On the Essentiality of Electronic Money

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Motivation

Recent innovations in retail payment systems (e.g. store-of-value card, Paypal, Bitcoin etc).

- association with digital devices and arrangement
- allows many new (useful?) features and fee structures (membership, interchange fee, reward)

Important questions: how do these innovations affect

- the functioning and efficiency of payment systems (any social value)?
- the optimal design and regulation of payment systems?

This paper

- develops a theoretical framework for the first principles of designing payment systems
- examines essential features of electronic money
- derives policy implications
Mechanism Design Approach

**Payment instrument**: money, IOU, debit card, Bitcoin etc

**Payment system**: mechanism incentivizing how payment instruments are used

**Normative theory**: design payment systems to implement efficient allocations subject to feasibility and incentive constraints

**Why mechanism design** approach to payment systems? (Wallace 2010 HB of Monetary Econ)

- **Coherent**: consistent with fundamental frictions that render money/ e-money necessary, by identifying the superior, fundamental features of money/ e-money

- **General**: considering all possible ways of achieving allocations (fixed fee, linear, ad-valorem and any other).
A Short Sample of Related Literature

Payment Economics: two-sided markets

- Shy-Tarkka (JMCB 02), Rochet-Tirole (JEEA 03), Wright (EER 03),
  Gans-King (BEJ Policy 03), Gowrisankaran-Stavins (Rand 04),
  Armstrong (Rand 06), **Shy-Wang** (AER 10), Wang-Wright (12).

Monetary Theory: micro-economic frictions

- Microfoundaation of payment: Townsend (JPE 89), Kocherlakota (JET 98), Wallace (10)
- Alternative means of payment: Monnet-Roberds (JME 08),
  Telyukova-Wright (ReStud 08), Li (RED 11), Lotz-Zhang (13)
- Optimal policy: Lagos-Wright (JPE 05), Andolfatto (JET 10),
  Gomis-Sanches (JMCB 12), Williamson (AER 12), Wallace (QJE 13)
- Mechanism design of trading protocol: **Hu-Kennan-Wallace** (JPE 09), Rocheteau (JET 12), Nosal-Rocheteau (JEDC 13)

This paper: mechanism design of payment system
Model

Introducing environment + equilibrium
No mechanism first
Model

Environment closely follows Rocheteau-Wright Emca 05

Preference: **Buyers:** $\sum \beta^t \{ U(q_t) - l_t \}$

**Sellers:** $\sum \beta^t \{ -C(q_t) + l_t \}$

**First-best** allocation: $U'(q^*) = C'(q^*)$

Day: random pairwise matching between a buyer and a seller
Night: centralized meeting of all agents

**Anonymity in day market:** day market trades need a medium of exchange, e.g., money with fixed supply (relax later)
Monetary Trades

**Equilibrium trade pattern**: buyers sell night goods for money, then buy day goods with money in next period

**Terms-of-trade** \((d, q)\) determined by buyer market power \(\theta \in (0, 1)\)

\[
\underbrace{U(q) - d} = \theta \underbrace{[U(q) - C(q)]},
\]

buyer’s surplus \quad \text{total surplus}

\(d = \text{money paid (in night goods) by buyer} = \text{night goods produced}\)

**Equilibrium**: buyer’s problem is equivalent to

\[
\max_{d,q} \{ -d + \beta U(q) \}\quad \text{s.t. (}d,q\text{) given by (1)}
\]

**Inefficiency** \(q \neq q^*\), buyers don’t hold enough money since

- impatience: \(\beta < 1\)
- trade externality: \(\theta < 1\)
Money-Only Mechanism

Introducing Mechanism Design with Money Efficiency Boundary of Money Payment System
Mechanism Design

More sophisticated arrangement to implement \( q = q^* \)?

Coherent:

- **Participation constraint**: agents can join or avoid mechanism (so lump-sum tax is not IC)
- **Information constraint**: money holding \( z \) is private info.
- **Budget constraint**: self-financed without outside resource

General:

- **Revelation principle**: only need to focus on transfers \( B(\hat{z}) \) based on agents’ report \( \hat{z} \leq z \) of their money holding (or portfolio in general)
- **Incentive compatible**: agents truthfully report \( \hat{z} = z \)
(1) General Money Mechanism
(1) Optimal Money Mechanism

Finding: When $\theta < \bar{\theta}$, NO incentive compatible and self-financed money mechanism can implement the first best.

Is there any payment system with alternative payment instrument (e-money here) can support the first-best $q = q^*$, when even the best money mechanism fails ($\theta < \bar{\theta}$)?

If exists, then these payment systems are essential
E-money

Introducing mechanism design with money and e-money:

1. **Limited participation**: e-money which allows the designer to restrict some entities from holding e-money (store-of-value cards)
2. **Limited transferability**: e-money which allows the designer to restrict some entities from sending/ receiving (Paypal, Bitcoin)
(2) E-money Mechanism with Limited Participation

Night Market

1. report $\hat{z}_b \leq z_b, \hat{n}_b \leq n_b$
2. pay $B_b(\hat{z}_b, \hat{n}_b)$

OR

buyer with $z_b, n_b$

skip the intervention

Day Market

 buyer uses both money and e-money

buyer uses only money

seller accepts both money and e-money

seller accepts only money

seller with $z_s, n_s$

skip the intervention

1. report $\hat{z}_s \leq z_s, \hat{n}_s \leq n_s$
2. pay $B_s(\hat{z}_s, \hat{n}_s)$
(2) E-money Mechanism with Limited Participation

Mechanism design to implement the first-best $q = q^*$ subject to:

- **Constant exogenous exchange rate with money**: e-money has to grow at the same exogenous rate $\mu$ of money, which is out of designer’s control.
- **Participation constraint**: agents can join or avoid mechanism.
- **Information constraint**: money AND e-money holding are private information (so still work for any offline system).
- **Budget constraint**: $0 = B_b(z_b, n_b) + B_s(z_s, n_s) + \mu \phi_t N_t$ (self-financed)
(2) E-money Mechanism with Limited Participation

**Finding:** Given $\mu$, an optimal e-money mechanism

(i) is at least as good (implementing FB) as money mechanism,

(ii) can implement the first best when $\theta \in [\bar{\theta}, \bar{\bar{\theta}})$ and $\mu > \bar{\mu}$

(money mech can implement FB iff $\theta \geq \bar{\theta}$)

(iii) **cross-subsidization** from sellers to buyers, ie, $B_b (z_b, n_b) < 0$ and $B_s (z_s, n_s) > 0$;

**Intuition:** More cross-subsidization can be financed by threatening to limit participation

**Simple example of indirect mechanism:** fixed membership fees on buyers & sellers + proportional rewards on buyer’s balances

- Implementation is not unique: other examples of indirect mechanism involving deposit
(3) E-money Mechanism with Limited Transferability

Night Market

1. report $\hat{z}_b \leq z_b, \hat{n}_b \leq n_b$
2. pays $B_b(\hat{z}_b, \hat{n}_b)$
3. buyer uses both money and e-money

OR

buyers with $z_b, n_b$

- skip the intervention

Day Market

1. report $\hat{z}_s \leq z_b, \hat{n}_s \leq n_s$
2. pay $B_s(\hat{z}_s, \hat{n}_s)$
3. seller accepts both money and e-money

OR

sellers with $z_s, n_s$

- skip the intervention

- buyer uses only money

- seller accepts only money
(3) E-money Mechanism with Limited Transferability

**Finding:** An optimal e-money mechanism

(i) is at least as good as money and e-money mechanism with limited participation

(ii) can implement the first best when $\theta \in [0, \theta)$ and $\mu > \bar{\mu}$

(limited participation can implement FB iff $\theta \geq \theta$ and $\mu > \bar{\mu}$)

(iii) cross-subsidization to buyers with interchange fee: $B_b (z_b, n_b) < 0$ and $\Delta_b + \Delta_s > 0$;

**Intuition:** efficient use of liquidity by charging interchange fee post-trade, more cross-subsidization can be financed

**Simple example:** proportional rewards on buyer’s balances + fixed interchange fees on sellers
Conclusion and Policy Implications
Takeaway

- E-money-based payment system is fundamentally different.
- E-money, maybe associated with digital devices, allows restriction on participation and transferability even in decentralized settings with anonymous users.

We find that

- these technological features of e-money are essential: without them, the set of feasible allocations is strictly inferior;
- an optimally designed e-money system features deposit, membership fees, interchange fees, and rewards to buyers;
Policy Implications

- Mechanism design useful
- E-money carries some superior features beyond mere transaction speed or convenience
- Pricing scheme like membership, interchange fees, rewards are necessary
  - to mitigate fundamental frictions
  - even to finance a costly operation of the payment system in an efficient way
- Fee regulation could be welfare-reducing