Who Should Pay for Two-Way Interconnection?

Sjaak Hurkens[1] Ángel L. López[2]

[1]Institute for Economic Analysis

[2]Public-Private Sector Research Center
IESE Business School

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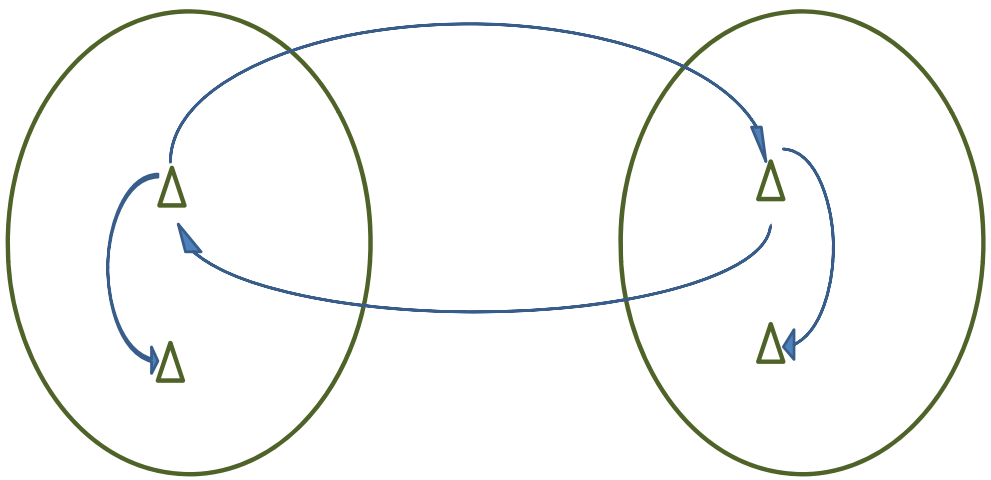
Two-way interconnection



Two-way interconnection

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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Two-way interconnection

Who should pay?

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 ecommended 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, HongKong, 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?*
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  - 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*
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RPP literature

- 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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  - 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
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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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RPP literature: connectivity breakdown result

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
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The Model: Timing

1. MTC is set
2. Consumers form expectations about the number of subscribers of each network i: β_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:

$$\begin{aligned} wi = \beta_i[(1+\beta)U(p_i, r_i) - (p_i + r_i)D(p_i, r_i)] \\ + \sum_{j \in N \setminus \{i\}} \beta_j[U(\hat{p}_i, \hat{r}_j) - \hat{p}_i D(\hat{p}_i, \hat{r}_j)] \\ + \sum_{j \in N \setminus \{i\}} \beta_j[\beta U(\hat{p}_j, \hat{r}_i) - \hat{r}_i D(\hat{p}_j, \hat{r}_i)] - F_i. \end{aligned}$$

- $w_i + \mu\varepsilon_i$

Subscription rates

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

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No On-net/Off-net Price Discrimination

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

$$\pi_i = \alpha_i[(p_i - c - (1-\alpha_i)m)\, q(p_i) + \alpha_i r_i q(p_i) + (1-\alpha_i)(r_i + m)q(p^*) + F_i - f].$$

FOC wrt p_i, keeping α_i constant

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

pecuniary externality

In symmetric equilibrium

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

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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 α_i constant

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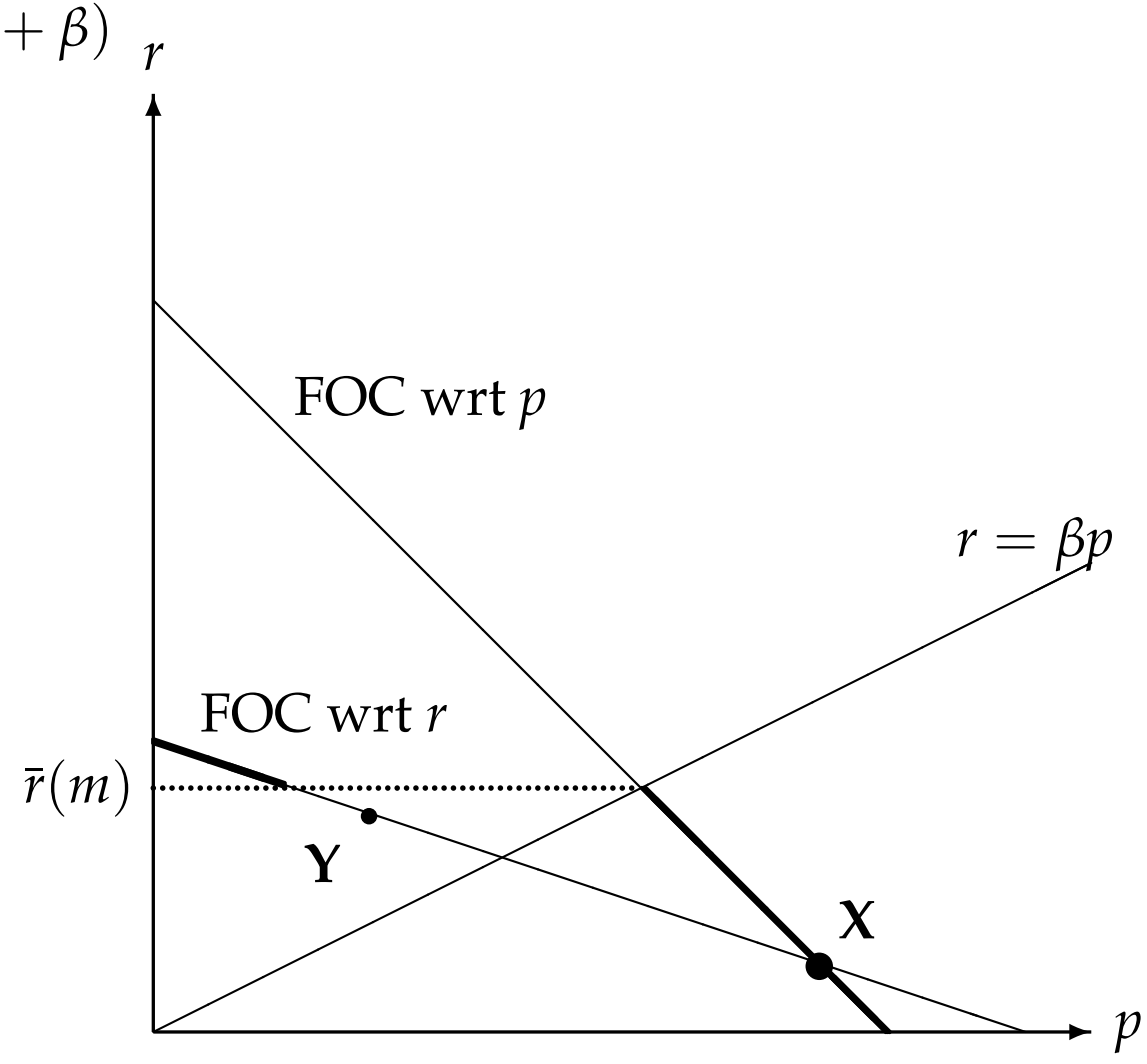
No On-net/Off-net Price Discrimination

$m > -\beta c/(1+\beta)$



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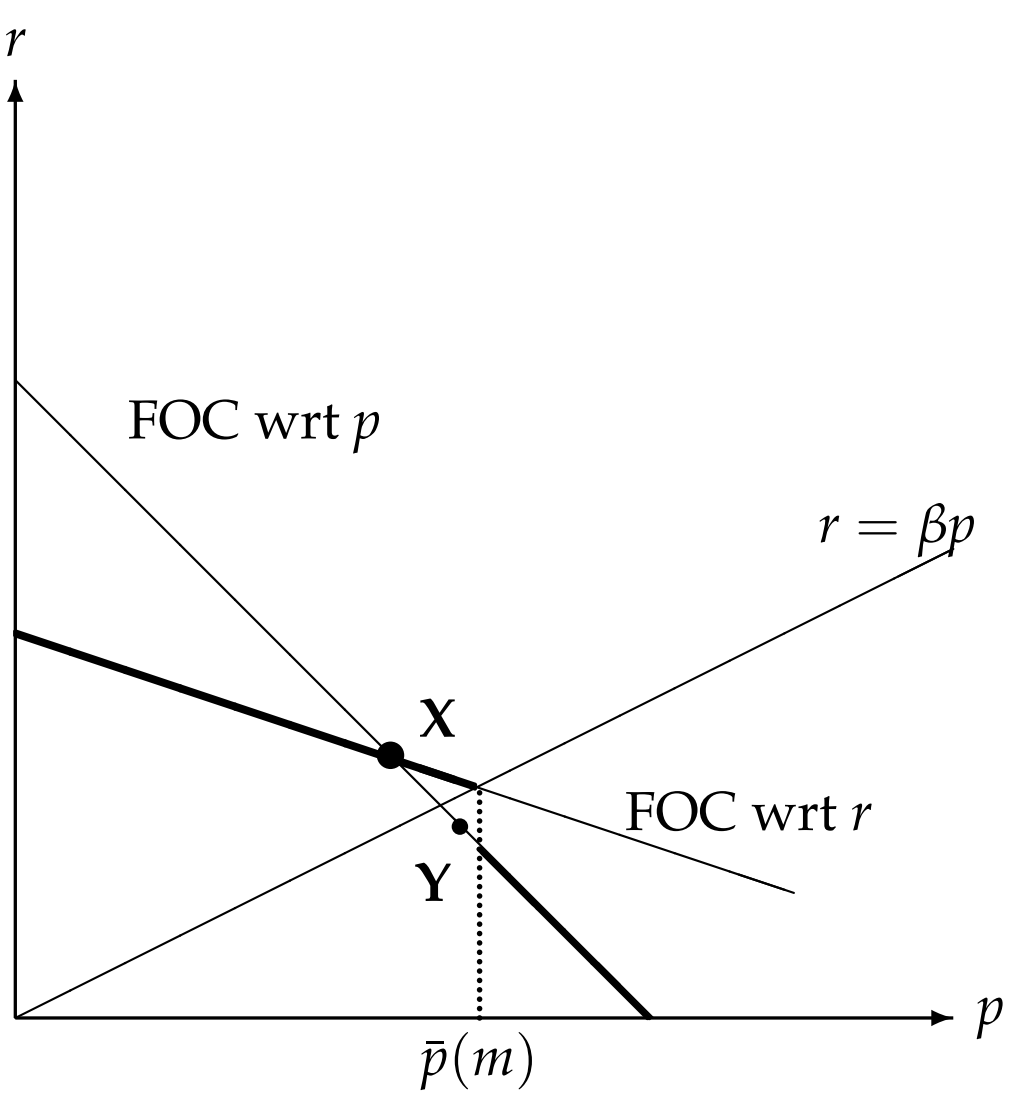

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Fixed fees and profits

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

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

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

profit neutrality result — full waterbed effect

No On-net/Off-net Price Discrimination

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:** $p = c/(1+\beta)$ 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

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

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  - 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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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 *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)
  - equilibrium that maximizes **industry profit**

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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

$$r^* = 0, p^* = \frac{c}{1+\beta}, \hat{r}^* = 0, \hat{p}^* = (c+m)\frac{n-1}{n-1-\beta}$$

  - 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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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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Equilibrium selection: Noise

- 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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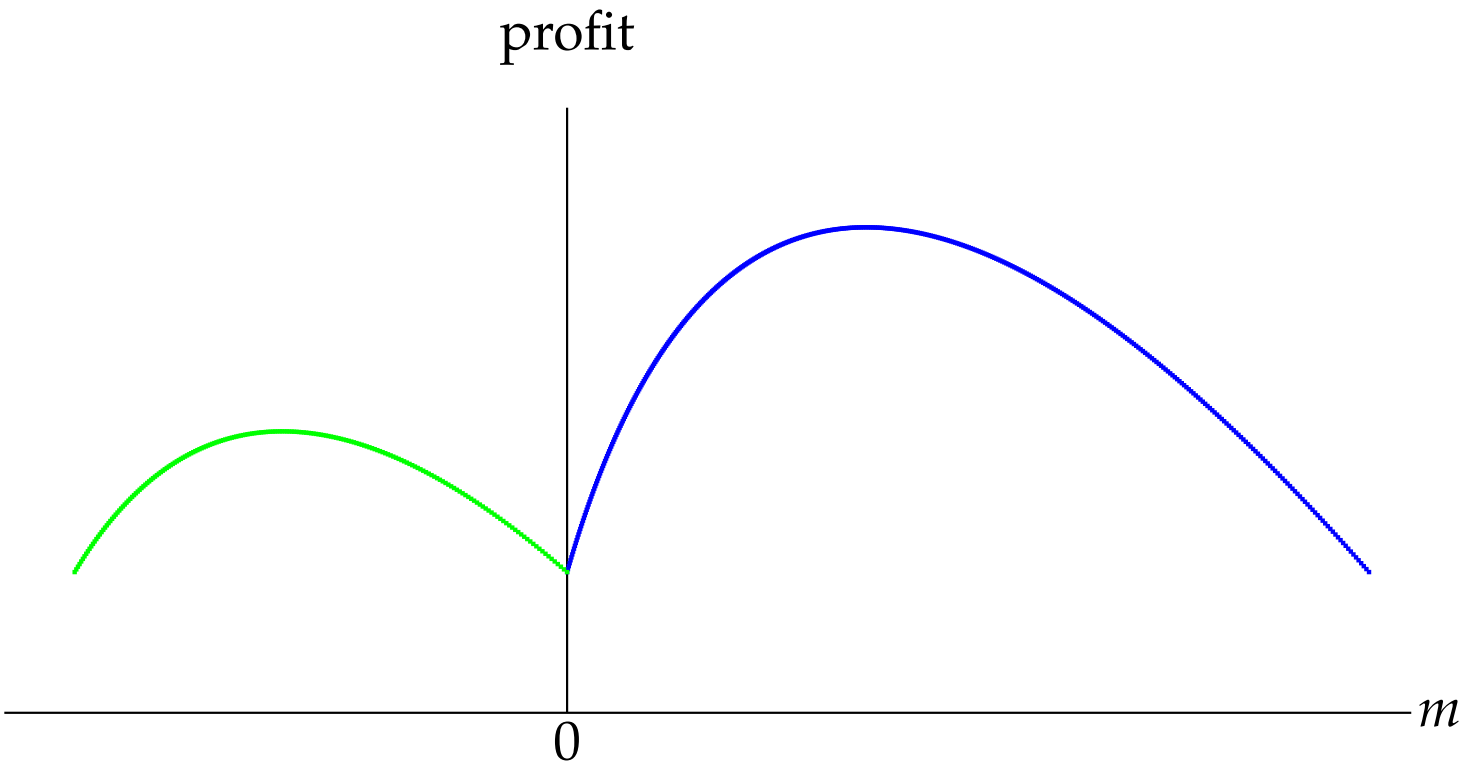
Equilibrium selection: Noise

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



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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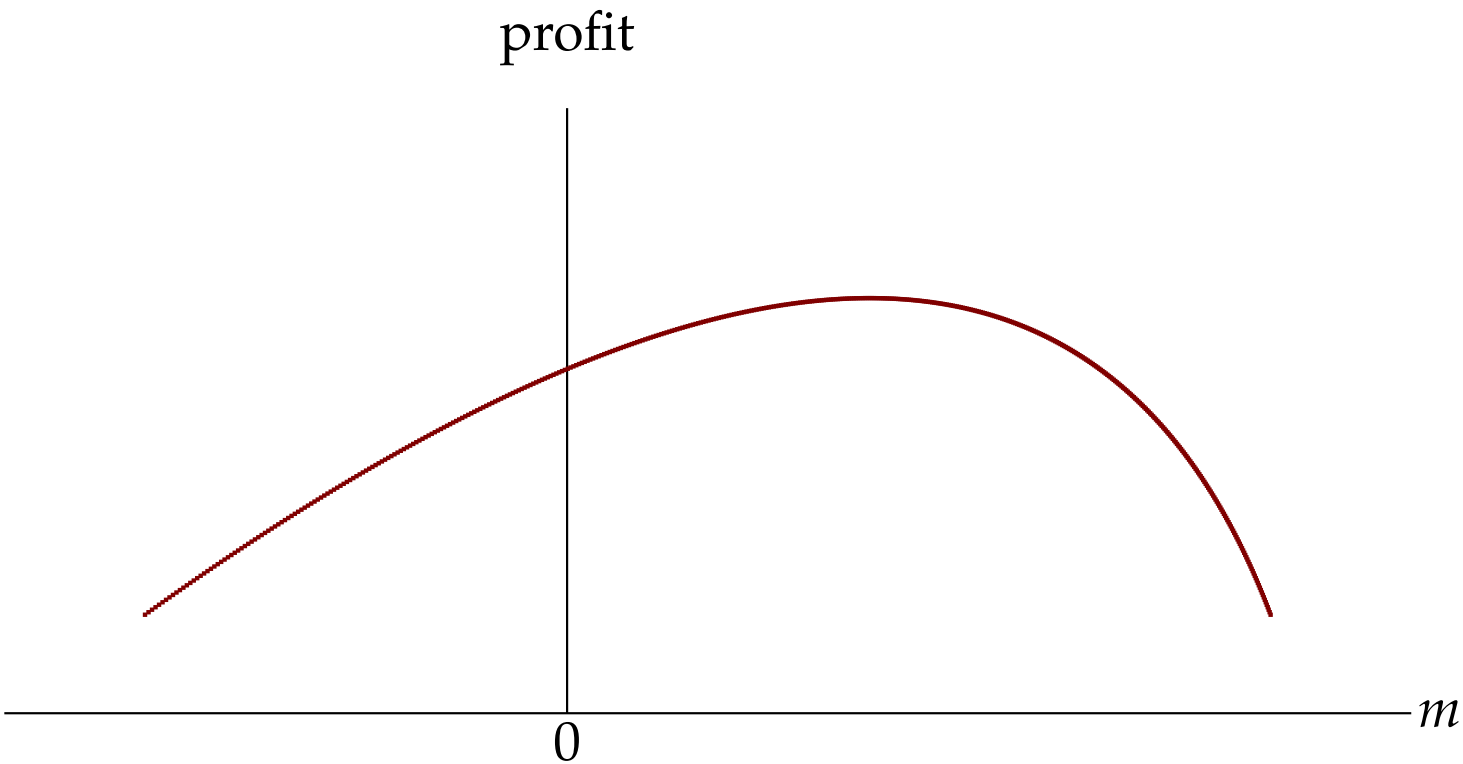
Assuming constant elasticity of call demand, **consumer surplus** and **total welfare** are maximized by MTC below cost. **Profit** is maximized by MTC above cost as long as call externality is relatively weak (or if elasticity is small)



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

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- but there is one exception!
- 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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The equilibrium off-net usage prices

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- $\hat{p}(m) = c + m$ and $\hat{r}(m) = \beta(c + m)$ *for* $m \geq \frac{-\beta c}{1+\beta} = \bar{m}$
- $\hat{p}(m) = -m/\beta$ and $\hat{r}(m) = -m$ *for* $m \leq \frac{-\beta c}{1+\beta} = \bar{m}$

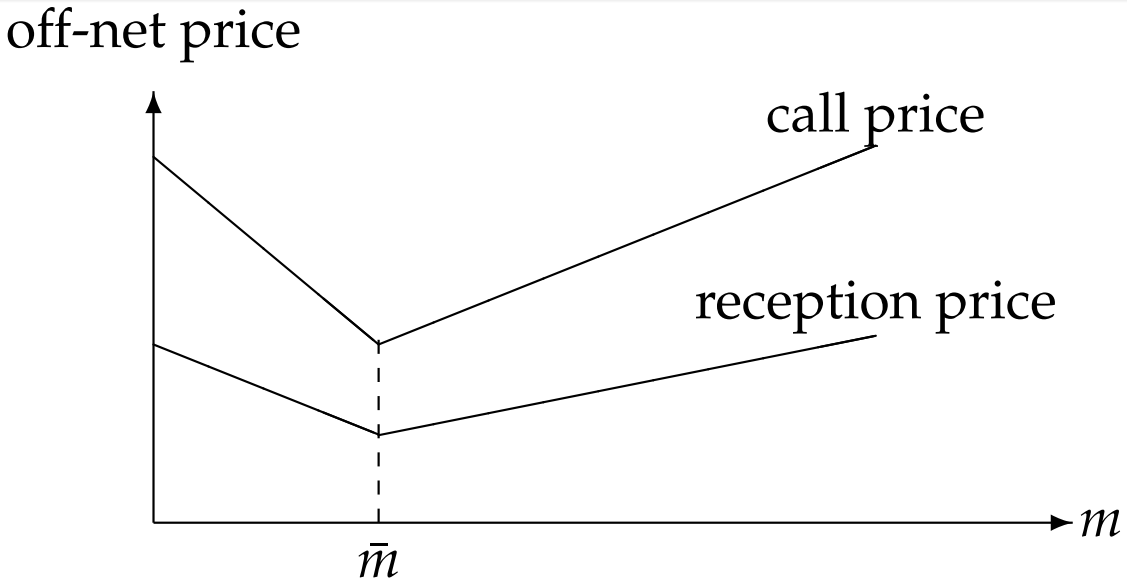

Figure: Off-net call and reception prices are minimal at $m = \bar{m}$.

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 *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

$$\begin{aligned} F^* = {} & \alpha^*(1+\beta)\left[v(p^*) + (n-1)v(\hat{p}(m))\right] \\ & -w_0 - \mu\log\left(\frac{\alpha^*}{1-n\alpha^*}\right) \end{aligned}$$

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

Proposition

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**

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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

Welfare

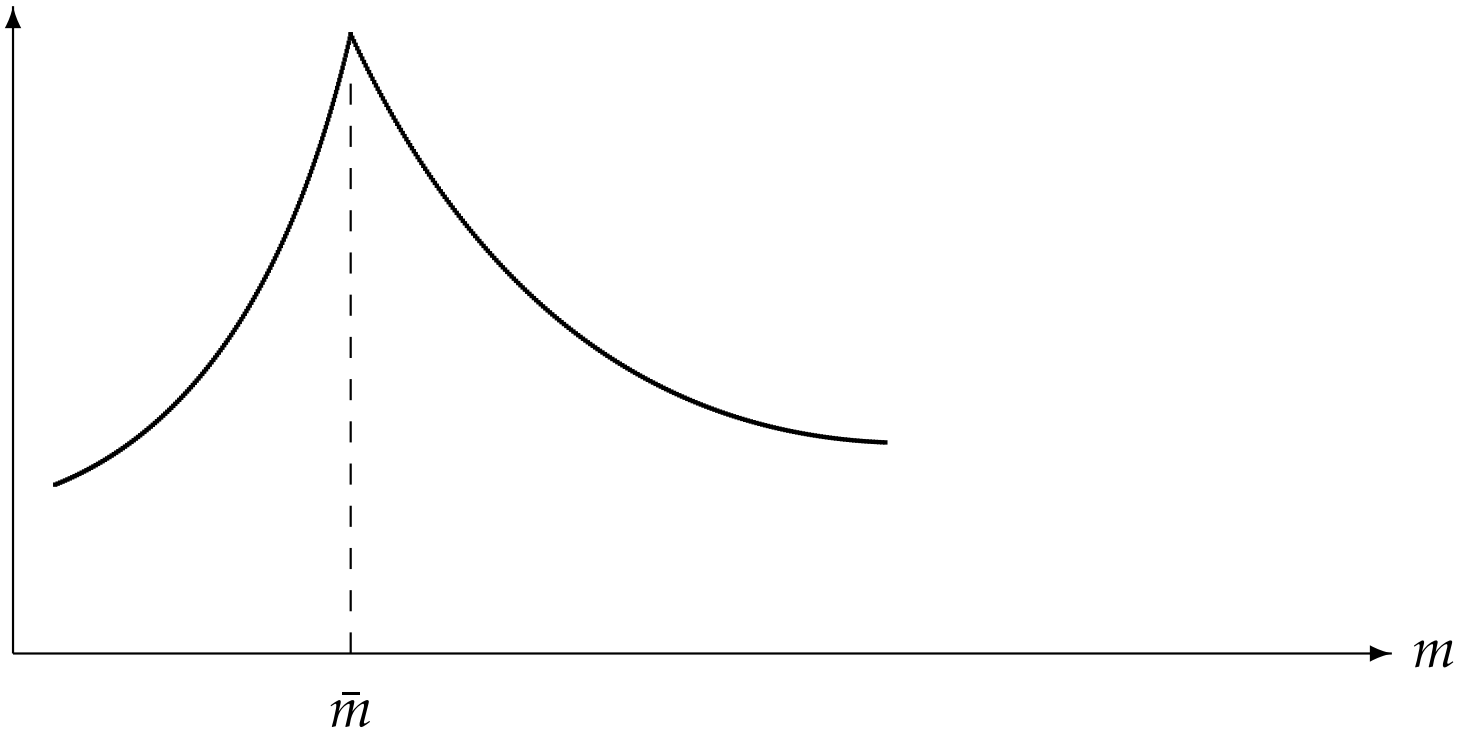

Figure: Consumer and total surplus is always maximized at $m = \bar{m}$.

Comparative statics: profits and welfare

Profits

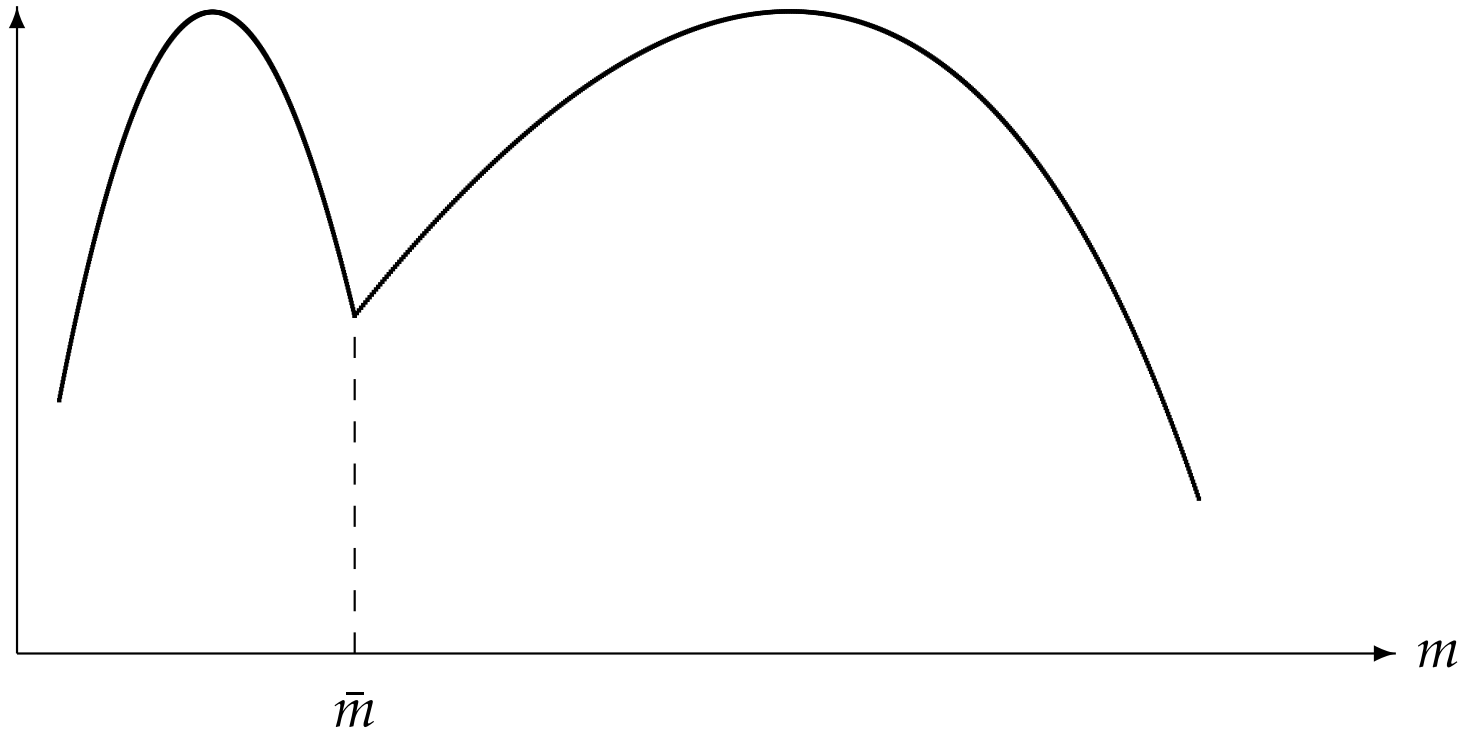

Figure: Profits are maximal with $m \neq \bar{m}$ when competition is effective.

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.