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 ditigal 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

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

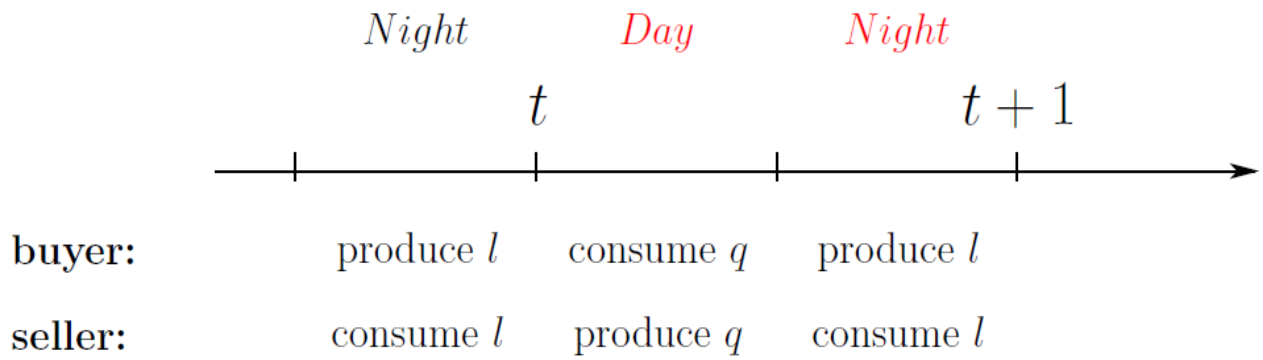
Sellers: $\sum \beta^t \{-C(q_t) + l_t\}$

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, eg 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 $\theta \in (0, 1)$

$$\underbrace{U(q) - d}_{\text{buyer's surplus}} = \theta[\underbrace{U(q) - C(q)}_{\text{total surplus}}], \tag{1}$$

$d =$ money paid (in night goods) by buyer = night goods produced

Equilibrium: buyer's problem is equivalent to

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

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 $q = q^*$?

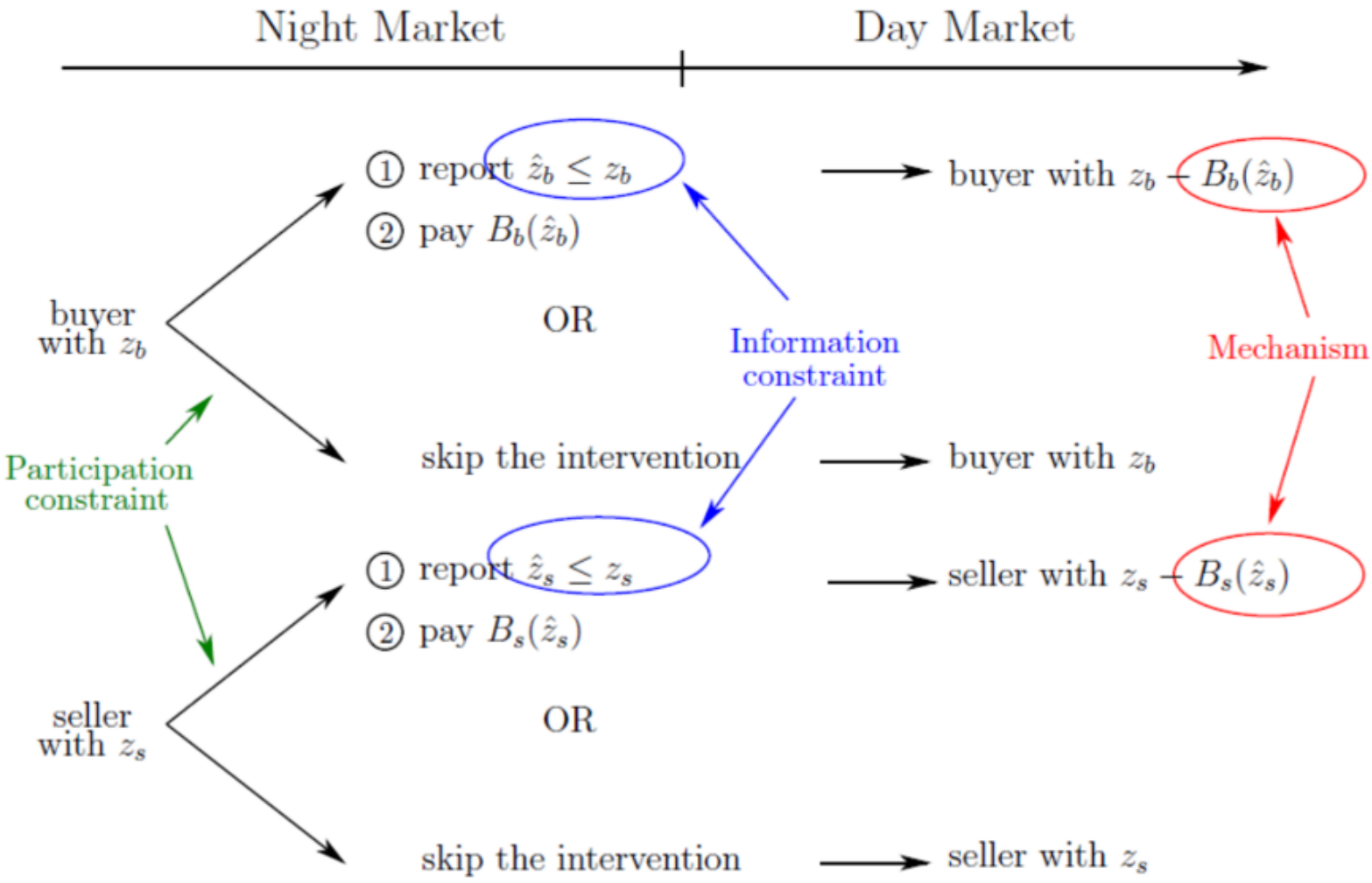
Coherent:

- **Participation constraint**: agents can join or aviod 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 $B(\widehat{z})$ based on agents' report $\widehat{z} \leq z$ of their money holding (or portfolio in general)
- Incentive compatible: agents truthfully report $\widehat{z} = z$

(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 ($\theta < \bar{\theta}$)?

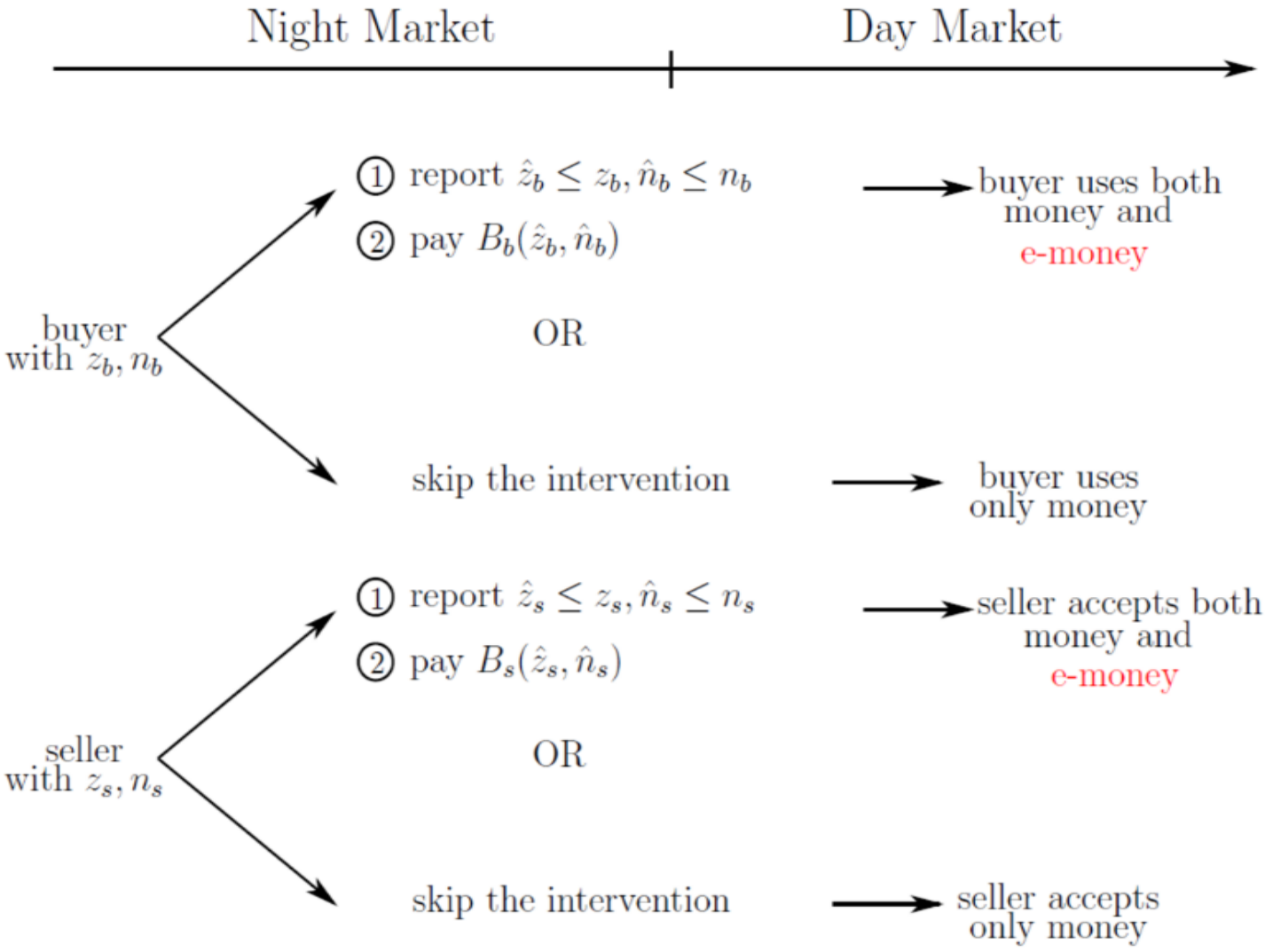
If exists, then these payment systems are **essential**

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/ recieving (Paypal,Bitcoin)

(2) E-money Mechanism with Limited Participation



(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 μ of money, which is out of designer's control
- **Participation constraint**: agents can join or aviod 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 μ , an optimal e-money mechanism

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

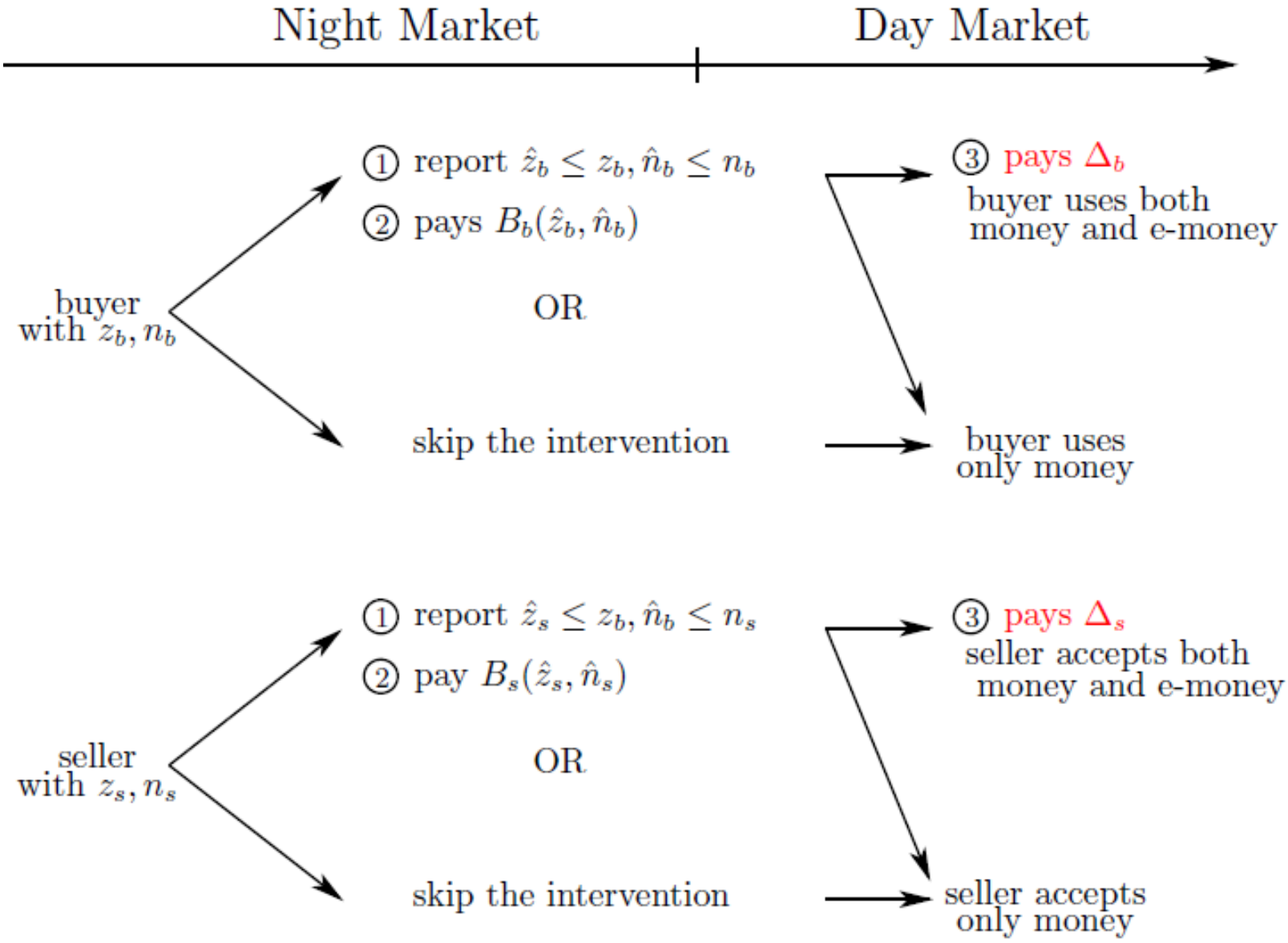
(ii) can implement the first best when $\theta \in [\underline{\theta}, \bar{\theta})$ and $\mu > \bar{\mu}$
(money mech can implement FB iff $\theta \geq \bar{\theta}$)
(iii) **cross-subsidization** from sellers to buyers, ie, $B_b(z_b, n_b) < 0$ and $B_s(z_s, n_s) > 0$;

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



(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 $\theta \in [0, \underline{\theta})$ and $\mu > \bar{\mu}$
(limited participation can implement FB iff $\theta \geq \underline{\theta}$ 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 ditigal 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 regualtion could be welfare-reducing