Sender or Receiver: Who Should Pay to Exchange an Electronic Message?

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Joint work with

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Communications networks give rise to network effects.

- Access Externalities
  - Benefits to members of a network from being able to send messages to a given subscriber
  - Widely studied
- Call Externalities
  - Benefits to the party receiving a message
  - Widely ignored (until recently)

Let's meet our happy couple.

- *A* and *B* Can exchange 0 or 1 messages
  - Key assumption 1: already on the network
  - Key assumption 2: lack of tit-for-tat calling
- Benefits v_A and v_B
  - May be stochastic at time of message initiation
- Types ω_A and ω_B
  - Innate characteristics and information
- Marginal cost of message exchange, m
  - Video files expensive even on the Internet
  - Even m = 0 can lead to non-zero prices

There are two cases to consider.

- One-way calling
  - One-way technologies (*e.g.,* paging)
  - Only one party knows value (*e.g.,* calling to make a dinner reservation)
  - Non-strategic behavior due to bounded rationality
- Two-way calling
  - Two-way technologies with two informed, strategic parties
- Will focus on one-way calling today with *A* the sender and *B* the receiver

We will examine several different pricing objectives.

- Total surplus maximization
  - First best: exchange message iff $v_A + v_B \geq m$
  - Information constrained: exchange message iff $E\{v_A + v_B \mid \omega_A, \omega_B\} \geq m$
  - Profit constrained (Ramsey pricing): $p + r \geq m$
- Profit maximization

Complexities of Learning

- Suppose it is common knowledge that
  - *A* knows the value of v_A
  - *B* does not know the value of v_B.
- Suppose $v_B = v_A$ (coincident interests)
  - First-best message exchange can be supported by setting $p = m/2 = r$
  - *B* takes *A*'s calling as a positive signal about the value of answering
- Suppose $v_B = \mu - v_A$ (opposing interests)
  - Big trouble
  - *B* takes *A*'s calling as a negative signal about the value of answering

Caller ID can raise or lower welfare.

- Caller ID may raise equilibrium welfare under the total-surplus-maximizing prices with or without a network profitability constraint.
  - Breaks pooling that would have blocked efficient message exchange.
- Caller ID may lower equilibrium welfare under the total-surplus-maximizing prices with or without a network profitability constraint.
  - Breaks pooling that would have helped internalize call externalities.

Two conditions for when to tax spam.

- Current email prices do not internalize call externalities
- A tax on spam can be optimal when
  - the expected social value of message exchange is an increasing function of the sender's expected value; and
  - the sender's value sometimes exceeds the social value.

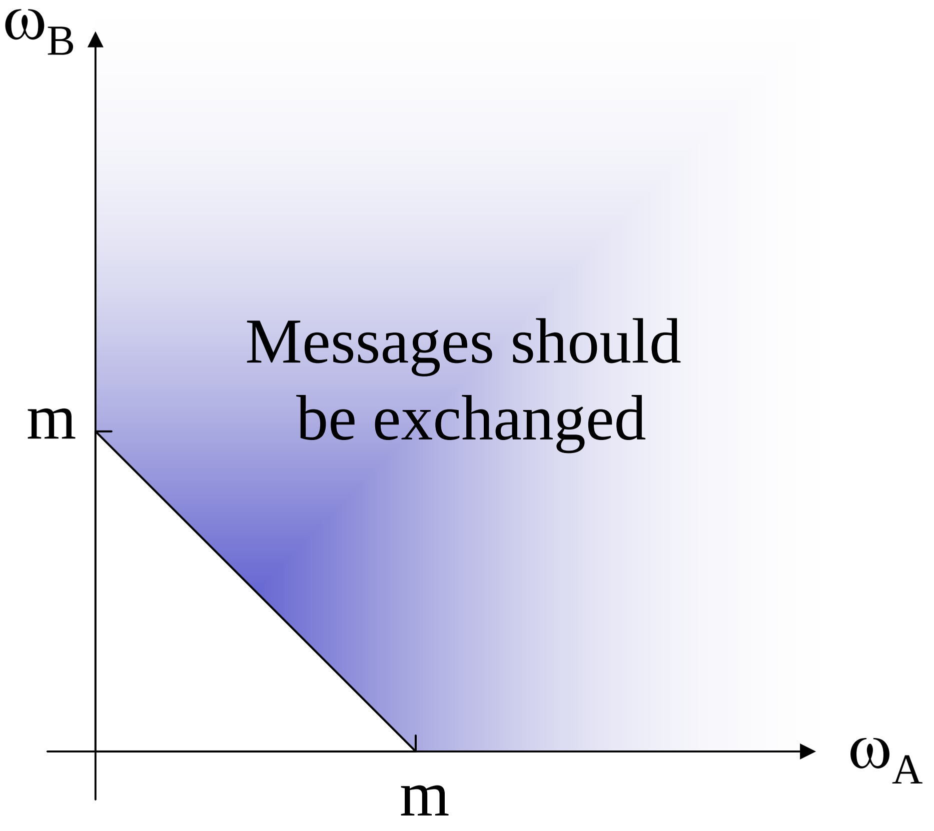
Maintained assumptions going forward.

A1. For $i = A,B$: $v_i = \omega_i + \eta_i$, where η_i is a random variable satisfying $E\{\eta_i | \omega_j\} \equiv E\{\eta_i | \omega_i, \omega_j\} \equiv 0$.

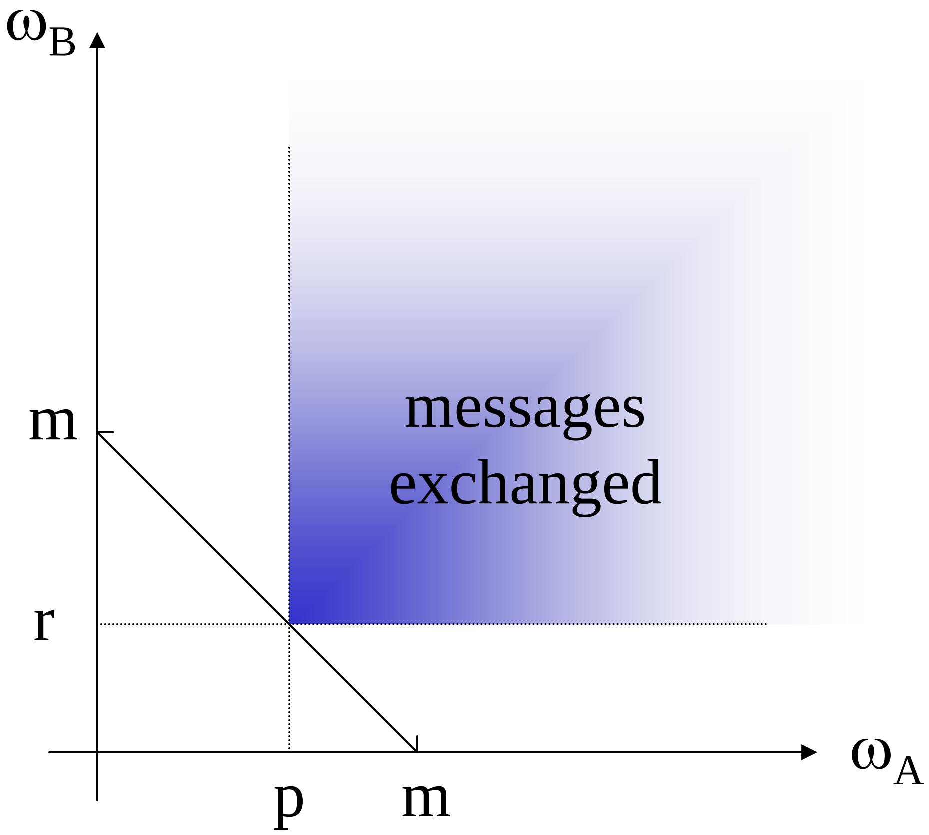
- ω_i contains no additional information useful to j in predicting the expected value of v_j *conditional* on the information he or she already possesses, ω_j.
- *Ex ante*, the parties' information, ω_i and ω_j, could be correlated.
- ω_i is now party i's expected value of communicating.

- *A2.* $\Pr\{\omega_A + \omega_B > m\} > 0$ and $\underline{\omega}_A + \underline{\omega}_B < m$, where $\underline{\omega}_i$ is the infimum of the support of ω_i, $i = A,B$.
  - Rules out trivial never-efficient-trade and always-efficient-trade cases.

Efficient Message Exchange



Equilibrium Message Exchange



Proposition 1 roughly characterizes socially optimal prices.

Suppose the parties' expected values of message exchange, ω_A and ω_B, are independently distributed with positive densities defined everywhere on their supports.

- Use of a single price pair cannot achieve information-constrained efficient message exchange.
- If the network provider is not subject to a profitability constraint, then socially optimal prices satisfy $p + r < m$.
- If the network provider is subject to $p + r \geq m$, then socially optimal prices satisfy $p + r = m$.

Key Mathematics

- Survival (demand) function

  $S_i(\omega) = \text{prob}\{\omega_i \geq \omega\}$

- Expected welfare when p + r = m

  $S_B(m\text{-}p)\int_p^\infty S_A(\omega)d\omega + S_A(p)\int_{m-p}^\infty S_B(\omega)d\omega$

- First-order condition

  $S'(p)\int_{m-p}^\infty S(\omega)d\omega - S'(m\text{-}p)\int_p^\infty S(\omega)d\omega = 0$

Proposition 2 characterizes the nature of Ramsey prices.

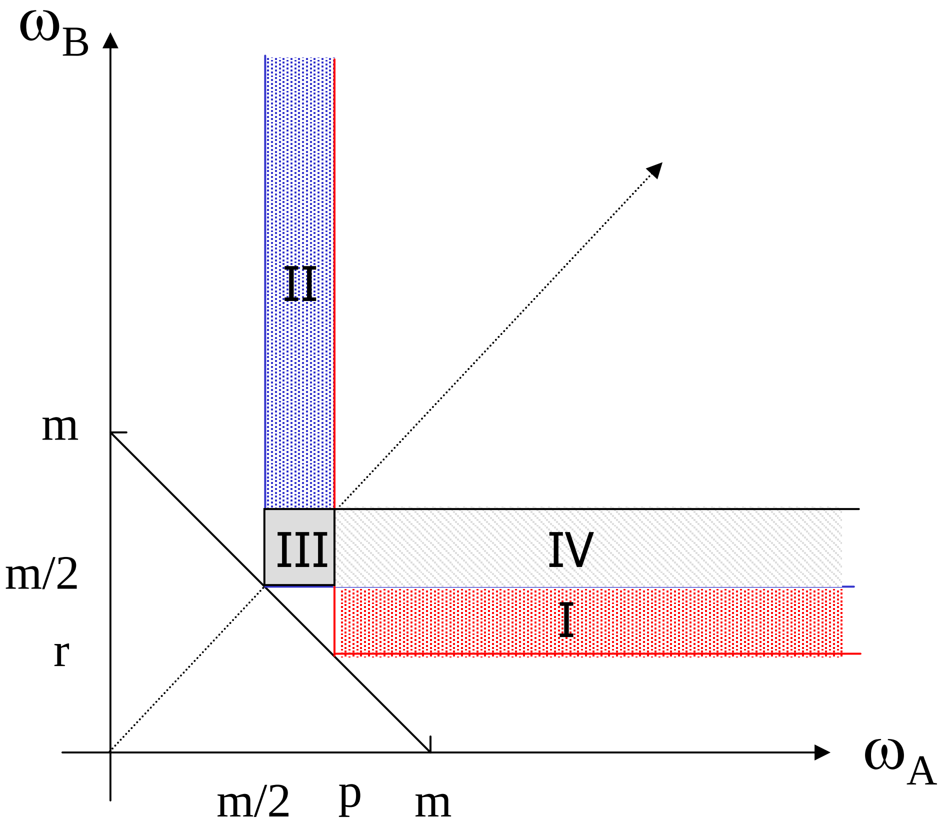
Suppose the network is subject to a profitability constraint and the parties' expected values of message exchange, ω_A and ω_B, are independently and identically distributed.

(i) If the hazard rate is everywhere increasing, then prices that divide the cost of a message equally between the sender and receiver are the unique socially optimal prices.

(ii) If the hazard rate is constant, then any prices such that $\underline{\omega} \leq p \leq m - \underline{\omega}$ and $r = m - p$ are socially optimal, where $\underline{\omega}$ is the infimum of the common support.

(iii) If the hazard rate is everywhere decreasing, then there are two socially optimal price pairs: one in which the send price equals $\underline{\omega}$ and one in which the receive price equals $\underline{\omega}$. In each case, the complementary price is set at $m - \underline{\omega}$.

The effects of a move toward equal cost sharing



Proposition 3 deals with some of the asymmetric cases.

Suppose that the parties' expected values of message exchange, ω_A and ω_B, are independently distributed according to differentiable distribution functions with associated densities $\psi_A(\cdot)$ and $\psi_B(\cdot)$, respectively.

If (a) $\psi_j(\omega)$ crosses $\psi_i(\omega)$ once from above at $\omega^c \geq m/2$ and (b) the hazard rates associated with $\psi_i(\cdot)$ and $\psi_j(\cdot)$ are non-decreasing, then party i pays more than party j under any socially optimal pricing scheme that satisfies the network profitability constraint.

Profit Maximization

- Consider the profit maximizer's problem in two stages:
  - For a fixed margin, choose p and r
  - Choose a margin
- For a given margin, the firm wants to maximize the probability of message exchange

Proposition 4 gives conditions under which profit-maximizing prices have the right structure but are too high.

Suppose the parties' expected values of message exchange, ω_A and ω_B, are independently and identically distributed. The sum of the profit-maximizing send and receive prices exceeds the sum of welfare-maximizing send and receive prices. Moreover,

1. If the hazard rate is everywhere increasing, then prices that divide the cost of a message equally between the sender and receiver are the unique profit-maximizing prices.
2. If the hazard rate is constant, then $S(\omega) = e^{(\underline{\omega}-\omega)/\mu}$, μ a positive constant and $\underline{\omega}$ the infimum of the common support, and the profit-maximizing margin is μ. Any prices such that $\underline{\omega} \leq p \leq \mu + m - \underline{\omega}$ and $r = \mu + m - p$ maximize profits.
3. If the hazard rate is everywhere decreasing, then there are two profit-maximizing price pairs: in one the send price equals $\underline{\omega}$ and in the other the receive price equals $\underline{\omega}$.

In general, profit maximization can lead to two biases.

- Given the margin, a profit maximizing network sets relative prices to maximize the *probability* of message exchange, rather than the *expected value*.
- A profit maximizer sets overall prices too high in order to extract consumer surplus.

Menus of prices can be beneficial to welfare and profits.

Consider an arbitrary menu of price pairs.

1. Adding an option for which the send price is greater than any existing send price and the sum of the send and receive prices is greater than or equal to the marginal cost of a message weakly raises welfare.
2. Expanding the menu by adding an option with a send price that is less than an existing send price, or for which the sum of the send and receive prices is less than the marginal cost of a message, can reduce welfare.
3. Profits weakly rise when an option is added for which (i) the send price is greater than any existing send price and (ii) the sum of the send and receive prices is greater than or equal to the sum of any existing option.

Unequal prices are optimal in the 2 x one-way calling case.

Proposition 6. Suppose the joint density function for the parties' expected values of message exchange, ω_A and ω_B, is continuous and strictly positive at $(m/2, m/2)$. Then under a pair of one-way calling models (*i.e.,* two-way calling with non-strategic users), the socially optimal breakeven send and receive prices are not equal.

Proposition 7. Under a pair of one-way calling models, if prices $p = k$ and $r = m - k$ are socially optimal for some constant, k, then prices $p = m - k$ and $r = k$ are also socially optimal.

Conclusion

- Viewing the sender as the “cost causer” is misleading.
- Efficient pricing requires consideration of demand conditions, even when marginal costs are constant.
- Non-zero prices to both sides are generally socially and privately optimal.
- Pricing menus are generally socially and privately optimal.