{**} = \beta u(x^{**})$
- Technology: 1 unit labor supply produces 1 unit perishable consumption good
- Key feature: Role for intertemporal exchange, with buyers productive in the CM, sellers productive in the DM.
- DM: Random bilateral matching (each buyer matched with a seller).
- CM: Everyone together in one location.

- Assume:
 - perfect memory (i.e. perfect recordkeeping)
 - limited commitment (cannot force anyone to work) – will be the key credit friction.
- Efficient stationary allocation: For $k \geq 0$, solve

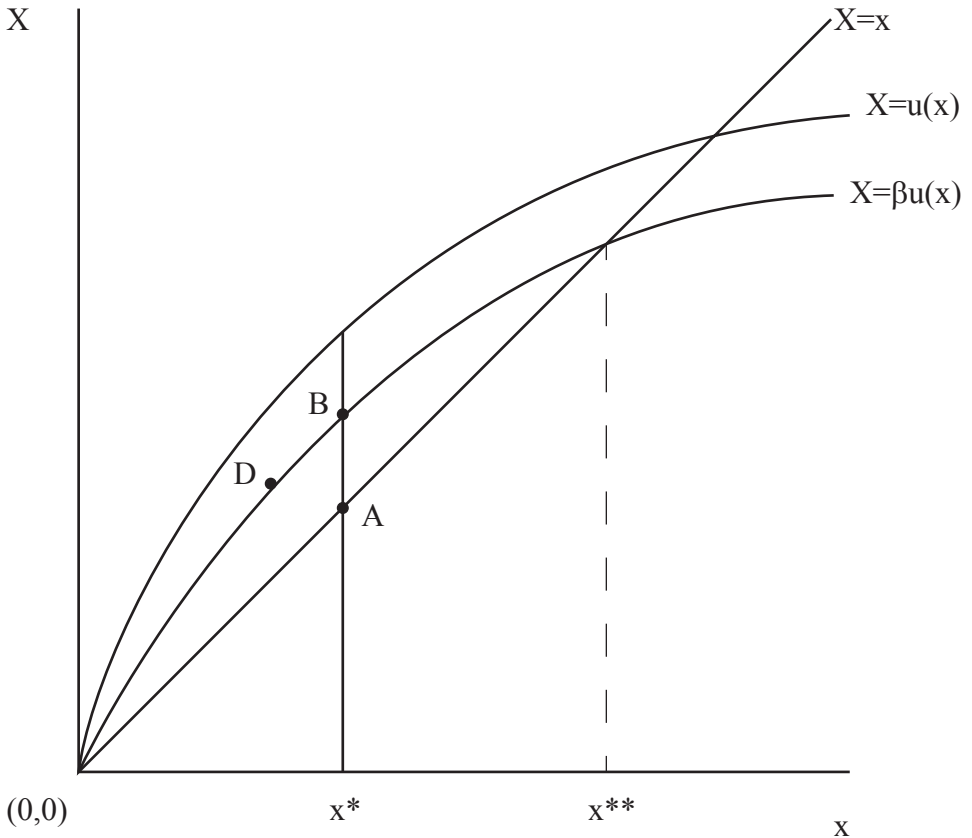
$$\max_{x, X} [u(x) - X]$$

subject to

$$-x + X = k \text{ (hold utility constant for sellers)}$$

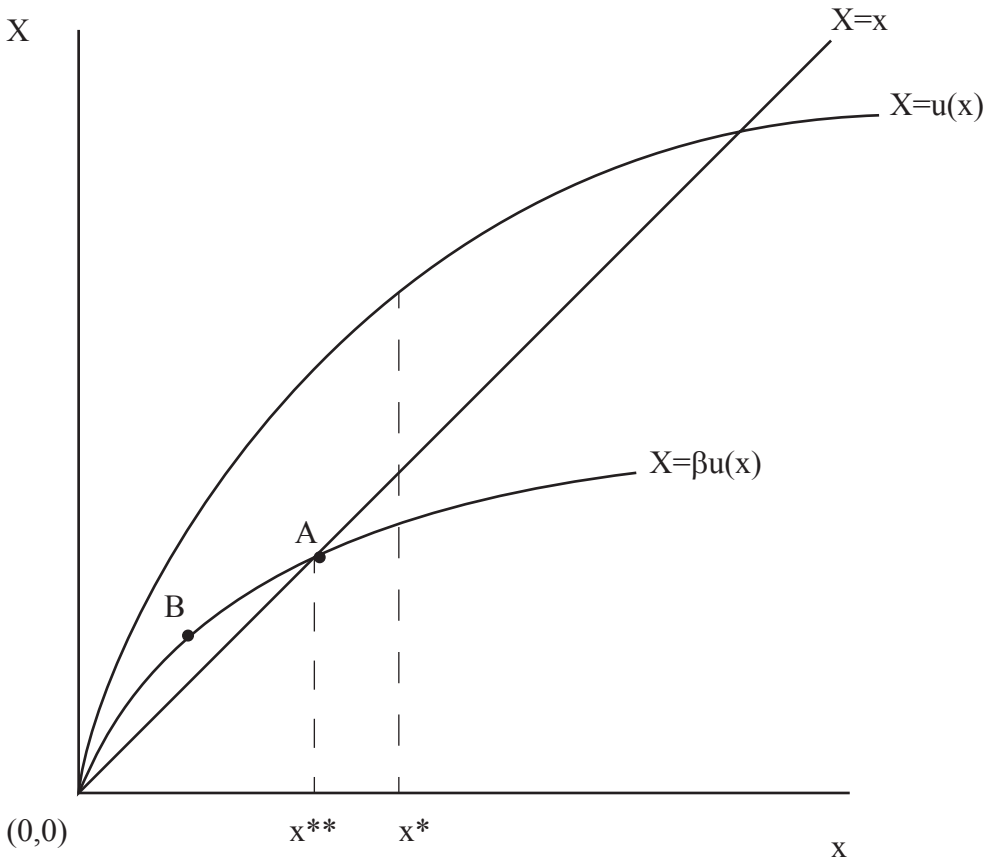
$$-X + \beta u(x) \geq 0 \text{ (I.C. for buyers - from limited commitment)}$$

Figure 1: Efficient Allocations if $x^* < x^{}$**



ABD is efficient

Figure 2: Efficient Allocations if $x^{} \leq x^*$**



AB is efficient

Unsecured Credit Equilibrium

- A buyer and seller meet in the DM and bargain over (x, X) . There are different ways to do this - Nash bargaining, competitive pricing, for example. Here, buyer's surplus = $u(x) - X$; Seller's surplus = $-x + X$; total surplus = $u(x) - x$, and assume that, when the buyer and seller bargain, they choose (x, X) to solve

$$\max[u(x) - x]$$

subject to

$$u(x) - X = \theta[u(x) - x] \text{ (bargaining rule - Kalai bargaining)}$$

and

$$-X + v \geq 0 \text{ (incentive constraint)}$$

where $0 \leq \theta \leq 1$ and v is the continuation value of the buyer after he or she repays his or her debts in the CM.

- No default in equilibrium – credit supported by the implicit threat of ostracism from the credit market if default occurs.

Solving the Bargaining Problem with Credit: Incentive Constraint Does Not Bind

- Suppose the incentive constraint does not bind. Then
 - $x = x^*$ to maximize total surplus and

$$X = (1 - \theta)u(x^*) + \theta x^*$$

- Then in equilibrium,

$$v = \frac{\beta\theta [u(x^*) - x^*]}{1 - \beta}.$$

Now, check the incentive constraint

$$(-1 + \beta + \theta) u(x^*) - \theta x^* \geq 0$$

or

$$\beta \geq 1 - \theta \left[1 - \frac{x^*}{u(x^*)} \right]$$

- Higher β : Buyer values the future more, so less inclined to default.
- Higher θ : Buyer receives more surplus in the future, so less inclined to default.
- If the unconstrained equilibrium exists, it is efficient.

Bargaining Problem With Credit: Binding Incentive Constraint

- Now consider an incentive constrained equilibrium.
 - From the bargaining rule,

$$v = (1 - \theta)u(x) + \theta x$$

and as above, v must solve

$$v = \frac{\beta\theta [u(x) - x]}{1 - \beta},$$

so we need to solve these two equations for v and x . Note first that one equilibrium is $v = x = X = 0$, and this equilibrium always exists (the no-trade equilibrium). This is an equilibrium where no seller will lend to a buyer, as each seller anticipates the buyer will receive no loans in the future, so the buyer has nothing to lose from defaulting - self-fulfilling for the economy to shut down.

Bargaining Problem Continued

- Look for an equilibrium with $x > 0$. Then x solves

$$\theta x = (\beta + \theta - 1)u(x),$$

and it must also be that case that $x < x^*$. We therefore require

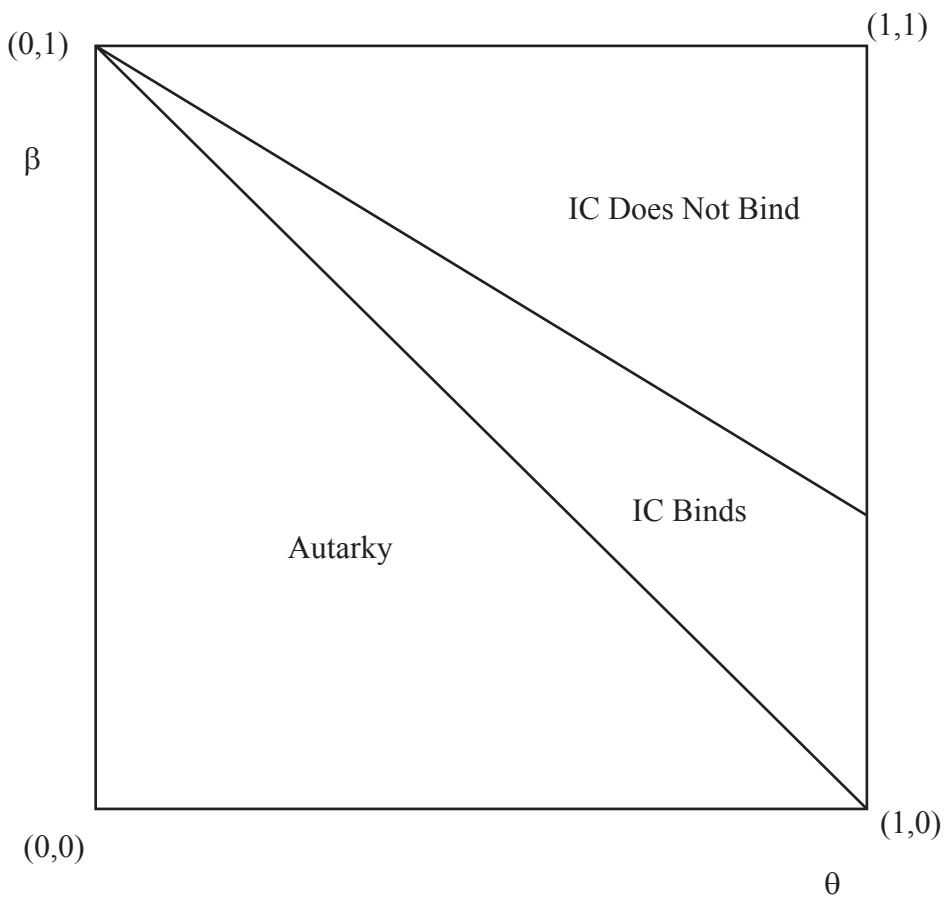
$$\beta \geq 1 - \theta$$

and

$$\beta < 1 - \theta \left[1 - \frac{x^*}{u(x^*)} \right]$$

- Therefore,
 - if $0 \leq \beta < 1 - \theta$, the only equilibrium is the no-trade equilibrium.
 - if $1 - \theta \leq \beta < 1 - \theta \left[1 - \frac{x^*}{u(x^*)}\right]$ we get the no-trade equilibrium and the constrained one with $x > 0$.
 - if $\beta \geq 1 - \theta \left[1 - \frac{x^*}{u(x^*)}\right]$ we get the unconstrained equilibrium and the no-trade equilibrium.
- If $\theta = 1$ the “Hosios condition” holds, and the equilibrium with trade is always efficient.
- But, two inefficiencies:
 - An equilibrium always exists in which trade shuts down – coordination failure.
 - If $\theta < 1$ and a constrained equilibrium exists, it is inefficient – bargaining inefficiency.

Figure 3: Credit Equilibria



- Set this up with standard Lagos-Wright assumptions to shut down credit
- ϕ_t = price of money in terms of goods in the CM.
- Assume no recordkeeping (no memory)
- ϕ_t all that is observed in the CM (can't see actions of other agents)
- lump-sum transfer τ_t (in units of goods, but think of this as a cash transfer) to each buyer in the the CM, set so that

$$M_t = \mu M_{t-1},$$

or

$$\tau_t = \phi_t M_t \left(1 - \frac{1}{\mu}\right),$$

and each buyer is endowed with M_{-1} units of money in the DM of period 0.

- In the CM, the implicit nominal interest rate must be non-negative

$$\frac{\beta\phi_{t+1}}{\phi_t} - 1 \geq 0,$$

which implies that it will be optimal for a seller to exchange any money they hold at the beginning of the CM for goods.

Monetary Equilibrium Continued

- For a buyer, value functions $V(m_C)$ (CM) and $W(m_D)$ (DM), where m_C , m_D denote real money balances.

$$V(m_C) = \max_{H, m_D} [-H + \beta W(m_D)]$$

subject to

$$\frac{\phi_t}{\phi_{t+1}} m_D = H + m_C + \tau,$$

or substituting in the objective function using the constraint (assume $H \geq 0$ not violated, for now):

$$V(m_C) = m_C + \tau + \max_{m_D} \left[-\frac{\phi_t}{\phi_{t+1}} m_D + \beta W(m_D) \right]$$

- Key features: $V(m_C)$ linear in m_C ; and choice of m_D and independent of m_C . Therefore, if the optimum is unique, then all buyers choose the same m_D .

- Pairwise meeting, with the same bargaining arrangement as previously. Buyer has m_D units of money (in units of the consumption good in following CM). Buyer trades d units of real money balances for x units of goods, where d and x solve

$$\max_{d,x} [u(x) - x]$$

subject to

$$u(x) - d = \theta [u(x) - x] \text{ (bargaining rule)}$$

$$d \leq m_D \text{ (cash constraint)}$$

- Cash constraint does not bind: Then $x = x^*$ and

$$d = (1 - \theta)u(x^*) + \theta x^*,$$

and checking that the cash constraint indeed does not bind, we require

$$m_D \geq (1 - \theta)u(x^*) + \theta x^*.$$

- Otherwise, the cash constraint binds and

$$m_D = (1 - \theta)u(x) + \theta x$$

determines x .

- Confine attention to stationary equilibria where m_D is constant in the DM, so money market clearing gives

$$\phi_t M_t = m_D \frac{\phi_t}{\phi_{t+1}}$$

for all t , which implies that $\frac{\phi_{t+1}}{\phi_t} = \frac{1}{\mu}$ for all t . Then, go back and solve the buyer's problem in the CM. We can safely confine attention to equilibria where the cash constraint binds. A straightforward way to write the buyer's problem is

$$V(m_C) = m_C + \tau + \max_x \{-\mu [(1 - \theta)u(x) + \theta x] + \beta u(x)\}.$$

Equilibrium Continued

- Then, note that if $\mu \geq \frac{\beta}{1-\theta}$, then the solution to this problem is $x = 0$, in which case the only equilibrium is one where money has no value ($\phi_t = 0$ for all t). Otherwise, there is a unique solution characterized by the first-order condition

$$\frac{u'(x)}{(1-\theta)u'(x) + \theta} = \frac{\mu}{\beta}$$

which solves for equilibrium x , and then, with m_D denoting real money balances in the DM,

$$X = m_D = (1-\theta)u(x) + \theta x$$

- In equilibrium, sellers will hold all the money balances at the beginning of the CM. Then, buyers work to acquire money in the CM, and receive a money transfer from the government. Then, buyers enter the DM with the entire money stock, and exchange it all for goods produced by sellers, etc.

Incentive Constraint - Taxation

- One last thing we need to check is an incentive constraint – it needs to be incentive compatible for buyers to pay their taxes in the CM. Assume that the government can punish everyone, i.e. $\mu = \infty$, if anyone does not pay their taxes.

$$\begin{aligned} & \tau - \mu [(1 - \theta)u(x) + \theta x] \\ & + \frac{\beta}{1 - \beta} \{u(x) + \tau - \mu [(1 - \theta)u(x) + \theta x]\} \\ \geq & 0 \end{aligned}$$

Note that

$$\tau = m \left(1 - \frac{1}{\mu}\right) = [(1 - \theta)u(x) + \theta x] (\mu - 1).$$

- We can show that $\beta > 1 - \theta$ is necessary for the constraint to hold. If $\beta > 1 - \theta$, we can write the constraint as

$$\beta \geq 1 - \theta + \theta \frac{x}{u(x)}$$

- Given μ , equilibrium x must satisfy the incentive constraint. Note that $\frac{x}{u(x)}$ is increasing in x , so the value of the right-hand side of the inequality increases as μ falls.

Existence of Stationary Monetary Equilibria

- If $\beta \geq 1 - \theta + \theta \frac{x^*}{u(x^*)}$, then an equilibrium with valued money exists for $\mu \in \left[\beta, \frac{\beta}{1-\theta} \right)$.
- If $1 - \theta < \beta < 1 - \theta + \theta \frac{x^*}{u(x^*)}$, then an equilibrium with valued money exists for $\mu \in \left[\tilde{\mu}, \frac{\beta}{1-\theta} \right)$, where $(\tilde{\mu}, \tilde{x})$ solves

$$\beta = 1 - \theta + \theta \frac{\tilde{x}}{u(\tilde{x})} \quad [\text{incentive constraint holds with equality}]$$

$$\frac{u'(\tilde{x})}{(1 - \theta)u'(\tilde{x}) + \theta} = \frac{\tilde{\mu}}{\beta} \quad [\text{equilibrium condition is satisfied}]$$

- If $\beta \leq 1 - \theta$, then an equilibrium with valued money does not exist.
- Can show that $\beta < \tilde{\mu} < 1$ (incentive constraint only matters when the government is levying a tax to support deflation).

Optimal Monetary Policy

- What is an optimal monetary policy? Set μ so that welfare W is maximized where

$$W = u(x) - x$$

- Solution: Want μ to be as low as possible.
 - If $\beta \geq 1 - \theta + \theta \frac{x^*}{u(x^*)}$, then $\mu = \beta$ is optimal.
 - If $1 - \theta < \beta < 1 - \theta + \theta \frac{x^*}{u(x^*)}$, then $\mu = \tilde{\mu} = \frac{\beta u'(\bar{x})}{(1-\theta)u'(\bar{x}) + \theta} > \beta$ is optimal.
- $\mu = \beta$ is the Friedman rule (zero nominal interest rate forever). Let q be the price (in money) of a nominal bond in the CM that can't be traded in the DM, and pays off 1 unit of money in the next CM. Then,

$$q = \frac{\beta}{\mu},$$

and the nominal interest rate is $\frac{1}{q} - 1 = \frac{\mu}{\beta} - 1$.

- Under an optimal policy, we recover the credit equilibrium under perfect recordkeeping – money is memory – see Kocherlakota (1998).

Key Properties of the Model

- Money is neutral - level changes in the money stock (change in M_{-1}) do not matter.
- Money is not super-neutral - an increase in μ increases the inflation rate, buyers take less money into the DM, and there is less trade.
- Friedman rule may not be optimal – taxes required to support it, and buyers need to have the incentive to pay their taxes.
- Money is memory - a monetary system, efficiently run, replicates the equilibrium allocation achieved in a credit system that has perfect memory (i.e. perfect recordkeeping)

- Change the sequencing of markets so that CM comes first, then DM (proves slightly more convenient). Otherwise, preferences (except for buyers – see below), technology, matching are the same.
- Assume no memory, so unsecured credit doesn't work.
- One asset, a Lucas tree (think of it as a house), that yields y units of service flow, only consumable by buyers in the CM.
- Lucas tree tradable in the CM (after dividend received) at price ψ_t ; one unit of perfectly divisible trees in existence.
- Buyers' preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t [-H_t + F_t + u(x_t)]$$

- Must be in possession of the tree to consume the service flow.

Bargaining problem in the DM

- Buyer brings assets a into the meeting. Choose consumption by the buyer x , assets to sell outright, a' , assets to post as collateral a'' , and secured loans l to solve

$$\max [u(x) - x - \beta ya']$$

subject to

$$u(x) - \beta l - \beta(\psi + y)a' = \theta [u(x) - x - \beta ya'] \quad [\text{bargaining rule}]$$

$$l = (\psi + y)a'' \quad [\text{collateral constraint}]$$

$$a \geq a' + a'' \quad [\text{asset constraint}]$$

Solution to the Bargaining Problem

- Solution: $a' = 0$, i.e. it is inefficient to sell assets outright, due to the asymmetry in payoffs between buyer and seller.
- Asset constraint does not bind, $x = x^*$, if

$$\beta(\psi + y)a \geq (1 - \theta)u(x^*) + \theta x^*$$

- Binding asset constraint: The following equation solves for x :

$$\beta(\psi + y)a = (1 - \theta)u(x) + \theta x$$

- Non-binding asset constraint:

$$\psi = \frac{\beta y}{1 - \beta} \text{ [fundamental pricing]}$$

$$\frac{\beta y}{1 - \beta} \geq (1 - \theta)u(x^*) + \theta x^*$$

- Binding asset constraint:

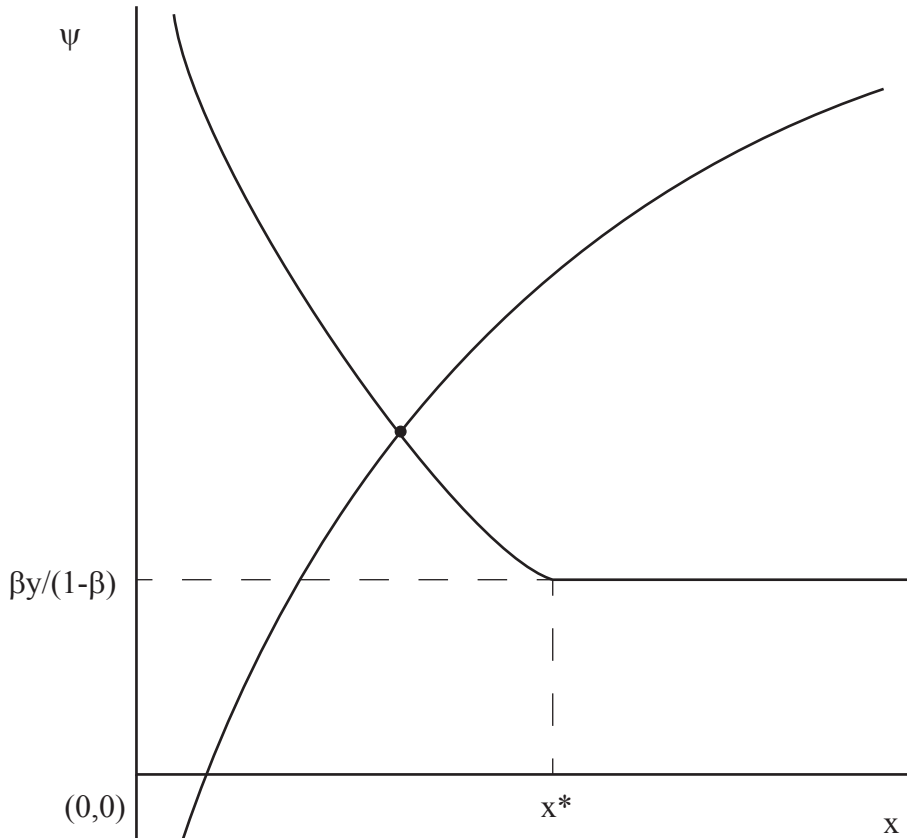
- In the CM, the buyer solves

$$\max_x \left[-\psi \frac{(1 - \theta)u(x) + \theta x}{\beta(\psi + y)} + u(x) \right]$$

- Asset price ψ and quantity traded x are determined by

$$\psi = \frac{\beta y u'(x)}{(1 - \theta - \beta)u'(x) + \theta}$$
$$\psi = \frac{(1 - \theta)u(x) + \theta x - \beta y}{\beta}$$

Figure 4: Secured Credit, Binding Constraint



Liquidity Premium

$$\psi = \frac{\beta y u'(x)}{(1 - \theta - \beta) u'(x) + \theta} = \underbrace{\frac{\beta y}{1 - \beta}}_{\text{fundamental}} + \underbrace{\frac{\beta y \theta [u'(x) - 1]}{(1 - \beta) [(1 - \theta - \beta) u'(x) + \theta]}}_{\text{liquidity premium}}$$

- liquidity premium is increasing in $u'(x)$, i.e. it increases with the inefficiency in exchange.
- Note that, in equilibrium, the Lucas trees are never traded – but there is a liquidity premium, much like what is associated with an asset that has value in part because it is used in exchange.

Open Market Operations and Banking

- Three assets:
 - currency, sells in the CM at price ϕ_t in terms of goods.
 - one-period nominal government bonds, which sell in the CM at price z_t in terms of money – each a claim to 1 unit of money in the next CM.
 - interest-bearing reserves, which are identical to government bonds, but are liabilities of the central bank, not the fiscal authority.
 - government bonds and reserves are electronic – not portable.
- Consolidated government budget constraints:

$$\phi_0 C_0 + \phi_0 z_0 (M_0 + B_0) = \tau_0$$

$$\phi_t (C_t - C_{t-1}) + \phi_t z_t (M_t + B_t) - \phi_t (M_{t-1} + B_{t-1}) = \tau_0, \quad t = 1, 2, \dots$$

- Add some economic agents: Bankers active only in CM with preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t (-H_t + X_t)$$

Information Structure and Commitment

- With probability ρ : Buyer meets a seller who cannot verify assets in the buyer's portfolio, so will accept only currency.
- With probability $1 - \rho$: Buyer meets a seller who can verify contents of the buyer's portfolio – government bonds and claims on financial intermediaries – seller accepts all assets.
- In the CM, buyers learn, at the end of the period after consumption and production take place, what type of seller they will meet in the next DM (whether they require currency or not).
- A buyer can contact at most one bank at the end of the CM, and buyers do not interact with each other.
- No memory, no commitment.
- Take-it-or-leave-it offers by the buyer in the DM ($\theta = 1$).

Bank's Problem

- Drop t subscripts (looking for a stationary equilibrium), and write everything in real terms (units of CM goods).
- μ = gross inflation rate.
- Bank chooses the deposit contract and its portfolio to maximize the expected utility of a representative depositor, subject to a break-even constraint and a collateral constraint:

$$\max_{k,c,d,m,b} \left[-k + \rho u \left(\frac{\beta c}{\mu} \right) + (1 - \rho) u(\beta d) \right]$$

subject to

$$k - \rho c - z(m + b) + \beta \left[-(1 - \rho)d + \left(\frac{m + b}{\mu} \right) \right] \geq 0 \text{ [b-e constraint]}$$

$$-(1 - \rho)d + \left(\frac{m + b}{\mu} \right) \geq 0 \text{ [collateral constraint]}$$

- Bank provides insurance to depositors – diversification important in fulfilling this insurance role. Like Diamond-Dybvig (1983).

Solve Bank's Problem

- Let λ denote the multiplier associated with the collateral constraint.
- Break-even constraint holds with equality at the optimum.

$$u' \left(\frac{\beta c}{\mu} \right) = \frac{\mu}{\beta}$$

$$\beta u'(\beta d) - \beta - \lambda = 0$$

$$-z + \frac{\beta}{\mu} + \frac{\lambda}{\mu} = 0$$

- Fiscal policy rule: Real value of the consolidated government debt constant forever ($= V$), so

$$V = \rho c + z(m + b)$$

- Look for an equilibrium for which the collateral constraint binds

$$-(1 - \rho)d + \left(\frac{m + b}{\mu}\right) = 0$$

- Define x_1 , x_2 , as consumption in currency and non-currency exchange in the DM, respectively. Then, two equations solving for (x_1, x_2) :

$$(1 - \rho)x_2 u'(x_2) + \rho x_1 u'(x_1) = V$$

$$z = \frac{u'(x_2)}{u'(x_1)}$$

Remainder of Equilibrium Solution

- Gross inflation rate:

$$\mu = \beta u'(x_1)$$

- Currency outstanding:

$$\rho c = \rho x_1 u'(x_1)$$

- Reserves and government bonds outstanding:

$$z(m + b) = (1 - \rho)x_2 u'(x_2)$$

- Gross real interest rate:

$$r = \frac{1}{\beta u'(x_2)} = \underbrace{\frac{1}{\beta}}_{\text{fundamental}} - \underbrace{\frac{1}{\beta} \left[\frac{u'(x_2) - 1}{u'(x_2)} \right]}_{\text{liquidity effect}}$$

- Central bank balance sheet needs to be sufficiently large to support a given nominal interest rate:

$$\rho c + z m \geq \rho x_1 u'(x_1)$$

- But, if that constraint holds, then open market operations (swaps of reserves for government bonds) are irrelevant, given z .
- With reserves outstanding, monetary policy consists of setting the interest rate on reserves, $\frac{1}{z} - 1$.
- Decrease in z (increase in the nominal interest rate), and assuming $-x \frac{u''(x)}{u'(x)} < 1$:
 - x_1 falls, x_2 rises.
 - real interest rate rises.
 - inflation rate rises.

Figure 5: Monetary Policy

