The Role of Social Networks on Regulation in the Telecommunication Industry: The Discriminatory Case.

Rodrigo Harrison, Gonzalo Hernández and Roberto Muñoz

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Motivation

- In this paper we study regulatory implications of equilibrium behavior in a market characterized by the competition between two interconnected networks, under the assumption that heterogeneous customers belong to a social network.

- We study two different regulatory interventions. First, access charge are fixed below marginal costs (as opossed to the standard marginal cost regulation) and second, the authority reduces switching costs, keeping marginal cost regulation in access charges.

Related Literature

- The Role of Access Charges in Interconnection Problems
  - Laffont, Rey and Tirole (1998a,b)
  - Armstrong (2002)
- The Role of Access Charges in Interconnection Problems with Heterogeneous Customers:
  - Dessein (2004)
  - Hahn (2004)
  - Harrison, Hernández y Muñoz (2006, 2008)

The Main Elements of the Game

Structural Assumptions

- Two firms, A and B, offering horizontally differentiated communication services (for example two mobile phone companies).
- A social network g formed by consumers and the relations among them.

Behavioral Assumptions

- Consumers optimally decide which firm to subscribe (if any).
- The firms maximize profits subject to two alternative kinds of discrimination. First, discrimination depending on the destiny of the call or, second, two part tariffs.

Modelling Assumptions

- Preferences and differentiation follow a "Hotelling kind" model where the taste random variable x_i cames from a uniform grid with support in $[0, 1]$. Firm A is "located" in 0 while firm B in 1.

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The Utility and Demand

$$U_i(q_i) = \sum_{j \in g, j \neq i} \delta^{t_{ij}} u(q_{ij}) \qquad \text{with} \qquad u(q_{ij}) = \frac{q_{ij}^{1-1/\eta}}{1-1/\eta} \tag{1}$$

where:

δ : social discount factor satisfying $0 < \delta < 1$.

t_{ij} : shortest distance (in terms of links) between agents i and j.

η : elasticity of demand ($\eta > 1$).

If agent i affiliates firm A then he/she solves:

$$W_i(p_A, \widehat{p}_A) = \max_{q_i} \left\{ U_i(q_i) - p_A \sum_{\substack{j \neq i \\ j \in I \setminus I_B}} q_{ij} - \widehat{p}_A \sum_{j \in I_B} q_{ij} \right\} \tag{2}$$

and then we have:

$$q_{ij}(p) = \left(\frac{p}{\delta^{t_{ij}}} \right)^{-\eta} \qquad \text{with} \quad p = p_A, \widehat{p}_A \text{ depending on } j\text{'s affiliation.} \tag{3}$$

The Affiliation Decision

Let us define the net surplus for consumer i when affiliates to firm I (A or B) as:

$$w_i(p_I, \widehat{p}_I, F_I, x_i^I) \equiv W_i(p_I, \widehat{p}_I) - F_I - t x_i^I \sum_{\substack{j \neq i \\ j \in I}} \delta^{t_{ij}}$$

The decision of affiliation to A or B depends on if x_i is to the right or the left of a critical value x_i^* given by:

$$w_i(p_A, \widehat{p}_A, F_A, x_i^*) = w_i(p_B, \widehat{p}_B, F_B, 1 - x_i^*)$$

Solving for x_i^*, we got:

$$x_i^* = \frac{1}{2} + \sigma_i \left[W_i(p_A, \widehat{p}_A) - F_A - \left(W_i(p_B, \widehat{p}_B) - F_B \right) \right]$$

So if $x_i < x_i^*$ (resp. $x_i > x_i^*$) then player i prefers network A (resp. B).

Let us define α_i as an IC constraint:

$$\alpha_i = \begin{cases} 0 & \text{if} \quad x_i < x_i^* \\ 0 \text{ or } 1 & \text{if} \quad x_i = x_i^* \\ 1 & \text{if} \quad x_i > x_i^* \end{cases} \tag{4}$$

$\alpha_i = 0$ means that agent i prefers firm A (otherwise firm B is preferred).

Finally, β_i is defined as an IR constraint:

$$\beta_i = \begin{cases} 0 & \text{if} \quad Max\left\{w_i(p_A, \widehat{p}_A, F_A, x_i), w_i(p_B, \widehat{p}_B, F_B, 1 - x_i)\right\} < 0 \\ 1 & \text{if} \quad Max\left\{w_i(p_A, \widehat{p}_A, F_A, x_i), w_i(p_B, \widehat{p}_B, F_B, 1 - x_i)\right\} \geq 0 \end{cases} \tag{5}$$

$\beta_i = 0$ means that agent i prefers to stay out of the market.

The Firm's Problem

When access charges are given by a_A and a_B, firm A will select its price p_A such that:

$$\max_{p_A, \widehat{p}_A, F_A \geq 0} \pi_A(p_A, \widehat{p}_A, p_B, \widehat{p}_B, F_A, F_B, a_A, a_B) =$$

$$\sum_{i \in I_A} \left\{ \sum_{\substack{j \in I \setminus I_B \\ j \neq i}} q_{ij}(p_A)(p_A - c_A^o - c_A^f) + \right.$$

$$\left. \sum_{j \in I_B} q_{ij}(\widehat{p}_A)(\widehat{p}_A - c_A^o - a_B) + F_A - f \right\} +$$

$$\sum_{i \in I_B} \sum_{j \in I_A} q_{ij}(\widehat{p}_B)(a_A - c_A^f) \tag{6}$$

After some nontrivial algebra, the problem becomes:

$$\underset{p_A,\widehat{p}_A,F_A\geq 0}{Max} \ \pi_A(p_A,\widehat{p}_A,p_B,\widehat{p}_B,F_A,F_B,a_A,a_B;\alpha,\beta) \tag{7}$$

$$\begin{aligned} s.t. \quad H_1\alpha &\leq z_1, \quad \alpha\in\{0,1\}^I \qquad (IC \text{ constraints}) \\ H_2\beta &\leq z_2, \quad \beta\in\{0,1\}^I \qquad (IR \text{ constraints}) \end{aligned}$$

This is a very difficult problem because the H's and z's depend on the vector of prices. It is useful to study two particular cases: discrimination by destiny $(F_A = F_B = 0)$ and two part tariffs $(p_A = \widehat{p}_A,\ p_B = \widehat{p}_B)$.

Case I: Discrimination by Destiny of the Call.

IR constraints are easily satisfied. But IC constraints implies:

$$H_1^I = \begin{bmatrix} -M & -(L_1^D)^t & \\ M & (L_1^D)^t & \\ -(L_2^U)^t & -M & -(L_2^D)^t \\ (L_2^U)^t & M & (L_2^D)^t \\ \vdots & \vdots & \vdots \\ -(L_i^U)^t & -M & -(L_i^D)^t \\ (L_i^U)^t & M & (L_i^D)^t \\ \vdots & \vdots & \vdots \\ & -(L_I^U)^t & -M \\ & (L_I^U)^t & M \end{bmatrix}_{2I\times I} \qquad z_1^I = \begin{bmatrix} -b_1 \\ b_1 + M \\ -b_2 \\ b_2 + M \\ \vdots \\ \vdots \\ -b_I \\ b_I + M \end{bmatrix}_{2I\times 1}$$

Case II: Two Part Tariff

In this case $L_i = 0 \ \ \forall i \in I$ so matrix H_1^{II} is considerably simpler. However, the *IR* constraint is now binding with:

$$H_2^{II} = \begin{bmatrix} -N & & \\ N & & \\ & -N & \\ & N & \\ \vdots & \vdots & \vdots \\ & & -N \\ & & N \end{bmatrix}_{2I \times I} \qquad z_2^{II} = \begin{bmatrix} -\Omega_1 \\ \Omega_1 + N \\ -\Omega_2 \\ \Omega_2 + N \\ \vdots \\ -\Omega_I \\ \Omega_I + N \end{bmatrix}_{2I \times 1}$$

It is interesting to note here that the absence of a network externality in the *IR* constraint is a consequence of the assumption that consumers not affiliated are reachable.

The Regulatory Interventions

In the subsequent analysis we consider two alternative regulatory interventions:

1. The authority can set access charges below marginal termination costs to enhance competition. Under this policy, the firms have an additional incentive to reduce prices, because a net outflow of calls is more profitable than a balanced pattern.

2. The authority can implement policies aimed at reducing switching costs, that is t in this model, which intensify rivalry to affiliate consumers.

Basic Data

Table 1: Default Values for Parameters

elasticity of demand	$-\eta = -1.2$
discount factor	$\delta = 0.9$
connectivity degree	$d = 8$
origination cost	$c_A^o = c_B^o = 0.75$
termination cost	$c_A^f = c_B^f = 0.75$
fix cost	$f = 50$
access charges	$a_A = a_B = 0.75$
number of individuals	$I = 100$
transportation cost	$t = \begin{cases} 0.5 \text{ in case } I \\ 0.25 \text{ in case } II \end{cases}$

Results for Case I

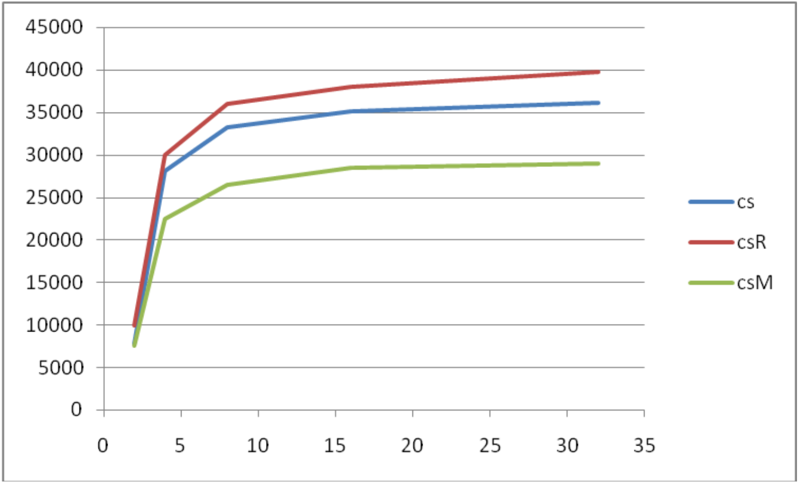

Figure: The impact of Connectivity degree on Consumer Surplus (CS).

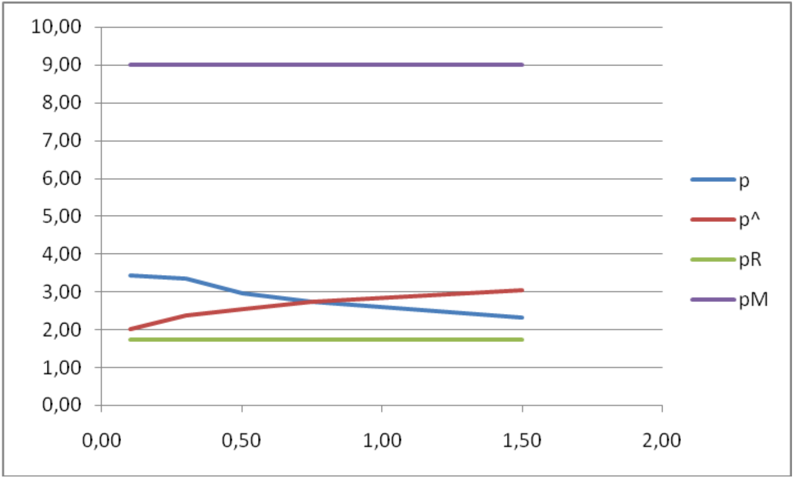

Figure: Average equilibrium prices (p and $\widehat{p}$) as a function of access charges.

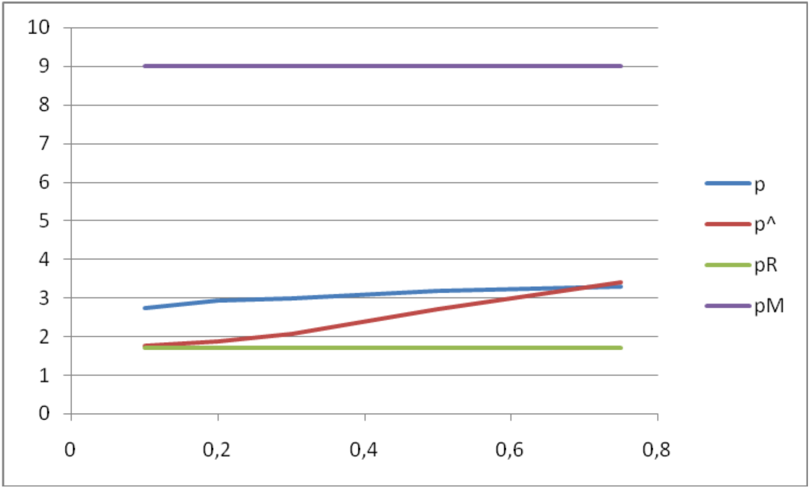

Figure: Average equilibrium prices (p and $\widehat{p}$) as a function of transportation costs.

Results for Case II

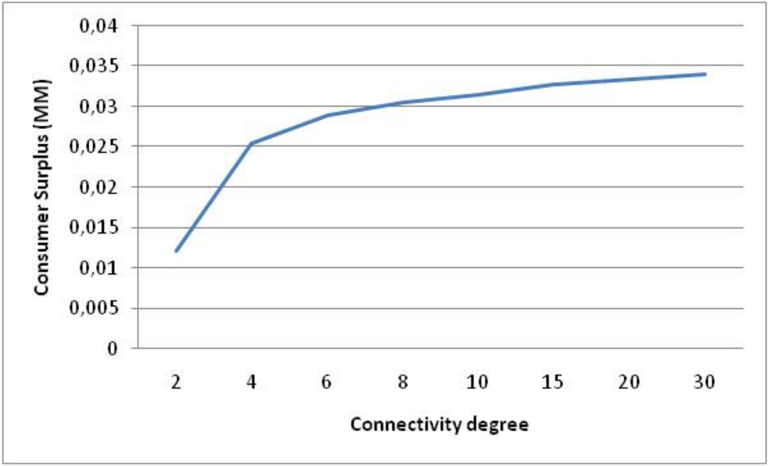

Figure: The impact of connectivity degree on Consumer Surplus (CS).

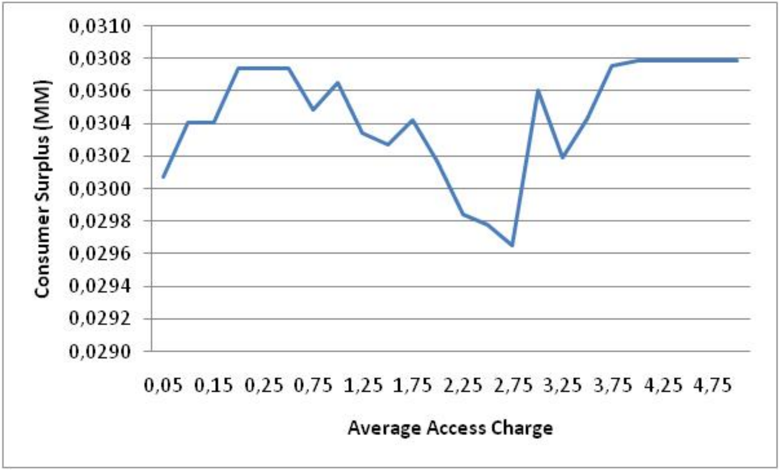

Figure: Consumer Surplus as a Function of Average Access Charge.

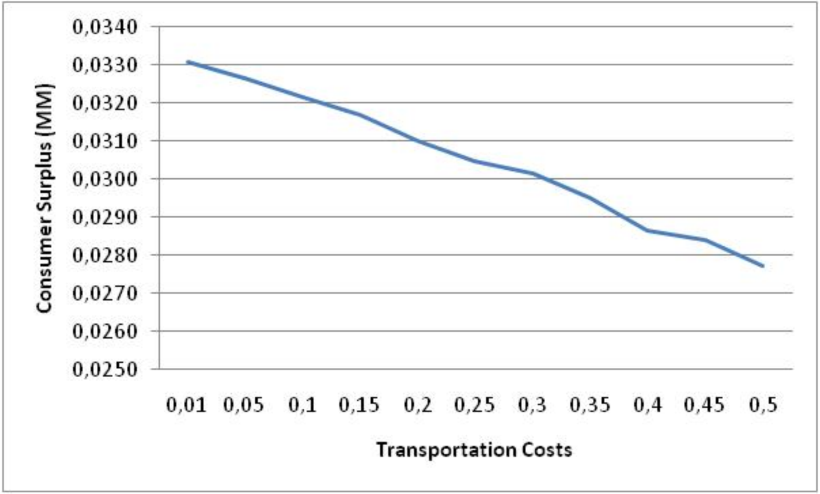

Figure: Consumer Surplus as a Function of Transportation Costs.

Conclusion

- This paper provides a new approach to deal with interconnections problems in the presence of heterogeneous customers. Heterogeneity here is the result of a social structure, and this structure affect final market. In the model, constraints at individual levels can be implemented.
- Equilibrium prices, consumer surplus and producer surplus depend on the connectivity parameter d, showing that social networks matter in the way how markets perform. For example, the higher the connectivity degree the more profitable is the collusive solution (not necesarilly more stable).
- In relation to the effectivity of different regulatory policies, our results showed that a policy intervention oriented to reduce switching costs is more effective than access charge regulation. In this line, policies such as number portability appear as highly desirable in telecommunication markets.