Gross and net settlement in payment systems
a (selective) survey

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Outline

1 Introduction
2 An (old) model
3 Some (older) payments history
4 Recent developments
Observation

- advanced economies require chains of bilateral credit transactions
  - Wicksell polygons, supply chains, etc.

Such chains inherently fragile (Kiyotaki & Moore 1997)

Payment systems

- mechanisms for (orderly) contraction of credit chains
Essential elements

Payment systems differ in details, but each has 2 essential elements

- System to (verifiably) communicate intent to transfer value (payment step)
- System to determine when value is considered transferred (settlement step)

In some systems (cash), elements are merged
Common theme: contract a credit chain by transferring debt along the chain (Kiyotaki & Moore 2000; Kahn & Roberds 2007)

- *hundi* (India)
- *ryogae* (Japan)
- *suftaja* (Middle East)
- *shansi* (China)
- *awak* (Armenia)
“Payment step” similar to above

- bill of exchange (*lettre de change, Wechselbrief, etc.*)
- dominant noncash payment through 19th century

“Settlement step” different from above

- more developed infrastructures
- forerunners of modern settlement institutions
Definitions

2 competing types of settlement infrastructures

- **Gross settlement**: obligation discharged by transfer of a designated asset
- **Net settlement**: discharge occurs in 2 stages
  - Stage 1: payment system’s participants’ debts are netted (set off) against one another
    - (in modern systems, payment obligations are *novated*—legally extinguished and replaced with new, net obligations against a central counterparty)
  - Stage 2: residual obligations are discharged by transfer of a designated asset
    - (net debtors transfer to payment system; net creditors receive transfers from payment system)
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1. Introduction
2. Model
3. History
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Model of net vs. gross settlement
(Kahn, McAndrews, & Roberds 2003)

- Historically, net settlement predominates
- Why?
  - standard argument
    - fewer assets required for settlement (triangle inequality)
  - alternative argument
    - can provide beneficial performance incentives
Model: agents, commodities, preferences

- $N > 2$ agents
- no uncertainty
- $t = 0, 1, 2$
- 2 types of goods
  - customizable intermediate goods
  - a final good
- each agent seeks to maximize its consumption of the final good in period $t = 2$
Model: endowments & production

- each agent has one indivisible unit of an intermediate good at \( t = 1 \)
- agents equally divided into \( I \) types, \( I > 2 \)
- to produce \( F > 1 \) units of a final good
  - agent of type \( i \) uses a customized intermediate good from type \( i - 1 \)
  - int. good customization & delivery take place at \( t = 1 \)
  - production of final goods takes place at \( t = 2 \)
- if not put to customized use, int. good only has salvage value \( C \in (0, 1) \)
Model: settlement and bankruptcy

- Agents’ trade at $t = 0$
  - trades are “goods for debt” & give rise to delivery/settlement obligations at $t = 1, 2$
- Incentives for strategic default arises through bankruptcy rules
- Payoffs to a bankrupt/creditor
  - if bankrupt has attachable assets $A$ and an unsettled obligation $O$

\[
\begin{align*}
\text{bankrupt gets} & \quad \max \left\{ (\alpha + \beta) A - O, \alpha A \right\} \\
\text{creditor gets} & \quad \min \{ O, \beta A \}
\end{align*}
\]

where $\{\alpha, \beta, \alpha + \beta\} \in (0, 1)$
Trade under gross settlement

Trade modeled as a 3-stage game

- **First stage** (contracting) at $t = 0$
  - agent $i$ seeks out an intermediate good supplier $i - 1$
  - $i, i - 1$ bargain over price $P$ of intermediate good, where $P \in (C, F)$

- **Second stage** (delivery) at $t = 1$
  - agents deliver customized intermediate goods

- **Third stage** (settlement) at $t = 2$
  - agents settle payment obligations by transferring $P$ final goods

Abstracting from bargaining, typical agent’s strategy is

$$\sigma = \text{(trade or not, deliver or not, settle or default)}$$
Consider agent $i$’s settle/default decision at $t = 2$

- if $(P/F) > (1 - \alpha + \beta)$, then $i$ defaults if his counterparties default
  - (“Mutually assured default”)
- if $(\frac{1-\alpha}{\alpha}) > (P/F) > \left(\frac{\beta}{1-\beta}\right)$, then $i$ settles if his counterparties settle
  - (“Mutually assured settlement”)
- MAD & MAS hold simultaneously for $\beta < \alpha < 1/2$ and $F/C \approx 1$

$\Rightarrow$ Exist parameter values where (autarky aka “gridlock”) and (trade, deliver, settle) are both equilibria
Trade under net settlement

- Trading game is played as before, except that (binding) netting of obligations occurs before any transfers at \( t = 2 \).
- Also, all transfers of final good occur through CCP ("payment system").
  - Need loss-sharing rule to cover default scenarios.
- Simplest case: unwinding rule
  - If an agent defaults, then its transactions are removed, net positions are recalculated, and settlement proceeds as in normal settlement.
Equilibrium under net settlement
(symmetric, pure-strategy)

- If MAD and MAS hold, only the (trade, deliver, settle) equilibrium occurs under net settlement.
- Intuition: netted obligations have de facto absolute priority, lessening default incentive at settlement stage.
Model extension

- If creditors’ priority is severly impaired ($\alpha \to 1$, $\beta \to 0$); then MAS cannot hold & only autarky holds under gross settlement.

- However trade may occur if agents have access to collateral facility:
  - agents store some fraction $\gamma$ of $t = 1$ intermediate good endowment in a facility operated by payment system
  - posting collateral a requirement for trade

- Storage has gross return $= 1$, and stored goods can be liquidated without (direct) cost.

- However storage entails opportunity cost $\gamma(F - C)$ since stored goods can’t be put to customized use.
Equilibrium under gross settlement with collateral

Say $\alpha \approx 1$, $\beta \approx 0$. Can show that (trade, deliver, settle) is still an equilibrium if $\gamma$ satisfies

\[ \frac{\gamma}{1 - \gamma} \geq (\alpha - \beta) \left( \frac{F}{2C} \right) \]

("settlement incentive condition"), and also satisfies

\[ \frac{\gamma}{1 - \gamma} \geq \alpha - (1 - \alpha) \left( \frac{F}{C} \right) \]

("delivery incentive condition")
Equilibrium under net settlement with collateral

Say $\alpha \approx 1$, $\beta \approx 0$. Then (trade, deliver, settle) an equilibrium under net settlement if

1. Loss-sharing satisfies Lamfalussy rule: agents collectively post enough collateral to cover default by any single agent
2. Collateral requirement $\gamma$ satisfies delivery incentive condition

In general

$$\text{collateral \{net settlement\} } \leq \text{collateral \{gross settlement\} }$$
Model lessons

- In some cases netting can eliminate gridlock w/o use of collateral
- If collateral is necessary, netting can provide performance incentives at lower cost
- "Network effect": if \( I > 3 \), an agent’s participation in netting generates benefits to agent(s) who are not direct counterparties
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Earliest European settlement institutions
13th-17th century (Velde 2009, Boerner & Hatfield 2010)

- Net settlement procedure for bills: *rescontre, skontrieren*, etc.
- Quarterly settlement among merchants in specific locations
  - “fair towns”: Antwerp, Frankfurt, Lyon, etc.
- Some specifics
  - no central counterparty or even central register of accounts
    - ad hoc netting “cycles”
  - low number of participants (≤ 100), obligations approximately offsetting
  - residual claims often carried over to next fair
  - collateral rarely required (however exclusion possible)
  - “cross-currency” arrangement
  - minimal government involvement
Limitations of rescontre emerge with negotiability

- More people using bills, harder to find offsetting cycles
- Lack of finality
  - possible to “settle” one bill by endorsing over another, perpetuating credit chain

Solution: require all bills payable in a certain city to be settled by book-entry transfer of deposits at municipal bank

Examples: Amsterdam, Genoa, Hamburg, Stockholm, etc.
Gross settlement under exchange bank system
17th-18th centuries (Quinn & Roberds 2010)

- **Advantages**
  - more participants (≈ 3000 in Amsterdam)
  - higher velocity (> 10,000 /yr.)
  - instant, absolute finality
  - new, highly liquid, quasi-fiat settlement asset
  - exchange banks take on quasi-CB role
    - OMOs
    - directed lending
    - repo facilities

- **Disadvantages**
  - loss of netting ⇒ higher liquidity costs, gridlock
  - exchange banks often shaky
  - greater governmental involvement
  - loss of cross-currency capability
Gross settlement: broad participation
Gross settlement: high velocity
Gross settlement: liquidity transformation
Return to net settlement
Anglo-American banking institutions, 19th-20th centuries

- Prototype: London Clearing House (1773)
  - like continental exchange banks
    - settlement in “privileged asset” (BOE notes, later accounts)
  - unlike continental exchange banks,
    - net settlement
    - membership restricted to deposit banks (originally, just 31)
  - settled bill transactions and increasingly, checks

- LCH design widely imitated in U.S. (see Warren’s talk)
  - New York Clearinghouse (1853), regional check clearinghouses

- Outlier: Fedwire (1918)
  - From the beginning, gross settlement system
  - Net settlement impractical in U.S. banking system (1918: >27,000 banks)
Demand on systems increase with demise of Bretton Woods

1970: NYCH creates a new, all-electronic system (CHIPS) to fund legs of FX transactions
  - multilateral net settlement among a small group of banks active in FX

Design of CHIPS (multilateral netting, unwinding rule) widely imitated
  - CHAPS (UK), BOJ-Net (Japan), etc.

Regulators increasingly concerned in wake of “tail events”
  - Bankhaus Herstatt 1974, Drexel Burnham Lambert 1990, BCCI 1991, etc.

Conversion of most LV systems to RTGS (real time gross settlement) systems by 2000
  - Exception: CHIPS (net with position limits)
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Net versus gross settlement, anno 2011

- How to design payment systems that combine desirable features of
  - gross settlement (esp. absolute finality & robustness to tail events), and
  - net settlement (lower liquidity costs & performance incentives)?

- Two important developments in LV systems
  - Queuing of payments in RTGS systems
  - Continuous Linked Settlement (CLS) for FX transactions
Queuing in gross settlement systems

- Basic idea: outgoing payments go into queues & are scanned by optimization software for matches or near matches (bilateral or multilateral)
  - payments are final when matched (leftover payments sent out at day’s end)

- Liquidity required for RTGS can be reduced
  - “net” liquidity reduced to $< 1\%$ of gross payment flows (Bech & Hobijn 2007)

  - queuing can improve intertemporal efficiency

- Open issue: effect of queuing on performance incentives
Continuous Linked Settlement
(Kahn & Roberds 2001)

- Majority of FX transactions settle through a private, special-purpose, U.S. chartered bank (CLS, est. 2002)
- Each day, commercial banks (“members”) deposit funds in CLS (“pay in”) in various currencies
- Traditional netting not feasible across currencies since no numeraire, so “quasi-netting” algorithm is used
  - banks’ payments are queued
  - settlement occurs as queued payments are matched with payment of other leg of FX trade
  - after settlement, funds automatically withdrawn by (“paid out to”) member banks
  - banks are allowed to overdraft CLS accounts subject to position limits; pay-ins < 4% gross flows
- World’s largest payment system by value (avg. > $3.5 trillion/ day; max $10.3 trillion)
- Incentive effects?
Summary

- Settlement a critical piece of payments architecture
- 2 basic designs
  - Net settlement: in practice, works well in "club" settings (small # participants, known to each other)
  - Gross settlement: more expensive & prone to "gridlock", but more practical with large # participants
- Some modern systems combine features of both designs