Firms, Bank Loans, and Monetary Policy

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1 The views expressed in this paper are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.
Introduction

- Monetary and banking frictions are important ingredients of Macro models.
- Monetary frictions affect the exchange process.
  - Agents’ portfolio decision.
- Banking frictions distort the allocation of capital.
- What is the interplay between these two frictions?
- Are they quantitatively relevant?
Introduction

- Most papers emphasize the monetary frictions faced by consumers.
  - Consumers hold part of their wealth in the form of non-interest-bearing assets.
  - They optimally economize on their holdings of these (usually liquid) assets.
  - Socially inefficient.

- The quantitative importance of this friction is apparently small.
What do we do?

- We emphasize the monetary frictions faced by the firm.
  - Firms hold part of their earnings in the form of non-interest-bearing assets.
    - Opportunity cost of holding these assets.
  - Firms need external finance (subject to CSV friction).
    - Not individually optimal for lenders to fund all firms.
    - Overall investment is suboptimal.
- Channel based on the interplay between these two frictions.
- Investigate the quantitative importance of this channel.
Results

- Monetary & banking frictions matter.
  - Monetary frictions amplify the banking frictions.
  - Our channel is quantitatively important.
Literature

- **Money**: Lagos & Wright (2005); Rocheteau & Wright (2005).
- **Banking & Business Cycles**: Bernanke & Gertler (1989); Williamson (1987b).
- **Money & Banking**: Williamson (1987b); Andolfatto & Nosal (2008); He, Huang & Wright (2008); Williamson (2011).
Discrete time: \( t = 0, 1, 2, \ldots \)

Each period is divided into two subperiods.

Two perishable goods:
- General good (GG) produced in the first subperiod.
- Special good (SG) produced in the second subperiod.

Two types of agents:
- Households: \([0, 1]\) continuum.
- Entrepreneurs: continuum with measure \( \alpha > 0 \).
Households produce GG only.

- $h$ units of effort $\Rightarrow h$ units of GG.

Entrepreneur is endowed with one *indivisible* project.

- 1 unit of GG $\Rightarrow \tilde{y}$ units of SG.
- $\tilde{y}$ is uniformly distributed over $[0, 1]$.
- The realization of $\tilde{y}$ is privately observable.

Households can verify at a cost (effort) the realization of $\tilde{y}$ at date $t + 1$.

- Monitoring cost: $\gamma > 0$ is uniformly distributed over $[0, \bar{\gamma}]$. 
Model: Preferences

- Households have preferences represented by
  \[ U^h_t (x_t, h_t, q_t) = x_t - h_t + u(q_t) \]
- Entrepreneurs have preferences represented by
  \[ U^e_t (e_{t+1}) = e_{t+1} \]
- Household’s discount factor \( \beta \in (0, 1) \).
• Suppose $\gamma = 0$.
• Planner solves:

$$\max_{(x,e,h,i,q) \in \mathbb{R}_+^5} \left[ x - h + u(q) \right]$$

$$h = x + \alpha e + i;$$

$$q = \frac{i}{2};$$

$$0 \leq i \leq \alpha;$$

$$e \geq \bar{U}^e$$

• Solution: $i = 2q^*$, where $u'(q^*) = 2$.
• Assume $\alpha = 2q^*$. 
Pure Credit Economy

- First subperiod (GG): Market for Loanable Funds
  - Entrepreneurs post the terms of the contract.
  - Perfectly competitive.
- Perfect recordkeeping & perfect enforcement of private liabilities.
Figure 1 - Optimal Contract

$p$ is the price of one unit of SG in terms of GG.
Figure 2 – Loans to Entrepreneurs

Lender’s expected payoff

\[ \varphi(r,p;\gamma) \]
\[ \varphi(r,p;\gamma') \]
\[ \varphi^b(r,p;\gamma'') \]

\[ \gamma < \gamma' < \gamma'' \]
Figure 3 – “Marginal” Entrepreneur

$$\gamma < \gamma' < \gamma''$$

**Lender’s expected payoff**

Lender’s expected payoff $\varphi(r, p; \gamma)$, $\varphi(r, p; \gamma')$, $\varphi(r, p; \gamma'')$.

**Graphical representation**

- Horizontal axis: $r$ (rate)
- Vertical axis: $1/\beta$
- Three curves: $\varphi(r, p; \gamma)$, $\varphi(r, p; \gamma')$, $\varphi(r, p; \gamma'')$

Points:
- $r_\gamma$
- $r_{\gamma'}$
- $p$
- $\gamma^* = \gamma'$
Household’s participation constraint (PC):

\[ r \left(1 - \frac{\gamma}{\hat{p}}\right) - \frac{r^2}{2\hat{p}} \geq \frac{1}{\beta} \]

Given \( \hat{p} \), entrepreneur \( \gamma \) offers \( r (\hat{p}; \gamma) \) satisfying PC with equality.

Only entrepreneurs indexed \( \gamma \leq \gamma_* \) can offer \( r \) satisfying PC.

Households create an FI that makes all loans to entrepreneurs.

- FI maximizes expected utility by taking deposits & making loans.
- FI holds a fully diversified portfolio.
- FI is able to promise a certain return \( \beta^{-1} \) to each depositor.
Household’s Problem

- Value function (second subperiod):

\[
\hat{V}(a) = \max_{q \in \mathbb{R}_+} \left\{ u(q) + \beta \max_{(x,h,a') \in \mathbb{R}_+^3} \left[ x - h + \hat{V}(a') \right] \right\}
\]

subject to

\[
x + \hat{p}q + a' = h + \beta^{-1}a
\]

- Demand for SG as a function of \( \hat{p} \):

\[
\beta \hat{p} = u'(q)
\]
Aggregate investment:

\[ i = \frac{\alpha \gamma_*}{\bar{\gamma}} \]

Market clearing:

\[ q = \frac{\alpha \gamma_*}{2\bar{\gamma}} \quad \& \quad a' = i \]

Relative price:

\[ \hat{p} = \gamma_* + \beta^{-1} + \sqrt{(\gamma_* + \beta^{-1})^2 - \gamma_*^2} \]

**Definition**

A credit eq. is a list \((a', i, \gamma_*, q, \hat{p})\) satisfying: (i) the Euler equation; (ii) the optimal investment choice; and (iii) the market-clearing conditions.
Pure Credit Economy

- \( \omega \equiv \gamma_*/\bar{\gamma} \).
- Social welfare is given by
  \[
  W^c = -2\omega q^* + u(q^*\omega)
  \]
- \( \partial\omega/\partial\bar{\gamma} < 0 \).
- Small \( \bar{\gamma} \) means CSV friction is small: credit economy is arbitrarily close to UE allocation.
- Large \( \bar{\gamma} \) means CSV friction is large: credit economy is far away from UE allocation.
Lack of recordkeeping & limited enforcement.

- A medium of exchange is required to settle transactions on the second market.

Walrasian market in the first subperiod: Agents trade GG for fiat money.

Government’s budget constraint:

$$\bar{M}_t - \bar{M}_{t-1} = T_t$$

- $$\bar{M}_t = \mu \bar{M}_{t-1}$$ for all $$t \geq 1$$.
- $$\phi_t$$ is the value of money at date $$t$$. 
households

Money

firms

GG

SG

$\beta$

GG
Household’s participation constraint (PC):

$$\frac{\mu r^2}{2p} - r + \frac{p}{2\mu} \geq \frac{1}{\beta}$$

Given $p$ & $\mu$, entrepreneur $\gamma$ offers $r(p, \mu; \gamma)$ satisfying PC with equality.

Only entrepreneurs indexed $\gamma \leq \gamma_*$ can offer $r$ satisfying PC.

Households create an FI that makes all loans to entrepreneurs.

- FI maximizes expected utility by taking deposits & making loans.
- FI holds a fully diversified portfolio.
- FI is able to promise a certain return $\beta^{-1}$ to each depositor.
Value function (second subperiod):

\[ V(a, m) = \max_{q \in \mathbb{R}^+} \left\{ u(q) + \beta \max_{(x, h, a', m') \in \mathbb{R}^4_+} [x - h + V(a', m')] \right\} \]

subject to

\[ a' + m' + x = h + \beta^{-1} a + \mu^{-1} (m - pq) + \tau; \]

\[ pq \leq m \]

Optimal choice of real balances:

\[ 1 = \frac{1}{p} u' \left( \frac{m'}{p} \right) \]
Monetary Economy

Equilibrium

- Aggregate investment:
  
  \[ i = \frac{\alpha \gamma^*_v}{\bar{\gamma}} \]

- Market clearing:
  
  \[ m' = p \frac{\alpha \gamma^*_v}{2\bar{\gamma}} \quad \text{and} \quad a' = i \]

- Relative price:
  
  \[ p = \mu \left[ \gamma^*_v + \beta^{-1} + \sqrt{(\gamma^*_v + \beta^{-1})^2 - \gamma^*_v} \right] \]

Definition

A monetary eq. is a list \((m', a', i, \gamma^*_v, p)\) satisfying: (i) the Euler equation; (ii) the optimal investment choice; and (iii) the market-clearing conditions.
\[ \frac{\partial \gamma^*_\mu}{\partial \mu} < 0. \]

Higher inflation rate \( \Rightarrow \) fewer entrepreneurs are funded (lower aggregate investment).

- Expected value of each project \( p/2\mu \) falls as the inflation rate rises.
- Only low-cost entrepreneurs are able to obtain external funds.
Social welfare is given by

\[ W(\mu) = -2\omega(\mu)q^* + u(\omega(\mu)q^*) \]

Friedman rule is optimal: \( \mu = \beta \).

It implements the same allocation as the credit economy.
Quantitative Analysis

- CRRA utility:
  \[
  \frac{(q + \chi)^{1-\sigma} - \chi^{1-\sigma}}{1 - \sigma} \quad \text{with } \sigma > 0 \text{ & } \chi \in (0, 1)
  \]
- \( \beta = 0.96; \sigma = 0.5 \).
- To calibrate \( \tilde{\gamma} \), we target the ratio \( i/m \).
  \[
  \frac{i}{m} = 0.67 = \frac{2}{\mu \left[ \gamma_* + \beta^{-1} + \sqrt{(\gamma_* + \beta^{-1})^2 - \gamma_*^2} \right]}
  \]
- C&I loans as a proxy for the investment of bank-dependent firms.
- M1 as a measure of the stock of money.
The Welfare Cost of Inflation

- Annual data: 1959-2010.
- Lagos & Wright (2005):
  \[-2\omega(\mu)q^* + u(\omega(\mu)q^*) = -2\omega(\beta)q^* + u(\omega(\beta)q^*\Delta_\mu)\]
  - Welfare cost: \(1 - \Delta_\mu\)
- Cooley & Hansen (1989):
  \[-2\omega(\mu)q^* + u(\omega(\mu)q^* + \Delta_\mu) = -2\omega(\beta)q^* + u(\omega(\beta)q^* + \bar{\Delta}_\mu)\]
  - Welfare cost: \(\bar{\Delta}_\mu / \omega(\mu)q^*\)
Benchmark: $i/m = 0.67 \ (\tilde{\gamma} = 0.95)$
- L&W: $1 - \Delta_{1.1} = 5.48\%$
- C&H: $\bar{\Delta}_{1.1}/\omega (1.1) q^* = 5.16\%$

Fraction $\eta \in (0, 1)$ of "credit" firms & fraction $1 - \eta$ of "cash" firms.
- Recalibrate the model (to be done).
Monetary & banking frictions matter.

- Monetary frictions amplify the banking frictions.
- Our channel is quantitatively important.