Düsseldorf Institute
for Competition Economics

DISCUSSION PAPER

No 52

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May 2012

HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

IMPRINT

DICE DISCUSSION PAPER

Published by
Heinrich-Heine-Universität Düsseldorf, Department of Economics, Düsseldorf Institute for Competition Economics (DICE), Universitätsstraße 1, 40225 Düsseldorf, Germany

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ISSN 2190-9938 (online) – ISBN 978-3-86304-051-2

How Regulation Affects Network and Service Quality in Related Markets*

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May 2012

Abstract

We analyze how network regulation affects investment into network infrastructure and complementary services. While regulation negatively affcets investment incentives in the regulated network market, the effects of network regulation on investment in complementary services can be either negative or positive, depending on the relative weight consumers assign to infrastructure versus service quality. We also find constellations, where regulation can enhance perceived total quality.

JEL Classification: D43, L13, L51, L96.

*We gratefully acknowledge comments received at the University of Marburg, Carnegie Mellon Portugal in Lisbon, the ITS Conferences in Montreal and Manama, the EEA Conference in Barcelona, and the EARIE Conference in Ljubljana. Part of this research was conducted while Gordon J. Klein worked at the ZEW, Mannheim.

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1 Introduction

How to regulate access prices in network industries has been one of the major issues of debate both in academic circles and among policy makers and regulators over the last 10 to 20 years. While the literature has initially focused on pricing issues in a static context (see, e.g., Armstrong, 2002; Laffont and Tirole, 1998), more recent contributions have analyzed the relationship between access regulation and investment (see, for example, Gans and King, 2004; Foros, 2004; Kotakorpi, 2006; Vareda, 2007).[1] Much of this literature concludes that stricter access price regulation usually has a negative impact on infrastructure investment, even though Vareda (2007) shows that the negative relationship between access price level and infrastructure investment only holds for quality enhancing investments, but not necessarily for cost-reducing investment. Common to most of these papers, however, is their shared focus on the incumbent's investments to replace or to extend the own network. Hence, the emphasis is on the investment incentives faced by existing infrastructure owners.

In contrast, a second stream of literature has focused on the entrants' investment incentives. In this literature it is often argued that tighter access regulation initially encourages competitors to invest into complementary infrastructure which they can later use to build alternative networks in order to bypass the incumbent's bottlenecks. This so-called "ladder of investment" idea has gained support and popularity among regulators and policy makers, particularly in telecommunications markets (see Cave & Vogelsang, 2003; Cave, 2006). While the "ladder of investment" idea highlights the importance of complementary infrastructure, it ultimatively also focuses on network substitution and infrastructure competition.

Our paper focuses on a third type of investment, namely investment into the quality of strictly complementary goods or services. To be more precise, we analyze the relationship between access regulation and investment incentives into both network and service quality if network usage and service provision are in a strictly complementary relationship to each other. Hence, in contrast to the "ladder of investment" perspective we analyze strictly complementary services which cannot substitute the original infrastructure but rather have to rely on access to this infrastructure.

An important example may be the (potential) regulation of broadband access markets, which also affects investment incentives for firms providing Internet services. Similarly, in railway markets the investment incentives for train operating companies (into rolling stock and services) are also influenced by the regulation of access to the rail network (i.e., the tracks, stations, traction power, etc.). The same holds for airlines whose investment incentives are at least

[1] For an overview also see Vogelsang (2003), Guthrie (2006) and the contributions in Dewenter & Haucap (2006).

partially determined by airport regulation (slot allocation, landing fees, etc.) or for ports, where shipping companies have to purchase complementary pilotage, towage and discharging services and also pay dock dues. Maybe most importantly, the relation between network charges and incentives to invest into complementary services is increasingly receiving attention in the debate over net neutrality regulations of the Internet (see, e.g., Schuett, 2010).

Our analysis considers the complementarity between infrastructure investments and service quality and also accounts for potential differences regarding consumers' valuation of network and service quality. The latter is motivated by the observation that both the quality of the network and the quality of the consumed services are typically important for consumers, but not necessarily to the same extent. One example is broadband Internet access and Internet services (e.g., video streaming). The download speed for a particular service usually depends on both investment into network capacity/quality *and* investment into data compression techniques, the number of download servers and the like so that, from a consumer perspective, the perceived total quality depends on investment levels into both network *and* service quality which are complementary to each other. Given this constellation, the benefit from an increase in network quality may be below or above the utility of improved Internet service quality (such as better data compression for video download/streaming).

As we will show, in this context network price regulation clearly has a negative effect on the network operator's incentives to invest into network quality, but this may be more than compensated by an increase in investment incentives for providers of complementary services. However, we also show that tighter price regulation may not only reduce incentives to invest into network infrastructure, but investment incentives for complementary service providers may also *decrease* in the regulated network price. Put differently, higher access prices may not only increase investment incentives for network operators, but also for firms that provide complementary services. This finding contrasts the conventional wisdom among regulators that tighter network price regulation stimulates investment into complementary services. We show that either can be true, depending on (a) the relative cost of investment into network vis-à-vis service quality and (b) the relative importance of network versus service quality for consumers. Moreover, our paper demonstrates that a regulatory focus on how regulation affects incentives to invest into network infrastructure by either incumbent or entrant operators can be far too narrow if investment into the quality of complementary services is also important.

2 Model Setup

Consider a natural monopoly upstream network N which is used to provide complementary downstream services S, which are offered by two firms $(S1, S2)$ who compete in Betrand fashion, offering differentiated services. The natural monopoly network is assumed to be regulated, and we analyze how changes in the regulated network charge p_N^R affect all three firms' decisions to invest into quality q_i $(i = N, S1, S2)$ as well as downstream firms' prices p_i $(i = S1, S2)$. We take the network charge (p_N^R) as exogenous. This appears sensible to us, as in many countries and most regulated industries the cost standard on which price regulation is based (such as long-run incremental cost) is enshrined in law and can only be changed by an act of parliament. Given the regulated network charge, all firms choose their quality q_i before the two downstream firms set their prices p_{S1} and p_{S2}. This sequence of moves reflects the idea that prices are typically easier to change than investments into quality or, put differently, quality decisions are rather long-term decisions while pricing decisions can be adjusted more quickly. Firms are assumed to maximize their profit:

$$\pi_i = p_i x_i - \frac{1}{2} k_i q_i^2 \tag{1}$$

for $i = N,\ S1,\ S2$.

The profit function consists of prices p_i $(i = N, S1, S2)$ multiplied by quantities x_i, less the investment costs comprising the increase in quality q_i given the quadratic investment costs $\frac{1}{2}k_i q_i^2$.[2] To reduce complexity we assume that there is no variable cost of production.

Consumers are assumed to jointly consume N and S. A variation of the representative consumer model gives the following demand[3]:

$$p_{S_j} = a_S + q_{S_j} + \gamma q_N - p_N - x_{S_j} - b x_{S_{-j}} \tag{2}$$

with $j = 1, 2$. Note that due to the complementarity between N and S demand for N is given as $x_N = x_{S1} + x_{S2}$. Note that the utility of minimum quality is given as $a_S > 0$ so that $q_{N,S1,S2}$ denote quality upgrades above the minimum quality level. The substitutability of the two downstream firms' services is reflected in b which, therefore, also determines the intensity of competition. The factor $\gamma \geq 0$ reflects the relative importance consumers assign to network quality compared to service quality. That is, we assume that in the eyes of consumers total quality is given by $q_{S_j} + \gamma q_N$, where a lower γ indicates less importance of network quality compared to the services' quality and vice versa. Prices $p_{S1,S2}$ and p_N^R affect demand negatively.

[2] This requires $k_i \geq 1/2$ (Assumption 1) to ensure investment levels are non-negative.

[3] The underlying utility function is: $U = (a_S + q_{S1} + \gamma q_A)x_{S1} + (a_S + q_{S2} + \gamma q_A)x_{S2} - (p_A + p_{S1})(x_{S1}) - (x_{S2})(p_A + p_{S2}) - \frac{1}{2}(x_{S1}^2 + 2b x_{S1} x_{S2} + x_{S2}^2)$; For a general description see, e.g., Vives 2001, pp. 144-148.

We now solve the game deriving Subgame Perfect Nash Equilibria and concentrate on a comparative static analysis of variations in p_N^R, as we consider this comparison to be most relevant for regulatory policy purposes. This is because (a) regulators are unlikely to pursue the objective of welfare maximization in reality and (b) even if they would, regulators usually lack the information and/or power to implement first-best prices. Hence, we focus on a comparative analysis of network price changes rather than on the calculation of first-best network charges.

3 Comparative Static Analysis

First, given an exogenously regulated network charge p_N^R, downstream price competition yields[4]:

$$p_{S_j}(\ q_N, q_{S_j}, q_{S_{-j}}, p_N^R) = \frac{\Lambda(2 - b(1+b))}{4 - b^2} \tag{3}$$

with $\Lambda = a_S + q_{S_j} + \gamma q_N - p_N^R$ for $j = 1, 2$.

Anticipating these prices, profit maximizing quality levels as a function of p_N^R are given as:

$$q_N(p_N^R) = \frac{2}{(2-b)(1+b)} \frac{\gamma}{k_N} p_N^R \tag{4}$$

$$q_{S_j}(\ p_N^R) = \frac{2}{\lambda} \left(\underbrace{a_S - p_N^R}_{\text{direct effect}} + \underbrace{\frac{2\gamma^2}{k_N(2-b)(1+b)} p_N^R}_{\text{indirect effect}} \right) (2 - b^2) \tag{5}$$

for $j = 1, 2$ with $\lambda = \big(8k_S + 4bk_S + 2b^2 - 6b^2 k_S - b^3 k_S + b^4 k_S - 4\big) > 0$ (Assumption 2).

The network operator's investment is always negatively affected by stricter regulation of network charges (equation 4), but the magnitude depends on the intensity of competition in services (as measured by b) in a U-shaped curve. Not surprisingly, the overall investment is smaller the more costly investments are (as measured by k_i).

How a change in p_N^R affects q_s is less obvious, as the sign of the derivative of $\partial q_s / \partial p_N^R$ is ambiguous. First, note that the sign of the nominator determines the sign of the derivative $\partial q_{S_j} / \partial p_N^R$ given Assumption 2. Secondly, as equation 5 shows, changes of p_N^R affect q_{S1} and q_{S2} through a *direct* and an *indirect* effect. On the one hand, p_N^R directly decreases the (residual)

[4] To ensure better readability, we assume symmetry of the competing downstream firms and present equilibrium values with $q_{S1} = q_{S2}$.

demand for services as given by 2 and, therefore, higher network charges negatively affect incentives to invest into service qualities. An increase in the access price p_A^R by an amount ϵ reduces consumers' willingness-to-pay for the complementary services exactly by that amount ϵ, i.e., by a factor of 1. Hence, a higher network charge decreases consumers' willingness-to-pay for services and, thereby, leads to a reduction of investment into service quality. On the other hand, there is a countervailing *indirect* effect: An increase in p_N^R also leads to an increase in network quality by a factor of $2\gamma/[k_N(2-b)(1+b)]$ as can be seen from equation (4). Any increase in network quality in turn also shifts out the demand for x_S by a factor of γ as the demand equation (2) reveals, so that the *indirect* effect of an increase in p_N^R is to raise consumers' willingness-to-pay by a factor of $2\gamma^2/[k_N(2-b)(1+b)]$, due to the resulting increase in q_N. Hence, the total effect that a change in p_N^R has on q_S depends on the size of γ and k_N. Put differently, the sign of the derivative $\partial q_S/\partial p_N^R$ is determined by the sign of $(2\gamma^2/[k_N(2-b)(1+b)]-1)$. If network quality is sufficiently important for consumers (as measured through γ) and/or if network upgrades are sufficiently inexpensive (as measured through k_N), network price regulation (a lower p_N^R) leads to lower network quality, q_N and also to a lower quality of complementary services. If, however, service quality is more important for consumers (and γ relatively small) and/or if network upgrades are sufficiently expensive (as measured through k_N), network price regulation (a lower p_N^R) leads to a higher quality of complementary services even though stricter regulation still induces a lower network quality, q_N.These findings are summarized in the following propositions:

Proposition 1. *Network price deregulation (i.e., a higher p_N^R) unambiguously leads to higher network quality and also to higher quality of related services if $\frac{2\gamma^2}{k_N(2-b)(1+b)}$ is sufficiently large.*

Proposition 2. *If the regulator strengthens price regulation for network charges (i.e., a lower p_N^R), network quality will decrease, but the quality level in the unregulated market for complementary services increases if $\frac{2\gamma^2}{k_N(2-b)(1+b)}$ is sufficiently small.*

Given the second proposition, we analyze the impact of regulation on the perceived total quality. To determine the perceived total quality, we ask how consumers' willingness-to-pay for x_S is affected. Put differently, we use a concept of perceived quality which is derived from the consumers' utility function and define total quality as:

$$Q_{Total} = \gamma q_N + \frac{x_{S1}}{(x_{S1}+x_{S2})} q_{S1} + \frac{x_{S2}}{(x_{S1}+x_{S2})} q_{S2}. \tag{6}$$

The derivative of the so-defined total quality, Q_{Total}, with respect to p_N^R is given by:

$$\frac{\partial Q_{Total}}{\partial p_N^R} = \frac{\gamma^2(4-b^2)k_S}{(2-b^2)k_A} - 1. \tag{7}$$

The more important network quality is (as measured by γ), the less likely it is that softer regulation of network charges has a positive impact on the overall perceived quality. The opposite is true for the cost of investment into network quality, k_A. This can be summarized in the following proposition:

Proposition 3. *Stricter regulation of network charges (i.e., a lower p_N^R) always leads to a decrease in network quality (q_N), but service quality (q_{S_j}) increases and overcompensates the loss in network quality so that the perceived total quality (Q_{Total}) increases iff $\gamma^2 \frac{k_S}{k_N}$ is sufficiently small.*

4 Conclusions

We have analyzed how network regulation affects investment into both a natural monopoly network infrastructure and complementary services provided by two firms competing in a differentiated Bertrand market. While stricter regulation of network charges negatively affects investment incentives for the regulated network operator, the effects on investment into complementary services can be either negative or positive, depending on the relative weight consumers assign to infrastructure vis-à-vis service quality. In fact, while stricter network price regulation always reduces the quality of the network infrastructure, it can still increase the perceived total quality if service quality is sufficiently important for consumers. From a policy perspective it may be interesting to note that a regulatory focus on how regulation affects incentives to invest into network infrastructure by either incumbent or entrant operators is too narrow if investment into the quality of complementary services is also important for consumers.

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ISSN 2190-9938 (online)
ISBN 978-3-86304-051-2