On the Welfare Effects of Credit Arrangements

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Motivation

- Recent policy debates on regulating the retail payment system are motivated by concerns about efficiency of different payment instruments.

- Some empirical studies show that the social costs of using cash is higher than other payment instruments.

- It is natural to think that credit arrangements can improve social welfare.
  - Benefit from credit function.
  - Low cost.
Motivation

- We construct an environment such that the above thinking may not be true.
  - Even though cash is costly to use and credit is costless.
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  - Even though cash is costly to use and credit is costless.

- The reason: agents fail to internalize the negative externality generated by credit users.
  - Some people cannot access credit (money users) and are liquidity constrained.
  - People who use credit typically demand more and bid up the price.
  - Money users suffer from the high price.
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- This price effect is absent in the frictionless world (Arrow-Debreu economy).
Research Questions

- Does credit arrangement always improve social welfare in a competitive equilibrium?
  - If not, where is the inefficiency coming from?
- What sorts of pricing mechanisms are needed to correct it?
The provision of credit and payment services can be welfare-reducing.
- general equilibrium price effects.

Inefficiencies can be mitigated by adopting an optimal trading mechanism.

Price discrimination is typically required to internalize price effects.
Our Answers

- The provision of credit and payment services can be welfare-reducing.
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  - The provision of credit and payment services becomes welfare-improving.
  - Price discrimination is typically required to internalize price effects.
  - Mitigate the social cost of inflation.
Environment I

- Each period is divided into day and night. Walrasian market in each subperiod.
- Buyers:
  - two permanent types: credit users ($\alpha$) and money users ($1 - \alpha$);
  - with prob. $\pi$, want to consume during the day (i.i.d. shock at the beginning of the day).
- Sellers: can produce but do not want to consume during the day.
- Monetary authority: $M_+ = \gamma M$. New money as lump-sum transfer (or tax) to buyers.
Environment II

- **Day:**
  - Buyers (fraction of $\pi$): $u(q)$
  - Sellers: $-c(q)$
  - Anonymity + lack of double coincidence of wants $\rightarrow$ money is essential

- **Night:**
  - Settle credit and adjust money balances.
  - All agents can consume and produce good $x$
  - Quasilinear preferences: $v(x) - y$
  - Linear production function.
Environment III

- Competitive banking sector
  - Open when $\pi$ is realized (before goods trading) in day.
  - Take deposits with rate $r^d$ and make loans with rate $r$.
  - Open again at night for settlement.
  - WLOG, all financial contracts are one-period contracts.
  - Record only financial history, not transaction history in the goods market.
Bank only lends out loans in terms of government money. 
⇒ credit creation subject to liquidity constraints,
Night Market Problem

For $j \in \{b, n, s\}$

$$W^j(m, \ell, d) = \max_{x,y,m_+} \{ v(x) - y + \beta V^j(m_+) \}$$

s.t. $y + \phi(m + \tau M) + (1 + r^d)d = x + \phi m_+ + (1 + r)\ell$.

$b$ : credit users
$n$ : money users
$s$ : sellers
Day Market Problem

Money users:

\[ V^n(m^n) = \max_{q^n} \pi \left[ u(q^n) + W^n(m^n - pq^n) \right] + (1 - \pi) W^n(m^n) \quad \text{s.t. } pq^n \leq m^n. \]
Day Market Problem

Money users:

\[ V^n(m^n) = \max_{q^n} \pi \left[ u(q^n) + W^n(m^n - pq^n) \right] + (1 - \pi) W^n (m^n) \]
\[ \text{s.t. } pq^n \leq m^n. \]

Credit users:

\[ V^b(m^b) = \max_{q^b,\ell,d} \pi \left[ u(q^b) + W^b(m^b + \ell - pq^b, \ell, 0) \right] \]
\[ + (1 - \pi) W^b(m^b - d, 0, d) \]
\[ \text{s.t. } pq^b \leq m^b + \ell, \]
\[ d \leq m^b. \]
Day Market Problem

Money users:

\[ V^n(m^n) = \max_{q^n} \pi [u(q^n) + W^n(m^n - pq^n)] + (1 - \pi) W^n(m^n) \quad \text{s.t. } pq^n \leq m^n. \]

Credit users:

\[ V^b(m^b) = \max_{q^b,\ell,d} \pi [u(q^b) + W^b(m^b + \ell - pq^b, \ell, 0)] + (1 - \pi) W^b(m^b - d, 0, d) \quad \text{s.t. } pq^b \leq m^b + \ell, \quad d \leq m^b. \]

Sellers:

\[ V^s(m^s) = \max_{q^s,\ell,d} [-c(q^s) + W^s(m^s + \ell - d + pq^s, \ell, d)] \quad \text{s.t. } d \leq m^s. \]
Banking Problem

The bank’s problem:

$$\max_{L,D} \left( rL - r^d D \right) \quad \text{s.t.} \quad L \leq D.$$ 

In equilibrium,

$$r = r^d > 0.$$ 

Banks channel money balances from those who have additional liquidity to those who need liquidity.
Monetary Equilibrium

- In equilibrium, \( r = i = \frac{\gamma}{\beta} - 1 \) and \((q^b, q^n, q^s)\) solve
  
  **credit:** \( u'(q^b) = (1 + i) c'(q^s), \)
  
  **money:** \( u'(q^n) = \left(1 + \frac{i}{\pi}\right) c'(q^s), \)
  
  **market clearing:** \( q^s = \pi \left[ \alpha q^b + (1 - \alpha) q^n \right]. \)

- **Note**
  
  1. \( q^b > q^n, \)
  2. \( q^b \) is directly affected by \( i. \)
  3. \( q^b \) and \( q^n \) interact through \( c'(q^s). \)
Inflation and Welfare

Aggregate welfare

\[ \mathcal{W} = \frac{1}{1 - \beta} \left\{ 2\nu(x^*) - 2x^* + \left[ \alpha \pi u(q^b) + (1 - \alpha)\pi u(q^n) - c(q^s) \right] \right\}. \]

Proposition

**Effects of inflation: \( i \uparrow \)**

\[
\begin{array}{c|c|c|c|c}
q^n & q^b & \textbf{or} & q^s & \mathcal{W} \\
\downarrow & \uparrow & & \downarrow & \downarrow
\end{array}
\]
Access to Credit and Welfare

Proposition

*Effects of access to credit:* $\alpha \uparrow$

\[
\begin{array}{c|c|c|c}
q^n & q^b & q^s & \mathcal{W} \\
\downarrow & \downarrow & \uparrow & \downarrow
\end{array}
\]
Price Effect

Money User:
\[ \frac{1}{1+i} u'(q^n) \]

Credit User:
\[ \frac{1}{1+i} u'(q^b) \]

Aggregate:
\[ AS c'(q^s) \]

Initial \( \alpha \)
Price Effect

Increase $\alpha$ by $\Delta\alpha$
Price Effect

\[ \phi p \]

Money User

\[ \frac{1}{1+i} u'(q^n) \]

\[ \phi p_1 \]

\[ \phi p_0 \]

\[ q^n \]

\[ q^n_1 \]

\[ q^n_0 \]

Welfare loss \( \approx \pi (1 - \alpha) \times \)

Credit User

\[ \frac{1}{1+i} u'(q^b) \]

\[ \phi p_1 \]

\[ \phi p_0 \]

\[ q^b \]

\[ q^b_1 \]

\[ q^b_0 \]

Welfare gain \( \approx \pi \Delta \alpha \times \)

Aggregate

\[ AS c'(q^s) \]

\[ \alpha \uparrow \]

\[ AD \]

\[ q^s \]

\[ q^s_0 \]

\[ q^s_1 \]

Welfare Change

Findings 18/26
Mechanism Design

- Inefficiency comes from price effects. Can pricing arrangement be improved to mitigate inefficiencies?
- Allow the most flexible trading mechanism to give us a welfare benchmark.
- Mechanism design approach à la Hu et al. (2009) and Rocheteau (2011).
  - Abstract from all pricing inefficiencies, and focus on monetary frictions.
- All types are publicly observable except money holdings.
- A mechanism maps an agent’s type \( j \) and his announced money balance to an allocation \((q^j, z^j)\).
Optimal Mechanism

To ensure that no one misreports his money holdings, a mechanism can be designed as

- the allocation does not depend on seller’s report;
- to support the desired allocation \((q^j, z^j)\) for a type \(j\) buyer, the mechanism will propose \((q^j, z^j)\) if the announce money balance is no less than \(z^j\), and will propose \((0, 0)\) otherwise.

Implementation concept: immune to individual deviation (Nash).

Focus on the mechanism that maximizes the social welfare subject to technological constraints and incentive constraints by different agents.
Comparison with Competitive Pricing

- Mechanism can achieve the first best even in the presence of small inflation.
- The reason:
  - not restricted to linear pricing;
  - can be contingent \((q, z)\) on the agent’s type and on the (self-reported) money holding;
  - prohibits side trades.
Extension: Credit as a Means of Payment

- Credit creation is not subject to liquidity constraint.
- Banks can issue inside money loan as a payment instrument.
- Findings:
  - Welfare reduces even more in a competitive equilibrium.
  - Under optimal pricing mechanism, credit serving a means of payment dominates the benchmark economy.
Extension: Imperfect Enforcement

- Suppose that repayment of credit cannot be enforced. The only punishment is to exclude from the banking sector forever. There exists an endogenous credit limit, $\ell$.

- Three types of equilibrium:
  - pure monetary equilibrium,
  - constrained credit equilibrium,
  - unconstrained credit equilibrium.

- In a constrained credit equilibrium, the presence of the credit limit brings an additional link between $q^b$ and $q^n$.

- Increase in $\alpha$

  $$q^n \downarrow \quad q^b \uparrow \quad q^s \uparrow \quad \mathbb{W} \uparrow$$
Conclusion

- Micro-founded model to evaluate the welfare implications of different payment arrangements.
  - Emphasize the role of frictions.

- The provision of credit and payment services is not necessarily welfare-improving.
  - Agents may fail to internalize the effects of their actions due to liquidity constraints.

- The welfare implications of different payment/credit arrangements depend critically on fundamental technologies
  - trading,
  - production,
  - enforcement.

- The optimal trading mechanism typically exhibits nonlinear pricing and price discrimination across different types.
Related Literature

Numerical Examples

- Numerical analysis: \( u(q) = \frac{1}{\rho} q^\rho \) and \( c(q) = \frac{A}{\eta} q^\eta \)
  
  Let \( \rho = 0.5 \), \( \eta = 2 \), \( A = 0.1 \)
  
  Benchmark: \( \pi = 0.5 \), \( \alpha = 0.5 \), \( \gamma = 1.1 \)

- black – pure monetary economy; blue – nominal loan economy; red – real loan economy
Consumption: agents who can access credit

\[ q^1 \]

consumption with nominal/real loan

money growth rate

money growth rate
Consumption: agents who cannot access credit

cconsumption without nominal/real loan

money growth rate

$q_0$
Price

The graph illustrates the relationship between the price and the money growth rate. As the money growth rate increases, the price decreases. The curve shows different lines for varying conditions or parameters, indicating how price changes in response to different levels of monetary growth.
Real Demand for Money

money demand

money growth rate

md

1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
0.5
1
1.5
2
2.5
3

1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
1
1.1
1.2
1.3
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1.8
1.9

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0.5
1
1.5
2
2.5
3

money demand

money growth rate

md
Access to Credit

Left: $\pi = 0.5$, Right: $\pi = 0.1$
Inflation: Benchmark

Welfare in Nominal Loan, Real Loan and Monetary Economies
Inflation: Different $\alpha$

Left: $\alpha = 0.9$, Right: $\alpha = 0.1$
Imperfect Enforcement: Economy 1

- $q_b$ vs. $q_d$
- $q_s$ vs. credit limit vs actual credit (red)
Imperfect Enforcement: Economy 2

credit limit verus actual credit (red)
Imperfect Enforcement: Welfare Comparison I

welfare and access to credit

fraction of agents with credit

W
Imperfect Enforcement: Welfare Comparison II

Welfare in Nominal Loan, Real Loan and Monetary Economies

Left: $\alpha = 0.9$, Right: $\alpha = 0.1$