Liquidity, Business Cycles, and Monetary Policy (Kiyotaki & Moore, 2008)

Jin Cao¹

¹Munich Graduate School of Economics, Department of Economics, Ludwig-Maximilians-Universität München

Macroeconomics Reading Group (WS08/09)
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Successful stories of RBC models

- $AR(1)$ technological shock $\ln z_{t+1} = \rho \ln z_t + \epsilon_{t+1}$ upon a simplest RBC model ($c$-green, $y$-blue, $i$-red)
However, caveat...

- The successful story relies on large, persistent and exogenous aggregate productivity shock.
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Step 1: Modelling credit system in RBC models

- Endogenized credit limits (in contrast to Bernanke & Gertler, 1999) may act as a propagation mechanism, after a small & temporary productivity/wealth distribution shock.

Features:

- Credit constraints because of incomplete contract, i.e. debts are not enforceable unless secured by collateral;
- Collateral: Future returns from present investment;
- Feedback: Temporary productivity shock → less collateral value → cut back investment to pay debts → persistence: slow recovery.
- However, “all-purpose good”, no clear definition for liquidity.
Step 2: Monetary economy, liquidity, and policy

- Based on the endogenous credit system, introducing money. Then
  - Money as an anchor to define all assets’ liquidity;
  - Role of monetary policy in liquidity-induced business cycles;

- However, more new problems than solved
  - Why are agents willing to hold money (essentially paper IOU, or fiat money)?
  - Portfolio of money and physical capital in business cycle?
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Preference and technology

- Representative agent’s problem: Consumption, investment, output, debt

\[
\max \{c_{\tau}, x_{\tau}, y_{t+1}, b_{t+1}\}_{\tau=0}^{+\infty} E_t \left[ \sum_{\tau=0}^{+\infty} \beta^{\tau} \ln c_{t+\tau} \right].
\]

- Heterogenous in productivity: Productive \( y_{t+1} = \alpha x_t \), or unproductive \( y_{t+1} = \gamma x_t \) with \( 1 < \gamma < \alpha \).

- “Transition matrix”:

\[
\begin{bmatrix}
1 - \delta & \delta \\
 n\delta & 1 - n\delta \\
\end{bmatrix}.
\]
Resource constraints and credit constraint

- (Intertemporal) Flow budget constraint: \( \forall t \)
  \[ c_t + x_t = y_t + \frac{b_{t+1}}{r_t} - b_t; \]

- (Intratemporal) Resource constraint: \( \forall t \)
  \[ C_t + C_t' + X_t + X_t' = Y_t + Y_t'; \]

- Borrowing (collateral) constraint: \( \forall t \)
  \[ b_{t+1} \leq \theta y_{t+1} \text{ with } \theta \alpha < \gamma. \]
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Collateral: A proportion of the future returns from present investment. In equilibrium, productive agents borrow up to the credit limit.

When a temporal negative productivity shock reveals at $t$ and all agents’ net worth declines

- Productive agents have more accumulated debts, net worth falls more;
- More investment’s cut back from productive agents;
- After $t$, slow recover of productive agents’ net worth and aggregate production.
Equilibrium analysis

- To highlight the importance of credit constraint, assume that $\delta$ is high and $n$ is low

$$\delta > \theta \frac{\alpha - \gamma}{\gamma - \theta \alpha - n \theta \gamma};$$

- Then risk-free interest rate $r_t = \gamma$.
- The share of net worth of productive agents ($R$ — rate of return on saving for productive agents)

$$s_{t+1} = \frac{(1 - \delta)R_s + n \delta \gamma (1 - s_t)}{R_s + \gamma (1 - s_t)} \equiv f(s_t).$$
Equilibrium analysis (cont’d)

- Transitional path after a temporary positive productivity shock
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Agents, preferences, and technology

- Heterogenous agents: Entrepreneurs and workers. Fiat money with fixed supply $M$.
- Entrepreneurs’ problem

$$\max E_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} \ln c_s \right], \text{ with}$$

$$y_t = A_t (k_t)^{\gamma} (l_t)^{1-\gamma}, \quad y_t - w_t l_t = r_t k_t, \quad \text{as well as}$$

$$k_{t+1} = \lambda k_t + i_t \text{ with probability } \pi \text{ (productive).}$$

- Neoclassical production function, competitive goods market.
Credit constraint, liquidity, and resource constraint

- Again, credit constraint $b_t \leq \theta i_t$;
- (Productive entrepreneurs’) Funding through issuing equity $n_t$

\[ n_{t+1} \geq (1 - \theta) i_t + (1 - \phi_t) \lambda n_t \text{ with } m_{t+1} \geq 0; \]

- And liquidity out of “resaleability constraint”: Only fraction of $\phi_t$ equity can be sold for money;
- Resource constraint (Equity price $q_t$, price of money $p_t$)

\[ c_t + i_t + q_t (n_{t+1} - i_t - \lambda n_t) + p_t (m_{t+1} - m_t) = r_t n_t. \]
Agents, preferences, and technology (cont’d)

- Workers’ problem

$$\max E_t \left\{ \sum_{s=t}^{+\infty} \beta^{s-t} u \left[ c'_s - \frac{\omega}{1+\nu} \left( l'_s \right)^{1+\nu} \right] \right\},$$

- Resource constraint

$$c'_t + q_t (n'_{t+1} - \lambda n'_t) + p_t (m'_{t+1} - m'_t) = w_t l'_t + r_t n'_t \text{ with } n'_{t+1} \geq 0 \text{ and } m'_{t+1} \geq 0.$$

- Inalienable human resource: No investment chance!
Equilibrium analysis: Two cases

- **Case 1**: Money is useless when equity is liquid enough

\[
(1 - \lambda) \theta + \pi \lambda \phi > (1 - \lambda)(1 - \pi);
\]

- **Case 2**: Money is valuable when

\[
0 < \pi \lambda \beta^2 (1 - \phi)(1 - \pi)[(1 - \lambda)(1 - \pi) - (1 - \lambda)\theta - \pi \lambda \phi] \\
+ [(\beta - \lambda)(1 - \pi) - (1 - \lambda)\theta - \pi \lambda \phi][1 - \lambda + \pi \lambda - (1 - \lambda)\theta - \pi \lambda \phi] \\
\cdot [\lambda (1 - \beta)(1 - \pi) + (1 - \lambda)\theta + \lambda (\beta + \pi - \pi \beta)\phi].
\]
Equilibrium analysis in monetary economy

- In steady state, workers choose to hold neither equity nor money;
- The price of money $p_t > 0$;
- Productive entrepreneurs face the binding liquidity constraints and will not choose to hold money, $m_{t+1} = 0$;
- Unproductive entrepreneurs choose to hold a portfolio with money, $m'_{t+1} > 0$ and equity. Trade off:
  - Probability to become productive — Money is most liquid for investments;
  - Probability to stay unproductive — Equity holdings to maximize returns.
Outline

Motivation
Beyond successful stories of RBC models
Solution: Including liquidity in RBC models

Baseline Model: Endogenized Credit System
Model specifications
Equilibrium

Extension: Liquidity, Business Cycles, and Monetary Policy
Money and liquidity in a monetary economy
Dynamics and monetary policy
Dynamics under cyclical technological shock
Government in the monetary economy

- Inefficiency of monetary economy with liquidity constraint: Fluctuations in consumption. Role for government?
- Government intervenes the economy through equity — Open market operations, i.e. buying (selling) equity via issuing (taking in) money.
- Flow budget constraint

\[
G_t + q_t \left( N_{t+1}^g - \lambda N_t^g \right) = r_t N_t^g + p_t \left( M_{t+1} - M_t \right) \quad \text{with}
\]

\[
K_t = N_t^g + N_t.
\]
Optimal monetary policy
Summary

- A compact, tractable framework of modelling liquidity in a typical macro framework.

- Key features:
  - Incomplete contract based credit system, collateral proportional to net worth;
  - Liquidity issues arise from resaleability constraint, with money as value-transfer medium upon wealth distribution shocks.

- Unsolved issues:
  - More instruments for monetary policy, e.g. interest rate?
  - Beyond no-default equilibrium: Modelling financial crisis as a crash state (à la Rietz)?
Kiyotaki, N. and J. Moore
*Liquidity, Business Cycles, and Monetary Policy.*
Mimeo, Princeton University, 2008.

Kiyotaki, N. and J. Moore
*Evil is the Root of All Money.*