Who Should Pay for Two-Way Interconnection?

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Two-way interconnection
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Why does it matter?

- **Examples:**
  - fixed and mobile communications
  - related to the literature on info exchange: a given call, e-mails, sharing files
  - interconnection fee between the buyer and seller’s banks when a credit card is used? not completely
  - other industries?

- **One spicy ingredient**
  - **Access price** (MTC) is the price to be paid by the *originating* operator to the *terminating* operator
  - MTC affects retail price competition
    - enters as a cost for originating off-net calls
    - generates revenue from terminating incoming calls
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Second fact: who obtains utility from the call

- So far most of related literature assumed that only the caller was obtaining utility from the call.
  - So in this case the **caller** is responsible for the cost. That means that the terminating will recover costs by charging the originating network. And the originating network will then pass the access price to its customer.
  - In fact this is the payment regime used in Europe, which is called the **Caller-Party-Pays (CPP) regime**.

But... it turns out that the receiver also obtains utility from the call, otherwise he or she would not answer the call, then **Who is responsible for the cost? Who should pay?**
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Two-way interconnection

Who should pay?

- If consumers derive benefits from receiving calls, **Who is responsible for the cost?**
  - Is the **caller** for placing a call? or Is the **receiver** for accepting it?
  - Should the **caller’s network** pay for termination access services? or Should the **receiver’s network** pay for origination access services?
  - **Who should pay?**
    - calling party, called party, calling party network or called party network?
    - complementary services — **everybody?**
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Findings

CPP vs RPP

- In May 2009, the EC recommended NRAs to set termination rates based on costs incurred by an efficient operator
  - *the average MTC in Europe could drop from about 8.55 euro cents per minute at the end of 2009, to about 2.5 euro cents per minute by 2012*

- Large European mobile operators warned the EC that cutting termination rates could mean the end of handset subsidies for consumers and lead to a price increase. *Why? Which is their argument?*
  - *Vodafone also claimed that cutting termination rates could result in a US style business model, where users pay for both placing and receiving calls*

- *Does the level of termination rates affect the form of competition?*
  - *literature has explored the impact of termination rates on competition/welfare by exogenously imposing CPP or RPP*
  - *however, the payment regime adopted by firms may be an endogenous response to the level of the termination charge*
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CPP vs RPP: Observations

Some countries have adopted the CPP regime, while others have adopted the RPP regime. The type of payment regime seems to produce different market characteristics:

CPP: consumers pay only for placing calls

- widespread and characterized by high termination charge, high price/minute (low usage), low(er) fixed fees, high(er) penetration rate and low ARPU

RPP: consumers pay both for placing and receiving calls

- adopted by few countries (e.g., US, Canada, China, Hong Kong, Singapore) and characterized by low termination charge (even zero: B&K), low price/minute (high usage), high(er) fixed fees, low(er) penetration rate (growth), and high ARPU

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What do we do?
A global setup

- We will assume that customers derive utility from receiving calls, and endogenize the firms’ decisions about whether they will choose CPP or RPP.

Research questions:

- How does the MTC affect the payment regime, prices, profits, welfare, and penetration rates?
- Why do European operators oppose cuts in MTC while US operators voluntarily agree on low MTC?
- Will European operators switch to RPP when termination rates are lowered even more?
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First contributions

- **Doyle and Smith (1998):** linear prices, fixed network and a duopoly of mobile operators
  - focus on the effect of RPP on prices of FTM calls: all calls made by mobile subscribers terminate on the fixed network
  - ad-hoc rule on prices for call reception

- **Kim and Lim (2001):** linear prices, no price discrimination between on-net and off-net calls
  - each network charges call reception to all consumers, i.e., each charges his own subscribers and the subscribers of the rival network for calls initiated on his own network.

- **DeGraba (2003):** considering a given call,
  - he shows that when both parties to a call share the value of the call, *it is efficient for them to share the costs in the same proportion that they share the value*
  - assuming firms set usage prices at the marginal cost (i.e., network competition is not modeled), efficiency can be achieved through the level of the MTC.
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LMRT (2003): Internet backbone competition
- two types of customers: senders or website and receivers or consumers
- fixed volume of transactions for each consumer-website match: *volume of traffic between each sender and receiver is not endogenously determined by the party with the lower marginal willingness to communicate*
- off-net-cost pricing principle

Hermalin and Katz (2004): strategic game of message exchange — who will be the sender and who the receiver
- no network competition, no interconnection fees, focus on per-message pricing
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Hermalin and Katz (2011): network competition, call externality, interconnection fees

- fixed fee, on-net and off-net calling and receiving prices
- passive expectations (network sizes are taken as given)

**Cournot competition:** carriers simultaneously choose their numbers of subscribers (prices adjust to clear the market)

- **implication for off-net pricing:** the standard result that firm $i$ has an incentive to increase its off-net price to hurt firm-$j$ customers no longer holds

- sender and receiver’s relative valuations of a message vary across messages — most of related papers assume that the receiver’s benefits is a given proportion of the sender’s benefit

- **implication:** without the proportionality assumption typically no level of the access charge can induce efficient off-net prices
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- **Jeon, Laffont and Tirole (2004):** network competition, call externality, interconnection fees
  - rationally responsive expectations (to non-equilibrium prices)
  - two operators, Hotelling model
  - fixed fee, (on-net/off-net) calling and receiving prices

**no on-net/off-net price discrimination**

- multiplicity of equilibria: by introducing noise in the receiver’s utility they single out one equilibrium
- callers hang up first with probability converging to one
- strategic marginal cost pricing $\Rightarrow$ off-net-cost pricing equilibrium

**on-net/off-net price discrimination**

- for $MTC > \bar{m}$: one symmetric candidate eq without connectivity breakdown
- for $MTC < \bar{m}$: any symmetric equilibrium exhibits connectivity breakdown
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- López (2011): extends the JLT’s model to asymmetric networks, introduces noise in both the callers’ and receivers’ utilities.

### no on-net/off-net price discrimination

- off-net-cost pricing equilibrium holds (non-vanishing noise)
- both the caller and the receiver can hang up with positive probability at the equilibrium
- the operators’ profits are neutral wrt the level of the MTC

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- On-net/off-net price discrimination
  - For \( \beta < 1 \): any symmetric equilibrium exhibits complete connectivity breakdown
Intuition: connectivity breakdown result

- Suppose that callers obtain more utility than the receivers from a given call, then
  
  - *in comparison with the rival’s offer, the attractiveness of the offer by the network where the call is received is reduced*
  
  - *since the terminating network reduces its relative attractiveness by allowing off-net calls, it is optimal for it to implement selective connectivity breakdown by charging an off-net reception price large enough*

- Cambini and Valletti (2008): *incentives to create connectivity breakdown are reduced when calls originated and received are complements in the information exchange.*
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Preview of results and contributions

Oligopolistic competition in non-linear prices

Inelastic subscription

- no on-net/off-net price discrimination
- on-net/off-net price discrimination
  - multiplicity of equilibria
  - strategic marginal cost pricing
  - no connectivity breakdown result
  - equilibrium selection: CPP, noise, coordination
  - socially and privately optimal MTC

Elastic subscription

- on-net/off-net price discrimination
  - equilibrium selection
  - socially and privately optimal MTC
The Model: Timing

1. MTC is set
2. Consumers form expectations about the number of subscribers of each network $i$: $\beta_i$.
3. All networks $i$ set non-negative tariff: $(F_i, p_i, r_i, \hat{p}_i, \hat{r}_i)$ (Fixed fee, on-net/off-net call price, on-net/off-net reception price).
4. Consumers subscribe to (at most) one network, leading to network sizes $\alpha_1, ... , \alpha_n$.

In a self-fulfilling equilibrium, expected and realized network sizes must coincide ($\beta_i = \alpha_i$).
The Model: Costs

- marginal cost of call: $c$
- marginal cost of call termination: $c_T$
- $MTC = a$, termination mark-up: $m = a - c_T$
- fixed cost per subscriber: $f$
The Model: Call demand

- utility of placing a call of length $q$: $u(q)$
  - Call placing demand $q(p)$ with $u'(q(p)) = p$

- utility of receiving a call of length $q$: $\beta u(q)$ with $0 < \beta < 1$
  - Call receiving demand $\tilde{q}(r)$ with $\beta u'(\tilde{q}(r)) = r$

- $D(p, r) = \min \{q(p), q(r/\beta)\} = q(\max \{p, r/\beta\})$

- $U(p, r) = u(D(p, r))$

- potential indeterminacy of equilibria:
  - Suppose $p$ and $r$ are such that the caller determines the call volume
  - As the reception charge has no impact on volume, from the viewpoint of firms and subscribers only the sum $F + rq$ matters, no its composition
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The Model: Subscription Demand (Logit)

Expected utility of subscribing to network $i$:

$$w_i = \beta_i[(1 + \beta)U(p_i, r_i) - (p_i + r_i)D(p_i, r_i)]$$

$$+ \sum_{j \in N \setminus \{i\}} \beta_j[U(\hat{p}_i, \hat{r}_j) - \hat{p}_iD(\hat{p}_i, \hat{r}_j)]$$

$$+ \sum_{j \in N \setminus \{i\}} \beta_j[\beta U(\hat{p}_j, \hat{r}_i) - \hat{r}_iD(\hat{p}_j, \hat{r}_i)] - F_i.$$

- $w_i + \mu \varepsilon_i$

Subscription rates

$$\alpha_i = \frac{\exp[w_i/\mu]}{\sum_{k=0}^{n} \exp[w_k/\mu]}.$$
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Subscription rates

$$\alpha_i = \frac{\exp[\frac{w_i}{\mu}]}{\sum_{k=0}^{n} \exp[\frac{w_k}{\mu}]}.$$
No On-net/Off-net Price Discrimination

**Caller determined volume:** $\beta p^* \geq r^* \geq 0$

$$\pi_i = \alpha_i[(p_i - c - (1 - \alpha_i)m)q(p_i)$$

$$+ \alpha_ir_iq(p_i) + (1 - \alpha_i)(r_i + m)q(p^*) + F_i - f].$$

FOC wrt $p_i$, keeping $\alpha_i$ constant

$$p_i = c + (1 - \alpha_i)m - \alpha_ir^*$$

**pecuniary externality**

In symmetric equilibrium

$$p^* = c + \frac{(n - 1)m - r^*}{n}$$

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**In symmetric equilibrium**

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No On-net/Off-net Price Discrimination

Receiver determined volume: \( r^* \geq \beta p^* \geq 0 \)

\[
\pi_i = \alpha_i[(1 - \alpha_i) (p_i - c - m) q(r^*/\beta) \\
+ \alpha_i(p_i + r_i - c)q(r_i/\beta) + (1 - \alpha_i)(r_i + m)q(r_i/\beta) + F_i - f].
\]

FOC wrt \( p_i \), keeping \( \alpha_i \) constant

\[
r_i = \alpha_i c - (1 - \alpha_i)m - \alpha_i p^*
\]

pecuniary externality

In symmetric equilibrium

\[
r^* = \frac{c - (n - 1)m - p^*}{n}
\]
No On-net/Off-net Price Discrimination

\[ m > -\beta c / (1 + \beta) \]

\[ \bar{r}(m) \]

\[ p \]

\[ q \]

\[ r = \beta p \]

\[ \text{FOC wrt } p \]

\[ \text{FOC wrt } r \]
No On-net/Off-net Price Discrimination

\[ m < -\beta c / (1 + \beta) \]

Figure: Equilibrium prices: No network-based price discrimination.
No On-net/Off-net Price Discrimination

Fixed fees and profits

\[ \pi_i = \alpha_i [(p^* + r^* - c)D(p^*, r^*) + F^* - f] \]

\[ F^* = f + \frac{n\mu}{n - 1} - (p^* + r^* - c)D(p^*, r^*) \]

\[ \pi^* = \frac{\mu}{n - 1} \]

profit neutrality result — full waterbed effect
Intuition: profit neutrality result

- López (2011), case two firms: all call activities yield zero profit

  - for \( n \geq 2 \) and vanishing noise: \( p = c + m \) and \( r = -m \)

  - **on-net calls**: they cost (per unit) \( c \) and yield revenue (per unit) \( p + r = c \)

  - **originating off-net calls**: they cost (per unit) \( c_O + a \) and yield revenue (per unit) \( p = c + m = c_O + a \)

  - **terminating off-net calls**: they cost (per unit) \( c_T \) and yield revenue (per unit) \( p = a + r = a - m = c_T \)
On-net/Off-net Price Discrimination

- **Efficient on-net prices:** \( p = \frac{c}{1 + \beta} \) and \( r = \frac{\beta c}{1 + \beta} \)
  - it is optimal for firms to maximize the size of the pie for on-net calls: on-net prices are set at the socially optimal levels
  - for on-net calls each network fully internalizes the externalities on callers and receivers

- **Off-net prices:** more complicated — affect consumers on other networks

### In symmetric equilibrium with caller determined volume

\[
\hat{p}^* = \frac{(n - 1)(c + m) - \hat{r}^*}{n - 1 - \beta}
\]

### In symmetric equilibrium with receiver determined volume

\[
\hat{r}^* = \frac{\beta((n - 1)m + \hat{p}^*)}{1 - (n - 1)\beta}
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- **Efficient on-net prices:** $p = c / (1 + \beta)$ and $r = \beta c / (1 + \beta)$
  - it is optimal for firms to maximize the size of the pie for on-net calls: on-net prices are set at the socially optimal levels
  - for on-net calls each network fully internalizes the externalities on callers and receivers

- **Off-net prices:** more complicated — affect consumers on other networks

In symmetric equilibrium with caller determined volume

$$\hat{p}^* = \frac{(n - 1)(c + m) - \hat{r}^*}{n - 1 - \beta}$$

In symmetric equilibrium with receiver determined volume

$$\hat{r}^* = \frac{\beta((n - 1)m + \hat{p}^*)}{1 - (n - 1)\beta}$$
In symmetric equilibrium with caller determined volume

The number of firms is important for the connectivity breakdown result to hold

- If the number of firms is high (so that \( \beta > 1/(n - 1) \)) there is no incentive to create connectivity breakdown

  - A connectivity breakdown provoked by network \( i \) will affect the subscribers of other networks only \textit{wrt} the calls made to subscribers of network \( i \), which is only a fraction \( 1/(n - 1) \) of all off-net calls made.

- As long as \( \beta > 1/(n - 1) \) a connectivity breakdown hurts subscribers from network \( i \) more than those of rival networks
On-net/Off-net Price Discrimination

Fixed fees and profits

\[ \pi_i = \alpha_i [(1 - \alpha_i)(\hat{p}^* + \hat{r}^* - c)D(\hat{p}^*, \hat{r}^*) + F_i - f] \]

\[ F^* = f + \frac{n\mu}{n-1} - \frac{n-2}{n}(\hat{p}^* + \hat{r}^* - c)D(\hat{p}^*, \hat{r}^*) \]

\[ \pi^* = \frac{\mu}{n-1} + \frac{1}{n^2}(\hat{p}^* + \hat{r}^* - c)D(\hat{p}^*, \hat{r}^*) \]

- For \( n = 2 \) there is no waterbed effect
- For \( n > 2 \) profit is maximal at equilibrium with \( \beta\hat{p}^* = \hat{r}^* \)
Equilibrium Selection

- Multiplicity of (symmetric) equilibria

- Networks face a huge coordination problem — difficult to do policy analysis

- We consider three possible equilibrium selection hypotheses:
  - CPP regime as an eq selection where the eq with zero reception charge is used
  - by introducing a (vanishing) noise in the utilities of receivers one can ensure that both callers and receivers sometime determine the length of the call, so that the two-first order conditions are satisfied simultaneously (unique equilibrium)
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Equilibrium Selection: CPP

- **No on-net/off-net price discrimination:**
  - the **socially optimal** termination mark-up would be the one that achieves the efficient call volume such that
    - \( p^* = c + ((n - 1)/n)m = c/(1 + \beta) \)
    - \( u(q) + \beta u(q) - cq \Rightarrow u' + \beta u' - c = 0 \Rightarrow p = c/(1 + \beta) \)
  - for sufficiently strong call externality, Bill and Keep is optimal

- **On-net/off-net price discrimination:**
  - firms play the equilibrium with
    \[
    r^* = 0, \hat{p}^* = \frac{c}{1 + \beta}, \hat{r}^* = 0, \hat{p}^* = (c + m) \frac{n - 1}{n - 1 - \beta}
    \]
  - eq exhibits asymptotic connectivity breakdown for \( n = 2 \) and \( \beta \to 1 \); this is not the case if there are at least three firms
  - profit is **not** neural wrt \( m \); firms’ profit is maximized for the \( m \) that yields off-net price equal to monopoly price
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  - for sufficiently strong call externality, Bill and Keep is optimal
Equilibrium selection: Noise

- No on-net/off-net price discrimination:
  - eq prices are found at the intersection of \( FOC_p \) and \( FOC_r \) (at point \( X \))
  - \( p^* = c + m, r^* = -m \) as long as \( m \leq 0 \)
  - for \( m > 0 \) : \( p^* = c + m/2 \) and \( r = 0 \)
- profit-neutrality result
- socially optimal termination mark-up:
  - \( p^* = c + m = c/(1 + \beta) \) for \( m = \frac{-\beta c}{1 + \beta} \)
Equilibrium selection: Noise

- **On-net/off-net price discrimination:**
  - JLT(2004) find the following equilibrium candidate as the noise vanishes, for the duopoly case, when \( -\frac{\beta c}{1+\beta} < m < 0 \):

    \[
    p^* = \frac{c}{1 + \beta}, r^* = \frac{\beta c}{1 + \beta}, \hat{p}^* = \frac{c + 2m}{1 - \beta}, \hat{r}^* = -m.
    \]

  - For \( m \geq 0 \) we have CPP at eq: \( \hat{r}^* = 0 \) and \( \hat{p}^* = (c + m) / (1 - \beta) \)
  - It is difficult to determine \( m^* \) that maximizes total profit
    - under \( q(p) = p^{-\eta} \): one can show that firms prefer a negative termination mark-up if and only if the call externality is sufficiently strong in relation to the elasticity of call demand.
  - The socially optimal termination mark-up would be the minimal one:
    \[
    m^W = \frac{-\beta c}{1 + \beta}.
    \]
  - However, according to JLT(2004) this eq candidate does not exist for \( m = \frac{-\beta c}{1 + \beta} \), so that the socially optimum cannot be reached
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  - JLT(2004) find the following *equilibrium candidate* as the noise vanishes, for the duopoly case, when $-\frac{\beta c}{(1+\beta)} < m < 0$:

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- However, according to JLT(2004) this eq candidate does not exist for $m = \frac{-\beta c}{1+\beta}$, so that the socially optimum cannot be reached
More importantly, we demonstrated that this candidate eq is not an eq for any $m < 0$ when there are only two firms:

- each firm has an incentive to cause connectivity breakdown with $\hat{r} = \infty$

Conjecture

- In a symmetric eq with at least three firms there is no incentive to cause connectivity breakdown
  - it hurts subscribers from rival networks only partially while it hurts subscribers of the own network fully

- If the number of firms is large enough, the termination mark-up that maximizes profit is always positive
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- If the number of firms is large enough, the termination mark-up that maximizes profit is always positive
Equilibrium selection: Noise

Consumer surplus and total welfare are maximized by MTCs below cost. Profit is maximized by MTC above cost as long as call externality is relatively weak. 

![Graph showing profit vs. MTC (m)]
Equilibrium selection: Coordination

If firms could coordinate they would play the eq with the highest profit

- if there are at least three firms, the profit maximizing eq is the one where $\beta \hat{p}^* = \hat{r}^*$
  - this maximizes the volume of calls and the sum of call and reception price
- for $n \geq 3$ and $m \geq -\beta c / (1 + \beta)$ firms will play the eq with
  $$p^* = \frac{c}{1 + \beta}, r^* = \frac{\beta c}{1 + \beta}, \hat{p}^* = c + m, \hat{r}^* = \beta (c + m),$$

- Note: $m > 0$ is compatible with positive reception charges!
- It is difficult to determine $m^*$ that maximizes total profit for general call demand function
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Equilibrium selection: Coordination

Assuming constant elasticity of call demand, consumer surplus and total welfare are maximized by MTC below cost. Profit is maximized by MTC above cost as long as call externality is relatively weak (or if elasticity is small)
Elastic subscription with on-net/off-net price discrimination

- It has been argued that RPP regimes lead to lower participation but the empirical evidence is not clear (Dewenter and Kruse [2010])
- no theoretical model has been developed to address this issue so far

- partial participation + call externalities + RPP regime $\Rightarrow$ very challenging
  - an increase in the call price of one network lowers the surplus of subscribing to any of the networks
  - the network can adjust its fixed fee in order to keep the number of its own subscribers constant, but it cannot avoid that the overall penetration goes down
  - in general it is not possible to adjust the fixed fee to keep all market shares constant, so one cannot maximize profits assuming that market shares stay constant

- but there is one exception!
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- When $\beta \hat{p}_i = \hat{r}_j$ a marginal increase in $\hat{p}_i$ will not affect the surplus from subscribing to network $j$ since the utility lost from receiving less calls is exactly compensated by the reduction in reception payments

$$\frac{\partial w_j}{\partial \hat{p}_i} = \beta_i (\beta \hat{p}_i - \hat{r}^*) q'(\hat{p}_i).$$

- we thus focus on this type of equilibrium
  - here in some sense both the caller and the receiver determine the call volume

- on-net prices are set efficiently — profits stem from the fixed fee, off-net calls and termination service
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- on-net prices are set efficiently — profits stem from the fixed fee, off-net calls and termination service
The equilibrium off-net usage prices

\[ \hat{p}(m) = c + m \text{ and } \hat{r}(m) = \beta(c + m) \text{ for } m \geq \frac{-\beta c}{1+\beta} = \bar{m} \]

\[ \hat{p}(m) = -m/\beta \text{ and } \hat{r}(m) = -m \text{ for } m \leq \frac{-\beta c}{1+\beta} = \bar{m} \]

Figure: Off-net call and reception prices are minimal at \( m = \bar{m} \).
Fixed fees and market penetration

Let $\hat{R}(m) = (\hat{p}(m) + \hat{r}(m) - c)q(\hat{p}(m))$ and $v(p) = u(q(p)) - pq(p)$

From the FOC \textit{wrt} $F$ we have:

$$F^* = f + \frac{\mu}{1 - \alpha^*} + (n - 1) \frac{\alpha^* (2\alpha^* - 1)}{1 - \alpha^*} \hat{R}(m)$$

Rational expectations in the Logit model require

$$\bar{\alpha} = \frac{\exp(w^* / \mu)}{n \exp(w^* / \mu) + \exp(w_0 / \mu)},$$

which can be rewritten as

$$F^* = \alpha^* (1 + \beta) [v(p^*) + (n - 1)v(\hat{p}(m))]$$

$$-w_0 - \mu \log \left( \frac{\alpha^*}{1 - n\alpha^*} \right).$$
Comparative statics

Lemma

For $|m - \bar{m}|$ small enough and $\mu > (1 + \beta)v(p^*)/4$ the system of two equations has a unique solution

Proposal

Overall subscription and equilibrium fixed fees are maximized at $m = \bar{m}$. Both increasing and decreasing $m$ away from $\bar{m}$ reduces overall subscription and equilibrium fixed fees

- For $m > \bar{m}$ origination of off-net calls is priced at perceived marginal cost $c + m$ while reception is charged above the cost of termination: consumers come with termination rents
- For $m < \bar{m} \Rightarrow$ consumers come with origination rents
- In both cases, competition for consumers becomes fiercer: lower fixed fees — waterbed effect at play
- However, consumers are not fully compensated (lower overall subscription rates): partial waterbed effect
Comparative statics

**Lemma**

For $|m - \bar{m}|$ small enough and $\mu > (1 + \beta)v(p^*) / 4$ the system of two equations has a unique solution.

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- For $m < \bar{m}$ ⇒ consumers come with *origination rents*.
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Comparative statics: profits and welfare

Proposition

- Consumer and total surplus are maximized at $m = \bar{m}$.
- Industry profit is maximized at $m = \bar{m}$ if and only if network externalities are very strong. Otherwise firms prefer either a lower or a higher termination mark-up.
Comparative statics: profits and welfare

Figure: Consumer and total surplus is always maximized at $m = \bar{m}$. 
Comparative statics: profits and welfare

Figure: Profits are maximal with $m \neq \bar{m}$ when competition is effective.
Concluding remarks

We analyze how termination charges affect prices, profit and welfare when receivers derive some utility from a call and firms may charge consumers for receiving calls.

We consider passive self-fulfilling expectations, oligopolistic markets and do not allow for negative reception charges. We also consider elastic subscription demand.

We confirm some results extend to oligopoly and passive expectations:

- Multiplicity of equilibria
- Strategic marginal cost pricing principle
- Profit neutrality with full participation and without on-net/off-net price discrimination
Concluding remarks

We obtain some new results:

- Alternative equilibrium selection theories (CPP and coordination)
- Connectivity breakdown threat is irrelevant when number of firms is high
- Under CPP firms prefer positive termination mark-up when call externality is weak or when \( n \) is large enough
- With elastic subscription demand socially optimal termination charge is below cost but positive (B&K only for \( \beta = 1 \)), while firms prefer lower or higher termination rate when competition is effective.