14.129
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Lecture 3
Distributed Ledger as Solution to an Information Problem

Fragmented Markets, Policy Objectives, Regulatory Solution, Distributed Ledger as Technology Solution, Statics

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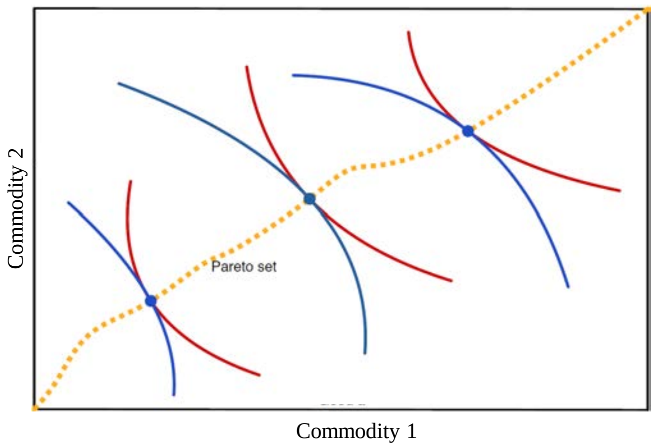
Outline

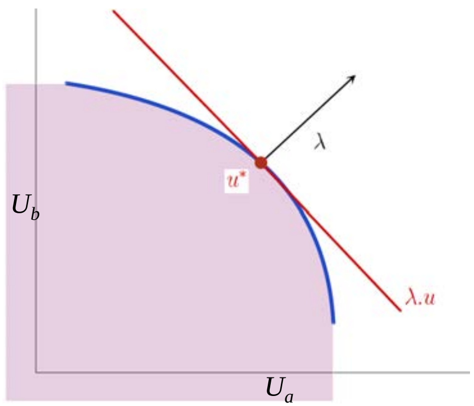
- Efficiency as the objective of public policy and private sector innovations
- Problems from fragmented markets
- Institutional workarounds exist but these come with problems
- The information solution with distributed ledger

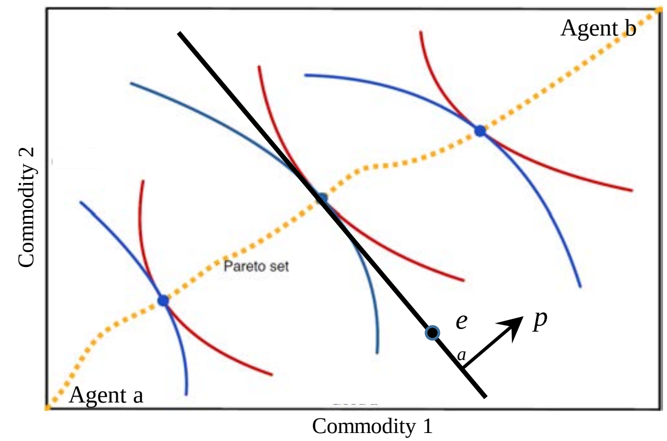
Efficiency as the Objective of Public Policy and Private Sector Innovations

- Finding Pareto efficient allocations
  - Through the planner's problem
  - Through competitive markets

Pareto Optimality and the Welfare Theorems







- **Standard**: commodities or digital representations thereof
- **Time:** Promises indexed by time, hence financial and digital assets
- **Uncertainty**: indexed by states of the world, hence contingent programmed promises

- Commodities $j = 1, \ldots L$
- Agents a element of set A
- Endowment e_a, consumption c_a
- Utility $U_a(c_a)$
- Feasible: sum over endowments = sum over consumption
- Price vector $p = (p_1, \ldots p_j, \ldots p_L)$

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General Setup

- Let $L > 0$ be the finite number of commodities in an economy
- Let $I > 0$ be the number of consumers
- Let $J \geq 0$ be the number of firms
- Each consumer $i = 1, 2, ..., I$ has a consumption set $X_i \subseteq \mathbb{R}_+^L$ and preferences $\succeq_i$ over bundles on X_i
- Each firm $j = 1, 2, ..., J$ has a technology, characterized by a production set $Y_j \subseteq \mathbb{R}^L$
- The economy resources are given by a vector of aggregate endowments $\overline{\omega} = (\overline{\omega}_1, \overline{\omega}_2, ..., \overline{\omega}_L) \in \mathbb{R}^L$

Utility Possibility Set

We will assume that preferences for each household i can be represented by an utility function $u^i : X_i \to \mathbb{R}$. An economy can then be summarized by the consumption sets, the utility functions, the technologies and endowments: $\mathcal{E} = \left\{ \{X_i, u^i\}_{i=1}^{I}, \{Y_j\}_{j=1}^{J}, \overline{\omega} \right\}$.

An **allocation** $(x, y) = (x_1, x_2, ..., x_I, y_1, y_2, ..., y_J) \in \mathbb{R}^{L(I+J)}$ is a specification of a consumption vector $x_i \in X_i$ for each consumer i and a production plan $y_j \in Y_j$ for each firm $j = 1, 2, ..., J$. We say that an allocation is **feasible** iff $\sum_{i=1}^{I} x_i = \overline{\omega} + \sum_{j=1}^{J} y_j$.

Given an economy $\mathcal{E} = \left\{ \{X_i, u^i\}_{i=1}^{I}, \{Y_j\}_{j=1}^{J}, \overline{\omega} \right\}$ we define the **Utility Possibility Set** $\mathcal{U} \subseteq \mathbb{R}^I$ as:

$$\mathcal{U} = \left\{ \begin{array}{r} \overline{u} = (\overline{u}_1, \overline{u}_2, ..., \overline{u}_I) \in \mathbb{R}^I : \text{ there exist a feasible allocation } (x, y) \\ \text{with } u^i(x_i) \geq \overline{u}_i \end{array} \right\} \tag{1}$$

Pareto Frontier

$\mathcal{U}$ is the set of utility level profiles for all households in the economy that can be attained by feasible allocations. Note that the set $\mathcal{U}$ has the property that if $u \in \mathcal{U}$ and $v \leq u \Longrightarrow v \in \mathcal{U}$, since u can be supported by a feasible allocation with greater or eqaul, then so can v.

Pareto Frontier

Given a utility possibility set $\mathcal{U} \subseteq \mathbb{R}^I$, we define the set $P(\mathcal{U})$ as:

$$P(\mathcal{U}) = \left\{ \begin{array}{c} u \in \mathcal{U} : \text{ there is no } u' \in \mathcal{U} \text{ such that } u'_i \geq u_i \text{ for all } i = 1, 2, ..., I \\ \text{and } u'_j > u_j \text{ for some } j \end{array} \right\}$$

We call the set $P(\mathcal{U})$ the **Pareto Frontier of** $\mathcal{U}$.

Pareto Optimality

Pareto optimality

An allocation (x, y) is **Pareto-optimal** iff it is feasible and there is no other feasible allocation (x', y') such that $x'_i \succsim_i x_i$ for all i and there is some $i' : x'_{i'} \succ_{i'} x_{i'}$. We call the set of all these allocations the **Pareto Set** of the economy.

A Pareto Optimal allocation is an allocation that cannot be changed to an alternative feasible allocation making everyone at least as well off, and at least some one strictly better off. This is the concept that economists refer to when talking about "efficiency".

Private Ownership Economies

- In the private ownership economy, each consumer i has an endowment vector $\omega_i \subseteq \mathbb{R}^L_+$ such that $\sum_{i=1}^{I} \omega_i = \overline{\omega}$
- Each consumer i also has an ownership share θ_{ij} of firm j''s profit. That is, if profits of firm j are π_j, then consumer i gets $\theta_{ij}\pi_j$ of its profits. We must have $\sum_{i=1} \theta_{ij} = 1$, so that all of each firm is owned by someone.
- So, a private ownership economy can be summarized by

$$\mathscr{E} \equiv \left\{ \{X_i, \succeq_i, \omega_i\}_{i=1}^{I}, \{Y_j\}_{j=1}^{J}, \{\theta_{ij}\}_{i=1,j=1}^{I,J} \right\}$$

Walrasian Equilibrium

Let $p \in \mathbb{R}^L_+$ be the price vector of all commodities. We define a Walrasian equilibrium for the private ownership economy $\mathscr{E}$ as follows:

Definition

A Walrasian equilibrium is an allocation (x^*, y^*) and a price vector $p^* \in \mathbb{R}^L_+$ such that:

1. For each j, y_j^* maximizes profits given prices p^*: $p^* \cdot y_j^* \geq p^* \cdot y_j$ for all $y_j \in Y_j$
2. For each i, x_i^* maximizes preferences given her budget: $x_i^* \succeq_i x_i$ for all $x_i \in X_i$ such that $p^* \cdot x_i \leq p^* \cdot \omega_i + \sum_j \theta_{ij} p^* \cdot y_j^*$
3. The allocation is feasible: $\sum_i x_i \leq \sum_i \omega_i + \sum_j y_j^*$

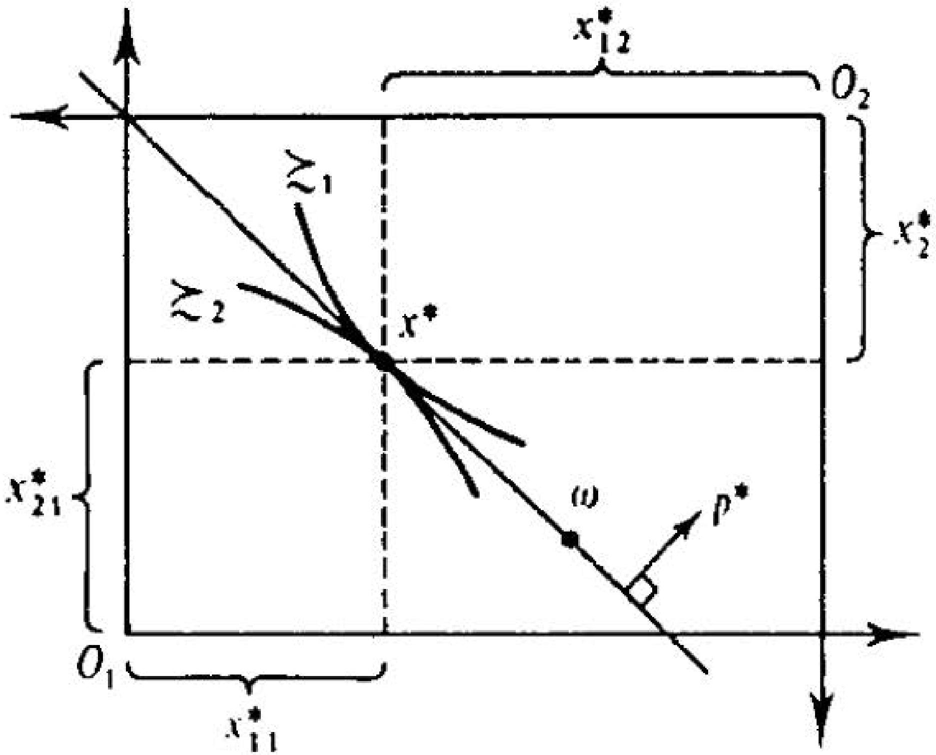
Statement of the Welfare Theorems

1. All Walrasian equilibria are Pareto Optimal
2. Any Pareto Optimum supported as a price equilibrium with transfers

Two Problems from Fragmented Markets

- The US national marketing system – as if trading at a common price
- The impossibility of informationally-decentralized efficient exchange, Ostroy-Starr

Equilibrium in Edgeworth Box



(a)

Here we represent the initial endowment ω, the equilibrium price vector p^* and the equilibrium allocation x^* for a Walrasian equilibrium in a pure exchange economy with 2 consumers.

Regulatory Solution to Fragmented Markets: The US National Marketing System

- Proposed regulations tie to an underlying market failure
  - The basic perspective of economists involved in financial regulation (or at least most SEC chief economists)
- A central feature of the SEC's framework for the equity markets is Regulation NMS (adopted in 2005 and implemented in 2007)
  - "Order protection" to ensure that retail orders are executed at the exchange with the most favorable pricing (an exchange has to match or respect a competitor's quote)
- How the exchanges compete for orders from brokers by using volume tiering (discounting to brokers who provide exchanges relatively more of their order flow) and the incentive to cross subsidize trading at the margin
- Ernst, Thomas and Chester Spatt (2024) "Regulating Market Microstructure"

SEC Recent Amendments; But in Another Case, SEC Is Inconsistent

The SEC voted unanimously to adopt changes to Regulation NMS (Reg. NMS) that address minimum pricing increments for securities, the access fees that securities exchanges charge, and increased transparency order prices. The Reg. NMS Amendments:

- Establish a second minimum pricing increment, also known as tick size, of $0.005 for certain stocks listed on a national securities exchange (NMS Stock) - Tick Size Provisions,
- Reduce the maximum fees that trading centers (e.g., securities exchanges) can charge for execution against protected quotations (access fee caps) and require that the amounts of all fees and rebates be determinable at the time of execution - Access Fee Provisions, and
- Accelerate the implementation of the round lot and odd lot information definitions adopted in 2020 and add information about the best odd lot order to the definition of odd lot information – Odd Lot Provisions.

Source: Sandoval, I. (2024) SEC Amends Regulation NMS to Provide for Half Penny Quoting in Securities and Reduction in Potential Rebate Money Orrick.com

- But see this: Federal judge issues sealed order in Amazon antitrust case

Amazon filed a motion to dismiss in December, arguing that its innovations led to consumer benefit and pushed its competition to follow suit. Amazon matches discounts provided by its competitors, features deals instead of overpriced items and uses the best delivery system for Prime subscribers.

Riquelmy (2024) Federal judge issues sealed order in Amazon antitrust case” Courthousenews.com

The Impossibility of Informationally Decentralized Efficient Exchange

The Information Problem of Fragmented Markets

- Ostroy-Star (1974)
  - Distributed ledgers solve an information problem that gets in the way of efficiency
  - Even if prices are common

Ostroy and Starr (1974)

- In the Ostroy-Starr model
  - A finite number of goods, assets, or digital assets
  - Agents are endowed with initial, beginning-of-period allocations of these securities.
  - Agents are also characterized by utility functions over end-of- period holdings of the vector of assets.
- The goal is to achieve over time the trades associated with the Walrasian equilibrium through a sequence of decentralized bilateral meetings (a Pareto optimum)
  - Traders are matched pairwise, and the pairings are known in advance
  - Equilibrium prices are used for atomic swaps of digital assets against each other
  - Each bilateral exchange satisfies a quid pro quo, fair trade condition
  - Traders are viewed as only needing coded instructions on how to behave in order to achieve the given goal, as if traders were computers executing instructions on the ledgers. The central issue addressed is how much information is needed to implement the code that can reach the target.

Mathematical Formalization of the Trading Process:

- J traders and finite number of commodities with given price vector p. A Walrasian environment
- Each trader is endowed with vector b and has excess demand z. If trades are completed successfully, the trader will have b+z commodities.
- Three basic underlying restrictions on z (denote them by U, undelying):
  i. for each trader, $p \cdot z = 0$
  ii. $\Sigma_{j \in J} z_j = 0$
  iii. z must be feasible given trader's endowment, so $z_c \geq -b_c$ for each commodity c A familiar example of U is a competitive equilibrium
- Mechanics of trading. A round of trading has T periods. In each period, traders meet in pairs, and T is the number of periods required so that a trader meets every other trader exactly once. If J is odd, one trader stays out of trading in each period.
- Let a_{it} be the vector that represents the trading outcome for trader i in period t.
  - A trade: positive number, acquisition of each commodity bought, but negative number meaning sale
- Three basic underlying restrictions on *a*
  i. a_{it} should not result in a negative holding of any commodity
  ii. commodities must be conserved, if trader i is meeting with trader j, $a_{it} + a_{jt} = 0$
  iii. trade should be fair (*quid pro quo*), for every trader i, $p \cdot a_{it} = 0$, payment and clearing
  iv. denote them by A, trade actions

Information Restrictions on Trades

- Information restrictions determine which variables can be used as arguments of trading process, as inputs to that function.
- The paper proposes three decentralizing D restrictions D.1, D.2, D.3; with higher number representing greater amount of information.
- It also proposes a centralizing restriction C, which allows two meeting traders to use information on other traders.
- Suppose traders i and j meet in period t:

D.1. $a_{it} = -a_{jt}$ is a function of traders i and j's initial excess demands z, for traders i and j, endowment b, for traders i and j, and total trading up to period t-1, $\sum_{u=1}^{t-1} a_{iu}$ and $\sum_{u=1}^{t-1} a_{ju}$

D.2. $a_{it} = -a_{jt}$ is a function of the arguments in D.1, and in addition the identities of i and j.

D.3. Same as D.2, but instead of the total trading up to t-1, a_{jt} is a function of the entire history of trading, $(a_{i1}, a_{i2}, \dots, a_{i(t-1)})$ and $\left(a_{j1}, a_{j2}, \dots, a_{j(t-1)}\right)$

C. Same as D.3, plus the initial excess demand z over all traders, and the trading history $a_{k1}, a_{k2}, \dots, a_{k(t-1)}$ for every trader k.

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Ostroy and Starr, 1974

Completion of Trades: Fast Efficient Chains, Key Broker

- **Theorem 1**: There is a trading rule that (i) uses information C; (ii) satisfies A; and (iii) completes trading within a single round for any (p, Z, B) satisfying U.
  - This tells us that physical decentralization is possible when information is shared. The following theorems limit the types of information used for trading (D.1, D.2, D.3)
- **Theorem 2**: There is NO trading rule that (i) uses information D.3; (ii) satisfies A; and (iii) completes trading within a single round for any (p, Z, B) satisfying U.
  - It implies that some extra assumptions are necessary to allow decentralization, Theorems 3 and 4 are in this line.

Institutional Workarounds Exist But These Come with Problems

- One security as money
- One trader as universal broker dealer
- An overdraft credit facility

Institutional Workaround: One Security as Money, Medium of Exchange

- A first mechanism - one security as money
  - Picking one security which has the property that at the specified prices each trader can use it in pairwise meetings to buy the requisite targeted exchanges, regardless of the ordering and timing of meetings.
  - Briefly, asset purchases can be accomplished before asset sales using this money-like security.
- Requirements
  1. Ex ante coordination on the security which is to be used as '**money**'
  2. Much liquidity, i.e., having enough of that security, regardless of the ordering of meeting of traders, over dates and pairings (in a given environment, that condition may not be met for any possible security choice)

Formalization: Ample Ex Ante Liquidity

- **Theorem 4**: There is a trading rule that (i) uses information D.1; (ii) satisfies A; and (iii) completes trading within a single round for any (p, Z, B) satisfying U such that there exists a commodity m and for every trader i, her endowment of commodity m is enough to fund all her purchases:

$$p_m b_{im} \geq \sum_{c \neq m} p_c [z_{ic}]^+$$

  - It is the case where commodity m serves as some type of money and in which every trader has a large enough stock of commodity m to pay for his purchases. Commodity m helps traders solve problems arising from the restriction of *quid pro quo*.
  - Without *quid pro quo*, easy to find trading process that completes trade within a single round without additional assumptions. However, with the restriction, when two meeting traders' excess demands do not precisely offset each other, they should decide which subset of their demands would be met at the meeting.
  - Money solves this problem because at each meeting, the traders can just fulfill individual demands as much as possible and settle the difference in commodity m.

Problem: Sufficient Liquidity Saving Mechanisms

1. Introduction

Large-value payments systems, used by banks to settle financial and commercial transactions, play a key role in the financial system. The importance of these payments systems can be illustrated by the large amounts they settle. Every year in the United States, the systems process value equal to approximately 100 times GDP.

Innovations in the design of large-value payments systems have led to many improvements in their operations. For example, over the last twenty years, many countries have adopted real-time gross settlement (RTGS) systems for their large-value payments. In an RTGS system, each payment is settled individually, on a gross basis, at the time the payment is sent. RTGS systems offer many advantages—for instance, they limit the risk exposure of payments system participants and allow for rapid final settlement of payments during the day. However, RTGS systems require large amounts of central bank balances to function smoothly.

More recent innovations have occurred in the design and implementation of various liquidity-saving mechanisms (LSMs) that are used in conjunction with RTGS systems.[1] An LSM gives participants in the payments system an additional option not offered by RTGS alone: A payment can be put into a queue and then released from the queue if some prespecified event occurs. Such mechanisms can reduce the amount of central bank balances necessary to operate the system smoothly as well as quicken the settlement of payments.

Martin and McAndrews (2008) "An Economic Analysis of Liquidity-Saving Mechanisms" FRBNY Economic Policy Review

Bank of England: Liquidity Saving Users Guide

- **Section 1: What is the Liquidity Saving Mechanism?**
  This section provides a high-level overview of the LSM including why it was introduced, how it works and its key benefits.
- **Section 2: Liquidity Saving Mechanism controls available to DPs**
  This section outlines how the LSM can help DPs manage payment flows and intraday liquidity in CHAPS. It provides a description of key operational controls available in the LSM to support management of payment flows and liquidity data available in RTGS Business Intelligence (RTBI).

Source: "Liquidity Saving Mechanism User Guide" (2021) BankofEngland.co.uk

Institutional Workaround: One Large Trader, Broker-Dealer

Formalization: One Large Trader, Broker-Dealer

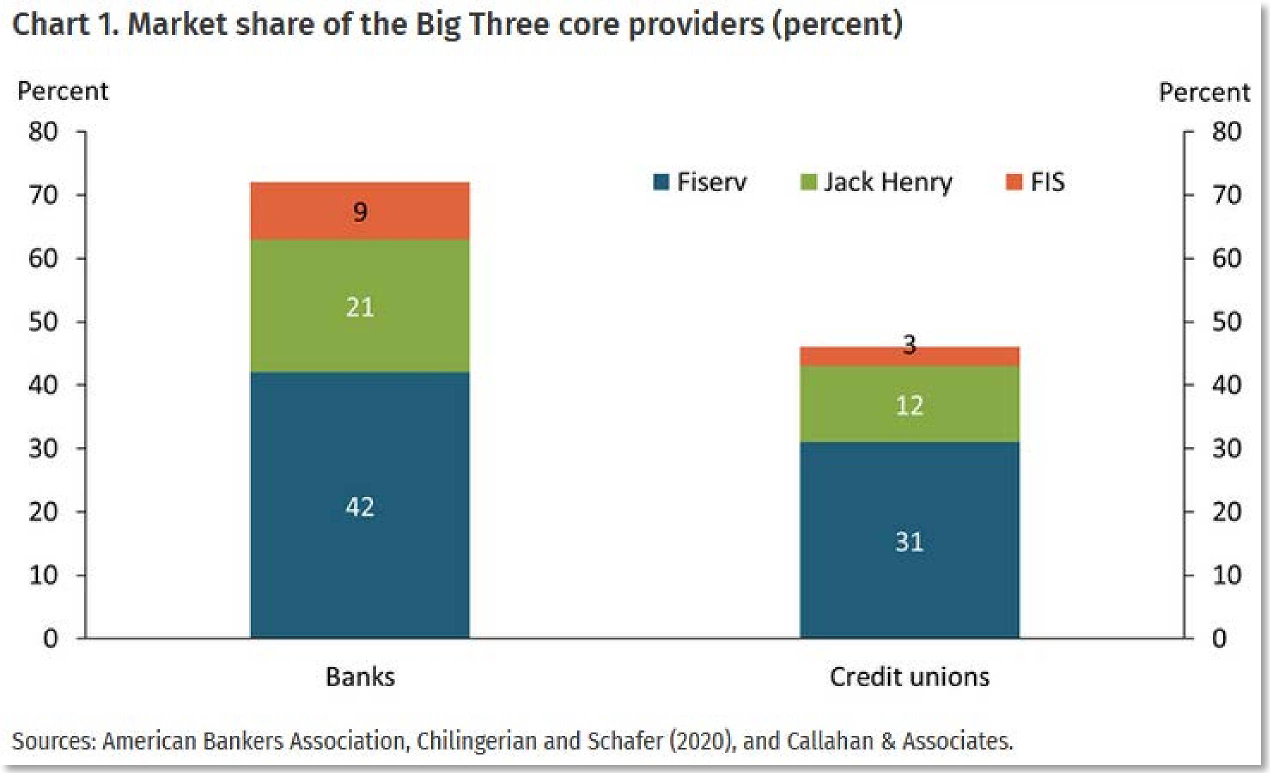
- A second mechanism is to designate one of the traders as a key intermediary broker-dealer, like a CCP (central counter party), and so all trade happens only with that broker-dealer (as a warehouse facility).
- The requirements
  - The key broker-dealer has sufficiently large inventories of each of the securities so as to be able to honor demands for any security exchange, of one asset for another, regardless of who comes to the intermediary early and who comes late (for a given environment, this condition may not be met, there is no such dealer).
- Theorem 3: There is a trading rule that (i) uses information D.2; (ii) satisfies A; and (iii) completes trading within a single round for any (p, Z, B) satisfying U such that there exists a trader i such that his endowment is enough to cover all the other traders' buying needs:

$$b_{ic} \geq \sum_{j \neq i} [z_{ic}]^{+} \qquad \text{for every commodity c}$$

  - It is the case in which trader i serves as a facilitator of trades (giant warehouse/supplier): She should have large enough stock of every commodity. It solves the difficulty of arranging trades when commodities are scarce and trades must be routed along the right chain to ensure that demands be met within a single round.

Problem: Market Power Concentration in the Core Services Market

- Alcazar et al (2024) "Market Structure of Core Banking Services Providers" [Federal Reserve Bank of Kansas City]
  - "The core services market is highly concentrated, as the "Big Three" core providers—FIS, Fiserv, and Jack Henry and Associates (Jack Henry)—which have sizable market shares.
  - "Collectively, the Big Three served more than 70 percent of banks surveyed in 2022 and nearly half of credit unions surveyed in 2020."



Problem, Market Power: Currencies Held By Top Dealers

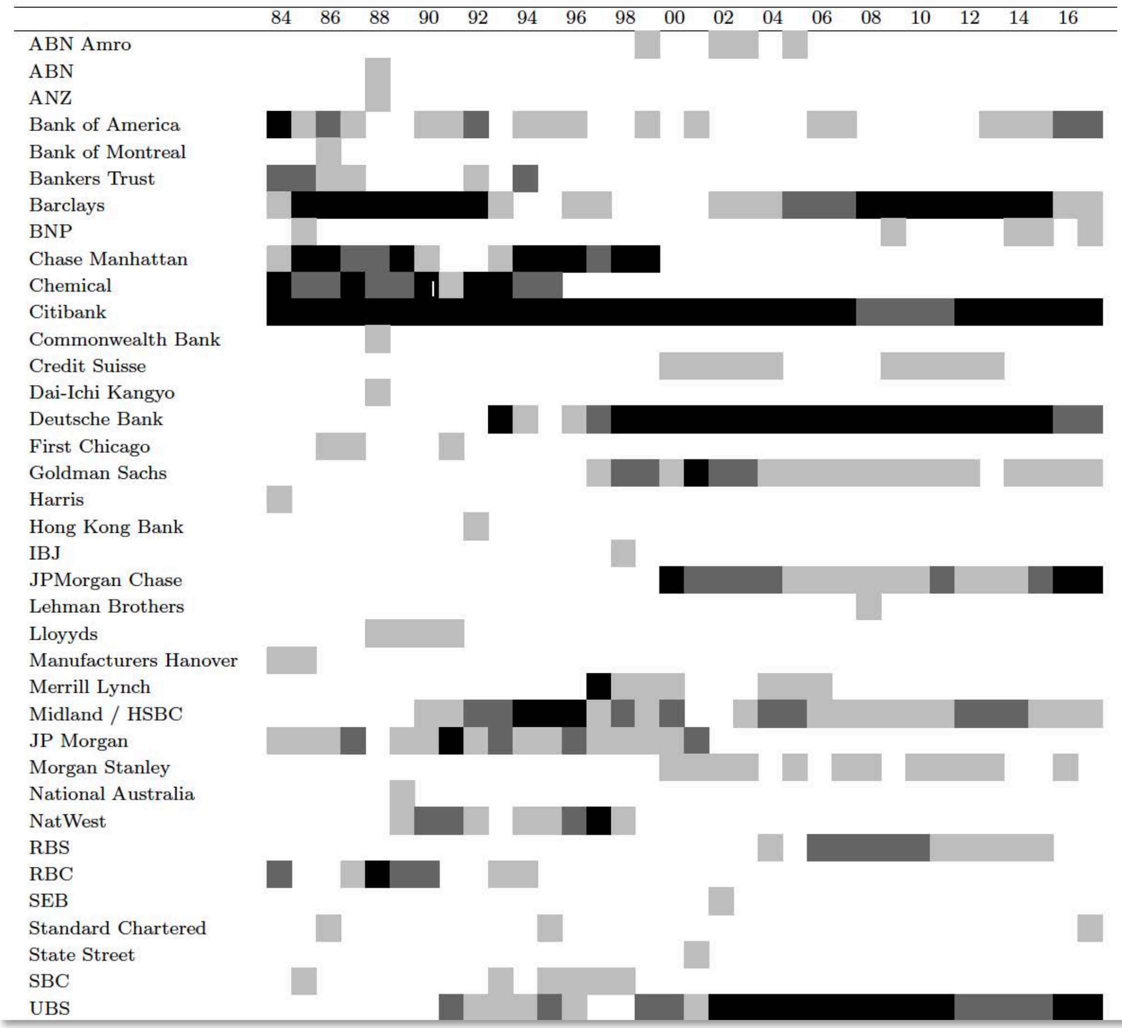
- **Citibank** has a presence in nearly **180 countries and jurisdictions**[1].
- **Deutsche Bank** operates in **57 countries**[2].
- **UBS** operates in over **50 countries**[3]

(references contain links to sources)

Then what about the countries *(resp. currencies)* **not serviced** *(resp. held)* **by these major dealers?** It would be interesting to cross check country lists.

Would including these countries / currencies on a new platform bring more access/use? *What other roles would intermediaries from these countries/currencies potentially need to do on the platform?*

This table shows the ranks of financial intermediaries in the Euromoney Forex Survey. Boxes indicate whether the intermediary in the given year was ranked within the top ten( ), five ( ) or three ( ) FX dealers by market share.



Empirical Validation of Balanced Flows/Risks For All But 3-4 Banks

- This is verified in the so-called "two tier" intermediation of FX markets
  - "The average (periphery) dealer is able to hand over her exposure from FX trading to major (core) dealers functioning as the ultimate liquidity providers […] core dealers tend to take risks on their balance sheets from their FX business instead of engaging in the hot potato" [Moore, Schrimpf, and Sushko (2016) confirmed by Hasbrouckand Levich (2019) using CLS settlement data].
    - Very few dealers take imbalances!
  - "If balance sheet effects of FX trading is neutralized for periphery dealers, but not for core dealers, then capital ratios of core dealers should contain most of the information relevant for FX pricing, while those of periphery dealers are less likely to be informative". [Reitz and Umland Bundesbank discussion note (2021)]
  - "Shocks to the equity capital ratios of the top three foreign exchange dealers have explanatory power for the cross-sectional variation in expected currency market returns, while those of the average dealer provide no substantial additional information" [Reitz and Umland (2021) empirically, Gabaix and Maggiori (2016) theoretically]
- The next "mystery" is why "core FX dealers" are ok absorbing imbalances, if it is sustainable, and its consequence for new multilateral platforms (in terms of access to new currencies, role of intermediaries…)

Institutional Workaround: An Overdraft Credit Facility

Institutional Workaround: An Overdraft Credit Facility

- A third mechanism - an overdraft credit facility
  - Introducing two extra rounds of trading and a special bank institution (either private bankers or a public central bank)
  - That external bank issues credits for trade in a first initial round, i.e., creating accounts without deposits, as an overdraft facility
  - Security exchange is then done with these bank notes instead of the securities or money
  - At the end, there is a second additional round for this debt to be repaid (no reneging is allowed)
- Limitations
  - In the context of Ostroy-Starr, this mechanism violates the stated goal of accomplishing the overall given Walrasian objective in one round (though costs of multiple rounds is not modeled)

Formalization: The Walras Banker, with Trade Credit, IOUs

- **Theorem 5**: There is a trading rule that (i) uses information. D.1; and (ii) completes trading within three rounds for any (p,Z,B) satisfying U in a 'bank credit economy'
  - In the credit bank economy, every trader can meet their excess demand using money, as in the 'monetary economy' described by theorem 4.
  - However, in the bank credit economy, the premise that every trader holds enough money at the beginning is not required. Instead, there is a bank that can create money (issue notes/IOUs).
  - In the first round, traders do nothing other than borrowing money from the bank, so all of them have enough money as required by the premise of the monetary economy.
  - In the second round, they make trades as they would do in the monetary economy. At the end of the second round, every trader has met his excess demand and holds the same amount of money that he started the second round with.
  - In the third round, traders pay back what they borrowed from the bank.

Ostroy and Starr, 1974

Townsend (1990), Medieval Trade Fairs

A key aspect of this banking system, then, is that credit transfers were possible. That is, the obligation of the debtor (purchaser) could be eliminated by written transfer of a credit in the books of a banker. In effect, the debts of the banker could be reassigned. Further, bankers could and did create credit by written entries in their books, even without the deposit of lawful currencies; a customer was simply granted an overdraft. Finally, bankers could and did keep accounts with one another, giving rise to a kind of interbank clearing system that potentially increased the scope of their operation.

Apparently, merchants came close to realizing the full set of possibilities of this banking transfer system with the great international trade fairs of Champagne. As noted above, such fairs had prespecified days, first for the introduction of goods, then for transactions in cloth, leather goods, and drugs and spices, and last, at the end, for settlements. There seems to be little doubt that bankers played a key role in this sequence. Indeed, Usher (1943) believes that traders brought relatively few coins with them to the fair. Somehow, then, potential sellers received credit from bankers for goods not yet sold, and this credit was transferred to other sellers relatively early on in the fair sequence. Similarly, book credits to these early buyers were not demand assets of the banker; payments were not due until the close of the fair. Again, Usher (1943) believes that only a small fraction of the transactions were actually discharged in specie. According to Clough and Rapp (1975) all principals did come together in the settlement period, so that in theory at least, if not in practice, relatively little specie was needed. Indeed, if

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Townsend (1990) "Financial Structure and Economic Organization"

market-clearing prices were somehow posted as if in a Walrasian auction (which of course they were not), then no coins whatever would be needed.

A complete separation of a book-transfer payment system from coins or specie is hard to imagine. Again, however, it appears that medieval merchants came quite close at times. Supporting evidence is provided by the use at various dates and locations of pure units of account for record-keeping purposes, as noted by Cipolla (1956). In fact we have already noted this use of pounds and shillings in Carolingian times. Later, accounts were kept in circulating coins of various denominations to facilitate record-keeping. Subsequent devaluations changed the relative value of circulating coins, potentially destroying the record-keeping system. However, merchants in Milan after 1340, for example, continued to use older coins in their record-keeping systems with the understanding that they were pure fictional units of account.

In short, then, record-keeping in units of account was not a problem. But what about actual payments? Certainly there was some uncertainty at the fair, about the valuation of goods for example. Some coins must have been needed. Again, however, medieval merchants were willing to extend their bookkeeping system to cope with this problem. Credit was extended to the next fair by having the debtor issue a personal IOU. Frequently the money changers (bankers) were used as intermediaries, extending credit for promises of future payment. Either way there arose well-documented exchange contracts or *lettres de foire*. With such letters, the requirements that accounts be balanced, essentially at a point in time, could be replaced by the requirement that accounts be balanced over time. Further, the regular periodic meetings of fairs and the use of *lettres de foire* gave rise to apparently massive international settlement periods, at the fairs of Lyon for example. Merchants could all write contracts payable at one of the fairs, with accounts settled at the outset in the centralized multilateral bank credit system. These international financial fairs persisted well beyond the trade in commodities which fathered them originally.

Problem: US Repo, Intraday Can Be Huge, Risk of Default

AI Overview

Key points about the 2010 tri-party repo reforms:

Reduced Intraday Credit:
The primary focus was on significantly decreasing the amount of intraday credit provided by clearing banks to dealers during repo transactions, aiming to minimize the potential for large-scale defaults if a dealer faced liquidity issues.

Enhanced Transparency:
The Federal Reserve Bank of New York started publishing detailed market data on the tri-party repo market, allowing regulators and market participants to monitor exposures and identify potential risks more effectively.

Improved Collateral Management:
Reforms included stricter collateral requirements and improved practices for managing collateral substitution, ensuring higher quality collateral was used in repo transactions.

Better Default Procedures:
New guidelines were established for how cash investors should handle securities in the event of a tri-party repo counterparty default, mitigating potential fire sales of collateral.

Task Force Recommendations:
These reforms were largely based on recommendations from a dedicated task force that studied the tri-party repo market and identified areas for improvement.

Google AI Overview of "tri party repo 2010 reforms description," Accessed 12/10/24

The Information Solution with Distributed Ledger Technology

- Tracking the history of exchange on the blockchain
- Private sector innovations

Impossibility of Decentralized Monetary Exchange

- With none of the above mechanisms available, there is an impossibility theorem, that is, the goal of achieving the objective cannot be accomplished IF the system is decentralized
- The impossibility of decentralized monetary exchange, proof by counter example
- Assert it is possible after all, and then show example environment in which it is necessary to share traders histories, not only the histories of each contemporary matched pair when they meet, but the histories of previous trades of those with whom the matched pair have not yet been matched

Two Solutions with Distributed Ledgers

- The ledgers work as a reference guide to provide the requisite (traders) history
  - Traders' histories can be secured with atomic swaps, and instantaneous payment-for-value exchanges can be posted on public distributed ledgers as they occur
  - In practice, entire histories do not need to be revealed. That depends on the patterns of exchange. What needs to be revealed are when choices are made at key pairings among pairwise equivalent quid pro quo contemporary alternatives.
- An alternative way: Past trades are recorded and condition possible contemporary trades as with smart contracts
  - That said, there is really no conflict of interest in the model. Traders are trying to achieve a given social goal, not trying to keep things secret.

Key Example of the Difficulty: Proof of Theorem 2 (Kyungmin Kim 2015)

Theorem 2: There is no trading rule that (i) uses information D.3; (ii) satisfies A; and (iii) completes trading within a single round for any (p, Z, B) satisfying U.

Proof: As the original paper attempted to, I find two economies such that in a certain meeting, (i) the two traders cannot decide which economy they are in; and (ii) they have to make different trades depending on which economy they are in.

There are five traders, $1, 2, ..., 5$, there are five periods, $t = 1, 2, ..., 5$, and there are four types of goods, $1, 2, 3$ and 4. The sequence of meetings is as follows:

$$t = 1 : \overline{25}, \overline{34}, \overline{1}.$$
$$t = 2 : \overline{15}, \overline{23}, \overline{4}.$$
$$t = 3 : \overline{12}, \overline{45}, \overline{3}.$$
$$t = 4 : \overline{14}, \overline{35}, \overline{2}.$$
$$t = 5 : \overline{13}, \overline{24}, \overline{5}.$$

Two traders under the same line are meeting with each other.

First, each type of good has the same price, so $p = (1, 1, 1, 1)$.
Let N be the matrix of excess demands at the beginning, where

$$N = \begin{bmatrix} 4 & -2 & -2 & 0 \\ -4 & 1 & 1 & 2 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 0 \end{bmatrix}.$$

Each row represents a trader and each column represents a type of good. For $N_{12} = -2$ means that trader 1's excess demand for good 2 is -2.

Let B be the matrix of endowment, with B_{ij} representing the number of good j that trader i has:

$$B = \begin{bmatrix} 0 & 2 & 2 & 0 \\ 4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Below, I go through individual periods. Trader 5 has zero endowment, so he can never trade.

In t= 1, trader 2 meets with 5, and 3 meets with 4. Since trader 5 does not trade, only traders 3 and 4 can trade. Both trader 3 and trader 4 have only 1 unit of good 4. Therefore, they do not make any trade, and no trade occurs in t= 1.

In t= 2, trader 1 meets with 5, and 2 meets with 3. Therefore, only traders 2 and 3 can make a nontrivial trade. After trading with 2, trader 3 does not trade with anyone until he trades with trader 1 in t = 5.

Both traders 1 and 3 want to hold zero amount of good 4. Therefore, trader 3 must give 1 unit of good 4 to trader 2 in t = 2; othewise, some good 4 must remain ·with traders 1 and 3 and their excess demands will not be met. In return, trader 2 gives 1 unit of good 1 to trader 3, since it is the only type of good that he has. After t = 2, the matrix of excess demands N2 and good holdings B2 are:

$$N_2 = N = \begin{bmatrix} 4 & -2 & -2 & 0 \\ -3 & 1 & 1 & 1 \\ -1 & 1 & 0 & 0 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 0 \end{bmatrix} ; B_2 = B = \begin{bmatrix} 0 & 2 & 2 & 0 \\ 3 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Trader 1 demands none of good 2, currently has 2 units. Has use for 1 only. So, give 1 unit of good to Trader 2 and 2 units of good 3.

In $t = 3$, trader 1 meets with 2 and 4 meets with 5. Therefore, only traders 1 and 2 can make a nontrivial trade. Trader 2 needs to give 3 units of good 1 to trader 1 because only trader 1 demands good 1; after $t = 3$, trader 2 meets with trader 4 in $t = 5$. so $t = 3$ is the last chance for trader 2 to pass his stock of good 1 to trader 1.

In return, trader 1 needs to give 3 units of goods 2 or 3 to trader 2. However, in $t = 5$, trader 1 needs to give 1 unit of good 2 to trader 3;

To complete the proof, I construct a similar but different economy. The price vector is the same: $p = (1, 1, 1, 1)$. The matrix of initial excess demands, denoted by M, is

$$M = \begin{bmatrix} 4 & -2 & -2 & 0 \\ -4 & 1 & 1 & 2 \\ 0 & 0 & 1 & -1 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \end{bmatrix}.$$

Traders 1 and 2 excess demands have not changed. History of Traders 3 and 4 at t = 1 is different but Traders 1 and 2 cannot know this.

M can be obtained from N by exchanging row 3 with row 4. The endowment is also given in the same way: The endowment of trader i in good j is $[-M_{ij}]^+$.

Going through the same steps as I did for the previous economy, I find that trader 1 needs to give 2 units of good 2 and 1 unit of good 3 to trader 2 in $t = 3$. In the previous economy, trader 1 needed to give 1 unit of good 2 and 2 units of good 3 to trader 2.

Finally, I show that traders 1 and 2 cannot know whether they are in economy N or M in $t = 3$. In both economies, the history of trader 1's excess demands is simply a repeat of $(4, -2, -2, 0)$ because he never trades before $t = 3$. In both economies, the history of trader 2's excess demands is: Before meeting with trader 3 in $t = 2$, the excess demand is $(-4, 1, 1, 2)$, and after the meeting in $t = 2$, it is $(-3, 1, 1, 1)$.

This completes the proof.

This is the entire history of trades of 2 and 3. Only under C do they know more.

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Innovations on the Blockchain

Walmart has long been known as a leader in supply chain management. However, its prowess could not insulate it from a problem plaguing the transportation industry for decades: vast data discrepancies in the invoice and payment process for freight carriers, which required costly reconciliation efforts and caused long payment delays. Then Walmart Canada pioneered a solution: It employed blockchain, a distributed-ledger technology, to create an automated system for managing invoices from and payments to its 70 third-party freight carriers.

Source: Vitasek et al (2022) "How Walmart Canada Uses Blockchain to Solve Supply Chain Challenges" Harvard Business Review

Tracr for Diamonds

De Beers Group is deploying the Tracr™ blockchain platform at scale for its diamond production. Tracr™ is the world's only distributed diamond blockchain that starts at the source and provides tamper-proof source assurance at scale, enabling Sightholders to provide an immutable record of a diamond's provenance, and empowering jewellery retailers to have confidence in the origin of the diamonds they purchase.

"De Beers group introduces world's first blockchain backed diamond source platform at scale" (2022) DeBeersGroup.com

Ghana Trade Finance and Tracker

Dr Maxwell Opoku-Afari, the 1st Deputy Governor of the Bank of Ghana said, "Project DESFT is aimed at supporting SMEs in Africa to engage in international trade by removing significant obstacles they face, such as establishing trust with overseas trade partners and obtaining support in cross-border payments and supply chain finance. We believe that the new generation of financial technology offers innovative approaches to these challenges. After nearly a year and two phases of development, we have crafted a reliable information exchange solution founded on UTC standards and Semi-fungible Token technology. Furthermore, we have rigorously tested a cross-border payment solution built upon the principles of Purpose Bound Money (PBM) and conducted real trade experiments which fully align with our predetermined objectives."

Source: "Press Release: Bank of Ghana Announces Successful Completion of Cross-Border Trade Using Digital Credentials" (2024) BOG.gov.gh