Fixed and mobile telephony: Substitution and Integration

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- Fixed-Mobile Substitution

Fixed-Mobile Substitution: Questions

- Research questions:
  - How does the possibility of substitution between fixed and mobile telephony affect both "markets"?
  - Is there a fundamental difference between *access* and *call* substitution?
  - When does the possibility of substitution matter for pricing?
  - What is the effect of regulation on market development, in particular the levels of termination rates?
  - Which consumer groups win or lose with different levels of termination rates, and which are the socially optimal ones?

Fixed and Mobile Telephony: Challenges

- Challenges in modelling:
  - Model needs to capture that fixed and mobile telephony are usage substitutes and still often bought together
    - Usage depending on time of day
    - Depending on individual consumers' characteristics
  - Model needs to allow for both call and access substitution
    - Multiple call prices and substitution possibilities
    - Consumer heterogeneity in relative valuation of fixed vs. mobile
  - To be realistic, three subscription configurations
    - "mobile-only" (M), "fixed-only" (F), and "fixed-mobile" (FM)

Fixed and Mobile Telephony: Results

- We build a model where
  - consumers first decide, based on expected mobile market outcome, whether to opt for M, F, or FM subscription
  - Given this decision, all networks set their tariffs
- Call substitution may affect call prices
  - But only does so when it serves to *price-discriminate* between customers with different call substitution possibilities
- Termination rates affect access substitution
  - High rates increase subscription, via waterbed effect (mobile and fixed)
- Asymmetric regulation of fixed and mobile networks:
  - High MTR and low FTR lead to transfer from fixed to mobile access
- Social optimum
  - FTR at cost and MTR above cost

Related Literature

- Substitution:
  - Policy: Bomsel et al. (2003)
  - Empirics: Vogelsang (2010), Briglauer et al. (2011), Grzybowski (2012), Barth and Heimeshoff (2012a,b), Ward and Zheng (2012), Grzybowski and Verboven (2014)
- Mobile termination rates:
  - Gans and King (2000), Wright (2002), Armstrong and Wright (2009), Hausman (2012)
  - Hansen (2006): fixed-mobile access substitution and heterogeneous mobility, but no interaction between mobility and call substitution; uses simpler scenarios
- **Model structure:** similar to Peitz (2009)

A Model (1): Basic Setup

- Fixed network:
  - Assume early phase of mobile markets, thus fixed network has regulated retail tariffs
  - Two-part tariff with call prices at cost and zero profits
  - Discriminates between on-net and off-net calls
- Mobile networks
  - Two symmetric mobile networks at endpoints of Hotelling line
  - Compete in two-part tariffs given total number of mobile subscribers
- Consumers: two independent characteristics
  - Relative benefits of different subscription options, learned first
  - Location $x \in [0,1]$ on Hotelling line, learned last

A Model (2): Subscription types

- Notation for subscription scenarios
  - M / FM – subscribers of network *i*: μ_i^m and μ_i^{mx}
  - All M / FM – subscribers: $\mu^m = \mu_1^m + \mu_2^m$ and $\mu^{mx} = \mu_1^{mx} + \mu_2^{mx}$
  - All mobile subscribers: $\mu = \mu^m + \mu^{mx}$
  - F – subscribers: μ^x
- In each group, the expected number of people "on the move" is a share $\lambda \in (0,1)$
- Earlier version had varying mobility, with more math but qualitatively similar results

A Model (3): Costs, Tariffs

- Two-part tariffs: mobile (F_i, p_i, p_{ix}), fixed (F_x, p_x, p_{xm})
- Cost parameters
  - Mobile on-net costs $c = c_o + c_t$
  - Fixed on-net costs $c_x = c_{xo} + c_{xt}$
  - Termination rates a, a_x; margins: mobile n, fixed n_x
  - We assume either *high* mobile termination rates:

$$c_x < c_o + a_x < c_o + \frac{c_t + a}{2} < c_{xo} + a$$

    with $p_x < p_{ix} < p_i < p_{xm}$ in equilibrium
  - Or *low* mobile termination rates:

$$c_x < c_o + a_x;\ c_{xo} + a \leq c_o + \frac{c_t + a}{2}$$

    with $p_x < p_{ix} < p_i;\ p_x < p_{xm} < p_i$ in equilibrium
  - Thus different substitution patterns depending on MTR level

A Model (4): Consumer Surplus

- Surplus of F-subscribers:

$$w^x = A_x - F_x + (1-\lambda)(\rho^m v_{xm} + \rho^x v_x)$$

where the number of others reachable at home is

$$\rho^x = (1-\lambda)(\mu^{mx} + \mu^x)$$

and $v_I = v(p_I)$ for index *I*, A_x is access surplus

- Mobile receivers: $\rho^m = \mu^m + \lambda\mu^{mx}$
- Surplus of M-subscribers:

$$w_i^m = A_m - F_i + \rho^m v_i + \rho^x v_{ix}$$

- Surplus of FM-subscribers, high or low MTR, respectively:

$$w_i^{mx} = A_{mx} - F_i - F_x + \rho^m v_i + \rho^x[\lambda v_{ix} + (1-\lambda)v_x]$$

$$w_i^{mx} = A_{mx} - F_i - F_x + \rho^m[\lambda v_i + (1-\lambda)v_{xm}] + \rho^x[\lambda v_{ix} + (1-\lambda)v_x]$$

A Model (5): Subscriber numbers

- Let $y : \mathbb{R} \to [0,1]$ with $y(0) = 1/2$, $y' > 0$ and $y'(0) = \sigma > 0$.
- Network *i*'s M- and FM-subscribers are

$$\mu_i^m = y(w_i^m - w_j^m)\mu^m \qquad \mu_i^{mx} = y(w_i^{mx} - w_j^{mx})\mu^{mx}$$

- Expected surplus in mobile market:

$$\bar{w}^m = \tfrac{1}{2}(w_1^m + w_2^m) - \kappa, \quad \bar{w}^{mx} = \tfrac{1}{2}(w_1^{mx} + w_2^{mx}) - \kappa$$

- Utility of consumer *l* of taking subscription decision $k \in \{m, mx, x\}$: $U_{lk} = \bar{w}^k + \varepsilon_{lk}$
- Finally, subscriber numbers are

$$\mu^k = P_k(\bar{w}^m, \bar{w}^{mx}, \bar{w}^x)$$

i.e. some discrete choice model with

$$\partial P_k/\partial \bar{w}^k > 0,\ \partial P_k/\partial \bar{w}^l \leq 0 \text{ for } l \neq k, \text{ and } P_m + P_{mx} + P_x \leq 1.$$

A Model (6): Profits (high MTR)

- Mobile networks' profits:

$$\pi_i = \mu_i\{F_i - f + [\rho^m(p_i - c) - \rho_j^m n]q_i\} + \rho_i^m \rho^x (p_{ix} - c_o - a_x)q_{ix} + \rho_i^m n[\mu_j q_j + (1-\lambda)\mu^x q_{xm}].$$

- Fixed network's profits:

$$\pi_x = (\mu^x + \mu^{mx})(F_x - f_x) + (\rho^x)^2(p_x - c_x)q_x + (1-\lambda)\mu^x \rho^m (p_{xm} - c_{xo} - a)q_{xm} + \rho^x n_x(\rho_1^m q_{1x} + \rho_2^m q_{2x}).$$

- Similar expressions for low MTR

A Model (7): Consumer Surplus and Welfare

- Consumer surplus:

$$CS = \mu^x w^x + \mu^{mx} \bar{w}^{mx} + \mu^m \bar{w}^m$$

- Welfare:

$$W = CS + \pi_1 + \pi_2 + \pi_x$$

- Remember: assumption of zero profits on fixed network
- Next step: find equilibrium tariffs

Equilibrium Tariffs, high MTR (1)

- The mobile-to-mobile call price is:

$$p_i^* = c + \frac{n}{2}$$

  - Equal to average marginal cost (standard result)
- The mobile-to-fixed call price is below marginal cost *if and only if the mobile termination rate is above cost*

$$p_{ix}^* = c_o + a_x + n(q_{ix}/q'_{ix})\Omega^{high}$$

  - where

$$\Omega^{high} = \frac{\mu q_i + (1-\lambda)\mu^x q_{xm}}{1/(2\sigma\Phi) - \rho^x q_{ix}^2/q'_{ix}}, \quad \Phi = \frac{\mu^m + \lambda^2 \mu^{mx}}{\rho^m} - \frac{\rho^m}{\mu} > 0$$

  - Price discrimination / waterbed! Service only used by M-customers, who bring in more termination profits
  - Combination of heterogeneity and substitution leads to distorted call pricing structure

Equilibrium Tariffs, high MTR (2)

- Fixed fees: $F_i^* = f + \frac{1}{2\sigma}\left(1 - n\frac{\rho^m \Omega^{high}}{\mu\Phi}\right) + \frac{\rho^m}{2} n q_i$
- Profits in mobile market: $\pi_i^* = \frac{\mu}{4\sigma}$
  - Complete waterbed effect on profit per subscriber: independent of termination rates
  - Still, *the number of subscribers* does depend on termination rates
- Fixed network: regulated monopoly outcome:
  - In particular, zero-profit condition also leads to a full waterbed effect via fixed termination profits

$$p_x^* = c_x,\ p_{xm}^* = c_{xo} + a, \text{ and } F_x^* = f_x - (1-\lambda) n_x \rho^m q_{ix}$$

Equilibrium Tariffs, low MTR

- Mobile-to-mobile call price is *also* distorted:

$$p_i^* = c + \frac{n}{2} + n(q_i/q_i')\Omega^{low}$$

- Mobile-to-fixed call price continues to be distorted:

$$p_{ix} = c_o + a_x + n(q_{ix}/q_{ix}')\Omega^{low}$$

where $\Omega^{low} = \frac{\rho^m q_i/2 + \rho^x q_{xm}}{1/(2\sigma\Phi) - \rho^m q_i^2/q_i' - \rho^x q_{ix}^2/q_{ix}'} > 0$

- Both prices are distorted downwards if *n > 0*
- Still: $F_i^* = f + \frac{1}{2\sigma}\left(1 - n\frac{\rho^m \Omega^{low}}{\mu\Phi}\right)$ and same profits $\pi_i^* = \frac{\mu}{4\sigma}$
- Thus more substitution possibilities give rise to more prices being distorted in equilibrium

Simulation Model

- Equilibrium prices make model high nonlinear
- For the following simulations we need to specify a subscription demand model and some other details
- Outside option $\bar{w}^o = 0$, customers $\mu^o = 1 - \mu^x - \mu^{mx} - \mu^m$
- Logit demand for options $K = \{o, m, mx, x\}$

$$\mu^k = \frac{\exp(b\bar{w}^k)}{\sum_{l \in K} \exp(b\bar{w}^l)}, \; k \in K$$

- Degree of heterogeneity is $b > 0$
- Consumer surplus: $CS = \ln\left(\sum_{k \in K} \exp(b\bar{w}^k)\right)/b$
- Other assumptions (costs, call demand) set out in paper
- MTR low/high-threshold is 0.28 in the following

Equilibrium Subscriber Shares

- Higher FTR / MTR increase the respective number of subscribers, via a waterbed effect, and reduce the number of those on the other network
- Higher MTR also *increase* the number of non-subscribers

	Total Mobile			Total fixed			Non-subscribers		
$a \backslash a_x$	0.01	0.055	0.10	0.01	0.055	0.10	0.01	0.055	0.10
0.10	80.3%	79.5%	78.6%	57.7%	59.7%	61.4%	5.6%	5.6%	5.7%
0.19	81.8%	81.0%	80.2%	55.1%	57.2%	59.1%	5.6%	5.6%	5.6%
0.28	81.9%	81.2%	80.4%	53.3%	55.6%	57.6%	6.0%	6.0%	6.0%
0.37	82.7%	82.0%	81.2%	52.3%	54.7%	56.8%	6.1%	6.0%	6.0%
0.46	83.1%	82.4%	81.7%	51.6%	54.0%	56.2%	6.3%	6.2%	6.2%

Consumer Surplus and Welfare

- Low FTR lead to highest CS, mobile profits and welfare
- Consumer surplus and welfare increase with MTR up to threshold between low and high MTR cases
- Mobile profits increase with even higher MTR

	Consumer Surplus			Mobile Profits			Welfare		
$a \backslash a_x$	0.01	0.055	0.10	0.01	0.055	0.10	0.01	0.055	0.10
0.10	2.86	2.85	2.84	0.201	0.199	0.197	3.26	3.25	3.23
0.19	2.87	2.87	2.87	0.204	0.203	0.201	3.28	3.28	3.27
0.28	2.80	2.80	2.80	0.205	0.203	0.201	3.21	3.21	3.20
0.37	2.79	2.80	2.80	0.207	0.205	0.203	3.20	3.21	3.20
0.46	2.77	2.78	2.78	0.208	0.206	0.204	3.19	3.19	3.19

Different Customer Groups

- Mobile-only customers prefer MTR close to threshold and low FTR, while the others want low MTR and higher FTR
- Thus the interests of mobile-only customers are more aligned with those of mobile networks than of the others

	Mobile-only			Fixed-Mobile			Fixed-Only		
$a \backslash a_x$	0.01	0.055	0.10	0.01	0.055	0.10	0.01	0.055	0.10
0.10	1.88	1.82	1.76	2.05	2.08	2.09	0.72	0.77	0.82
0.19	1.95	1.90	1.84	2.03	2.06	2.08	0.72	0.77	0.83
0.28	1.92	1.87	1.81	1.93	1.97	2.00	0.54	0.61	0.67
0.37	1.92	1.87	1.82	1.91	1.96	1.99	0.53	0.61	0.67
0.46	1.91	1.86	1.81	1.88	1.93	1.97	0.53	0.61	0.67

Policy Conclusions

- **Fixed termination rates at cost**
  - Preferred by mobile-only subscribers and mobile operators
  - Fixed-and-mobile and fixed-only subscribers prefer a higher level
  - Lowered total number of fixed subscriptions
- **Mobile termination rates above cost**
  - Level above cost of termination is socially optimal
  - Mobile-only subscribers prefer a level somewhat below, and all other consumer groups prefer a level at cost
  - Mobile operators prefer a higher level
  - Increased both number of mobile subscribers and non-subscribers
- **Was MTR / FTR policy correct?**
  - *Qualitatively*, yes, but whether MTR *levels* were ok is another matter (which needs to be tackled in a properly calibrated model)

- Fixed-Mobile Integration

Fixed-Mobile Integration

- In many countries the largest mobile operator is owned by the incumbent fixed network
- Competitive implications of integration have not been taken into account in network competition literature
- Does the integrated mobile network obtain an advantage or is it hurt by integration?
  - Fixed-to-mobile termination profits are spend competing for consumers
- We consider incentives to set cross-network prices and the relevant externalities

Fixed-Mobile Integration in Europe

State	Fixed Incumbent	Controlled Mobile Operator	Market Shares (Subscribers, 2012)	Number of MNOs (2012)
Austria	Telekom Austria	A1 - Mobilkom	40.7% (L)	4
Belgium	Belgacom	Proximus	41.1% (L)	3
Denmark	Tele Danmark	TDC Mobil	46.5% (L)	4
Finland	Sonera	Sonera	34% (S)	3
France	Orange	Orange	41.4% (L)	3
Germany	Deutsche Telekom	T-Mobile	30.5% (S)	4
Greece	OTE	Cosmote	48.5% (L)	3
Ireland	EIRCOM	Meteor	20% (S)*	4
Italy	Telecom Italia	TIM	35.4% (L)	4
Luxemburg	P&T Luxemburg	LuxGSM	60% (L)*	4
Netherlands	KPN	KPN Mobile	41.3% (L)	3
Portugal	Portugal Telecom	TMN	42.8% (L)	3
Spain	Telefonica de Espana	Movistar	40.5% (L)	4
Sweden	Telia	Telia	46.6% (L)	4
UK	British Telecom	O2 (up to 2005)	26.5% (2005,L)**[10]	4

* Source: Company web site

** Source: Ofcom (2005), "The Communications Market - Telecommunications"

L = Market Leader

S = Second-biggest operator

Related Literature

- Competition between mobile networks:
  - Without FTM calls: Armstrong, LRTa,b (1998)
  - Call externalities: Jeon, Laffont and Tirole (1994), Berger (2004/05), Hoernig (2007), Cambini and Valletti (2008), Hermalin and Katz (2011)
  - With FTM calls: Wright (2002), Armstrong/Wright (2009), Vogelsang (2010)
- Competition between integrated pairs: Mu (2008)
- Integration between local and long-distance operators: Cambini (2001)
- Large literature on vertical integration

A Model

- **Fixed market:**
  - One fixed network, charges two-part tariff
  - Can discriminate between FTM calls to different mobile networks
  - We obtain the same results assuming competition in the fixed market
- **Mobile market:**
  - For simplicity, assume separate consumer groups
  - Two (asymmetric) mobile networks, charge two-part tariffs
  - Standard Hotelling model, call externalities, MTM and MTF calls
- **Integration:**
  - Integrated fixed network and mobile network 1 set prices such as to maximize sum of profits

Mobile Market

- Market shares: $\alpha_i \geq 0, \alpha_i + \alpha_j = 1$
- Tariffs: $(F_i, p_i, \hat{p}_i, \tilde{p}_i)$
- Quantities and indirect utilities:

  $q_i = q(p_i), \hat{q}_i = q(\hat{p}_i)$, etc.
- Gross surplus of connecting to network *i*:

  $w_i = \alpha_i(v_i + \gamma u_i) + \alpha_j(\hat{v}_i + \gamma \hat{u}_j) + N(\tilde{v}_i + \gamma u_i^x) - F_i$
- Access benefit: $A_1 \geq A_2$
- Market shares: $\alpha_i = \frac{1}{2} + \sigma(w_i + A_i - w_j - A_j)$
- Profits:

$$\pi_i = \alpha_i(F_i - f) + \alpha_i^2(p_i - c)q_i + \alpha_i\alpha_j[(\hat{p}_i - c_o - a)\hat{q}_i + (a - c_t)\hat{q}_j]$$
$$+ \alpha_i N[(\tilde{p}_i - c_o - a_x)\tilde{q}_i + (a - c_t)q_i^x].$$

Fixed Market, and Welfare

- Tariff: (F_x, z_1, z_2)
- Subscription utility:

$$A_x + w_x = A_x + \alpha_1(v_1^x + \gamma\tilde{u}_1) + \alpha_2(v_2^x + \gamma\tilde{u}_2) - F_x \geq 0$$

- Profits:

$$\pi_x = N(F_x - f_x) + \sum_{i=1,2} \alpha_i N[(z_i - c_{xo} - a)q_i^x + (a_x - c_{xt})\tilde{q}_i]$$

- Consumer surplus in both markets

$$CS = \sum_{i=1,2}\left[\alpha_i(w_i + A_i) - \frac{\alpha_i^2}{4\sigma}\right] + N(w_x + A_x)$$

- Total welfare in both markets:

$$W = CS + \pi_1 + \pi_2 + \pi_x$$

Outcome under Separate Networks

- Without integration, calls prices are set as follows:
  - FTM and MTF prices are equal to network cost plus termination rate: $z_1^N = z_2^N = c_{xo} + a \quad \tilde{p}_i^N = c_o + a_x$
  - MTM prices are set as in Jeon et al. :

$$p_i^N = \frac{c}{1+\gamma} \qquad \hat{p}_i^N = \frac{c_o + a}{1 - \gamma \alpha_i / \alpha_j}$$

- Thus while MTM prices are set strategically, cross-market prices are set purely based on the relevant cost
  - No internalization of the termination margin
  - No internalization of call externalities
  - No upward distortion for "off-net" prices

Outcome under Integration

- Non-integrated network sets all call prices as before
- Integrated mobile network sets MTM prices as before, but charges efficient MTF price:

  $\tilde{p}_1^I = \frac{c_o + c_{xt}}{1+\gamma}$
- Fixed network charges efficient FTM price to integrated partner, but sets high FTM price to rival network:

  $z_1^I = \frac{c_{xo} + c_t}{1+\gamma} \qquad z_2^I = \frac{c_{xo} + a}{1 - \gamma\alpha_1/\alpha_2}$
- On-net price internalizes termination and call externality
- Off-net price has strategic distortion depending on the size of *mobile* networks
  - i.e. independent of size of fixed network

Competitive Effects

- Our results imply that integrated networks have exactly the same incentives to distort cross-network prices strategically as do mobile networks for off-net MTM calls
  - This also applies to MTF calls to entrants in the fixed market!
- As a result, market shares and profits of the integrated network increase and those of the rival network decrease
  - Stronger with larger call externality and size of fixed network
  - Prior asymmetries are magnified
- New Zealand's competition authority decided to follow FTM the same way it is already following MTM prices
- (Short-run) welfare effect has two components:
  - More (less) efficient pricing for on-net (off-net) calls

Remedies

- Existing wholesale remedies (control of termination rates) do not remove retail pricing incentives
  - Integrated firm prefers zero FTM termination rate! (of *rival*...)
- Structural remedy: Functional separation
  - Idea: separate maximization of profits
  - Result: Pricing as under separation, of course
  - Disadvantage: no internalization of termination margin
- Retail pricing remedy: Uniform pricing obligation
  - Idea: outlaw setting different prices for different FTM calls
  - Equilibrium price: $z^U = c_{xo} + \alpha_1 c_t + \alpha_2 a$
  - More efficient than under separation because maintains internalization of termination margin

Policy Conclusions

- **The policy issue**:
  - Joint ownership of fixed and the largest mobile networks is pervasive
  - How does this affect competition in the mobile market?
- **Our findings**:
  - Various externalities are at work which affect call pricing decisions
  - "On-net" calls are priced efficiently because termination payments and call externalities are internalized
  - "Off-net" FTM call prices are distorted upwards for strategic motives
  - Same issues as with MTM call pricing!
  - Competitive advantage for integrated mobile network
  - Wholesale (termination) regulation ineffective for this issue
  - Obligation of uniform off-net pricing would be effective (retail) remedy

- Further Research

Ongoing Research

- One issue which still have to advance on is the question of why mobile networks have (at least for a while) charged excessive prices for calls to the fixed network
  - Fixed terminations rates were very low, thus no cost reason
  - This pricing policy was even in place on mobile networks that were owned by a fixed network: no reason to "choke" calls
  - Even with multi-part tariffs: call prices tend to be efficient
- Two hypotheses:
  - An attempt to "force" consumers to take up mobile subscriptions
  - An attempt to protect FTM termination from MTF calls
  - Main issue: Profitable in equilibrium?

- Merci beaucoup!