Information markets: of efficient monopolies and inefficient firewalls

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Summary

Introduction *(1/5)*

- **Motivation**:
  - Potential competitors talk all the time.
  - Example: financial markets, where information seems vital and "rival."
  - Information acquisition is not free, and may be valuable, so a market may (or may not) develop.

Introduction *(2/5)*

- In environments like this we want to understand:
  - Is information acquired and transferred, or does the market break down because of information problems?
  - When there is a market, how is the market organized (how many buyers, how many sellers, who trades with who)?
  - How "truthful" is transmission when truth is not contractible?
  - Is the market efficient? What does this depend on?
  - Is efficiency enhanced if information is transmitted by a disinterested agent?

- **Model:**
  - Several potential buyers of a good can participate in an auction for the good.
  - Good is horizontally differentiated, and different buyers like randomly (i.i.d.) chosen varieties.
  - Quality is not known ex-ante, but can be ascertained at a cost, directly, or from other buyers who have done so before.
  - Information is transmitted through “cheap talk” messages from other potential buyers (thus potential competitors).

- **Results:**
  - In equilibrium information is indeed transmitted and sold, when acquisitions costs are not too high.
  - At most one seller gets informed, and he sells at positive price to all individuals (but possibly one).
  - The good is allocated efficiently, if information is acquired at all.
  - Information acquisition is not efficient, if it cannot be sold "unequally."
  - Information sold in a discriminating way is acquired efficiently.
  - Disinterested information transmitters do not help to achieve efficiency.

- **Literature:**
  - Admati, Pfleiderer (1988, 1990): Noise on information sale or revelation through price.
  - Crawford, Sobel (1982): Cheap talk.
  - Milgrom (1981): How to inform if too good info hurts you.
  - Lizzeri (1999): Certification intermediaries.
  - Morgan, Stocken (2003): Cheap talk in financial information transmission - reputation/rents tradeoff.
  - Womack (1996), Michaely and Womack (1999), Barber et al. (2001): Empirical.

Model *(1/2)*

- One object for sale, type $v \in S = \{1, 2, ..., k\}$ equiprobable.
- N potential buyers, B_i with $i \in \{1, ..., N\}$.
- Buyer B_i prefers $\theta_i \in S$. Variable θ_i is i.i.d. and private information.
- That is,

$$u_{B_i} = I_v - cI_e - P_{B_i}$$

  - P_{B_i} is the sum of net monetary transfers paid by B_i
  - I_v is an indicator, 1 if B_i owns the object and $v = \theta_i$.
  - I_e is another indicator, 1 if B_i decides observe the type of the object.

Model *(2/2)*

The timing of the game

1. First, agents sign a binding contract to explore the type of the object or not.

2. Buyers who will explore, engage in side contracts with other buyers in two phases:

   (a) Uninformed buyers report their type to the informed buyer who sells to them.

   (b) The seller of information agrees to reports a signal for a price.

3. Final chance to sign a contract to obtain the information directly.

4. A second price auction takes place to allocate the object.

The signaling of sellers of information

- We consider a case that seems particularly favorable to information markets emerging.
  - Informers are expected to be “truthful” when they have nothing to lose from it.
  - Otherwise, they “garble” the signal.
- J informed traders. B_1 through B_J.
- $\mathcal{N}(B_i)$ set of buyers who buy from B_i, $N(B)$ number of different realizations of θ_i in $\mathcal{N}(B_i)$.

- Reporting strategy of informed buyers, B_i:

$$m_i = \begin{cases} v, & if \;\; v \neq \theta_i \\ y \text{ with probability } \frac{1}{k-N(B_i)}, & \text{if} \;\; v = \theta_i \\ \text{for all } y \neq \theta_j, \;\; \forall\, j \in \mathcal{N}(B_i), & \end{cases}$$

- Then for buyer $j \in \mathcal{N}(B_i)$

$$\Pr(v = \theta_j | m_i = \theta_j) = 1$$

and

$$\Pr(m_j = \theta_i) = \left(\frac{k-1}{k}\right)\frac{1}{k}, \quad \Pr(m_j \neq \theta_i) = 1 - \left(\frac{k-1}{k}\right)\frac{1}{k}$$

so

$$\Pr(v = \theta_i | m_j \neq \theta_i) = \frac{1}{k(k-1)+1}$$

- BUT *correct bid* if signal $m_j \neq \theta_i$ is 0. This signal can be received if:
  - $v = \theta_i$ and $v = \theta_j$, but then j, cannot win.
  - $v = \theta_i$ and $v \neq \theta_j$, j may indeed win, but negative surplus.
- Signals create affiliation.
- The buyers who do not listen to reports have beliefs/bids

$$\Pr(v = \theta_i) = \frac{1}{k}, \quad \Pr(v \neq \theta_i) = \frac{k-1}{k}$$

Equilibrium structure

Value of c	**Equilibrium structure**
$c \geq \frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}$	No one connected
$\frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \geq c \geq \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}$	One connected directly, one unconnected
$\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \geq c \geq \frac{1}{N-2}\frac{1}{k^2}$	One directly, one unconn. or two directly, one unconn.
$\frac{1}{N-2}\frac{1}{k^2} \geq c$	One connected directly no one unconnected

At the equilibrium with intermediate values of c, the price of information is:

$$p(1) = \min\left\{\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}, c\right\}$$

Remark 1 *This is for $k > N$. For $k < N$, there may be more than 1 unconnected.*

Payoffs under different candidates to equilibria

1. One monopolist, one unconnected

$B_1 \to S$, $N-2 \to B_1, B_N$ unconnected.

$$\begin{aligned}
\pi_{B_N}(1) &= \left(\frac{k-1}{k}\right)^{N-1} \frac{1}{k} \\
\pi_{B_1}(1) &= \frac{1}{k}\left(1-\frac{1}{k}\right) + (N-2)p(1) - c \\
\pi_{B_i}(1) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-2}\left(1-\frac{1}{k}\right) - p(1) = \max\{\pi_C(1), \pi_U(1)\} \\
\pi_C(1) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-2}\left(1-\frac{1}{k}\right) - c = \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} - c \\
\pi_U(1) &= 0
\end{aligned}$$

2. One monopolist, no one unconnected.

$B_1 \rightarrow S$, $N-1 \rightarrow B_1$.

$$
\begin{aligned}
\pi_{B_1}(2) &= \frac{1}{k} + (N-1)p(2) - c \\
\pi_{B_i}(2) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} - p(2) = \max\{\pi_C(2), \pi_U(2)\} = \pi_U(2) \\
\pi_C(2) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} - c \\
\pi_U(2) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \Longrightarrow \pi_U(2) > \pi_C(2) \Longrightarrow p(2) = 0
\end{aligned}
$$

Equilibrium without price discrimination *(8/13)*

3. Two monopolists, no one unconnected.

$B_1, B_2 \to S$, $N-2 \to B_1 \cup B_2$. $p(3) = 0$.

$$\begin{aligned}\pi_{B_i}(3) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \\ \pi_{B_1}(3) &= \pi_{B_2}(3) = \pi_{B_i}(3) - c\end{aligned}$$

The reason for not having a positive price

- An agent does not want to pay a positive price for two signals.
- Only equilibria with positive prices - buyers of information splitting.
- But then, the providers have an incentive to undercut.

4. No one connected.

$\emptyset \longrightarrow S$

$$\pi_{B_i}(4) = 0$$

5. One monopolist, two unconnected

$B_1 \to S$, $N-3 \to B_1, B_N, B_{N-1}$ unconnected.

$$
\begin{aligned}
\pi_{B_N}(5) &= \pi_{B_{N-1}}(5) = 0 \\
\pi_{B_1}(5) &= \frac{1}{k}\left(1-\frac{1}{k}\right) + (N-3)p(5) - c \\
\pi_{B_i}(5) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-3}\left(1-\frac{1}{k}\right) - p(5) = \max\{\pi_C(5), \pi_U(5)\} \\
\pi_C(5) &= \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-3}\left(1-\frac{1}{k}\right) - c = \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-2} - c \\
\pi_U(5) &= 0
\end{aligned}
$$

- Then, price is chosen so that only one unconnected if:

$$\pi_{B_1}(1) \geq \pi_{B_1}(5)$$

$$\begin{aligned} (N-2)p(1) &\geq (N-3)p(5) \\ (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} &\geq (N-3)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-2} \end{aligned}$$

But this is always satisfied since;

$$\frac{N-2}{N-3} \geq \frac{k}{k-1} \Longleftrightarrow 1 + \frac{1}{N-3} \geq 1 + \frac{1}{k-1} \Longleftrightarrow k-1 \geq N-3$$

- When there is a choice between equilibrium 1 and 2, the monopolist chooses 1 if

$$\frac{1}{k}\left(1-\frac{1}{k}\right)+(N-2)p(1)-c \; = $$

$$\frac{1}{k}\left(\frac{k-1}{k}\right)+(N-2)\min\left\{c,\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}\right\}-c \; \geq \; \frac{1}{k}-c$$

Which can be true if:

$$c \geq \frac{1}{N-2}\frac{1}{k^2} \tag{1}$$

- Finally 1 stops being an equilibrium when

$$\frac{1}{k}\left(\frac{k-1}{k}\right)+(N-2)\min\left\{c,\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}\right\}-c\leq 0$$

The relevant constraint is

$$\frac{1}{k}\left(\frac{k-1}{k}\right)+(N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}-c\leq 0$$

Welfare *(1/6)*

- Given the mechanism, allocation is ex-post efficient.

- Thus, only consideration is efficiency in information acquisition.

- Total welfare if one player is informed is:

$$W_1 = P(\exists i | v = \theta_i) - c = 1 - \left(\frac{k-1}{k}\right)^N - c$$

- Total welfare if nobody is informed is:

$$W_0 = \frac{1}{k}$$

- Welfare if $T > 1$ individuals get informed is

$$W_T = P(\exists i | v = \theta_i) - Tc = 1 - \left(\frac{k-1}{k}\right)^N - Tc$$

Welfare *(2/6)*

- $W_T < W_1$ so the relevant comparison is W_1 with W_0.

$$W_1 \geq W_0 \Longleftrightarrow 1 - \left(\frac{k-1}{k}\right)^N - c \geq \frac{1}{k} \Longleftrightarrow \left(\frac{k-1}{k}\right)\left(1 - \left(\frac{k-1}{k}\right)^{N-1}\right) \geq c$$

- One agent will be informed in equilibrium if:

$$\frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \geq c$$

- So there will be underinvestment of information if the range:

$$\frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} \leq c \leq \left(\frac{k-1}{k}\right)\left(1 - \left(\frac{k-1}{k}\right)^{N-1}\right)$$

is non-empty, as it is indeed the case.

- **Explanation:**
  - The change from not obtaining information to doing it in equilibrium when $\pi_{B_1}(1) - \pi_{B_1}(4)$ changes sign
  - Whereas the change from acquiring to not doing it efficiently is when $W(1) - W(0)$ changes sign.
  - So efficiency and equilibria do not align when

$$sign\left(\pi_{B_1}(1) - \pi_{B_1}(4)\right) \neq sign\,(W(1) - W(0))$$

  - For showing this is possible it suffices to show that

$$\pi_{B_1}(1) - \pi_{B_1}(4) < W_1 - W_0$$

  - Which reduces to:

$$0 < \pi_S(1) - \pi_S(4) + \pi_{B_N}(1) - \pi_{B_N}(4)$$

- Since

$$\begin{aligned}\pi_S(1) &= 1 \cdot \Pr(v \neq \theta_1 \text{ and } \exists i, j > 1, \text{ with } v = \theta_i = \theta_j) \\ &\quad + \frac{1}{k} \cdot \Pr(\exists \text{ a single } i \neq N | v = \theta_i)\end{aligned}$$

- thus

$$\begin{aligned}\pi_S(1) + \pi_{B_N}(1) &= \\ 1 \cdot \left(\left(\frac{k-1}{k}\right) \left(1 - \left(\frac{k-1}{k}\right)^{N-2} - (N-1)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-3}\right)\right) \\ + \frac{1}{k} \cdot \left(\frac{1}{k} + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-2}\right) + \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}\end{aligned}$$

- But notice that then

$$
\begin{aligned}
\pi_S(1) + \pi_{B_N}(1) \quad &> \\
1 \cdot \left(\frac{1}{k} \left(\frac{k-1}{k} \right) \left(1 - \left(\frac{k-1}{k} \right)^{N-2} - (N-2) \frac{1}{k} \left(\frac{k-1}{k} \right)^{N-3} \right) \right) & \\
+ \frac{1}{k} \cdot \left(\frac{1}{k} + (N-2) \frac{1}{k} \left(\frac{k-1}{k} \right)^{N-2} \right) + \frac{1}{k} \left(\frac{k-1}{k} \right)^{N-1} & \\
= \frac{1}{k} \left(\left(\frac{k-1}{k} \right) + \left(\frac{1}{k} \right) \right) = \frac{1}{k} = \pi_S(4) = \pi_S(4) + \pi_{B_N}(4) &
\end{aligned}
$$

Welfare *(6/6)*

- Notice the problem is "rent dissipation" (appropriated buyer N, and in some cases by the seller, not the purchaser of info).

- *How to improve on this?*

A disinterested seller of information *(1/2)*

- Introducing a disinterested seller does not change the ex-post efficiency of equilibria without price discrimination.

- Conditions for equilibrium are similar.

- Condition that makes it possible that he is a monopolist is if he has positive profits

  - In particular, this implies he is a monopolist.

- The price other buyers are prepared to pay for information is

$$\min\left\{c, \frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}\right\}.$$

A disinterested seller of information *(2/2)*

- Highest level of c for which this equilibrium exists is:

$$\pi_{B_u} = (N-1)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} - c \geq 0$$

- The equilibrium condition with information and a monopolist trader is:

$$\pi_{B_1} = \frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} - c \geq 0$$

- But $\pi_{B_1} > \pi_{B_u}$ since

$$\frac{1}{k}\left(\frac{k-1}{k}\right) + (N-2)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1} > (N-1)\frac{1}{k}\left(\frac{k-1}{k}\right)^{N-1}$$

- Thus underinvestment result is actually worsened with this "disinterested player."

Price discrimination *(1/11)*

- Same game, except now the seller of info can sell signals of different quality.

- Uninformed buyers arranged in a set of L *layers (or levels)*, $L \geq 1$.

- The buyer selling the information sends a (possibly different) message m_l to all buyers in each layer l, $l = 1, .., L$.

- Buyers in any layer l observe messages sent to all other layers below l, i.e. observe m_j, $j \geq l$.

- Reporting strategy of the informed buyer, B_1. Layer 0, only B_1. $N(B)$ number of different realizations of θ_i.

$$m_1 = \begin{cases} v, & \text{if } v \neq \theta_1 \\ y \text{ with probability } \frac{1}{k-N(B_i)}, & \text{if } v = \theta_1 \\ \text{for all } y \neq \theta_j, \ \forall j \in \mathcal{N}(B_i), & \end{cases} \tag{2}$$

and, for $l = 2, .., L$

$$m_l = \begin{cases} m_{l-1}, & \text{if } m_{l-1} \neq \theta_i \text{ for all} B_i \text{ in } l-1 \\ y, \text{ with probability } 1/[N - N(B)], \ \text{for all } y \neq \theta_j, \ j = 1, .., N, & \text{if } m_{l-1} = \theta_i \text{ for some } B_i \text{ in } l-1 \end{cases} \tag{3}$$

Price discrimination *(3/11)*

- At each layer message is truthful if object is not wanted in any previous layer.

- Otherwise, the informed trader randomizes over any value different from the type of any of the buyers

- *As before, the optimal bid is 1 when* $m_j = \theta_i$*.and 0 when* $m_j \neq \theta_i$*.*

Payoffs in the chain - one unconnected (optimal for c "high")

- Let n_l number of buyers in layer l and N_l the aggregate in layers 0 through l (hence $N_l = \sum_{j=0}^{l} n_j$), with $n_0 = N_0 = 1$.

- A buyer in layer l will get object with positive surplus when he likes it and nobody in above and current layer likes it.

- In that event (probability $\left(\frac{k-1}{k}\right)^{N_L-1}\frac{1}{k}$), he will pay will be the second highest bid after his, the bid made by least informed bidders - $\frac{1}{k}$

$$\left(\frac{k-1}{k}\right)^{N_l-1}\frac{1}{k}\left(1-\frac{1}{k}\right) = \left(\frac{k-1}{k}\right)^{N_l}\frac{1}{k}$$

- If we add to this the price paid to acquire the information:

$$\pi_{B_i} = \left(\frac{k-1}{k}\right)^{N_l} \frac{1}{k} - p_l.$$

- Alternative payoff if he chooses not to buy is $\pi_u = 0$. Alternatively, $\pi_c = \left(\frac{k-1}{k}\right)^{N-2} \frac{1}{k}\left(1 - \frac{1}{k}\right) - c = \left(\frac{k-1}{k}\right)^{N-1} \frac{1}{k} - c$.

- $\max\{\pi_u, \pi_c\} = \max\left\{\left(\frac{k-1}{k}\right)^{N-1} \frac{1}{k} - c, 0\right\}$

- Price charged, is thus given by

$$p_l = \frac{1}{k}\left(\frac{k-1}{k}\right)^{N_l} - \max\{\pi_u, \pi_c\} \tag{4}$$

$$= \min \frac{1}{k}\left(\left(\frac{k-1}{k}\right)^{N_l}, \left(\frac{k-1}{k}\right)^{N_l} - \left(\frac{k-1}{k}\right)^{N-1} + c\right) \tag{5}$$

- The total payoff of B_1:

$$\pi_{B_1}(1) = \frac{1}{k}\left(1 - \frac{1}{k} + \sum_{l=1}^{L} n_l \min\left(\left(\frac{k-1}{k}\right)^{N_l}, \left(\frac{k-1}{k}\right)^{N_l} - \left(\frac{k-1}{k}\right)^{N-1} + c\right)\right) -$$

Proposition 2 *The optimal distribution is to create as many layers as remaining players.*

Proof. To see this notice

1. The price paid at the auction does not change by increasing the number of layers.

2. If an old layer l is split in two l' and l'', then the willingness to pay of individuals in old layers $l+r$ does not change as they only care about the number of people in their layer or above, not their distribution.

Price discrimination *(7/11)*

3. If an old layer l is split in two l' and l'', then the willingness to pay of individuals in old layers $l-r$ does not change as they only care about the number of people in their layer or above, and this has not changed.

4. If an old layer l is split in two l' and l'', then the willingness to pay of individuals in old layer l who is now in the new lower layer l'' does not change as they only care about the number of people in their layer or above, and this has not changed.

5. If an old layer l is split in two l' and l'', then the willingness to pay of individuals in old layer l who is now in the new upper layer l' strictly increases as they only care about the number of people in their layer or above, and this is now strictly lower.

■

- **Intuition:** A buyer only cares about who are “‘‘less-well” informed.
  - Willing to pay to “stay on top”.
  - Does not care about people equal to himself.

Price discrimination *(9/11)*

- When is each type of monopoly (no unconnected, one unconnected) possible? $\pi_{B_1}(2) \geq \pi_{B_1}(1)$ iff

$$1 - \left(\frac{k-1}{k}\right)^{N-1} \geq \left(\frac{k-1}{k}\right) - \left(\frac{k-1}{k}\right)^{N} + (N-2)c$$

$$\frac{1}{k}\left(1 - \left(\frac{k-1}{k}\right)^{N-1}\right) \geq (N-2)c$$

Welfare

- The condition for anybody to be informed at all is:

$$\pi_{B_1}(1) = \left(\frac{k-1}{k}\right)\left(1 - \left(\frac{k-1}{k}\right)^{N-1}\right) - c \geq 0$$

- The condition for efficient information acquistion is:

$$W_1 \geq W_0 \Longleftrightarrow \left(\frac{k-1}{k}\right)\left(1 - \left(\frac{k-1}{k}\right)^{N-1}\right) - c \geq 0$$

- We have efficient investment.

Price discrimination *(11/11)*

Discrimination does not always yield efficiency

Proposition 3 *For sufficiently low* c*, in all "refined" equilibria (i.e. where the signals are as in 2 and 3), and without destructive subgame outcome, there are at least two sellers of information.*

- **Intuition: for** c low, there are always enough rents that an entrant can be profitable

- Either asking for a "bribe" so better informed do not lose the privilege.

- Or replicate the optimal structure and attract all.

Seller of the good as seller of information *(1/4)*

Proposition 4 *Less than efficient level of investment in information. In particular, if c is in:*

$$\left(\frac{k-1}{k}\right)\left(1-\left(\frac{k-1}{k}\right)^{N-2}\right) \leq c \leq \left(\frac{k-1}{k}\right)\left(1-\left(\frac{k-1}{k}\right)^{N-1}\right) \tag{6}$$

information acquisition is socially efficient, but information is not acquired in equilibrium.

Intuition: Auction prices do not matter, if they increase price of information decreases. Thus:

$$\begin{aligned}\pi_S &= \sum_{i=1}^{N-1} E_S\left(\Pr(B_i \text{ wins auction} | v = \theta_i)\right) - c \\ &= 1 - \left(\frac{k-1}{k}\right)^{N-1} - c\end{aligned}$$

Seller of the good as seller of information *(2/4)*

Information acquisition in equilibrium:

$$1 - \left(\frac{k-1}{k}\right)^{N-1} - c \geq \frac{1}{k}$$

Efficient information acquisition is:

$$1 - \left(\frac{k-1}{k}\right)^{N} - c \geq \frac{1}{k}$$

Owner "hypes the good"

- Good comes in 2 quality levels, H (High) and L (Low), and k varieties.

- Buyers are also of two types: sensitive to quality (Se) and sinsensitive (In).

- An In consumer has a constant valuation of 1 for a good of the type he desires.

- An Se consumer values a good of his type as V, if the good is of H quality; and 0 if L quality.

- H and L have identical probabilities, and consumers have identical probabilities to be of type Se and In.

Proposition 5 *For any pair of messages* $m^H = (i, H)$ $m^L = (i, L)$ *beliefs must be so* $\Pr(v \in S^H | m^H) = \Pr(v \in S^H | m^L) = \Pr(v \in S^H) = \frac{1}{2}$. *Thus, if* $V > 2$, *and* m *the* Se *type buyers bid more fthan the* In *type. If* $V < 2$, *vice versa.*

Remark 6 *The previous proposition shows that there is an inefficient allocation of the good as long as* $V \neq 2$.

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