Marketmaking Middleman

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What is a marketmaking middleman?

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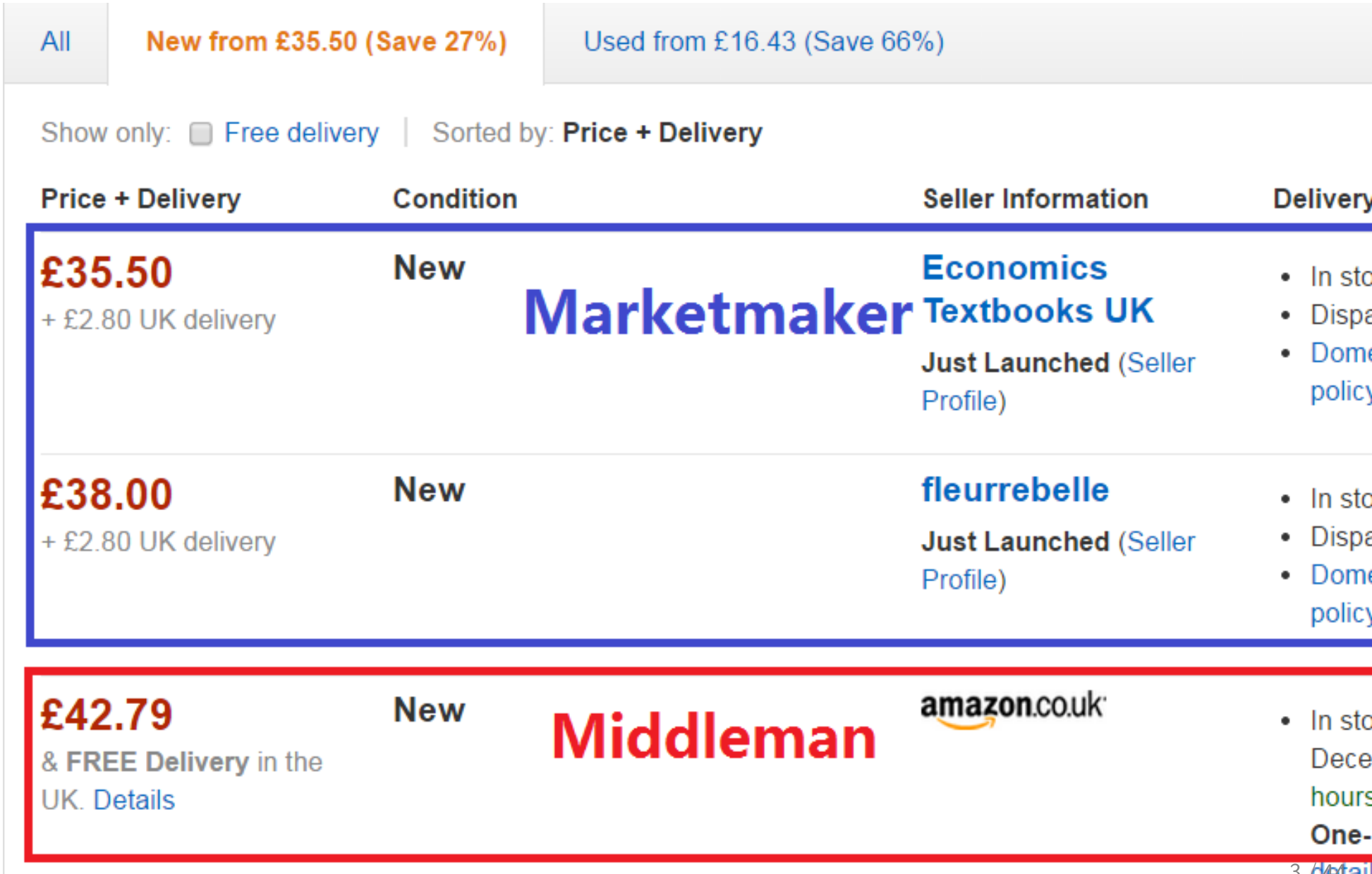
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What is a marketmaking middleman?



What is a marketmaking middleman?



Figure: the spectrum, intermediaries defined by functioning

literature

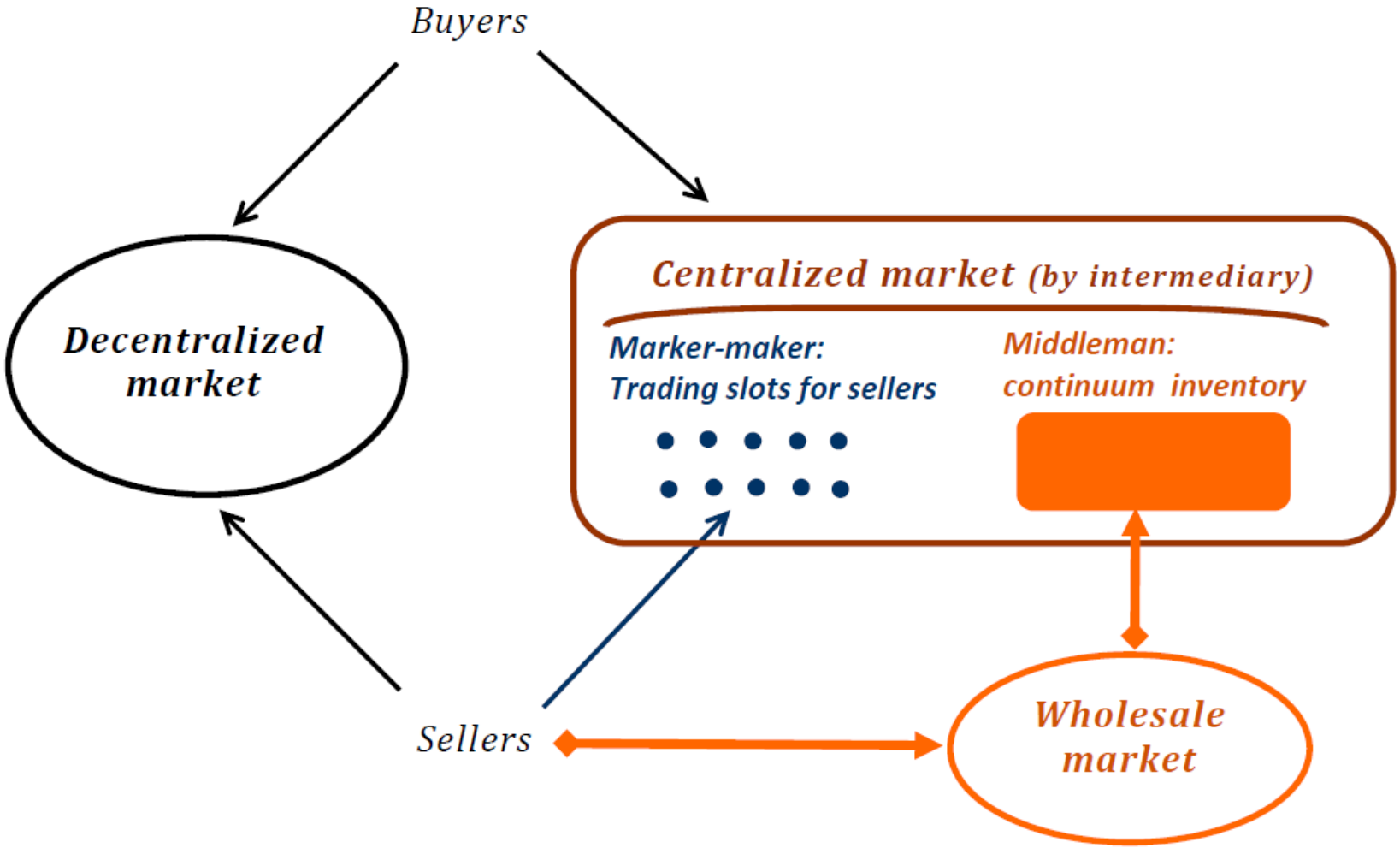
- Two-sided market literature: cross-group externality.

  Rochet and Tirole (2003, 2006), Caillaud and Jullien (2003), Armstrong (2006).

- Middlemen literature: high meeting rate, demand variety and the high inventory capacity.

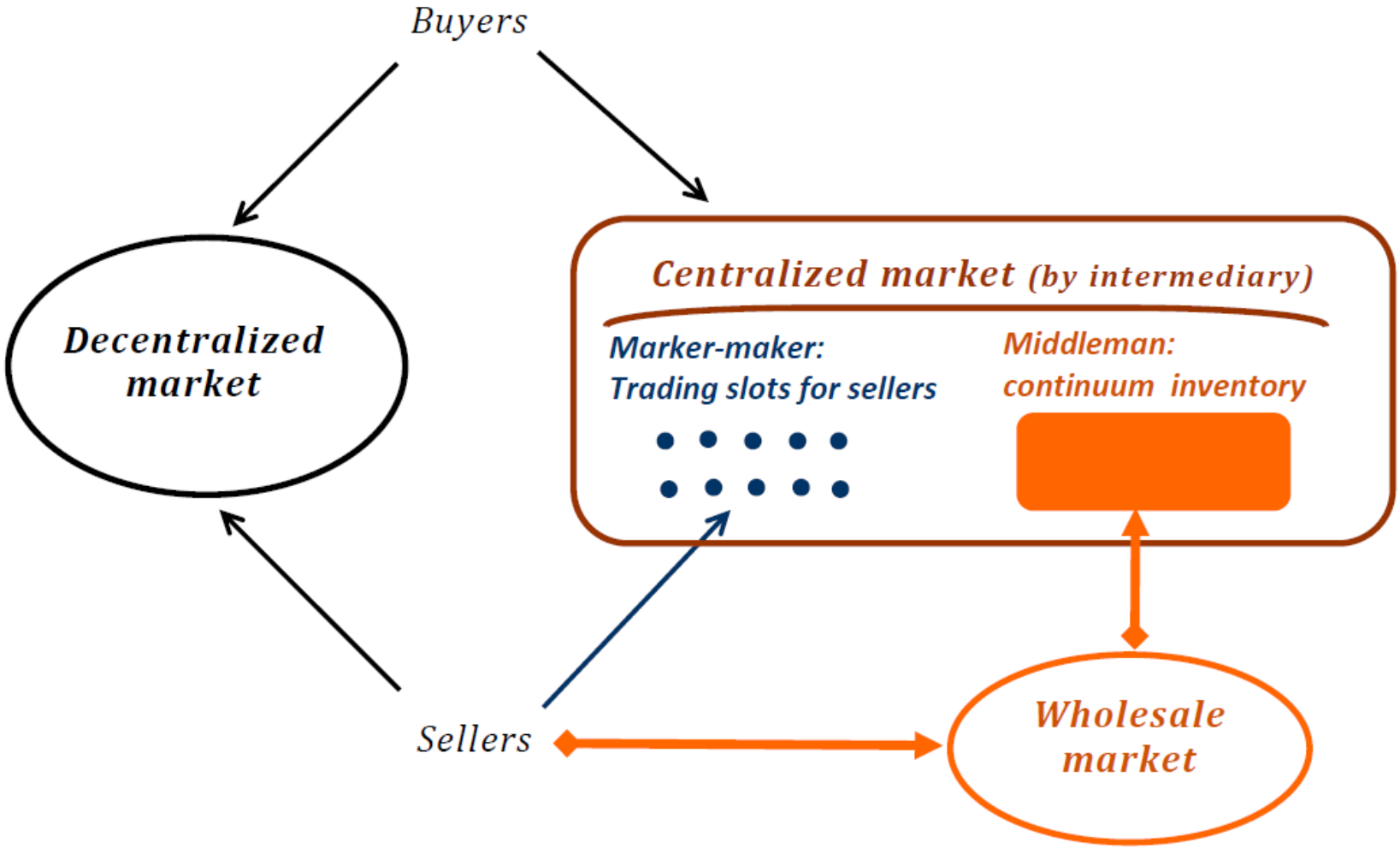
  Rubinstein and Wolinsky (1987), Shevichenko (2004) and Watanabe (2010, 2013).

the model



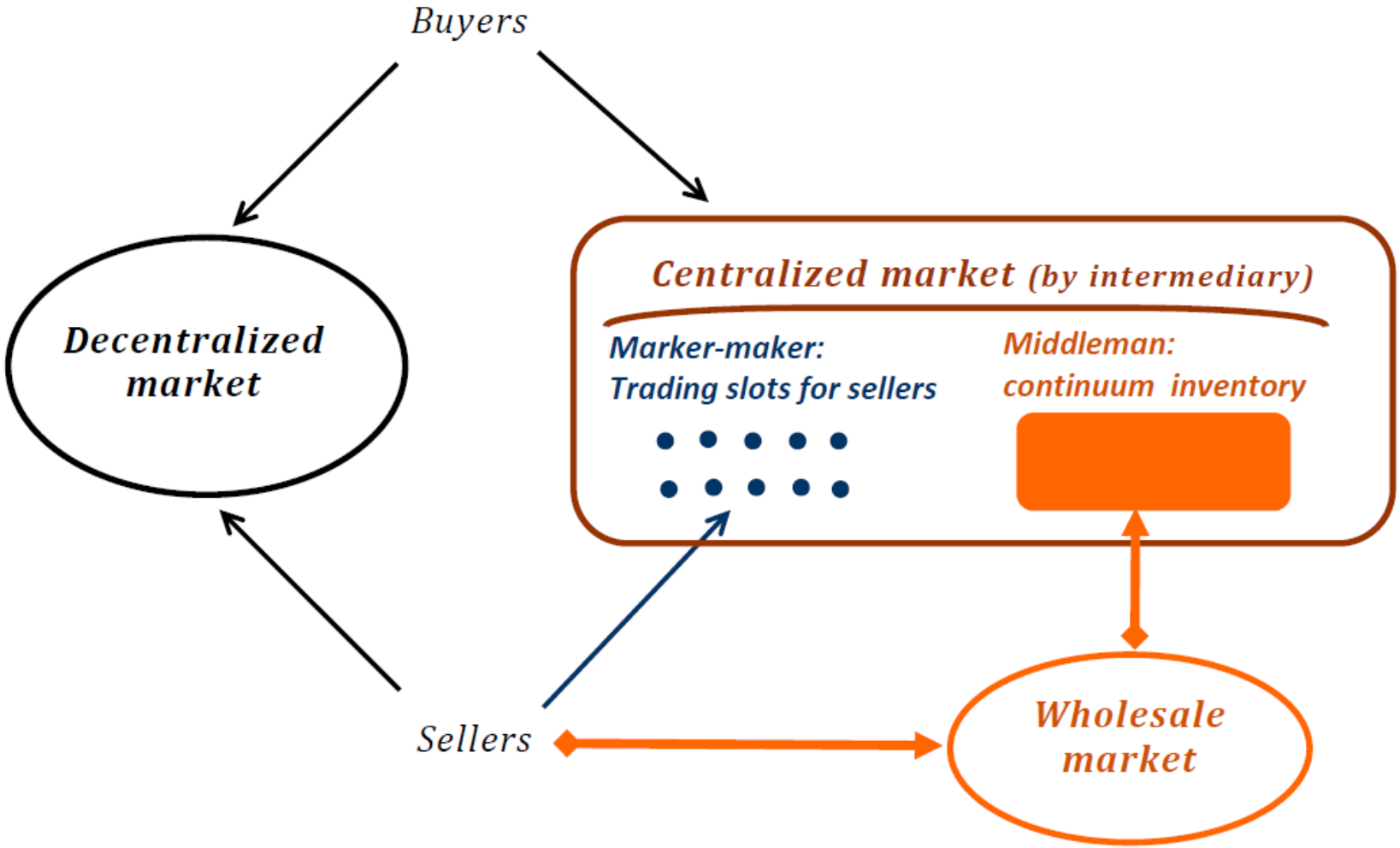
- a mass B of buyers, a mass S of sellers
- homogenous goods: unit demand/unit sell, common consumption value normalized to 1, marginal cost is $c \in [0, 1)$

the model



- D(ecentralized) market
  - random meeting, meeting rate $\lambda^b, \lambda^s \in (0,1)$, $B\lambda^b = S\lambda^s$
  - bilateral bargaining, θ for buyers, $1-\theta$ for sellers

the model

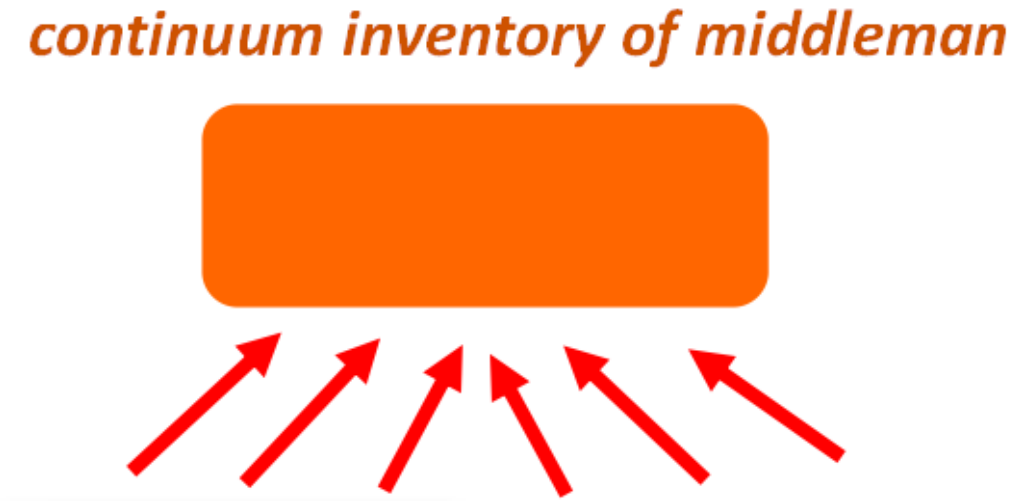


- C(entralized) market
  - marketmaker: profits from the transaction and registration fees.
  - middleman: stock a mass inventory in a competitive wholesale market, resells to buyers

centralized market

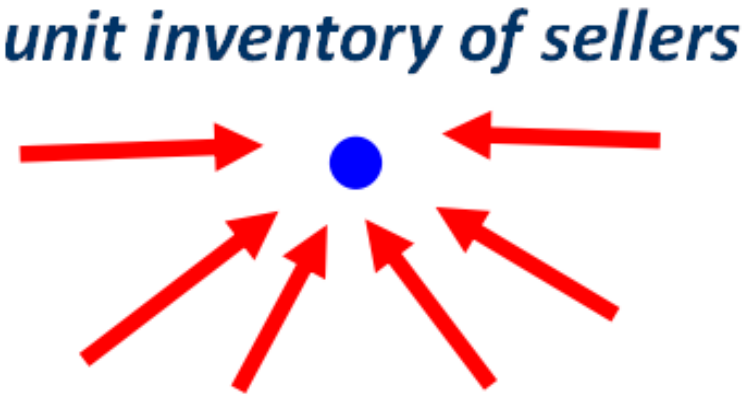
- a two-sided market
  - cross-group externality
  - subsidize one type, the other type will come soon
- price observed by all, buyers can't coordinate their actions
  - more buyers than the seller's inventory, then some buyers will be rationed. (Coordination frictions)
- suppose buyers visit the middleman x^m, the rest visit the marketplace $B - x^m$
  - on average each seller gets $x^s = \frac{B - x^m}{S}$
  - middleman optimally adjusts inventory equal to x^m, $\Pr[served] = 1$
  - sellers have limited 1 unit inventory, $\Pr[served] = \eta^s(x^s) \leq 1$ (high coordination frictions).

centralized market



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centralized market



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urn-ball matching process

- given fees F, suppose B' buyers and S' sellers participate in C market
  1. all participating sellers post a price simultaneously
  2. all participating buyers choose a seller to visit simultaneously
- directed search friction
  - in a large market, buyers can't coordinate their visits
  - if more than one buyers visit a seller, then allocate the good randomly
  - the number of buyers visits a seller N follows a Poisson distribution

$$\Pr(N = n) = \frac{e^{-x^s}(x^s)^n}{n!}$$

where $x^s = \frac{B'}{S'}$

urn-ball matching process

- for finite integers B' and S', the number of buyers visits a seller, denoted as N, follows a Binomial distribution

$$\Pr\left(N=n\right)=\binom{B'}{n}\left(\frac{1}{S'}\right)^{n}\left(1-\frac{1}{S'}\right)^{B'-n}$$

- take $B', S' \to \infty$ and $B'/S' = x^s$, N follows a Poisson distribution

$$\begin{aligned}\lim_{\substack{b,s\to\infty \\ b/s=x^s}} \Pr\left(N=n\right) &= \frac{e^{-x^s}\left(x^s\right)^n}{n!} \\ \lim_{\substack{b,s\to\infty \\ b/s=x^s}} \Pr\left(N>0\right) &= 1-e^{-x^s}\end{aligned}$$

- a deviating seller with an expected queue of buyers, denoted as x
  - the seller receive at least one buyer with $1-e^{-x}$
  - a visiting buyer is served with $\eta^s\left(x\right) \equiv \frac{1-e^{-x}}{x}$

timing

- a competitive wholesale market opens. The intermediary purchases a mass k inventory at wholesale price c
- two retail markets open to buyers, C market and D market
- the intermediary announces the fee structure for the marketplace
- observing these fees and inventory, buyers and sellers simultaneously decide which market to participate in
  - singlehoming, agents visit only one market
  - multihoming, agents can visit both markets C & D market

single-homing

- agents can participate in only one market.
- intermediary essentially becomes a monopolist
  - once agents are in the centralized market, switching to the decentralized market is not feasible,
- all trade surplus can be extracted

$$\pi^{\text{Single}} = (B - x^m)\,\eta^s\,(x^s)\,(1-c) + x^m\,(1-c)$$

- the middleman mode creates more transactions, thus is preferred

$$x^{m*} = B$$

multi-homing

- participating all markets is allowed
- compete against the outside market, the intermediary has to lower price and fees, give buyers their outside option value $V^b_{(D)}$
- the profits of intermediary

$$\pi^{\text{Multi}} = (B - x^m)\,\eta^s\,(x^s)\left[1 - c - V^b_{(D)}\right] + x^m\left[1 - c - V^b_{(D)}\right],$$

where $V^b_{(D)} = \lambda^b e^{-x^s}\theta\,(1-c)$, $x^s = \frac{B - x^m}{S}$.

multi-homing

$$\pi^{\text{Multi}} = (B - x^m)\,\eta^s\,(x^s)\left[1 - c - V^b_{(D)}\right] + x^m\left[1 - c - V^b_{(D)}\right],$$

- middleman mode is efficient in creating more transactions $\Longrightarrow$ a higher x^m;
- buyer's outside option value $V^b_{(D)}$ increases in x^m $\Longrightarrow$ a lower x^m;
  - a higher x^m leads to less transactions in the marketplace, more sellers available in D market, buyers are easier to match in D market
- the trade-off between more transactions and more profits per-trade pins down

$$x^{m*} < B$$

conclusion

- non-exclusive intermediation service leads to a hybrid business mode
  - an active marketplace to lower buyers' outside option value
- competition for intermediation can deteriorate the efficiency and welfare
  - social planner's viewpoint, pure middleman mode since it minimizes market frictions
  - in the presence of outside competition, hybrid mode is more profitable for the intermediary

agenda remainder of talk

- the marketmaking middleman under singlehoming (section 3)
  - participate in only one market
- the marketmaking middleman under multihoming (section 4)
  - allowed to participate in both markets

singlehoming, the model

- a one-period economy
- agents: a mass B of buyers, a mass S of sellers, *one* intermediary
- homogenous goods:
  - unit demand/unit sell/a continuum of inventory
  - common consumption value normalized to 1;
  - marginal cost is $c \in [0, 1)$.
- D(ecentralized) market
  - random meeting, meeting rate $\lambda^b, \lambda^s \in (0, 1)$, $B\lambda^b = S\lambda^s$
  - bilateral bargaining, θ for buyers, $1 - \theta$ for sellers
- C(entralized) market
  - marketmaker: transaction fees $f^b, f^s \in [0, 1]$, participation fees $g^b, g^s \in [-1, 1]$
  - middleman: profits from inventory

singlehoming, timing of events

1. a competitive wholesale market opens, the intermediary stocks a continuum of inventory $k \in [0, B]$ from producers/sellers
2. retail markets open
    1. the intermediary announces a set of fees $F \equiv \left\{ f^b, f^s, g^b, g^s \right\}$
    2. observing F, buyers and sellers simultaneously decide which market to attend (singlehoming)
    3. trade occurs in each market (standard directed search game in C market)

singlehoming, timing of events

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    2. observing F, buyers and sellers simultaneously decide which market to attend (singlehoming)
    3. **trade occurs in each market (standard directed search game in C market)**

singlehoming, the directed search equilibrium sellers

- a deviating seller with an expected queue of buyers, denoted as x
  - the seller receive at least one buyer with $x\eta^s(x) = 1 - e^{-x}$
  - a visiting buyer is served with $\eta^s(x) \equiv \frac{1-e^{-x}}{x}$
  - the problem

$$\max_p V^s = x\eta^s(x)(p - f^s - c)$$
$$s.t. V^b = \eta^s(x)\left(1 - p - f^b\right)$$

- equilibrium values

$$\begin{aligned} V^b &= e^{-x^s}(1 - f - c) \\ V^s &= \left(1 - e^{-x^s} - x^s e^{-x^s}\right)(1 - f - c) \end{aligned}$$

where $x^s = \frac{B'}{S'}$, $f \equiv f^b + f^s$

singlehoming, the directed search equilibrium middleman

- expected queue of buyers visiting middleman x^m,

$$S' x^s + x^m = B'$$

- the serving probability of a buyer visiting the middleman

$$\eta^m \left(x^m \right) = \frac{\min \left\{ k, x^m \right\}}{x^m}$$

- the middleman's problem

$$\begin{aligned} \max_{p^m} V^m &= \min \left\{ k, x^m \right\} \left(p^m - c \right), \\ s.t. V^b \left(x^m \right) &= \eta^m \left(x^m \right) \left(1 - p^m \right). \end{aligned}$$

  note the large market assumption does not hold $V^b \left(x^m \right)$
- optimal $x^m \leq k$

singlehoming, timing of events

1. a competitive wholesale market opens, the intermediary stocks a continuum of inventory $k \in [0, B]$ from producers/sellers
2. retail markets open
    1. the intermediary announces a set of fees $F \equiv \left\{ f^b, f^s, g^b, g^s \right\}$
    2. **observing F, buyers and sellers simultaneously decide which market to attend (singlehoming)**
    3. trade occurs in each market (standard directed search game in C market)

singlehoming, buyers' and sellers' decision

- agents hold a pessimistic expectation
  - they would rather believe no one of the other type is in C market
- resort to divide and conquer strategies
  - DbCs

$$\begin{aligned} \text{Db} &: -g^b \geq \lambda^b \theta \left(1-c\right), \\ \text{Cs} &: V^s - g^s \geq 0. \end{aligned}$$

  - DsCb

$$\begin{aligned} \text{Ds} &: -g^s \geq \lambda^s (1-\theta) \left(1-c\right), \\ \text{Cb} &: V^b - g^b \geq 0. \end{aligned}$$

  - these induce all agents to join the C market, $B' = B$ and $S' = S$.

singlehoming, timing of events

1. a competitive wholesale market opens, **the intermediary stocks a continuum of inventory** $k \in [0, B]$ **from producers/sellers**
2. retail markets open
   1. **the intermediary accounces a set of fees** $F \equiv \left\{ f^b, f^s, g^b, g^s \right\}$
   2. observing F, buyers and sellers simultaneously decide which market to attend (singlehoming)
   3. trade occurs in each market (standard directed search game in C market)

singlehoming, the intermediary's problem

$$\max_{f,k} \Pi = Bg^b + Sg^s + Tf + x^m p^m - kc,$$
$$s.t.\ DbCs \text{ or } DsCb$$

where $T \equiv S(1 - e^{-x^s})$ is the expected trade of sellers.

- g^b and g^s are the determined by DC restrictions
- f is set to be maximum $1 - c$ to extract all surplus from participating agents
- the trade-off on inventory
  - recall the optimal $x^m \leq k$, but $k > x^m$ only incurs more cost, $k = x^m$
  - set $f = 1 - c$ and ignore the $Bg^b + Sg^s$ (constant)

$$\max_k \underbrace{S\left(1 - e^{-\frac{B-k}{S}}\right)(1-c)}_{\text{marketmaker } (-k)} + \underbrace{k\,(1-c)}_{\text{middleman } (+k)}$$

singlehoming, the intermediary's problem

Proposition

The profit-maximizing intermediary divides (subsidies) buyers when $\theta < 1-\theta$ *and divides sellers when* $\theta > 1-\theta$*, the optimal transaction fee is* $f = f^b + f^s = 1 - c$*, optimal inventory is* $k = B$*. The corresponding profits are*

$$\begin{aligned} \Pi_{DbCs} &= B\left(1-\lambda^b\theta\right)(1-c), \\ \Pi_{DsCb} &= B\left(1-\lambda^b(1-\theta)\right)(1-c). \end{aligned}$$

agenda remainder of talk

- the marketmaking middleman under singlehoming (section 3)
  - participate in only one market
- the marketmaking middleman under multihoming (section 4)
  - allowed to participate in both markets

multihoming, timing of events

1. a competitive wholesale market opens, the intermediary stocks $k \in [0, B]$ from producers/sellers as inventory
2. retail markets open
    1. the intermediary announces a set of fees $F \equiv \left\{ f, g^b, g^s \right\}$
    2. observing F, buyers and sellers simultaneously decide which one or two markets to attend (multihoming), make the decision on where to trade after outcomes of two markets are revealed.

multihoming

- matching outcomes
  - if 1 match from C or D market, chooses the market that is matched
  - if 2 matches from both markets, chooses the preferred one by comparing prices.
    - ★ price in D market is fixed, $\theta(1-c)$ or $(1-\theta)(1-c)$
    - ★ price in C market depends on f, as will detailed later
    - ★ this means the intermediary can set f to change agents' choice
- depending on the value of f, there are four possible cases
  - BCSC: all types choose C market
  - BCSD: buyers choose C market, sellers choose D market
  - BDSC: buyers choose D market and sellers choose C market
  - BDSD: all agents prefer D market

multihoming, BCSC incentive constraints

- buyers prefer middleman to D market

$$1 - p^m \geq \left(1 - x^s \eta^s \left(x^s\right)\right) \theta \left(1 - c\right)$$

- buyers prefer sellers in C market to D market

$$1 - p^s - f \geq \left(1 - x^s \eta^s \left(x^s\right)\right) \theta \left(1 - c\right)$$

- sellers prefer C market to D market

$$p^s - c \geq \rho \left(x^s, x^m\right) \left(1 - \theta\right) \left(1 - c\right)$$

where $\rho \left(x^s, x^m\right) \equiv 1 - \frac{x^m}{B'} \eta^m \left(x^m\right) - \frac{S' x^s}{B'} \eta^s \left(x^s\right)$.

multihoming, BCSC sellers

Consider a deviating seller characterized by an expected queue x

$$\max_{p} V^s = x\eta^s(x)(p-c) + (1-x\eta^s(x))\lambda^s\rho(x^s,x^m)(1-\theta)(1-c)$$

subject to

$$V^b = \eta^s(x)(1-p-f) + (1-\eta^s(x))\lambda^b(1-x^s\eta^s(x^s))\theta(1-c)$$

where $\rho(x^s,x^m) \equiv 1 - \frac{x^m}{B'}\eta^m(x^m) - \frac{S'x^s}{B'}\eta^s(x^s)$.

Solution

Solve this problem gives p^s, V^b and V^s.

multihoming, BCSC the middleman

The middleman is characterized by an expected queue x^m, the optimal price is obtained by solving

$$\max_{p^m} V^m = \min\left\{x^m, k\right\}\left(p^m - c\right)$$

subject to

$$V^b = \eta^m\left(x^m\right)\left(1 - p^m\right) + \left(1 - \eta^m\left(x^m\right)\right)\lambda^b\left(1 - x^s\eta^s\left(x^s\right)\right)\theta\left(1 - c\right)$$

To rule out increasing demand function, we need λ^b to be small enough.

Solution

When λ^b is small, solve this problem gives the optimal queue $x^m \leq k$ and the equilibrium p^m.

multihoming, divide and conquer conditions

- divide and conquer conditions are modified as
  - DbCs

$$\begin{aligned} \text{Db:} \quad & -g^b \geq 0, \\ \text{Cs:} \quad & V^s - g^s \geq \lambda^s \rho\left(x^s, x^m\right)(1-\theta)(1-c). \end{aligned}$$

  - DsCb

$$\begin{aligned} \text{Ds:} \quad & -g^s \geq 0, \\ \text{Cb:} \quad & V^b - g^b \geq \lambda^b e^{-x^s} \theta (1-c). \end{aligned}$$

multihoming, the intermediary's problem

- The intermediary's problem

$$\max_{f,k} \Pi = Bg^b + Sg^s + Tf + x^m p^m - kc,$$

  subject to *DbCs* or *DsCb* constraint and BCSC constraints.

- It is optimal to set maximum f, so the restriction on f must be binding.

multihoming, the intermediary's problem

illustrate choice of k by DsCb, impose $c = 0$ (for shorter expression)

$$\max_k \Pi = k\left(1-\lambda^b e^{-x^s}\theta\right) + S\left(1-e^{-x^s}\right)\left(1-p^s-\lambda^b e^{-x^s}\theta\right).$$

$$\frac{\partial \Pi}{\partial k} = \underbrace{\left(1-\lambda^b e^{-x^s}\theta\right) + \frac{\partial S\left(1-e^{-x^s}\right)}{\partial k}\left(1-p^s-\lambda^b e^{-x^s}\theta\right)}_{\text{transaction effect: positive}}$$

$$\underbrace{-\left[k+S\left(1-e^{-x^s}\right)\right]\frac{\partial e^{-x^s}\lambda^b\theta}{\partial k}}_{\text{competition effect: negative}} \underbrace{+S\left(1-e^{-x^s}\right)\frac{\partial\left(1-p^s\right)}{\partial k}}_{\text{externality effect: positive}}$$

multihoming, the intermediary's problem

$\frac{\partial \Pi}{\partial k}|_{k=B} = -\lambda^s \theta (1-c) < 0$ implies $k^* < B$. Thus,

$$\Pi(k^*) > \Pi(k = B) = B\left(1 - \lambda^b \theta\right)$$

Same analysis applies to DbCs strategy, but divide buyers means giving up the surplus of buyers, less profitable.

Proposition

In the case of BCSC, when λ is small, DsCb strategy is optimal. The optimal transaction fee is its upper bound and the optimal inventory is set to be strictly smaller than B, $0 \leq k^* < B$. The corresponding profit is higher than $B\left(1 - \lambda^b \theta\right)(1-c)$.

multihoming, the intermediary's problem

Proposition

With λ is small, the DsCb strategy involving BCSC directed search equilibria constitutes the optimal strategy.

- Strategies involving BDSC and BDSD equilibria, the max amount of transactions $B\left(1-\lambda^{b}\right)$, and the max profit is $B\left(1-\lambda^{b}\right)(1-c)$..
- Strategies involving BCSD equilibria, $k^{*}=B$, and the max profit is $B\left(1-\lambda^{b}\theta\right)(1-c)$.

Conclusion

- Without outside competition (singlehoming), middleman mode (inventory trade) is optimal.
- With outside competition (multihoming), using a hybrid mode can be profitable for the intermediary. The intermediary is a marketmaking middleman.
- The marketmaking middleman reduces its inventory from the efficient level. Hence, competition for intermediation can deteriorate the efficiency and welfare.

Appendix on multihoming

BCSC incentive constraints

$$
\begin{aligned}
\text{BC:} \quad & 1 - p^m \geq \left(1 - x^s \eta^s\left(x^s\right)\right) \theta \left(1 - c\right), && (1)\\
& 1 - p^s - f \geq \left(1 - x^s \eta^s\left(x^s\right)\right) \theta \left(1 - c\right), && (2)\\
\text{SC:} \quad & p^s - c \geq \rho\left(x^s, x^m\right)\left(1 - \theta\right)\left(1 - c\right), && (3)
\end{aligned}
$$

indifferent between visiting sellers and the middleman

$$
\begin{aligned}
V^b_{(m)} &= V^s_{(m)} \\
1 - p^m &= \eta^s\left(1 - p^s - f\right) + \left(1 - \eta^s\right) \lambda^b e^{-x} \theta \left(1 - c\right)
\end{aligned}
$$

only (1) and (3) can be binding.

Appendix on multihoming

the intermediary's problem

Corollary

When buyers' D market value is big enough, satisfies $\left(4\lambda^b + 3\right)\theta > 5$ *and* $\left(3\lambda^b - 1\right)\theta > 1$, $k = 0$ *is optimal for some small but strictly positive buyer-seller ratio* $B/S > 0$.

Corollary

An increase in buyer's bargaining power θ *in the decentralized market leads to a lower inventory level* k.

Appendix on multihoming

BCSC incentive constraints

With $p^s(f)$ and $p^m(f)$, BCSC incentive constraints become

$$1 - f - c \geq \left[\lambda^s \rho\left(x^s, x^m\right)(1-\theta) + \left(1-\lambda^b\right)\theta + \lambda^b e^{-x}\theta\right](1-c),$$

$$1 - f - c \geq \left[\frac{1 - e^{-x} - \lambda^s x e^{-x}}{1 - e^{-x} - x e^{-x}}\rho\left(x^s, x^m\right)(1-\theta) + \lambda^b e^{-x}\theta\right](1-c).$$