Mobile Termination, Network Externalities, and Consumer Expectations

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Mobile Termination Charges

- Competing mobile network operators need to interconnect to provide service
- MTC is the price to be paid by *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
- Terminating operator has SMP
  - Ex-ante regulation may be justified and called for
  - EC recommends NRAs to lower MTC towards cost
  - Operators oppose

Network-based discrimination

- Laffont-Rey-Tirole (RAND *98b*):
  - Marginal prices are set at the perceived marginal cost
  - Profits come from the collection of fixed fees and from the provision of termination services
  - Total profit is strictly decreasing in termination charge
- Gans and King (*Econ. Lett.* 01):
  - A below-cost MTC *softens* competition (increases fixed fees)
  - Intuition: when the MTC is above cost, off-net calls will be more expensive than on-net calls so that consumers will then prefer to belong to the larger network

    −> *lowering the fixed fee becomes a more effective competitive tool to increase market share and price competition is thus intensified*
  - Profit maximizing MTC below cost (>100 per cent waterbed effect)
  - Welfare maximizing MTC equal to cost

Practice vs. Theory

- Practice: Mobile operators have repeatedly opposed the cuts in termination rates imposed by the NRAs during the last decade
- Theory: The literature predicts the opposite and that welfare maximizing termination charges are at cost (when prices are non-linear)
- Reducing MTC to cost seems therefore welfare increasing:
  - However, this conclusion is drawn from models that at the same time predict that operators would favor reductions in termination charges, which is certainly wrong
- Recent theoretical developments to reconcile theory with real world practice:
  - Armstrong and Wright (EJ, 09) [FTM = MTM]
  - Jullien, Rey and Sand-Zantman (09) [light and heavy users]
  - Hoernig, Inderst, and Valletti (09) [calling clubs]
  - **This paper** [modeling consumer expectations]

Network Effects and Rationally Responsive Expectations

Expectations are important in any model with network effects

- direct network externality: total number of subscribers
- tariff-mediated network externality: the size of each network

The literature so far assumes that:

- First firms compete in prices, then consumers form expectations about network sizes (and these thus may depend on the prices chosen by firms) and finally consumers make optimal subscription decisions, given the prices and their expectations (rationally responsive expectations)
  - –> Any change of a price by one firm is assumed to lead to an instantaneous rational change in expectations of all consumers, such that, given these changed expectations, optimal subscription decisions will lead realized and expected network sizes to coincide
  - –> A unilateral change in price does not lead only to a change in market shares, but it also leads consumers to accurately predict how market shares will change

We replace the assumption of rationally responsive expectations by one of fulfilled equilibrium passive expectations (as in Katz and Shapiro [1985]):

- First, consumers form expectations about network sizes, then firms compete, and finally consumers make optimal subscription or purchasing decisions, given the expectations (passive expectations)
- These decisions then lead to actual market shares and network sizes. We impose that, in equilibrium, realized and expected network sizes are the same

We show that when expectations are passive, results about termination charges in mobile network industries are in fact in line with real world observations:

- Firms typically prefer above cost termination charges and regulators are justified in their efforts to push termination charges down

- Two horizontally differentiated networks
- Value of network i of size s_i: $v_i(s_i)$ with $v_i' > 0$; expectations about $s_i : \beta_i$
- Net surplus: $w_i = v_i(\beta_i) - F_i - tx$

Passive Expectations: consumers expect β_i, market share of network i is then: $s_i = \frac{1}{2} + \frac{1}{2t}\left[v_i(\beta_i) - v_j(1-\beta_i) + F_j - F_i\right]$. Given this, firms compete in prices:

$$s_i = f(\beta_i, F_i, F_j)$$

–> Characterizing equilibrium prices by FOCs is easy

Rationally Responsive Expectations: *for given prices F_i, F_j,* consumers form expectations about network sizes s_i, s_j, then market share of network i is: $s_i = \frac{1}{2} + \frac{1}{2t}\left[v_i(s_i) - v_j(1-s_i) + F_j - F_i\right]$, i.e.,

$$s_i = f(s_i, F_i, F_j)$$

- Under RRE, consumers solve a fixed-point problem - A tâtonnement process

Suppose that F_i decreases to F_i':

- With **PE**, consumers take into account only the direct pecuniary effect of the lower price (some consumers will switch to network i and that's all)
- With **RRE** the story continues: given that these switches have occurred and network i has increased in size (from s_i^0 to s_i^1), v_i also increases.
  - Then, some other consumers switch, this in turn increases $v_i(s_i^1)$ to $v_i(s_i^2)$, inducing some other consumers switch,...
  - The story continues until $\lim_{k\to\infty} s_i^k = s_\infty$ with $s_\infty = f(s_\infty, F_i', F_j)$
- With *positive (negative)* network effects, RRE *intensifies (relaxes)* competition in comparison with PE: lowering the fee is a more (less) effective competitive tool as consumers take into account all the indirect, higher order, effects on network size

The Model: Timing

1. MTC is set
2. Consumers form passive expectations (β_1, β_2) about size of networks 1 and 2
3. Two firms set tariff: $(F_i, p_i, \hat{p}_i)$ (Fixed fee, on-net price, off-net price)
4. Consumers subscribe to one network, leading to market shares α_1, α_2

In a self-fulfilling equilibrium, expected and realized market shares must coincide $(\beta_i = \alpha_i)$.

The Model: Costs and Call demand

Costs

- marginal cost of a call $c = c_O + c_T$
- MTC $= a$,
- termination mark-up $m = a - c_T$,
- mc off-net call: $= c_O + a = c + m$
- fixed cost of serving costumer f

Call demand

- utility of making calls of length $q : u(q)$, increasing and bounded
- call demand $q(p)$ defined by $u'(q(p)) = p$
- indirect utility $v(p) = u(q(p)) - pq(p)$
- $v'(p) = -q(p)$

The Model: Profits

- The profit earned on the on-net calls is: $R(p) = (p - c)q(p)$
- Monopoly price $p^M = \arg\max_p R(p)$
- The profit earned on the off-net calls is: $\hat{R}(\hat{p}) = (\hat{p} - c - m)q(\hat{p})$
- α_i denotes the market share of network i
- The profit of network i is

$$\pi_i \equiv \alpha_i \left(\alpha_i R(p_i) + \alpha_j \widehat{R}(\widehat{p}_i) + F_i - f \right) + \alpha_i \alpha_j m q(\widehat{p}_j).$$

Full participation, Non-linear Pricing, Symmetry

- Expected utility from subscribing to network $i \neq j = 1, 2$

$$w_i = \beta_i v(p_i) + \beta_j v(\hat{p}_i) - F_i.$$

Market shares

$$\begin{aligned}\alpha_1 &= \frac{1}{2} + \frac{1}{2t}(w_1 - w_2) \\ &= \frac{1}{2} + \sigma\left[\beta_1\left(v(p_1) - v(\widehat{p}_2)\right) + \beta_2\left(v(\widehat{p}_1) - v(p_2)\right) - F_1 + F_2\right].\end{aligned}$$

Passive beliefs

$$\frac{\partial \beta_i}{\partial F_i} = 0 \Longrightarrow \frac{\partial \alpha_i}{\partial F_i} = -\sigma$$

Full participation, Non-linear Pricing, Symmetry

- Perceived Marginal Cost Pricing: in equilibrium firms set

$$p_i = c \text{ and } \widehat{p}_i = c + m.$$

- Equilibrium Fixed Fees:

$$\begin{aligned}\pi_i &= \alpha_i\left(\beta_i, F_i, F_j\right)\left[F_i - f + \alpha_j\left(\beta_j, F_j, F_i\right)R(c+m)\right]\\ 0 &= \frac{\partial \pi_i}{\partial F_i} = -\sigma\left(F_i - f\right) + \alpha_i - \sigma\left(1 - 2\alpha_i\right)R(c+m)\end{aligned}$$

Full participation, Non-linear Pricing, Symmetry

Proposition: any shared market eq is symmetric and is characterized by

on-net price $p_1 = p_2 = c$

off-net price $\hat{p}_1 = \hat{p}_2 = c + m$

fixed fee $F_1 = F_2 = f + 1/(2\sigma)$

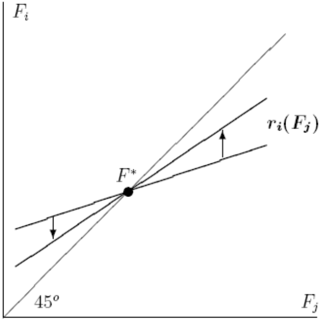
profit

$$\pi_1 = \pi_2 = \frac{1}{4\sigma} + \frac{R(c+m)}{4}$$

- No waterbed effect in duopoly
- Profit maximizing mark-up is $m^* = p^M - c > 0$; Welfare maximizing mark-up is 0
- With PE: $\frac{d\pi_i}{dm} = \frac{1}{4}\frac{dR}{dm}(c+m)$
- With RRE: $\frac{d\pi_i}{dm} = \frac{1}{4}\frac{dR}{dm}(c+m) - \frac{1}{2}q(c+m) \longrightarrow \left.\frac{d\pi_i}{dm}\right|_{m \geq 0} < 0.$

Effect of an increase of m on eq. fixed fees in duopoly

- Termination profits are only made on calls originated on the rival network. Firm i terminates $n_i = \alpha_i(1 - \alpha_i)$ of such calls. At the symmetric equilibrium $\alpha_i = 1/2$ and n_i is in fact maximized.
- This is independent of m so that an increase in m will not induce firms to fight more aggressively for consumers, at equilibrium, since a marginal change in the fixed fee will have no impact on n_i.



(a) Passive expectations (b) Responsive expectations

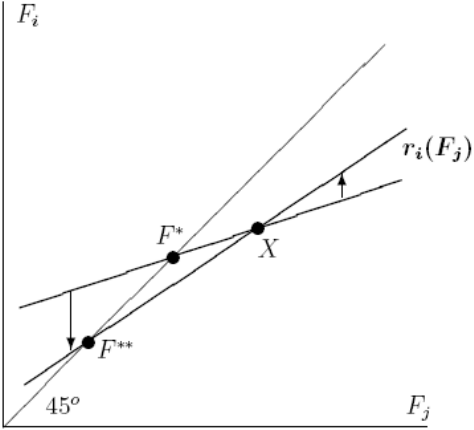
Oligopolistic Competition (n>=3)

- No waterbed effect in duopoly (on the F_i)
- Partial waterbed effect in oligopoly with 3 or more firms

$$\frac{d\pi_i}{dF_i} = \left[\alpha_i + \frac{d\alpha_i}{dF_i}(F_i - f)\right] + \frac{d\alpha_i}{dF_i}(1 - 2\alpha_i) R(c + m).$$

- At any symmetric equilibrium $\alpha_i = \frac{1}{n} < \frac{1}{2}$, implying that F_i^* will depend on m
- F_i^* decreases with m (as long as $m < m^*$): n^o terminated off-net calls is $n_i = \alpha_i(1 - \alpha_i)$, which is increasing in α_i at $\alpha_i = \frac{1}{n}$. As m increases, the profit from terminating calls increases and each firm will compete more fiercely for market share
- Yet, the waterbed effect is less than one hundred per cent
- The eq. profit is still maximized with the m that maximizes the termination profit per terminated call: $m^* = p^M - c > 0$

Effect of an increase of m on eq. fixed fees in oligopoly (passive expectations)



Full participation, Non-linear Pricing, Symmetry

Call Externality: Consumers obtain also utility $\lambda u(q)$ from receiving calls $(0 < \lambda < 1)$

- In contrast with Jeon et al. (2004) and Berger (2005), the termination mark-up does not affect the fixed fee
- Networks maximize shared-market equilibrium profits by setting the termination mark-up m* that maximizes the retail profit from the off-net calls (gross of termination payments): $R(\widehat{p})$
- The eq. profits are therefore higher with an above cost access charge than with a below cost access charge when λ is relatively low.
- Moreover, $m^W < 0 < m^*$

Full participation, Linear Pricing, Symmetry

Linear Pricing:

- The on-net price does not react to the level of the termination mark-up (in contrast with LRT [1998b])
- The off-net price always increases with the termination mark-up
  - with RRE, the off-net price increases with m if σ is small (though it may decrease with m otherwise)
- Networks find it profitable to increase the access charge above the cost as it exerts upward pressure on the off-net price (towards the monopoly level), which leads to higher profits
- Total welfare is maximized by a termination subsidy $m^W < 0$
- If the number of competing networks is larger than two (Logit model), then there will exist a partial waterbed effect on the on-net price

Full participation, Non-linear Pricing, Asymmetry

Asymmetric Networks: we allow for brand loyalty (extra utility $\gamma t > 0$)

- Equilibrium prices:
  - $p_i = c$ and $\hat{p}_i = c + m$ (cost-based usage prices)
  - $F_i = f + \alpha_i/\sigma + 2(\alpha_i - 1/2) R(c + m)$
- Increasing the access charge above the cost,
  - * raises the fixed fee of the large network and lowers the fixed fee of the small network
  - * raises the equilibrium profit for both networks while it reduces total welfare. Why?
    - −> *in the asymmetric case an increase in termination profit makes the large (small) firm compete less (more) fiercely for market share because this makes the market shares less asymmetric, which increases the number of calls to be terminated*

Partial Coverage, Non-linear Pricing

- **No Termination-Based Price Discrimination** (Dessein, RAND 03)
  - Profit maximizing MTC below cost
  - Welfare maximizing MTC above cost iff competition is effective (i.e., more subscribers in duopoly than in monopoly)
- **Termination-Based Price Discrimination** (Hurkens and Jeon, 09)
  - Profit maximizing MTC below cost
  - Welfare maximizing MTC above cost iff competition is effective

Externality Surcharge: It has been argued by some mobile operators and regulators that the termination charge should include a network externality surcharge so as to facilitate the internalization of the externality

Partial Coverage, Non-linear Pricing, Price Discrimination

Random Utility (Logit model):

$$U_i = w_i + \mu\varepsilon_i$$

with

$$w_i = \beta_i v(p_i) + \beta_j v(\hat{p}_i) - F_i,$$

where $\varepsilon_1, \varepsilon_2, \varepsilon_0$ are iid double exponentially, and $\mu > 0$ reflects product differentiation. w_0 denotes utility from not subscribing.

Market shares

$$\alpha_i = \frac{\exp[w_i/\mu]}{\sum_{k=0}^{2}\exp[w_k/\mu]}.$$

Partial Coverage, Non-linear Pricing, Price Discrimination

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Market shares

$$\alpha_i = \frac{\exp[w_i/\mu]}{\sum_{k=0}^{2} \exp[w_k/\mu]}.$$

Passive Expectations:

$$\frac{\partial \alpha_i}{\partial F_i} = -\frac{\alpha_i(1-\alpha_i)}{\mu} \quad \text{and} \quad \frac{\partial \alpha_j}{\partial F_i} = \frac{\alpha_i \alpha_j}{\mu}.$$

Partial Coverage, Non-linear Pricing, Price Discrimination

Firms set variable price equal to perceived marginal cost: $p_i = c$ and $\widehat{p}_i = c + m$. Given this, profits are $\pi_i = \alpha_i(F_i - f) + \alpha_i \alpha_j m q(\hat{p}_j)$

Symmetry and FOC

$$F^{FOC} = f + \frac{\mu}{1-\alpha} - mq(\hat{p})\frac{\alpha(1-2\alpha)}{1-\alpha}. \quad (1)$$

Self-fulfilling expectations gives relation between equilibrium fixed fees and market shares:

$$\alpha = \frac{\exp[(\alpha v(p) + \alpha v(\hat{p}) - F)/\mu]}{2\exp[(\alpha v(p) + \alpha v(\hat{p}) - F)/\mu] + \exp[w_0/\mu]}$$

This can be rewritten as

Self-fulfilling (rational) expectations

$$F^{RE} = \alpha v(p) + \alpha v(\hat{p}) - w_0 - \mu \log\left(\frac{\alpha}{1-2\alpha}\right). \quad (2)$$

Partial Coverage, Non-linear Pricing, Price Discrimination

Lemma

Symmetric equilibrium is given by (1) and (2). It exists and is unique for $|m|$ small and $\mu > v(c)/4$.

Proposition

A marginal increase in the termination mark-up above 0 **lowers** overall subscription and equilibrium fixed fees.

Proposition

(i) A marginal increase in the termination mark-up above 0 increases profits if and only if duopolistic competition leads to higher penetration than colluding duopolists.

(ii) In order to maximize either consumer surplus or total surplus, termination mark-up must be negative.

Conclusion

- We re-examined literature on MTC by replacing the usual assumption of rationally responsive expectations by one of self-fulfilling passive expectations
- Using passive expectations simplifies the analysis so that models can be made richer (e.g., asymmetric oligopolies)
- Results change dramatically. Our results are more in line with real-world observations
  - Partial waterbed effect exists (Genakos and Valletti, 2009)
  - Networks oppose cuts in termination charges
- Policy implications: in a number of cases, $m^W < 0$.
- Further issues for future research: heterogenous consumers, receiving party pays, competition between fixed and mobile