

**On Competition and Regulation in Media and
Telecommunications Markets:
Four Essays in Industrial Organization**

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Preface

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Chapter 1

Introduction

This thesis analyzes various recent competition and regulation issues in media and telecommunications markets. In both markets, the European Commission recently defined new rules for regulation. In media markets, the “Audiovisual Media Services Directive” has been codified in March 2010. Among others, this directive regulates television advertising time and content. For telecommunications markets, the European Commission defined new obligations, e.g. regulation of wholesale and resale prices, for voice, text message, and data services. In its “Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU” it sets out its view of how national regulators should regulate termination rates of telecommunications operators in the future. In July 2010 it has set new price caps for roaming services between providers. These directives and proposals of the European Commission are subject of the present thesis. How regulatory intervention affects competition and welfare is analyzed with the help of microeconomic models for both markets. The markets are analyzed in two parts.

Part I deals with effects of advertising and advertising time regulation on viewers, broadcasters, and advertisers in television markets. The Audiovisual Media Services Directive allows broadcasters to air a maximum amount of 12 minutes of advertising per hour and 9 minutes per hour on average per day. Regulation of advertising time has adverse impacts on concerned market participants. Typically, advertisers are interested in placing their adverts on channels with many viewers. Contrary, to viewers, advertisement is often a nuisance as it interrupts and dis-

turbs the content. They are interested in media with few adverts. Consequently, a broadcaster has to optimally balance both effects and try to get the two sides of the market “on board” by appropriately charging each side. Hence, broadcasters serve as a classical example for a so called “two-sided market”. Two-sided markets are roughly defined as markets in which one or several platforms enable interactions between end-users. Conceptually, the theory of two-sided markets is related to the theory of network externalities (Farrell and Saloner (1985) and Katz and Shapiro (1985)). This literature states that there are externalities among end-users, which are usually not properly internalized by them. This theory has largely neglected price structure issues, which is now a major focus of the the two-sided market literature. The ad avoidance of viewers serves as a starting point for two analytical models. The first model explicitly analyzes the effect of viewers’ opportunities to avoid advertising messages on viewers, broadcasters, and advertisers in the distinct pricing regimes of free-to-air and pay-TV broadcasting. The second model additionally introduces public service broadcasting and explores the effect of restricting advertising time on the different interest groups in broadcasting markets.

Chapter 2, entitled **Getting Beer During Commercials: Adverse Effects of Ad Avoidance**¹ and coauthored with Tobias Wenzel deals with the effects of ad avoidance behavior in broadcasting markets. Viewers always had the opportunity to avoid advertising messages, simply by leaving the room or using the remote control. With digitalization of contents, however, it is even more comfortable to avoid advertising than in times of analogue television, e.g. by means of digital video recorders or TiVo. These technology advances enable the viewers to unbundle the content from the advertising messages and allow them to bypass advertising messages completely. Since viewers can avoid traditional advertising spots, advertisers face difficulties to reach viewers, and, in turn, are willing to pay less for placing their messages. Ad avoidance behavior is widely neglected in the literature on media economics. In most theoretical models viewers have the option to watch either channel, depending on their preferences and on the amount of advertising. The present chapter introduces a demand function for television. Viewers do not only decide which channel to watch, but additionally, decide on the time they spend watching and may turn off the TV completely. The model ex-

¹This chapter is published as Stühmeier and Wenzel (2011) in a slightly different version.

plores the effects of ad avoidance opportunities in two different financing regimes of free-to-air and pay-TV television. It can be shown that pay-TV broadcasters are generally less strongly affected by ad-avoidance opportunities.

Chapter 3, entitled **Regulating Advertising in the Presence of Public Service Broadcasting** and coauthored with Tobias Wenzel introduces another common financing regime of broadcasting: Public service broadcasting. Typically, commercial and public service broadcasters (PSB) coexist and compete for viewers and advertisers but are financed in different ways. PSB channels are financed by license fees or from the General Government budget, whereas commercial channels have to finance themselves by advertising income or directly by charging viewers. However, these business models may be undermined by viewers' ad avoidance, which chapter 2 highlights. The Audiovisual Media Services Directive regulates advertising time on broadcasting channels in Europe. Member states usually impose stricter regulation for their public service broadcasting channels, e.g. in the UK the BBC may not air any advertising, in Germany ARD and ZDF must not air advertising after 8 p.m., and in France advertising is sequentially removed from public service broadcasting channels until 2011. In Germany and Spain, politicians also intend to ban advertising from PSB channels altogether to reduce the dependency on the advertising industry. The discussion whether to restrict advertising on PSB channels is largely based on a political, but not always on an economic basis. In light of the two-sided market literature, the economic effects of regulation of advertising levels are yet unclear. This chapter focuses on the economic consequences of regulation of advertising time on PSB and free-to-air channels. It analyzes whether commercial broadcasters benefit when the public service competitor is subject to regulation and whether regulation is necessarily detrimental to the public service broadcaster. Typically, the media economic literature considers competition among broadcasters in the viewer market but not in the advertising market. This chapter incorporates competition in both markets. It turns out that broadcasters can benefit or suffer from regulation of advertising time, depending on the magnitude of positive and negative effects of regulation in the viewer and the advertising market.

Part II of the thesis addresses regulation of interconnection and roaming terms in telecommunications markets. The liberalization of telecommunications mar-

kets in Europe in the 1990s led to market entry of new providers. Given various instruments of wholesale regulation, authorities already opened to market for entry and competition in the formerly monopolized market of fixed-line telephony and in the mobile telecommunications market. However, there are still open questions concerning regulation of interconnection terms between networks. Customers subscribe to different services and providers, but they want to call any recipient, independent of the networks. A call originated in a network may be either terminated in the same network (on-net) or in another network (off-net). If it is terminated off-net, the providers have to agree on, or are regulated to, the terms of interconnection. The European Commission has issued a new “Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU” in May 2009, where it sets out its view of how national regulators should regulate termination rates in the future. Especially when traveling abroad, voice, text message, and data services are delivered by a foreign network operator, which charges the home operator for the service. International roaming charges are assessed by the European Commission and are sequentially reduced during the next years. Two chapters analyze the effect of different regulatory regimes on competition with two relatively new services: Telephony based on the Internet protocol, labeled as Voice over IP (VoIP) and the mobile Internet, which have not been in the focus of the economic literature. It turns out that VoIP and mobile Internet services may be differently affected by regulation of termination and roaming charges than traditional fixed-line and mobile telecommunications services.

Chapter 4, entitled **Fixed to VoIP Interconnection: Regulation with Asymmetric Termination Costs**, analyzes competition between telecommunications providers which differ in the size of their subscriber base and in the cost for terminating calls. This especially holds for competition between traditional fixed-line and VoIP providers. The VoIP adoption of households is steadily increasing throughout the last years. In the US it increased from 28 % in 2008 to expected 50 % in 2010. The same holds for Germany, where the share of calls placed on IP networks increased by 10 % in 2006 to 34 % in 2009, whereas the share of calls placed on fixed-line is accordingly decreasing. Interconnection between both kinds of services opens new questions for regulation of interconnection terms, since the services exhibit two kinds of asymmetries: A demand-side

asymmetry in market shares and a supply-side asymmetry in termination costs. Termination costs in electronic networks are significantly lower than in fixed-line networks. This supply-side asymmetry has hardly been addressed in the literature. It is an open question whether the proposed terms of regulation by the European Commission optimally account for the asymmetries between telecommunications providers. Chapter 4 explores the effects of a deviation from the proposed regimes of cost-based and reciprocal regulation of termination rates. For both regimes, the literature on asymmetric network competition concluded that a deviation from the regimes leaves providers' market shares locally unaffected. In terms of profits, the provider who is allowed to charge a markup on termination costs benefits and the rival suffers. However, by introducing a supply-side asymmetry, the chapter shows that this may no longer hold. An asymmetry in termination costs leads to adverse effects of different regulatory regimes for subscribers and providers. A markup on termination costs may even be to the detriment of the respective provider's profit and both providers may prefer termination charges to be regulated to costs.

Finally, in Chapter 5, entitled **Roaming and Investments in the Mobile Internet Market**, both the media and the telecommunications market converge. New kinds of mobile phones, so called smartphones like the Apple iPhone, do not only offer the service of mobile communications but allow access to the Internet and media content while being mobile. There is a growing demand for these third generation (3G) services. The growth rates in term of revenues from mobile data traffic in 2010 compared to 2009 vary from 8.1 % in Germany, 16.7 % in France to 25.3 % in the US. Mobile network operators (MNOs) have to meet the growing demand for data services by investing in their network infrastructure since mobile data traffic occupies significantly larger resources than pure voice telephony. Network operators already responded to capacity constraints by agreeing on reciprocal roaming, i.e. by sharing their network facilities. This induces externalities of investments (investment spillovers) as both fellow and rival subscribers benefit from a better network infrastructure when roaming in the rival network. The chapter analyzes how to optimally enhance investment levels. Explicitly, it addresses the issue of whether or not to allow networks to collaborate on the investment level and if and how a regulator can enhance investments, and in effect welfare, by properly regulating roaming charges. It can be shown

that semi-collusion over investment levels can be welfare enhancing. Moreover, roaming charges below and above costs can enhance mobile network operators' investment levels and accordingly increase welfare.

Part I

Media Markets

Chapter 2

Getting Beer During Commercials: Adverse Effects of Ad-Avoidance*

2.1 Introduction

Media markets are frequently modeled as two-sided markets. In the TV market, broadcasters act as platforms and serve two types of customers: advertisers and viewers. Typically, advertisers are interested in placing their adverts in media platforms with many viewers; that is, there is a positive network externality from viewers on advertisers. Contrary to viewers - who want to enjoy media content - advertisement is often a nuisance. Viewers are interested in media with few commercials. Thus, the externality from advertisers on viewers is negative.¹

If advertising is a nuisance to viewers, viewers may avoid advertising messages placed on the platform. As documented, for instance, in Wilbur (2008), there are many ways for viewers to avoid advertisements: for example, change the channel, divert attention to other things, leave the room and get a beer, mute or turn off the TV, fast-forward through recorded programs, or make use of ad-avoidance technologies such as TiVo. In addition, if the number of adverts is too large, viewers may switch off completely or reduce the amount of TV consump-

*This chapter is published as Stühmeier and Wenzel (2011) in a slightly different version.

¹Advertising may not always be perceived as a nuisance. There is empirical evidence that magazine readers may value advertising positively, see, e.g., Kaiser and Wright (2006) and Kaiser and Song (2009).

tion. Wilbur et al. (2009) show that a 10 % increase in advertising time reduces the audience size by 15 %. As media markets are two-sided markets, this avoidance behavior by viewers has immediate, adverse consequences on the other side of the market, the advertising industry: placing an ad with a media platform has a much lower value for advertisers if viewers avoid this advert. This, in turn, has consequences for the media platform when deciding about pricing its media product to viewers and advertisers.

Since the opportunities to reach viewers via classical advertising spots are reduced, broadcasters and the advertising industry have to find new ways to get advertising messages delivered to viewers. Broadcasters increasingly use the instrument of placing products in its content to account for viewers' avoidance of traditional advertising breaks. Wilbur et al. (2009) find empirical evidence that broadcasters in the US have responded to ad-avoidance technologies such as TiVo and digital video recorders by increasing product placements in their shows by about 40 % during the years 2005 to 2008. The same can be expected for Europe, where the European Commission recently defined rules on product placements in the new "Audiovisual Media Services Directive"² in March 2010. Until 2010 product placement where subject to several restrictions. However, this new directive defines several exceptions, so product placements are generally allowed on commercial broadcasters. The effect on broadcasters and viewers is still debated. Balasubramanian et al. (2006) review the behavioral literature on product placement which shows difficulties of reproducing significant effects of product placement on consumers in laboratory settings. This seems to be in line with Ephron (2003) who states a conjecture about product placement: "If you notice, it's bad. But if you don't, it's worthless". Our model contributes to this discussion and analyzes the effect of bypassing opportunities on broadcasters' profit in a free-to-air and pay-TV regime.

To study the issues raised above we develop a two-sided market model of the broadcasting industry where broadcasters compete for viewers and advertisers. We follow Anderson and Coate (2005) and Peitz and Valletti (2008) in considering broadcasters which are horizontally differentiated à la Hotelling or Salop. In our base model, we consider two broadcasters and analyze the outcomes under free-

²See http://ec.europa.eu/avpolicy/reg/avms/index_en.htm.

to-air and under pay-TV. Later, we extend our model to an arbitrary number of broadcasters to analyze entry behavior. The main innovation of the model is to incorporate ad-avoidance behavior by viewers into the analysis, as empirically analyzed by Wilbur et al. (2009). We model this by specifying a function that maps the amount of advertising at a channel into consumers' avoidance behavior. In line with the above discussion, viewers' bypassing of commercials is the higher the more commercials are placed on a channel.

We find that the impact of ad-avoidance differs in the financing regime. In the free-to-air regime, if viewers can avoid commercials more easily, this may lead to an increase or decrease in the level of advertising. Revenues decrease unambiguously. In the pay-TV regime, the advertising level decreases. However, the loss in revenues from advertising can be compensated by an increase in revenues from subscription. In our model with fixed total viewership, total revenues in the pay-TV regime are independent of any ad-avoidance behavior. However, if we introduce elastic subscription, profits may decrease. This difference between free-to-air and pay-TV has also implications for the diversity in the TV market. An increase in ad-avoidance decreases the level of entry in the free-to-air regime, but has a smaller impact in a pay-TV market.

There is a large literature analyzing the broadcasting industry from a two-sided market perspective. Many papers are based on spatial models of product differentiation such as the Hotelling model, see, for instance, the contributions by Gabszewicz et al. (2004), Anderson and Coate (2005), Choi (2006), Armstrong and Weeds (2007a), Peitz and Valletti (2008), Crampes et al. (2009) or Reisinger et al. (2009). In these models, advertising typically affects viewers adversely, but the viewers' only possible reaction to high advertising levels is to switch among channels. In contrast, in this chapter, we introduce another way by which viewers can react to advertising as we allow viewers to avoid commercials.

There are several recent papers that analyze ad-avoidance behavior. Closest to our model is the contribution by Anderson and Gans (2011). who study a specific consumer reaction to high advertising levels. In their paper, viewers can bypass advertisement by investing into an ad-avoidance technology such as TiVo. Viewers are heterogenous in their disutility from advertising. Compared to the case of no ad-avoidance technology the adoption of such a technology leads to

higher advertising levels. The reason is that only viewers with lower disutility from advertising remain without the ad-avoidance technology leading broadcasters to increase advertising levels. Our base model differs in two aspects: i) our model introduces a demand function which captures various sorts of advertising avoidance behavior, and ii) our focus lies on competition between duopolists while Anderson and Gans (2011) consider a monopolistic broadcaster.³ We provide two alternative extensions of the base model, where we discuss channels' entry decisions and the effects of elastic subscription for television.

Related are also papers that compare business models where firms can offer a version of a product with and without advertisement. Offering a version without adverts may serve as a price discrimination device to separate consumers with low and high nuisance to advertising. These issues are analyzed by Prasad et al. (2003) and Tag (2009).

The chapter proceeds as follows. Section 2.2 sets up the base model with two broadcasters. In Section 2.3 we study free-to-air broadcasting while in Section 2.4 we turn to pay-TV. Section 2.5 provides two extensions of the base model, where we consider market entry and the effects of elastic subscription. Finally, Section 2.6 concludes.

2.2 The Base Model

This section describes our model setup.

2.2.1 TV Stations

In our base model, there are two TV stations, called A and B , competing for viewers and advertisers.⁴ These two stations offer differentiated content, thus, following Anderson and Coate (2005), we assume the stations to be located at

³In an extension, Anderson and Gans (2011) consider a free-to-air duopoly version of their model.

⁴In Section 2.5.1, we will extend the setup to an arbitrary number of stations using the Salop formulation in order to study entry decisions.

opposite ends of a unit Hotelling line.⁵

We compare two distinct financing regimes: free-to-air and pay-TV. In the free-to-air regime, TV stations cannot charge viewers directly. Revenues from advertising are the only source of income. In the pay-TV regime, TV stations are able to additionally charge viewers directly for TV consumption. In this case, stations have two sources of income: subscription fees and advertising revenues.

2.2.2 Viewers

Advertising annoys viewers who may avoid advertising. To formalize this, we assume that there exists a function $q(a, k)$ which maps the amount of advertising at a channel (a) into a demand for TV consumption.⁶ This function is identical for all consumers.⁷ In line with our previous discussion $\frac{dq(a, k)}{da} < 0$, that is, the higher the advertising level on the channel the less attention is paid to adverts. Hence, advertising levels have the same impact on viewers' demand for TV consumption as prices in other product markets. The parameter k is a shift parameter in the demand for TV consumption with $\frac{dq(a, k)}{dk} < 0$ and $\frac{d^2q(a, k)}{dadk} \leq 0$. The parameter k can be interpreted as viewers' responsiveness to advertising, where higher values of k lead viewers to switch off more quickly.

Denote the absolute value of the avoidance elasticity with respect to advertising as

$$\epsilon = -\frac{dq(a, k)}{da} \frac{a}{q(a, k)}. \quad (2.1)$$

We now introduce the following assumption:

Assumption 2.1. *The absolute value of the advertising elasticity ϵ is strictly increasing in $a \in (0, \hat{a})$ and $\lim_{a \rightarrow \hat{a}} \epsilon(a) \geq 1$,*

⁵Peitz and Valletti (2008) study the broadcasters' incentives to offer differentiated content in pay-TV and free-to-air regimes.

⁶Technically, we follow Gu and Wenzel (2009a) and Gu and Wenzel (2009b) who introduce a price-dependent demand function into the Salop model.

⁷In this aspect, our model differs from Anderson and Gans (2011) who assume that viewers differ in their intensity of advertising nuisance. Note, however, that the function $q(a, k)$ could be interpreted as the result of aggregating over a mass of heterogenous viewers.

where $\hat{a}$ denotes the level of advertising that reduces the demand for TV consumption to zero, thus $q(\hat{a}, k) = 0$. This assumption is needed to ensure equilibrium existence. Note that our setup so far implies that $\frac{d\epsilon}{dk} > 0$.

As an example, assumption 1 is satisfied if advertising has a linear influence on the demand for TV consumption, e.g. $q(a, k) = A - B \cdot a \cdot k$, where both A and B are suitable positive constants.

Such a demand function for TV consumption can be derived as follows: Suppose viewers can divide their time between two activities, TV consumption (q) and all other leisure activities (d). Utility is given by: $U = u(q, k) + d$, where $u(q, k)$ gives the utility from TV consumption and all other activities enter linearly. Now assume that advertising annoys consumers, that is, it imposes a psychic cost on viewers. Optimization then leads to the demand function $q(a, k)$ for TV consumption. The associated indirect utility to this demand is given by $V(a, k)$. Under the assumption of quasi-linearity, indirect utility can be written as:

$$V(a, k) = \int_a^{\hat{a}} q(a, k) da. \quad (2.2)$$

Viewers have preferences about the content of the two channels and are located uniformly along the Hotelling-line. The position on the line is given by x . There are linear transportation costs at a rate t . The transportation cost parameter t can be interpreted as a measure for the competition. The indirect utility for a viewer, located at x , is then:

$$U = \begin{cases} \int_{a_A}^{\hat{a}} q(a, k) da - tx - s_A & \text{if choosing channel A} \\ \int_{a_B}^{\hat{a}} q(a, k) da - t(1 - x) - s_B & \text{if choosing channel B,} \end{cases} \quad (2.3)$$

where a_A (a_B) denotes the level of advertising at channel A (B) and s_A (s_B) denotes the subscription price at channel A (B). The marginal viewer ($\bar{x}$), who is indifferent between choosing station A or B, is then characterized by

$$\int_{a_A}^{\hat{a}} q(a, k) da - t\bar{x} - s_A = \int_{a_B}^{\hat{a}} q(a, k) da - t(1 - \bar{x}) - s_B. \quad (2.4)$$

This can be reformulated as:

$$\bar{x} = \frac{1}{2} + \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da + \frac{s_B - s_A}{2t}. \quad (2.5)$$

Hence, the difference in advertising levels affects the market shares. That is, advertising levels can be regarded as hedonic prices and have the same effect as the subscription prices.

2.2.3 Demand for Advertising Space

The advertisers' demand for placing advertisement with a channel positively depends on the number of viewers watching this channel. However, the advertisers' willingness to pay is reduced when viewers avoid advertising. We assume the following per-viewer revenue function:

$$\Omega(a) = [R \cdot q(a, k)] \cdot a. \quad (2.6)$$

A channel's advertising revenue depends on the number of spots (a) and the viewers' demand ($q(a, k)$). When viewers avoid advertisements the advertisers' value of a spot is reduced. We capture this by assuming that advertisers pay an amount of $R \cdot q(a, k)$ per customer for each spot. This price per spot depends on the demand for TV consumption. If $q(a, k)$ is high and the viewers pay attention to advertisement messages, TV channels receive a high price per spot. If, on the other hand, the viewers avoid advertisements ($q(a, k)$ is low), TV channels receive a low price per spot. The parameter R can be interpreted as the price for actual or effective ad consumption per spot and per viewer.⁸

The assumed revenue function can be derived as follows. Suppose there is a unit mass of homogenous advertisers. Each of them makes a revenue of R whenever a viewer happens to receive its advertisement message. The broadcasters hold monopoly power over access to their viewers, that means, in the terminol-

⁸Here we follow Gabszewicz et al. (2004) and Mangani (2003) who assume that TV channels receive a fixed price per ad. This might be motivated by the assumption that the channels are too small to influence the overall advertising market. Anderson and Coate (2005), Peitz and Valletti (2008), and Armstrong and Weeds (2007b) assume that the advertising revenues are a concave function in the number of adverts.

ogy of the two-sided market literature they act as a competitive bottleneck (see Armstrong (2006)). Thus, the advertisers can only sell their product to those viewers, who have seen the ad. Whether a viewer receives the ad depends on the ad-avoidance behavior. If q is large there is a high probability that the viewer watches the message. If, however, viewers avoid advertising, that is, q is small, there is a rather low chance that the viewer receives a certain advertising message. Assume that $\phi(q)$ with $\frac{d\phi}{dq} > 0$ measures the probability of watching an ad. For simplicity, we set $\phi(q) = q$. Hence, an advertiser's willingness to target a viewer is $R \cdot \phi(q)$. Assuming that advertisers are price-takers, this willingness to pay coincides with the advertising revenue per viewer, and hence $\Omega(a) = [R \cdot q(a, k)] \cdot a$.

2.3 Free-to-air-TV

We start our analysis with the free-to-air regime. In the free-to-air regime, there are no subscription fees and the TV channels' only source of income is the advertising revenue. Hence, $s_A = s_B = 0$. The marginal consumer can then be expressed as:

$$\bar{x} = \frac{1}{2} + \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da. \quad (2.7)$$

The revenues of the TV channels are:

$$\Pi_A = \left[\frac{1}{2} + \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da \right] R \cdot q(a_A, k) \cdot a_A, \quad (2.8)$$

and

$$\Pi_B = \left[\frac{1}{2} - \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da \right] R \cdot q(a_B, k) \cdot a_B, \quad (2.9)$$

where we abstract from any fixed and variable costs.

The first-order condition of a symmetric equilibrium with respect to the optimal level of advertising is given by:

$$\frac{1}{2} q(a, k) R - \frac{1}{2t} [q(a, k)]^2 a R + \frac{1}{2} \frac{dq(a, q)}{da} a R = 0 \quad (2.10)$$

An increase in the level of advertising has three effects on revenues. First, it

increases advertising revenues for a given number of viewers and for a given level of ad-avoidance (first term in equation (2.10)). However, additionally advertising has adverse consequences for revenues. An increase in advertising on one channel leads to a loss in the market share of this channel as well as to a lower demand for TV consumption. The second term measures the loss in market share while the third term reflects the decrease in demand of TV consumption. Note, that this third effect is not present in models without endogenous ad-avoidance behavior.

Our equilibrium condition can be rewritten as:

$$t[1 - \epsilon(a^*, k)] = q(a^*, k)a^*, \quad (2.11)$$

where $\epsilon(a^*, k) = -\frac{dq(a,k)}{da} \frac{a}{q(a,k)}|_{a=a^*}$ denotes the individual elasticity of advertising evaluated at the equilibrium level of advertising. Note that in equilibrium the demand elasticity ($\epsilon(a^*, k)$) is smaller than one.⁹

We can now study the properties of the equilibrium. We are particularly interested in the impact of a higher responsiveness of viewers to advertising on the equilibrium level of advertising. Total differentiation of equation (2.11) with respect to k yields:

Proposition 2.1. *In the free-to-air regime, an increasing responsiveness to advertising, as measured by k , has an ambiguous effect on equilibrium advertising. That is, $\frac{da^*}{dk} \geq 0$.*

Proof. See Appendix 2.A. □

The reason is that an increase in k affects the factors that determine the equilibrium advertising level in different ways. To see this, divide equation (2.10) by $\frac{R \cdot q(a,k)}{2}$ to obtain:

$$1 - \frac{1}{t}aq(a, k) - \epsilon = 0 \quad (2.12)$$

Equation (2.12) shows the relative importance of the three effects. Note first that an increase in k has no impact on the relative importance of the direct effect of an increase in a . The second effect, the loss in market share decreases

⁹The proof for the existence of a unique equilibrium is provided in the Appendix to this chapter.

in k , meaning that this raises the incentives to increase the level of advertising. Intuitively, when viewers avoid adverts anyway (k is high), a marginal increase of advertising does hardly affect the distribution of viewers. Otherwise, if k is low, broadcasters have stronger incentives to compete for an additional viewer by holding advertising at a low level. Thus, this effect is due to a decreased level of competition. Finally, the demand elasticity increases with k leading to a lower demand for TV consumption. This tends to reduce advertising. The overall effect is thus determined by the relative strength of the competition effect and the ad-avoidance effect. To demonstrate the possibility that an increase in k can both increase and decrease equilibrium advertising, suppose $q(a, k) = 1 - 0.1a - k$ and $t = 1$. We solve for equilibrium advertising numerically. The result is shown in Figure 2.1.

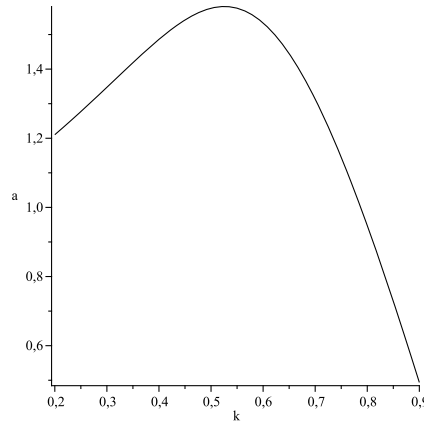


Figure 2.1: Equilibrium advertising in the free-to-air regime for $q(a, k) = 1 - 0.1a - k$ and $t = 1$.

Our results complement those from Anderson and Gans (2011). While in Anderson and Gans (2011) the introduction of TiVo increases equilibrium advertising unambiguously, in our model equilibrium advertising may increase or decrease. The reason in their model is that the viewers who adopt TiVo are those with a high nuisance to advertising. Thus, only those with low nuisance remain and in

consequence, advertising is high. We introduce a new effect which may lead to an decrease in advertising, namely the competition effect. Broadcasters compete on advertising levels to gain market shares from the rival.

Inserting the equilibrium advertising level into the revenue function we obtain the revenues earned by each of the two channels:

$$\Pi^* = \frac{1}{2}tR[1 - \epsilon(a^*, k)] \quad (2.13)$$

Proposition 2.2. *In the free-to-air regime, a higher responsiveness to advertising decreases broadcasters' equilibrium revenues.*

Proof. See Appendix 2.A. □

Since in equilibrium the demand elasticity $0 < \epsilon(a^*, k) < 1$ the revenue is lower than the standard Hotelling revenue with inelastic demand. The revenue approaches zero if demand for TV consumption is more elastic and turns to the standard Hotelling case if demand is more inelastic. This is due to the result that the revenue per viewer decreases with the demand elasticity and that the market share is constant at $\frac{1}{2}$ in equilibrium. Hence, competition in the viewer is tougher as viewers react stronger to advertising.

Thus, the opportunity to avoid advertising messages, measured by the demand function $q(a, k)$, unambiguously leads to lower profits in the free-to-air scenario. Consequently, advertisers and broadcasters have to find less obvious and nuisance advertising methods, such as product placements. The European Commission recently announced a new “Audiovisual Media Services Directive” in 2010, which among others defines conditions under which product placement is permitted. Generally, product placements are liberalized compared to previous legislation.¹⁰ Broadcasters may use the instrument of placing products in their content to account for viewers' avoidance of traditional advertising breaks. Broadcasters in the US have responded to ad-avoidance technologies such as TiVo and digital video recorders by increasing product placements in their shows by about 40 % during

¹⁰Article 11 (2) of the directive states that product placements are generally forbidden. It defines several exception, though. According to Article 11 (3,a) product placement shall be admissible in cinematographic works, films and series made for audiovisual media services, sports programmes and light entertainment programmes, which certainly includes much of the television content.

the years 2005 to 2008 (Wilbur et al. 2009). It is presumed that viewers are less able to avoid this instrument of advertising, as advertising becomes less obvious and thus harder to skip. Although, the effect of product placements on profits and viewers is yet unclear. Products are placed in the editorial content, so that viewers should not really be aware of the new kind of advertising and do not skip. However, if consumers are not aware of product placements, it is an open question, whether product placement is an effective method of advertising (Balasubramanian et al. 2006).

2.4 Pay-TV

In the pay-TV regime, TV channels have subscription fees as an additional source of income. Advertising is still possible. We allow for negative subscription prices, that is, subsidies to viewers. These subsidies might be program decoders the viewers are offered for free or at a lower charge.¹¹

The broadcasters' revenues are now given by:

$$\Pi_A = \left[\frac{1}{2} + \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da + \frac{s_B - s_A}{2t} \right] [R \cdot q(a_A, k) \cdot a_A + s_A], \quad (2.14)$$

and

$$\Pi_B = \left[\frac{1}{2} - \frac{1}{2t} \int_{a_A}^{a_B} q(a, k) da + \frac{s_A - s_B}{2t} \right] [R \cdot q(a_B, k) \cdot a_B + s_B]. \quad (2.15)$$

Solving for a symmetric equilibrium, we obtain the following conditions for a broadcaster's advertising level and subscription price:

$$R[1 - \epsilon(a^\#, k)] = 1, \quad (2.16)$$

and

$$s^\# = t - R \cdot q(a^\#, k) \cdot a^\#. \quad (2.17)$$

The first condition implicitly defines the level of advertising in equilibrium.

¹¹This is common in other markets, too, for instance, in the mobile telecommunications industry where the customers' handsets are often subsidized by the operators.

Note that the level of advertising only depends on the revenue parameter R and the shape of the function $q(a, k)$. The intensity of competition, measured by t , does not play a role for equilibrium advertising. The second condition determines the subscription price charged to customers. The price depends largely on the intensity of competition and advertising revenues ($R \cdot q(a^\#, k) \cdot a^\#$).

The first term of the pay-per-view price is the standard Hotelling term. This is lowered by the second term. It reflects the role of advertising to generate revenues. If platform i admits more advertising than the competing platform it has to compensate its own subscribers via a lower pay-per-view price, since a share of ad averse viewers would otherwise migrate to the competing platform. Moreover, the higher the advertising revenue per viewer, the more attractive viewers are. Hence, prices are lowered to subsidize viewers. This illustrates that the platform can adjust the pay-per-view price to the advertising space it provides. As in the models by Choi (2006) and Peitz and Valletti (2008) there is a full pass-through of advertising revenues into the pay-per-view price. By introducing market size effects in section 2.5.2 this pass-through effect is reduced.

Differentiating the equilibrium conditions for advertising and the subscription price with respect to k , we obtain:

Proposition 2.3. *In the pay-TV regime, equilibrium advertising decreases in the responsiveness to advertising while the subscription price increases. That is, $\frac{da^\#}{dk} < 0$ and $\frac{ds^\#}{dk} > 0$.*

Proof. See Appendix 2.A. □

Notice that in the pay-TV regime an increase in k has an unambiguous negative impact on the level of advertising. The reason is that in contrast to free-to-air the effect of relaxed competition is not present. With increasing values of k advertising levels are decreasing, subscription prices are increasing.

The broadcasters' equilibrium revenues from advertising ($R_a^\#$) and subscription ($R_s^\#$) are:

$$R_a^\# = \frac{1}{2} R \cdot q(a^\#, k) a^\#, \quad (2.18)$$

and

$$R_s^\# = \frac{1}{2} [t - R \cdot q(a^\#, k) a^\#] = \frac{1}{2} s^\#. \quad (2.19)$$

Total income is then the sum of the sources of income:

$$\Pi^{\#} = \frac{t}{2}, \quad (2.20)$$

which solely depends on the degree of competition in the media market. This is exactly the profit of a standard Hotelling model with inelastic demand and is an immediate implication of the full pass-through of advertising revenues into the subscription price, confirming the “profit neutrality” result of Peitz and Valletti (2008). Even though viewers responsively respond to advertising, i.e. demand is elastic, every loss in advertising income is compensated by the income from subscription. Thus, a larger responsiveness to advertising leaves total revenues constant but changes the composition of the two sources of revenue. While the revenues from advertising decrease there are higher revenues from subscription. We summarize this in the following proposition:

Proposition 2.4. *In the pay-TV regime, equilibrium revenues are unaffected by the viewers’ responsiveness to advertising, but the composition of revenues is altered: income from advertising decreases while income from subscription increases.*

Proof. See Appendix 2.A. □

2.5 Extensions

We discuss two extensions of the base model: Entry decisions and effects of elastic subscription.

2.5.1 Entry

We can generalize our model to the case with more than two competitors. Instead of the Hotelling setup we now turn to the Salop framework (Salop 1979) which enables us to analyze entry decisions. There is a unit mass of viewers distributed uniformly on the unit circle. The n channels are located equidistantly on this circle. There is a fixed cost of f for entering the market. We assume that competition follows a two-stage game. In the first stage, channels decide whether

to enter. In the second stage, firms decide on the number of adverts and, in the pay-TV regime, also on the subscription price. We are interested in determining the impact of ad-avoidance on the number of channels that enter in a free-entry equilibrium.

Consider a situation with a given number of channels n in the market and seek for a symmetric equilibrium. Thus, we consider the situation of a representative channel i . Let a_i (s_i) denote the advertising level (subscription price) at this channel while all remaining channels set advertising (subscription prices) at a_o (s_o). The revenue of a representative channel can then be written as:

$$\Pi_i = \left[\frac{1}{n} + \frac{1}{t} \int_{a_i}^{a_o} q(a, k) da + \frac{s_o - s_i}{2t} \right] [R \cdot q(a_i, k) a_i + s_i] - f. \quad (2.21)$$

First consider free-to-air broadcasting, i.e. $s_i = 0$. Solving for a symmetric advertising level, we obtain

$$q(a^*, k) \cdot a^* = \frac{t}{n} [1 - \epsilon(a^*, k)]. \quad (2.22)$$

Again, an increase in k may lead to more or less advertising. A larger number of channels decreases the equilibrium advertising level. Inserting equation (2.22) into equation (2.21) gives the equilibrium revenues for a given number of firms:

$$\Pi^* = \frac{t}{n^2} R [1 - \epsilon(a^*, k)] - f. \quad (2.23)$$

The impact of an increase in k on revenues is unambiguous. A higher responsiveness to advertising ($\frac{d\Pi^*}{dk} < 0$) and a larger number of competitors ($\frac{d\Pi^*}{dn} < 0$) decrease revenues.

By a zero profit condition we seek to determine the number of firms entering the market, which implicitly defines the free-entry number of firms:

$$\frac{t}{n^2} R [1 - \epsilon(a^*, k)] - f = 0. \quad (2.24)$$

In general, it is not possible to explicitly express the number of entrants since the equilibrium demand elasticity $\epsilon(a^*, k)$ depends on the number of competi-

tors. However, we know that revenues decrease monotonically in the number of firms. Hence, we know that a unique solution to equation (2.24) exists.¹² As a larger value of k decreases revenues, it follows immediately that an increasing responsiveness to advertising, measured by k , decreases entry and hence reduces diversity.

Consider now additional revenues from subscription. We obtain the following conditions for the revenue maximizing levels of advertising and subscription fees:

$$R[1 - \epsilon(a^\#, k)] = 1, \quad (2.25)$$

and

$$s^\# = \frac{t}{n} - R \cdot q(a^\#, k)a^\#. \quad (2.26)$$

Note that the equilibrium level of advertising is identical to our solution in the duopoly model and hence advertising is independent of the number of channels. The reason is the full pass-through of advertising revenues into the subscription fee leading to a profit neutrality result (see Section 2.4). Only the subscription price is affected by the number of competing channels. The more channels are in the market, the lower is the subscription price. Revenues decrease in the number of channels competing in the market. However, the two sources of income are affected differently by a rising number of competitors. While revenues from advertising are constant, revenues from subscription decrease. Thus, with a larger number of channels revenues from advertising gain relative importance.

As in the duopoly case, equilibrium revenues are independent of the possibilities to avoid advertising:

$$\Pi^\# = \frac{t}{n^2} - f, \quad (2.27)$$

As can be easily seen, revenues decrease in the number of channels competing in the market. However, the two sources of income are affected differently by a rising number of competitors. While revenues from advertising are constant, revenues from subscription decrease. Thus, with a larger number of channels revenues from advertising gain relative importance.

¹²We assume that the market is viable for at least two firms. This can be ensured assuming that transportation costs are sufficiently large or fixed costs of entry are sufficiently small.

The number of channels entering in a free-entry equilibrium follows from setting equation (2.27) equal to zero:

$$n = \sqrt{\frac{t}{f}}. \quad (2.28)$$

Note that the number of firms entering in the pay-TV regime coincides with entry in the standard Salop model. As revenues are independent from the possibility of ad-avoidance, so is the number of channels that enter in a free-entry equilibrium. Thus, diversity in the media market is not affected by ad-avoidance behavior. This is a direct result from the pass-through effect of advertising income into the subscription price.¹³

Proposition 2.5. *A rising responsiveness to advertising reduces diversity in the free-to-air regime and has no impact on diversity in the pay-TV regime.*

Allowing for market size effects in 2.5.2 the level of entry in the pay-TV regime will be affected, although to a lower extent than in the free-to-air regime.

2.5.2 Elastic Subscription

A limitation of the base model is that the market size is exogenously fixed. The number of television viewers is normalized to one. In this extension, we discuss the implications of incorporating elastic subscription. That is, channels may increase total viewership by charging low subscription prices and broadcasting fewer adverts. In this section, we show that the result that pay-TV profits are unaffected by ad-avoidance relies on the previous assumption of a fixed market size. Accounting for elastic subscription profits are no longer constant but decrease with an increasing responsiveness towards advertising. However, pay-TV profits are affected to a much smaller extent than profits in the free-to-air regime. The reason for this result lies in the fact that with elastic subscription there is only a partial pass-through of advertising revenues into the subscription price.

¹³For a discussion of welfare optimal advertising levels, subscription prices and entry in the distinct regimes we refer to the paper by Choi (2006). He shows that with pay-TV the equilibrium advertising is less than the social optimal level, while the extent of entry is excessive. However, in the free-to-air regime, advertising levels and entry can be excessive or insufficient.

Following Armstrong and Wright (2009) we use a tractable variant of the Hotelling model with hinterlands. We assume that demand at firm i is now given by:

$$d_i = \frac{1}{2} + \frac{1}{2t} \int_{a_i}^{a_j} q(a, k) da + \frac{s_j - s_i}{2t} + \lambda \left[\int_{a_i}^{\hat{a}} q(a, k) da - s_i \right]. \quad (2.29)$$

In a symmetric equilibrium, the total market size is then given by:

$$D = 1 + 2\lambda \left[\int_a^{\hat{a}} q(a, k) da - s \right]. \quad (2.30)$$

The total size of the market is no longer constant, but decreases with the subscription price and the advertising level. The parameter $\lambda > 0$ serves as a measure for the importance of elastic subscription.¹⁴

Equilibrium advertising in the free-to-air regime is characterized by:

$$t[1 - \epsilon(a^*, k)] \left[1 + 2\lambda \int_{a^*}^{\hat{a}} q(a, k) da \right] = q(a^*, k) a^* (1 + 2t\lambda). \quad (2.31)$$

As in the base model, the advertising level may increase or decrease with the responsiveness towards advertising. Additionally, when subscription becomes more elastic (λ increases), the advertising level is lower. Corresponding equilibrium profits are given by:

$$\Pi = \frac{1}{2} t R [1 - \epsilon(a^*, k)] \frac{[1 + 2\lambda \int_{a^*}^{\hat{a}} q(a, k) da]^2}{1 + 2t\lambda}. \quad (2.32)$$

Under pay-TV equilibrium advertising and the equilibrium subscription price are characterized by:

$$R[1 - \epsilon(a^\#, k)] = 1 + 2t\lambda, \quad (2.33)$$

and

$$s^\# = \frac{t - R \cdot q(a^\#, k) a^\# + 2t\lambda \int_{a^\#}^{\hat{a}} q(a, k) da}{1 + 2t\lambda}. \quad (2.34)$$

¹⁴Setting $\lambda = 0$ reproduces the base model.

When introducing elastic subscription the pass-through of advertising revenues is only partial. As can be seen from equation (2.34) only a fraction $\frac{1}{1+2t\lambda}$ of the advertising revenues is passed through. The more important elastic subscription is (larger λ), the lower is the pass-through. In equilibrium, each channel earns profits of

$$\Pi^\# = \frac{1}{2t}(s^\# + R \cdot q(a^\#, k)a^\#)^2. \quad (2.35)$$

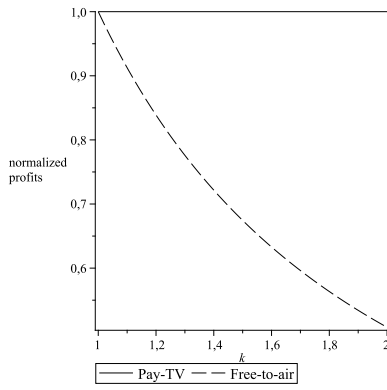
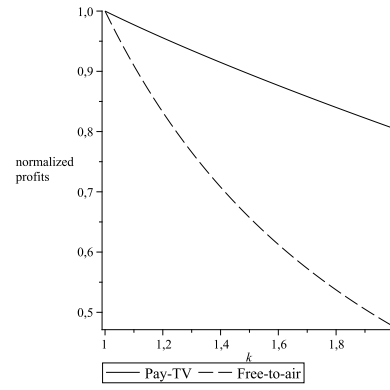
Base model ($\lambda = 0$).Elastic subscription ($\lambda = 0.1$).

Figure 2.2: Relative profits in free-to-air and in pay-TV regime for $q(a, k) = 1 - ak$, $t = 1$, $R = 2$.

In contrast to the base model with a fixed total viewership, also profits of pay-TV channels decrease when consumers become more averse towards advertising (larger k). A decrease in advertising revenues cannot be fully compensated by an increase in revenues from subscription. However, profits in the pay-TV regime are affected to a smaller extent than profits in the free-to-air regime. This difference due to elastic subscription is demonstrated in Figure 2.2 where we compare free-to-air and pay-TV profits for $q(a, k) = 1 - ak$. In each regime, we normalize profits at $k = 1$ to one so that deviations can be interpreted as percentage changes in profits. The left picture of Figure 2.2 shows profits in our base model with fixed viewership where pay-TV profits are unaffected by ad-avoidance behavior (k). In contrast, pay-TV profits are affected if we introduce elastic subscription. The right picture of Figure 2.2 shows that an increase in viewers' responsiveness towards advertising from $k = 1$ to $k = 2$ reduces profits in the free-to-air regime by about 50 %, but only by roughly 20 % in the pay-TV case.

The effect on broadcasters' profits directly translates into an effect on market entry. An increase in ad-avoidance opportunities will decrease entry to a larger extent in the free-to-air regime than in the pay-TV regime.

2.6 Conclusion

This chapter has considered the impact of ad-avoidance behavior on media markets. As media markets are two-sided markets, the avoidance behavior of viewers has an impact on the other side of the market, namely on the advertising industry. If advertisement messages are avoided by viewers, the value of placing adverts is reduced to a large extent.

We have considered two alternative schemes in which media channels are financed: free-to-air and pay-TV. We have shown that ad-avoidance behavior of viewers has a very different impact in these two regimes. In the free-to-air regime, channels rely exclusively on advertisements as the only source of revenue. Then, channels are hurt if viewers have better opportunities to avoid advertisement messages. This, in turn, leads to a fewer number of channels that can survive in the market. Channels in the pay-TV regime also face lower revenues from advertising. However, as revenues from subscription increase at the same level, total revenues are not affected by viewers' avoidance behavior. In the free-entry version of our model this leads immediately to an unchanged number of channels. However, when subscription for pay-TV is elastic, a higher responsiveness to advertising decreases broadcasters' profits.

Viewers always had the opportunity to bypass advertisement messages. However, due to technological advances, such as the digital video recorder, these avoidance possibilities have become more comfortable. In the light of our analysis, these increased bypassing possibilities will have an impact on the financing structure of television and broadcasting. Business models that rely exclusively on advertising revenues will become relatively unattractive while pay-TV will become a more attractive business model. With elastic demand for TV consumption, in a free-to-air regime, broadcasters' profits are lower compared to the standard Hotelling setup with inelastic demand. Otherwise, due to the pass-through of advertising income into the subscription price, in a pay-TV regime, broadcasters'

profits are unaffected by viewers' ad avoidance behavior.

Furthermore, due to opportunities to bypass advertisement messages broadcasters might replace traditional advertising spots by product placements, which are more difficult to bypass. Our model contributes to the discussion on the effects of ad-avoidance technologies and the advertising industry, broadcasters, and viewers. The European Commission recently allowed for product placements on commercial broadcasters to account for decreasing abilities to reach viewers via classical advertising breaks. The effect of product placement is yet unclear. Some arguments state that product placements will likely have no effect if viewers do not notice it as advertising. Others fear an increase of placing products. We have shown that this may lead to an adverse effect of ad-avoidance: Due to the avoidance of classical advertising breaks, viewers may be annoyed to an even larger extent by new ways of advertising, which are even harder to avoid.

2.A Appendix

Equilibrium Existence

Here we provide the proof for the existence of a symmetric equilibrium in the free-to-air regime. We provide the proof for the entry version of our model. The proof follows the one in Gu and Wenzel (2009b).

First, we show that in equilibrium $\epsilon < 1$. Note when $\epsilon \geq 1$, i.e. $\frac{dq(a)}{da} \frac{a}{q(a)} \leq -1$, the first-order derivative is

$$\frac{d\Pi_i}{da_i} = \underbrace{-[q(a_i)]^2 a_i \frac{1}{t}}_{\text{negative}} + \underbrace{\left[\frac{1}{n} + \frac{1}{t} \int_{a_i}^{a_o} q(a) da \right] q(a_i)}_{\text{positive}} \underbrace{\left[1 + \frac{a_i}{q(a_i)} \frac{dq(a)}{da} \Big|_{a=a_i} \right]}_{\text{non-positive}} \quad (2.36)$$

and obtains a strictly negative value. The middle part on the right-hand side of Equation (2.36) is positive because we are interested in symmetric equilibrium ($a_i = a_o$). With $\frac{d\Pi_i}{da_i}$ being negative, whenever demand elasticity exceeds or is equal to 1, a firm wants to reduce the amount of advertising. In equilibrium,

however, the first-order condition (2.22) holds,

$$\begin{aligned} & 1 + \frac{a^*}{q(a^*)} \frac{dq(a)}{da} \Big|_{a=a^*} > 0 \\ \implies & \frac{a^*}{q(a^*)} \frac{dq(a)}{da} \Big|_{a=a^*} > -1 \\ \implies & \epsilon^* < 1. \end{aligned}$$

In the next step, we show that the first-order condition admits a unique solution. Define $\Delta(a) = q(a)a - \frac{t}{n}[1 - \epsilon(a)]$. The functions $q(a)$ and $\epsilon(a)$ are continuous and differentiable. Hence, $\Delta(a)$ is continuous. Note that

$$\lim_{a \rightarrow 0} \Delta(a) = 0 - \frac{t}{n} \left[1 - \lim_{a \rightarrow 0} \epsilon(a) \right] = 0 - \frac{t}{n} < 0.$$

From assumption 1 follows that $\mu(a) = aq(a)$ is unimodal, which means it has a unique global maximum $\tilde{a}$ in $(0, \hat{a})$. Then,

$$\Delta(\tilde{a}) = q(\tilde{a})\tilde{a} > 0.$$

Because of continuity, $\Delta(a) = 0$ obtains solution(s) for $a \in (0, \tilde{a})$. Take the derivative of $\Delta(a)$,

$$\frac{d\Delta(a)}{da} = \frac{d\mu(a)}{da} + \frac{t}{n} \frac{d\epsilon(a)}{da}.$$

Following Assumption 1, $\frac{d\epsilon(a)}{da} > 0$; since $\mu(a)$ is strictly unimodal, for $a \in (0, \tilde{a})$, $\frac{d\mu(a)}{da} > 0$ as well. Hence, we conclude $\frac{d\Delta(a)}{da} > 0$. Because of this monotonicity, $\Delta(a) = 0$ obtains a unique solution in $(0, \tilde{a})$. When $a \in [\tilde{a}, \hat{a})$, we know $\epsilon(a) \geq 1$ which means $\Delta(a) > 0$ for $[\tilde{a}, \hat{a})$. So the solution given by $q(a)a = \frac{t}{n}[1 - \epsilon(a)]$ for $a \in (0, \tilde{a})$ has a unique solution.

Derivations of Section 2.3

To obtain proposition 2.1, take the total differential of equation (2.11) with respect to k :

$$\begin{aligned} \frac{dq}{dk}a^* + \frac{dq}{da}\frac{da^*}{dk}a^* + \frac{da^*}{dk}q &= -t \left(\frac{d\epsilon}{dk} + \frac{d\epsilon}{da}\frac{da^*}{dk} \right) \\ \Rightarrow \frac{da^*}{dk} &= -\frac{t\frac{d\epsilon}{dk} + \frac{dq}{dk}a^*}{q^*(1-\epsilon^*) + t\frac{d\epsilon}{da}} \geq 0. \end{aligned}$$

The denominator is positive as $\epsilon^* < 1$ and $\frac{d\epsilon}{da} > 0$. The nominator can be positive or negative as $\frac{d\epsilon}{dk} > 0$ and $\frac{dq}{dk} < 0$.

To obtain proposition 2.2, differentiate equation (2.13) with respect to k :

$$\begin{aligned} \frac{d\Pi^*}{dk} &= -\frac{1}{2}Rt \left[\frac{d\epsilon}{dk} + \frac{d\epsilon}{da}\frac{da^*}{dk} \right] \\ &= -\frac{1}{2}Rt \left[\frac{q^*(1-\epsilon^*)\frac{d\epsilon}{dk} - \frac{d\epsilon}{da}\frac{dq}{dk}a^*}{q^*(1-\epsilon^*) + \frac{d\epsilon}{da}t} \right] < 0. \end{aligned}$$

Numerator and denominator are both positive, so $\frac{d\Pi^*}{dk} < 0$.

Derivations of Section 2.4

To obtain proposition 2.3, take the total differential of equation (2.16) with respect to k :

$$\begin{aligned} 0 &= -R \left(\frac{d\epsilon}{dk} + \frac{d\epsilon}{da}\frac{da^\#}{dk} \right) \\ \Rightarrow \frac{da^\#}{dk} &= -R \frac{\frac{d\epsilon}{dk}}{\frac{d\epsilon}{da}} < 0. \end{aligned}$$

Since $\frac{d\epsilon}{da} > 0$ and $\frac{d\epsilon}{dk} > 0$, $\frac{da^\#}{dk} < 0$.

Take total differential of equation (2.17) with respect to k :

$$\begin{aligned}\frac{ds^\#}{dk} &= -R \left(\frac{da^\#}{dk} q^\# + \frac{dq}{dk} a^\# + \frac{dq}{da} \frac{da^\#}{dk} a^\# \right) \\ &= -R \left(\frac{da^\#}{dk} q^\# (1 - \epsilon^\#) + \frac{dq}{dk} a^\# \right) > 0.\end{aligned}$$

Since $\frac{da^\#}{dk} < 0$ and $\frac{dq}{dk} > 0$, it follows that $\frac{ds^\#}{dk} < 0$.

Take total differential of equation (2.18) with respect to k :

$$\frac{dR_a^\#}{dk} = -\frac{1}{2} \frac{ds^\#}{dk} < 0.$$

Take total differential of equation (2.19) with respect to k :

$$\frac{dR_s^\#}{dk} = \frac{1}{2} \frac{ds^\#}{dk} > 0.$$

Chapter 3

Regulating Advertising in the Presence of Public Service Broadcasting*

3.1 Introduction

In most countries of the European Union commercial television and Public Service Broadcasting (PSB) coexist and compete for viewers and advertisers. Most public broadcasters are financed by a mix of advertising income and public funds (often a licence fee), though the precise terms of finance vary to a large extent.

The “Audiovisual Media Services Directive”¹, codified in March 2010, regulates television advertising for all broadcasters in the European Union. However, member countries may impose stricter regulation. This especially holds for Public Service Broadcasters, which usually must set lower advertising levels than their commercial counterparts. In the UK, the BBC is even not allowed to broadcast any advertising. The same holds for Sweden where the two public broadcasters (SVT1 and SVT2) do not air any advertisements. In Germany, ARD and ZDF, the two main public broadcasters, are not allowed to show commercials after 8 pm, on Sundays and public holidays, and only a total amount of advertising of 20

*The research of this chapter is part of a joint project with Tobias Wenzel.

¹See http://ec.europa.eu/avpolicy/reg/avms/index_en.htm. This directive replaces the “Television Without Frontiers Directive” of 1989 to account for on-demand services.

minutes per day. These restrictions do not apply to their commercial competitors. There are similar rules in the Netherlands. In France, advertising is sequentially removed from public service broadcasting channels. Since 2009, public broadcasters are not allowed to show commercials after 8 pm. Starting in 2011, public broadcasters must not display any advertisement. The French President Sarkozy argues that quality of public service broadcasting increases without broadcasters having to rely on advertising incomes; programs do not have to match a mainstream taste any more. Similarly, in Germany and Spain, tighter advertising caps for public broadcasters are discussed. We take this observed asymmetric regulation of public broadcasters as the starting point for our analysis.

This chapter is hence concerned with competition in media markets where public and commercial broadcasters compete. Our focus lies on the consequences of asymmetric regulation of advertising. Do private broadcasters benefit if the public service competitor is subject to stricter regulation? Is asymmetric regulation necessarily to the detriment of the more heavily regulated firm? What happens to the overall level of advertising and the price advertisers have to pay to get their message delivered to viewers? Note, however, that the present chapter is not concerned with the rationale of such asymmetric regulations nor the existence of public service broadcasters in general, but rather we study the consequences of asymmetric regulation of the type that can be observed.²

We try to provide answers to the questions asked above. For this task we set up a simple model of a two-sided broadcasting market following the seminal contribution by Anderson and Coate (2005). Two broadcasters offer differentiated content and choose how much advertisement to air. Viewers—averse to commercials—choose among the two broadcasters' programs. One central assumption in Anderson and Coate (2005) is that broadcasters hold a monopoly position over their viewers, meaning that an advertiser can reach a given viewer only via one broadcaster. More technically, broadcasters act as a "competitive bottleneck". An immediate consequence of this assumption is that advertising levels of the rival do not affect the own advertising price. This assumption is used

²For a discussion on the rationale of regulating advertising time and content we refer the reader to Anderson (2007) ; for a discussion on the rationale for public service broadcasting to Armstrong and Weeds (2007b).

in the existing literature on advertising in media markets.³ In this chapter, we depart from this assumption and show that this enables us to explain some features of competition between public and private broadcasters that cannot be explained otherwise.

The key feature of our model is that there is competition for advertisers on the advertising market. If one broadcaster increases the amount of advertising this influences directly the price for advertising slots for all broadcasters. Thus, there is a negative externality between broadcasters on the advertising market. Reisinger et al. (2009) term this externality a “pecuniary externality”. These externalities in the advertising market are also considered in recent papers by Kind et al. (2007), Godes et al. (2009), and Dewenter et al. (2011). Yet, none of these papers considers asymmetric regulation which—as described above—seems to be a widespread characteristic within the European Union. Reisinger et al. (2009) focus on symmetric commercial channels and endogenous entry into the market. Dewenter et al. (2011) analyze the effects of collusion over advertising on market outcomes and Kind et al. (2007) focus on whether there is over- or underprovision of advertising. Godes et al. (2009) analyze the influence of competition on the relative importance of income from the reader/ viewer side compared to income from selling advertising slots.

Our model shows that the profit of the private, non-regulated broadcaster may increase if the public broadcaster is regulated with respect to the amount of advertising it can air. This result is consistent with casual evidence. In Germany, the association of private broadcasters (VPRT) opposes plans to allow public broadcasters to air commercials after 8 pm.⁴ This statement makes sense in the light of our model. To grasp the intuition behind our finding consider first the effect of an introduction of a binding asymmetric regulation in a model applying the competitive bottleneck assumption. As viewers do not like advertising this imposes pressure on the non-regulated broadcaster to decrease advertising as well, leading immediately to lower revenues from advertising. This effect is also present in our model but there is a second, opposing effect which works via the advertising mar-

³Among many others, the assumption of competitive bottlenecks has been applied in Armstrong (2006), Armstrong and Weeds (2007a), Peitz and Valletti (2008), Crampes et al. (2009).

⁴Press release. Verband Privater Rundfunk und Telemedien e.V. (VPRT), 26.09.2003.

ket. The regulation of advertising of the public broadcaster leads to an increase in the price for advertising spots for the private broadcaster which tends to increase revenues. This effect may outweigh the first one, leading to higher profits for the private broadcaster.

We also demonstrate that due to asymmetric regulation the level of advertising of the non-regulated broadcaster may increase or decrease. Yet, the total level of advertising in the market is always lower and hence, the price for adverts is always higher under regulation. Thus, the model shows that regulation of advertising is detrimental for the surplus of the advertisers. This is consistent with complaints by the German association of the advertising industry (OWM). According to them, advertising prices are higher during times where the public broadcaster is not allowed to show commercials.⁵

In a brief section, we also consider symmetric regulation where both broadcasters are subject to the same cap on advertising. We show that in these situations profits of both broadcasters may increase. The reason for this result is again the externality between broadcasters in the advertising market. When setting the level of advertising a broadcaster does not take the impact on the competitor's profits into account which in turn can lead to high advertising levels and low advertising prices. The overall level of advertising can be above the one that maximizes joint profits. In this setting, as regulation lowers each broadcasters advertising level, regulation can lead to higher prices for advertising and thus to higher profits. Again, this result cannot be reached with the assumption of competitive bottlenecks. Our result is also consistent with Dewenter et al. (2011) who show that semi-collusion over advertising leads to lower advertising levels, higher prices for advertising and higher broadcaster profits.

The rest of the chapter is organized as follows: Section 3.2 presents the basic model with two non-regulated broadcasters. Section 3.3 considers the impact of regulation. First, we consider symmetric regulation and then turn to asymmetric

⁵OWM: Organisation Werbungtreibende im Markenverband. Unfortunately, we are not aware of any systematic, empirical evidence on whether the claim is true. A direct comparison may not suffice as there may be other effects driving the results. For instance, advertisers may have different willingness to pay to reach viewers of afternoon shows (where in Germany public broadcasters may air commercials) than for reaching prime time viewers (where public broadcasters may not air commercials).

regulation where only one broadcaster is regulated. Section 3.4 concludes.

3.2 The Model

We present a model of the media market along the lines of Reisinger et al. (2009). There are two TV stations, called 1 and 2, that compete for viewers and advertisers. These two stations offer differentiated content, thus following Anderson and Coate (2005) we assume the stations to be located at opposite ends of a unit Hotelling line.⁶ Broadcasters are free-to-air, that is, advertising revenues are their only source of income.

3.2.1 Viewer Market

Viewers have preferences for the content of two stations and are located uniformly along the Hotelling line. The position on the line is given by x . Viewers' utility is decreasing in their distance from the channels' location, magnified by a transportation costs parameter t . Advertising annoys viewers as it decreases the pleasure of watching television.⁷ The indirect utility for a viewer, located at x , is then:

$$U = \begin{cases} V - tx - a_1 & \text{if choosing station 1} \\ V - t(1 - x) - a_2 & \text{if choosing station 2,} \end{cases} \quad (3.1)$$

where a_1 (a_2) denotes the level of advertising at channel 1 (2) and V labels the gross utility of watching TV, which is assumed sufficiently high so that every viewer chooses to watch one channel. The marginal viewer ($\bar{x}$), who is indifferent between choosing station 1 or 2, is then characterized by

$$\bar{x} = \frac{1}{2} + \frac{(a_2 - a_1)}{2t}. \quad (3.2)$$

⁶Peitz and Valletti (2008) study the broadcasters' incentives to offer differentiated content in pay-TV and free-to-air.

⁷Wilbur (2008) and Anderson and Gans (2011) analyze consumers' reactions to avoid advertising messages. Chapter 2 of this thesis provides a model where viewers may avoid advertising messages.

The difference in advertising levels affects market shares. That is advertising levels have the same impact as prices in other markets and can be regarded as hedonic prices, so that advertising exerts a participation externality on the rival's market share. Channel 1 takes a market share of $s_1 = \bar{x}$ and channel 2 of $s_2 = 1 - \bar{x}$.⁸

3.2.2 Advertising Market

There is a continuum of advertisers with measure 1. Advertisers come in two types: Single-homing advertisers place their ads only with one channel, whereas multi-homing advertisers may place ads on both channels. The share of single-homing advertisers is β and the remaining share of $1 - \beta$ are multi-homing advertisers.⁹ This is in line with observation in practice. For instance, products that are specific to a certain group of consumers are typically advertised on a single channel while products that are less specific are often advertised on multiple channels.¹⁰

Advertisers are located uniformly on a unit line where the location (y) denotes a firm's preference to advertise with a channel. Advertisers with a low (high) value of y generate a high (low) benefit from advertising with channel 1 (2). The per-viewer-profit of an advertiser, located at y , is

$$\Pi^A = \begin{cases} R - \theta y - p_1 & \text{advertise with channel 1} \\ R - \theta(1 - y) - p_2 & \text{advertise with channel 2.} \end{cases} \quad (3.3)$$

The channels charge a per-viewer price of p_i to place the ads. The location

⁸We assume that viewers single-home, i.e. only watch one channel. Hence, our model is on competition in time slots, which is standard in the literature, see, e.g., Anderson and Coate (2005) or Crampes et al. (2009).

⁹Gal-Or and Duke (2003) endogenously determine whether advertising firms choose single-homing or multi-homing advertising. In a more general framework, advertisers indexed near $x = \frac{1}{2}$ would seek to multi-home, whereas advertisers near the extremes would seek to single-home.

¹⁰In 2010 the average age of viewer of ZDF (one of the two public service broadcasters in Germany) is 61 years, whereas the average age of viewers of RTL (a major commercial broadcaster in Germany) is 45 years (Source: DWDL "Das Medienmagazin" 25.06.2010). Hence, e.g., pharmaceutical products are largely advertised on PSB channels and seldom on commercial channels. Otherwise, producers of general purpose products, e.g. the food industry, places ads on all channels, since their target group is less specific.

y , magnified by the parameter θ , reflects the importance of the difference in the contents broadcasted by the channels in relation to the type of products or services sold by an advertising firm y .¹¹ R denotes the gross benefit for an advertiser for reaching a single viewer.

Single-homing advertisers choose whether to advertise with channel 1 or channel 2. Then, there is an advertiser which earns the same profit whether it places its ad with channel 1 or channel 2. Hence, the demand from single-homing advertisers on a channel is given by the Hotelling formula

$$a_i^{SH} = \frac{1}{2} + \frac{p_j - p_i}{2\theta}.$$

Multi-homing advertiser may place ads with both channels. The demand of those at each channel is denoted as

$$a_i^{MH} = \frac{R - p_i}{\theta}.$$

This gives total demand of advertising on channel i as

$$a_i = \beta \left(\frac{1}{2} + \frac{p_j - p_i}{2\theta} \right) + (1 - \beta) \left(\frac{R - p_i}{\theta} \right).$$

Inverting the demand system and solving for both prices simultaneously gives the inverse demand function for advertising at channel i :

$$p_i = R + \frac{\beta\theta}{2(1-\beta)} - \frac{(2-\beta)\theta}{2(1-\beta)}a_i - \frac{\beta\theta}{2(1-\beta)}a_j.$$

We normalize $\theta = \frac{2(1-\beta)}{2-\beta}$ and denote $b = \frac{\beta}{2-\beta}$ and $A = R + b$ to write advertising demand more compactly:

$$p_i = A - a_i - ba_j. \quad (3.4)$$

Note that there is a pecuniary externality among broadcasters.¹² Increasing

¹¹Comparably, in their empirical framework Chandra and Collard-Wexler (2009) also assume that advertisers have a greater valuation of readers located closer to them.

¹²This advertising demand function has also been derived by Godes et al. (2009), Dewenter

the amount of adverts at one channel has adverse consequences on the price for adverts at the other channel, as the advertising price is determined by the total supply of advertising. Our setup can also reproduce the standard advertising demand function used e.g. in the models of Anderson and Coate (2005), Peitz and Valletti (2008) or Crampes et al. (2009). If there are only multi-homing advertisers ($\beta = 0$) it follows that $b = 0$ which reproduces the competitive bottleneck assumption of the literature.

Following from equation (3.4) total advertising revenues and hence broadcasters profits are

$$\Pi_i = s_i a_i p_i, \quad (3.5)$$

where s_i labels the market share and a_i the advertising level of channel i .

3.2.3 Unregulated Scenario

As a benchmark we consider the case without any restriction on the number of adverts.

Maximizing equation (3.5) yields the first-order condition of channel i :

$$\frac{\partial \Pi_i}{\partial a_i} = p_i \left(\frac{\partial s_i}{\partial a_i} a_i + s_i \right) + s_i a_i \frac{\partial p_i}{\partial a_i} = 0. \quad (3.6)$$

This yields the following best-response function for broadcaster i :

$$a_i = \frac{1}{3}(t + (A + (1 - b)a_j)) - \frac{1}{3} \left(\sqrt{t^2 + A(A - (1 + 2b)a_j - t) + a_j(t(2 + b) + (a_j(1 + b + b^2)))} \right). \quad (3.7)$$

The optimal advertising level solves the trade-off between a quantity and a price effect. Due to viewers' advertising aversion the advertising level can be interpreted as a hedonic price for the viewers. Higher advertising levels lead viewers to switch to the competing channel. Due to the pecuniary effect, the advertising price is determined by the total supply of advertising, with increasing advertising

et al. (2011), and Kind et al. (2009). Following Singh and Vives (1984) they derive their demand function by maximizing the utility of a representative advertiser. Our approach differs, since we do not derive advertisers' demand from a utility but from a profit function.

levels reducing the advertising price and thus the profit per viewer of all channels. If a channel sets a higher advertising level, it directly increases the supply of time units per viewer but also changes the distribution of viewers, which in turn changes the supply of viewer-time units. This indirect effect has a further impact on the price.

The symmetric equilibrium, leading to equal market shares, can be characterized as follows:

Lemma 3.1. *In a symmetric equilibrium, advertising levels¹³ are*

$$a_i^* = \frac{1}{1+b} \left(t + \frac{1}{2}(A + bt - \kappa) \right), \quad (3.8)$$

where $\kappa = \sqrt{(A - bt)^2 + 4t^2(1+b)}$. The advertising price is

$$p_i^* = \frac{1}{2} (A - (2+b)t + \kappa). \quad (3.9)$$

Profits are given as

$$\Pi_i^* = \frac{1}{8(1+b)} (A + t(2+b) - \kappa) (A - t(2+b) + \kappa). \quad (3.10)$$

In models using the competitive bottleneck assumption advertising levels act as hedonic prices to viewers, only affecting the distribution of viewers over the channels. Then, as in standard Bertrand competition, best-response functions are upward sloping, thus advertising levels are strategic complements. This is not necessarily true if there is an additional pecuniary externality on the advertising price (see Reisinger et al. (2009)).

From the Implicit Function Theorem we know that

$$\frac{da_i}{da_j} = -\frac{\frac{\partial^2 \Pi_i}{\partial a_i \partial a_j}}{\frac{\partial^2 \Pi_i}{\partial a_i^2}}.$$

The denominator equals the second order condition to determine maximum ad-

¹³For a comparative static analysis we refer to the model of Reisinger et al. (2009).

vertising levels, hence

$$\text{sign} \left\{ \frac{da_i}{da_j} \right\} = \text{sign} \left\{ \frac{\partial^2 \Pi_i}{\partial a_i \partial a_j} \right\}.$$

Thus advertising levels are complements (substitutes) if

$$\frac{\partial^2 \Pi_i}{\partial a_i \partial a_j} > (<) 0. \quad (3.11)$$

Differentiating equation (3.7) with respect to a_j yields that advertising levels are strategic complements, i.e. $\frac{da_i}{da_j} > 0$, if the degree of differentiation in the viewer market is sufficiently small compared to the per-viewer income from advertising, i.e.

$$t < \bar{t} = \frac{b(3A - a_j(4 + 2b)) + 2\sqrt{b}(b - 1)(A - ba_j)}{b(4 - b)}. \quad (3.12)$$

Lemma 3.2. *Advertising levels are strategic complements if competition in the viewer market is sufficiently intense. Otherwise they are strategic substitutes.*

In the viewer market advertising has the property of strategic complements because of the market share effect. In the advertising market it has the property of strategic substitutes because of the pecuniary effect. If the differentiation parameter in the viewer market (t) is high, the market share effect is soft and a change in the advertising levels has a small effect on the distribution of viewers. Therefore, for larger values of transportation costs, the pecuniary effect dominates and advertising levels have the property of strategic substitutes. Observe further that the level of the rival's advertising level determines the property of advertising levels, which will be essential in our scenario where broadcasters are regulated.

We can insert equilibrium advertising levels of equation (3.8) into equation (3.12), which yields that advertising levels are strategic complements in the symmetric equilibrium if

$$t < \tilde{t} = A \frac{\sqrt{b} + 1}{\sqrt{b}(b + \sqrt{b} + 2)}. \quad (3.13)$$

The strategic nature of advertising will essentially determine how the commercial broadcaster reacts to the introduction of a cap on the public broadcaster's advertising level. This will be analyzed in the next section.

3.3 Regulation

3.3.1 Symmetric Regulation

Before turning to asymmetric regulation we start by considering the impact of a symmetric advertising cap on broadcasters' profits. We consider a binding cap on advertising set at $\bar{a}$, e.g. an overall limit of 12 minutes of advertising per hour as stated in the Audiovisual Media Services Directive.

We compare the advertising level in the non-regulated scenario a_i^* of section 3.2 with the advertising level that maximizes joint profits ($\hat{a}_i$). The level of advertising that maximizes joint advertising revenues per consumer is

$$\hat{a}_i = \frac{A}{2(b+1)}. \quad (3.14)$$

Comparison with the non-cooperatively defined advertising level of equation (3.8) yields that $a_i^* > \hat{a}_i$ if

$$b > \frac{A}{2t}. \quad (3.15)$$

Thus, in equilibrium the competitive advertising level may exceed the one that maximizes joint profits and hence broadcasters have a joint interest in reducing advertising. Obviously, whenever $a_i^* > \hat{a}_i$ any cap on advertising between the profit-maximizing level and the competitive one is beneficial for the broadcasters. Thus, regulation might be beneficial for broadcasters as it solves the problem how to commit on lower advertising levels in competition. However, even stricter caps can be beneficial. Broadcasters' profit functions are hump-shaped. Define $a^c < \hat{a}_i$ as the advertising level that corresponds to the profit in the unregulated equilibrium of $\hat{a}_i > a^c$ such that $\Pi(a^c) = \Pi(a_i^*)$. Now, any cap $\bar{a} \in (a^c, \hat{a}_i)$ increases profits compared to an unregulated outcome.

Proposition 3.1. *If $b > \frac{A}{2t}$, the introduction of a symmetric cap on advertising levels $\bar{a} \in (a^c, a_i^*)$ leads to higher broadcaster profits.*

Proposition 3.1 demonstrates that regulation can benefit broadcasters. Intuitively, a binding advertising cap solves an externality problem between the broadcasters. When deciding how much to advertise each broadcaster does not take the

impact on the competitor's advertising price into account, the pecuniary externality. And hence, if the pecuniary externality is sufficiently strong, that is, b is sufficiently large, broadcasters set advertising above the one that maximizes joint profits. Then, the cap on advertising helps to overcome the externality problem and broadcaster profits rise. Notice that higher transportation costs t relax condition (3.15). For higher levels of transportation costs, the effect of advertising on broadcasters' market shares is weaker. Hence, the pecuniary effect becomes relatively more important so that it is more likely that broadcasters set advertising levels above the profit-maximizing level.

Proposition 3.1 is in contrast to the standard models applying the competitive-bottleneck assumption where advertising levels are strategic complements and regulation in form of advertising caps is detrimental for profits. The competitive bottleneck assumption corresponds to $b = 0$ in our model. In this case, condition (3.15) can never hold as $A, t > 0$. Hence, the equilibrium level of advertising is below the joint optimum and profits would decrease by binding regulation. Only for $b > 0$ both broadcaster can individually gain by regulation.

Our result that regulation may be profit-enhancing is in line with Dewenter et al. (2011) where newspaper collude over lower advertising levels to raise the price for adverts. The authors show that semi-collusion over advertising levels (but not on newspaper copy prices) does not only positively affect profits but even total welfare, as collusion induces a price structure that is more favorable to higher newspaper circulation, but lower advertising. Reisinger et al. (2009) analyze market entry into the broadcasting market. They show that for an intermediate number of broadcasters, additional entry may increase profits, as competition on advertising levels may decrease the equilibrium advertising level towards the collusive level. Therefore the effects of advertising ceilings have to be carefully analyzed. Our model analytically confirms their statement by solving for an explicit advertising cap, where broadcasters indeed benefit from a regulation of advertising.

3.3.2 Asymmetric Regulation

Now suppose that only one broadcaster is regulated. As mentioned above, usually PSB channels must set lower advertising levels than their commercial rivals. We

assume that the PSB, say broadcaster 2, is restricted to a binding advertising cap $\bar{a}_2$, where $0 \leq \bar{a}_2 < a_i^*$, hence the advertising level of the regulated broadcaster is exogenously set by a regulatory authority to $a_2 = \bar{a}_2$. For simplicity, there is no advertising cap for the commercial broadcaster.

The commercial broadcaster sets its advertising level according to the best-response function, equation (3.7), given that the advertising level of the PSB is fixed at $\bar{a}_2$:

$$\tilde{a}_1 = \frac{1}{3}(t + (A + (1 - b)\bar{a}_2)) - \frac{1}{3} \left(\sqrt{t^2 + A(A - (1 + 2b)\bar{a}_2 - t) + \bar{a}_2(t(2 + b) + (a_j(1 + b + b^2)))} \right). \quad (3.16)$$

We are interested in the commercial broadcaster's reaction to the introduction of a regulation for the PSB broadcaster. Therefore, first suppose that both broadcasters are unregulated and set advertising levels a_i^* according to equation (3.8). Next suppose, a binding marginal cap on advertising just below the unregulated equilibrium level is introduced, i.e. $\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} \big|_{a_1=a_2=a^*}$. It follows immediately:

Proposition 3.2. *Due to a marginal cap on advertising on the PSB, the commercial rival increases its advertising level if (in the unregulated equilibrium) advertising is a strategic substitute and it decreases its advertising level if (in the unregulated equilibrium) advertising is a strategic complement.*

The proposition follows immediately from Lemma 3.2. Accordingly advertising levels can be either strategic substitutes or complements. In the case of strategic substitutes, the optimal response of the unregulated broadcaster is to increase its advertising level, whereas in the case of strategic complements the best response is to decrease its advertising level.

To explain this reaction intuitively we decompose the impact of regulation into two effects: (1) The impact on the number of viewers and (2) the impact on advertising revenue per viewer. Due to viewers' advertising aversion advertising levels are generally strategic complements. If the regulated channel reduces its advertising level, because the advertising cap $\bar{a}_2$ is more restrictive, this negatively affects the distribution of viewers for the unregulated channel. Thus, the market share effect is clearly negative. However, due to an overall reduced level of advertising

broadcasters earn higher advertising revenues per viewer turning it more attractive for broadcasters to increase advertising (the pecuniary effect). As these effects oppose each other, the total effect is ambiguous and depends on the strength of the two effects.

The previous part has analyzed the impact of asymmetric regulation around the symmetric equilibrium. Similarly, one can analyze the impact of a marginal decrease in the cap for any given level of a cap. The commercial broadcaster increases its advertising level if the following condition is met and advertising serves as a strategic substitute:

$$\bar{a}_2 > \frac{2Ab^2 - 2bt + Ab - b^2t + \sqrt{b(b-1)^2(bt+A)^2}}{2b(1+b^2+b)} \quad (3.17)$$

Otherwise, the commercial broadcaster decreases the advertising level. It can be shown that the impact does not need be monotone if the regulator successively tightens the cap. Figure 3.1 illustrates this for $A = 1, t = 1$ and $b = 0.5$.

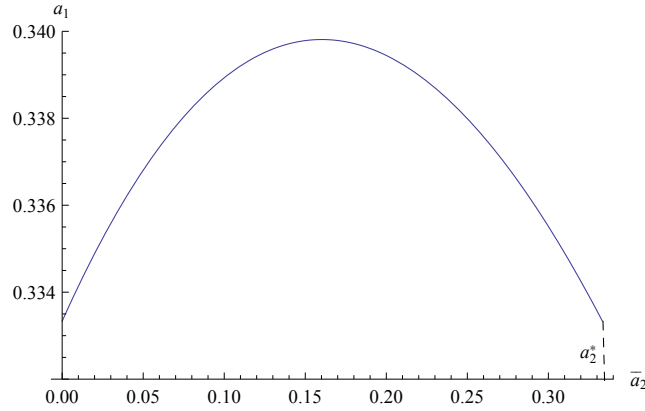


Figure 3.1: Advertising at commercial broadcaster depending on cap $\bar{a}$.

Resulting advertising prices are denoted as $\tilde{p}_1 = A - \tilde{a}_1 - b\bar{a}_2$ and $\tilde{p}_2 = A - \bar{a}_2 - b\tilde{a}_1$ at the commercial and the public broadcaster, respectively. Both prices are affected by regulation:

Lemma 3.3. *The price for adverts, both at the commercial and the public broadcaster, increases monotonically in the degree of regulation. That is, $\frac{\partial \tilde{p}_1}{\partial \bar{a}_2} < 0$ and $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} < 0$.*

Proof. See Appendix 3.A. □

Lemma 3.3 shows that advertising prices increase if the public broadcaster is regulated. Thus, our theory is in line with complaints by the advertising industry that caps on advertising at public broadcaster may hurt them via high access prices to viewers.

Next, we are interested in the reaction of the profit of the unregulated broadcaster to the regulation of the rival. The reaction of the non-regulated advertising level has direct consequences for the profit of the unregulated broadcaster. To determine the impact of regulation on the private, unregulated broadcaster we analyze the effect of an introduction of a marginal cap on advertising around the equilibrium without regulation.

If $\frac{\partial \bar{\Pi}_1}{\partial \bar{a}_2} \big|_{a_1=a_2=a^*}$ is negative (positive) broadcaster 1 earns higher (lower) profits when broadcaster 2 must set less advertising. Either is possible, it depends on the relative size of the pecuniary relative to the market share effect.

Proposition 3.3. *Due to a marginal cap on advertising on the PSB, the commercial broadcaster earns higher profits if*

$$b > \frac{A}{2t}. \quad (3.18)$$

Otherwise, profits fall.

Proof. See Appendix 3.A. □

The introduction of the cap has two opposing effects on the commercial broadcaster's profit. First, due to the cap advertising at the regulated broadcaster is lower and, hence, consumer find the channel more attractive. Thus, some consumers change to the public broadcaster and hence, the commercial one suffers from a loss in market share. Second, the price for advertisements per viewer is higher and, hence, the commercial broadcaster earns higher profits per viewer. The total effect on profits depends on the strength of the two effects. Note that condition (3.18) is more easily fulfilled, and hence profits are more likely to increase, if b and t are large. If b is large the pecuniary externality is strong, and a limit on the rival's amount of advertising has a large influence on the advertising

price. If t is large consumers are reluctant to switch between channels and, hence, the market share effect is weak.

We are also able to determine whether a tougher cap benefits the private broadcaster:

Lemma 3.4. *Tightening the advertising cap of the regulated broadcaster increases the profit of the unregulated rival, $\frac{\partial \Pi_1}{\partial \bar{a}_2} < 0$, if and only if*

$$\bar{a}_2 > \frac{2Ab + A - 2bt - b^2t}{3b(1+b)} = \bar{a}^{cr} \quad (3.19)$$

Proof. See Appendix 3.A. □

The principal trade-off for profits is the same as when considering the introduction of a cap around the symmetric equilibrium: market share effect versus pecuniary externality effect. According to equation (3.19) it depends on the strength of regulation, $\bar{a}_2$, which of both effects dominate. If $\bar{a}_2 > \bar{a}^{cr}$ the pecuniary externality effect dominates and profits increase. However, as regulation becomes successively stricter, the market share effects becomes more important until for $\bar{a}_2 < \bar{a}^{cr}$ it dominates and profits begin to shrink. Note, however, that scenarios are possible where the pecuniary externality effect is dominant for all values of $\bar{a}_2$. In particular, if the differentiation among broadcasters is sufficiently large,

$$t > \frac{2Ab + A}{b(2+b)}, \quad (3.20)$$

and, hence, $\bar{a}^{cr} < 0$, the commercial broadcaster always benefits from the tightening of the advertisement cap on its public competitor.

The effect of regulation on the public broadcaster's advertising revenues is also ambiguous. As the general expressions are rather cumbersome we demonstrate the outcomes for $A = 1, t = 1, b = 1$. Then, the profits of the public broadcaster simplify to

$$\Pi_2 = \left(\frac{5}{6} - \bar{a}_2 - \frac{1}{6} \sqrt{1 + 3\bar{a}_2^2} \right) \left(\frac{1}{3} + \frac{1}{3} \sqrt{1 + 3\bar{a}_2^2} \right) \bar{a}_2. \quad (3.21)$$

Figure 3.2 shows the profits depending on the cap on advertising $\bar{a}_2$. One can

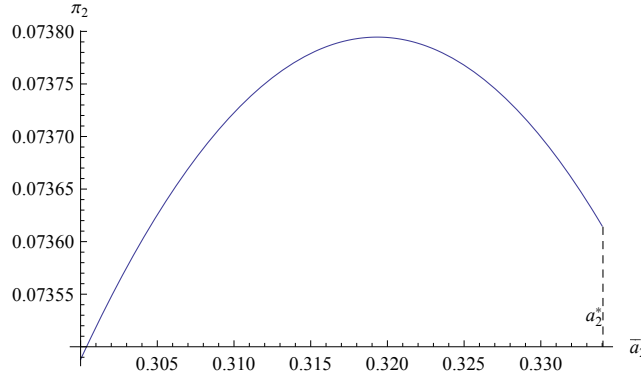


Figure 3.2: Profits of the regulated public broadcaster depending on cap $\bar{a}_2$.

see that for moderate levels of the cap profits of the regulated firm can increase due to regulation. However, as regulation becomes tougher (low levels of $\bar{a}_2$) the effect on profits is clearly negative. We summarize the impact of regulation on the regulated broadcaster in the following lemma:

Lemma 3.5. *If regulation is not too restrictive the profit of the regulated, public service broadcaster may increase due to the implementation of the regulation.*

3.4 Conclusion

This model has analyzed the effects of regulating advertising levels of broadcasters in a duopolistic environment. The European Commission’s “Audiovisual Media Services Directive” regulates advertising levels of all broadcasters to a maximum of 12 minutes per hour. Currently, there is a debate across members of the European Union to further restrict the advertising levels on their Public Service Broadcasting channels, which shall be effective in France in 2011. In the UK, the BBC is not even allowed to broadcast any advertising. The regulatory authorities argue that the quality would increase if broadcasters do not have to rely on advertising receipts. In Germany, there is the same debate, whether to ban advertising completely from Public Service Broadcasters, which the commercial rivals would embrace. However, given the knowledge about two-sided markets it is little surprising, as commercial channels would lose viewers. Advertising is assumed to be a nuisance to viewers, so that they migrate to the Public Service channels.

Nevertheless, apart from Reisinger et al. (2009) most of the literature applies a “competitive bottleneck” assumption, which neglects the impact of total advertising time available in the market on a broadcaster’s advertising price. Hence, our model is in line with Reisinger et al. (2009) and introduces a pecuniary externality.

We have distinguished two kinds of regulation of advertising levels: With symmetric regulation both channels are regulated to a binding advertising cap, while with asymmetric regulation only one broadcaster is regulated. This asymmetric regulation accounts for the mixed duopoly structure of many broadcasting markets, where regulated Public Service Broadcasting channels compete with unregulated (or less regulated) commercial broadcasters. We have shown that both channels can improve profits by regulation of advertising for sufficiently low degrees of competition in the viewer market. With asymmetric regulation the non-regulated commercial channel faces two countervailing effects. Regulation of the rival’s advertising level induces the standard negative market share effect, but this also induces a positive pecuniary effect. Due to the limited advertising level of the PSB, the advertising price rises, and the commercial channel gains additional market power in the advertising market. These two effects determine whether the commercial rival is positively or negatively affected by regulation. If the pecuniary effect is sufficiently strong, the commercial rival gains profits by restricting the PSB advertising levels.

3.A Appendix

Proof. of Lemma 3.3:

It is to show that $\frac{\partial \tilde{p}_1}{\partial \bar{a}_2} < 0$. By equation (3.7) it follows that

$$\begin{aligned} \frac{\partial \tilde{p}_1}{\partial \bar{a}_2} &= -\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b = \\ &= -\frac{2}{3}b - \frac{1}{3} + \frac{1}{6} \frac{-2Ab + A + 2b^2\bar{a}_2 + 2b\bar{a}_2 + tb + 2\bar{a}_2 + 2t}{\sqrt{A^2 - 2Ab\bar{a}_2 - At - A\bar{a}_2 + b^2\bar{a}_2^2 + bt\bar{a}_2 + b\bar{a}_2^2 + t^2 + 2t\bar{a}_2 + \bar{a}_2^2}}. \end{aligned} \quad (3.22)$$

First, consider the boundaries of $\lim_{\bar{a}_2 \rightarrow 0} (-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b)$ and $\lim_{\bar{a}_2 \rightarrow \infty} (-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b)$.

Evaluation at the inner boundary of zero yields that

$$\lim_{\bar{a}_2 \rightarrow 0} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) = -\frac{1}{6}(2 + 4b) - \frac{1}{6} \frac{A - 2t + 2Ab - tb}{\sqrt{A^2 - tA + t^2}}.$$

It holds that $\lim_{\bar{a}_2 \rightarrow 0} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) < 0$ if $-\frac{1}{6}(2 + 4b) < \frac{1}{6} \frac{A - 2t + 2Ab - tb}{\sqrt{A^2 - tA + t^2}}$. After squaring both sides and rearrangement it follows that $\lim_{\bar{a}_2 \rightarrow 0} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) < 0$ if and only if $(2(A - t)^2 + 3t^2 + 2A^2)b^2 + ((A - t)^2 + 3(A^2 + t^2))b + A^2 > 0$, which is always fulfilled. Evaluation at the outer boundary of $\bar{a}_2 \rightarrow \infty$ yields that

$$\lim_{\bar{a}_2 \rightarrow \infty} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) = -\frac{1}{3}(1 + 2b) + \frac{1}{3}\sqrt{1 + b + b^2}.$$

Applying same technique, it holds that $\lim_{\bar{a}_2 \rightarrow \infty} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) < 0$ if $-(1 + 2b) < \sqrt{1 + b + b^2}$. After squaring both sides and rearrangement it follows that $\lim_{\bar{a}_2 \rightarrow \infty} \left(-\frac{\partial \tilde{a}_1}{\partial \bar{a}_2} - b \right) < 0$ if and only if $-3b(1 + b) < 0$, which is always true. In the next step, we show that $\frac{\partial \tilde{p}_1}{\partial \bar{a}_2}$ is continuous and monotone. This is done by evaluating the second derivative of

$$\frac{\partial^2 \tilde{p}_1}{\partial \bar{a}_2^2} = \frac{1}{4} \frac{(A + tb)^2}{(A^2 - 2Ab\bar{a}_2 - At - A\bar{a}_2 + b^2\bar{a}_2^2 + bt\bar{a}_2 + b\bar{a}_2^2 + t^2 + 2t\bar{a}_2 + \bar{a}_2^2)^{\frac{3}{2}}},$$

which is always positive.

As the first derivative is monotone sloping, we can conclude that $\frac{\partial \tilde{p}_1}{\partial \bar{a}_2} < 0$ for any $\bar{a}_2 \in (0, \infty)$.

Consider the impact of advertising regulation on the PSB's price. The price $\tilde{p}_2$ reacts according to $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} = -1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2}$ given as

$$-1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2} = -1 - b \left(\frac{1}{3}(1 - b) - \frac{1}{6} \frac{-2Ab + A + 2b^2\bar{a}_2 + 2b\bar{a}_2 + tb + 2\bar{a}_2 + 2t}{\sqrt{A^2 - 2Ab\bar{a}_2 - At - A\bar{a}_2 + b^2\bar{a}_2^2 + bt\bar{a}_2 + b\bar{a}_2^2 + t^2 + 2t\bar{a}_2 + \bar{a}_2^2}} \right).$$

It can be shown that $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} < 0 \forall \bar{a}_2$. The proof goes along the previous line. The limit value at the point of zero is given as

$$\lim_{\bar{a}_2 \rightarrow 0} \left(-1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2} \right) = -\frac{1}{6} \frac{(6 + 2b(1 - b))\sqrt{A^2 + t^2 - tA} + Ab(1 + 2b) - tb(2 + b)}{\sqrt{A^2 + t^2 - tA}}.$$

This is negative for $(6 + 2b(1 - b))\sqrt{A^2 + t^2} - tA > Ab(1 + 2b) - tb(2 + b)$. After rearranging and squaring it holds that $\lim_{\bar{a}_2 \rightarrow 0} (-1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2}) < 0$ for $(A - t)^2(12 + 8b - 4b^3 - 8b^2) + tA(12 - 2b^3) + 8Atb(1 - b) + b^2(A^2 + t^2b^2) > 0$, which holds for every $b \in (0, 1)$. The limit value at infinity is given as

$$\lim_{\bar{a}_2 \rightarrow \infty} (-1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2}) = \frac{1}{3} \frac{b(1 + b + b^2) + (b^2 - b - 3)\sqrt{1 + b + b^2}}{\sqrt{1 + b + b^2}}.$$

After simple rearranging and squaring it follows that $\lim_{\bar{a}_2 \rightarrow \infty} (-1 - b \frac{\partial \tilde{a}_1}{\partial \bar{a}_2}) < 0$ if $b(b^3 + b^2 + 2b - 1) - 3 < 0$, which also holds for every $b \in (0, 1)$. Again, to show that $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} < 0$ it is sufficient to show that $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2}$ is continuous and monotone. As the second derivative of $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} = \frac{1}{4} \frac{b(A+tb)^2}{(A^2 - 2Ab\bar{a}_2 - At - A\bar{a}_2 + b^2\bar{a}_2^2 + bt\bar{a}_2 + b\bar{a}_2^2 + t^2 + 2t\bar{a}_2 + \bar{a}_2^2)^{\frac{3}{2}}} > 0$, we can state that $\frac{\partial \tilde{p}_2}{\partial \bar{a}_2} < 0$ for any $\bar{a}_2 \in (0, \infty)$. $\square$

Proof. of Proposition 3.3:

Profits of the commercial broadcaster are $\Pi_1(\tilde{a}_1, \bar{a}_2)$. Differentiation with respect to $\bar{a}_2$ yields:

$$\frac{d\Pi_1}{d\bar{a}_2} = \frac{\partial \Pi_1}{\partial a_1} \frac{d\tilde{a}_1}{d\bar{a}_2} + \frac{\partial \Pi_1}{\partial \bar{a}_2}. \quad (3.23)$$

As in equilibrium $\frac{\partial \Pi_1}{\partial a_1} = 0$ (first-order condition for profit maximization), the expression simplifies to

$$\frac{d\Pi_1}{d\bar{a}_2} = \frac{\partial \Pi_1}{\partial \bar{a}_2} = \frac{a_1}{2t} (A - a_1 - b\bar{a}_2) - ba_1 \left(\frac{1}{2} + \frac{\bar{a}_2 - a_1}{2t} \right). \quad (3.24)$$

Evaluating around the symmetric equilibrium ($a_1 = \bar{a}_2 = a_i^*$) without regulation gives that $\frac{d\Pi_1}{d\bar{a}_2} \leq 0$ if and only if:

$$a_i^* \geq \frac{A - tb}{1 + b}. \quad (3.25)$$

Using condition (3.8) this reads

$$\frac{d\Pi_1}{d\bar{a}_2} \leq 0 \Leftrightarrow b \geq \frac{A}{2t}. \quad (3.26)$$

Hence, the introduction of a marginal cap benefits the commercial broadcaster if

$$b > \frac{A}{2t}.$$

□

Proof. of Lemma 3.4:

The proof builds on the proof for Proposition 3.3. Evaluate equation (3.24) at $a_1 = \tilde{a}_1$ to get that $\frac{d\Pi_1}{d\bar{a}_2} \leq 0$ if and only if

$$\tilde{a}_1 \geq \frac{A - 2b\bar{a}_2 - bt}{1 - b}. \quad (3.27)$$

Using equation (3.16) and solving for $\bar{a}_2$ the condition reads

$$\bar{a}_2 \geq \frac{A + 2Ab - 2bt - b^2t}{3b(1 + b)}. \quad (3.28)$$

Thus, for $\bar{a}_2 \geq \frac{A+2Ab-2bt-b^2t}{3b(1+b)}$ the commercial broadcaster gains. Otherwise, profits of the commercial broadcaster decrease. □

Part II

Telecommunications Markets

Chapter 4

Fixed to VoIP Interconnection: Access Regulation with Asymmetric Termination Costs

4.1 Introduction

The emergence of voice telephony based on IP networks (VoIP) leads to fundamental changes in the telecommunications markets and disrupts the position of fixed-line incumbents. The VoIP adoption of US households has been steadily increasing from 28 % in 2008 to expected 50 % in 2010.¹ The same holds for Germany, where the share of calls placed on IP networks increased from 10 % in 2006 to 34 % in 2009², whereas the share of calls placed on traditional fixed-line is accordingly decreasing.

VoIP providers offer their service based on the Internet Protocol (IP), where access to end consumers is often controlled by fixed-line network operators. By regulatory requirements to offer local loop unbundling and bitstream access at the wholesale level, regulatory authorities have facilitated market entry of alternative providers into telecommunications markets.³ However, there are still open ques-

¹See http://www.ostermanresearch.com/execsum/or_voip2009execsum.pdf.

²See <http://www.bundesnetzagentur.de/media/archive/17897.pdf>.

³For a discussion on various regulatory instruments concerning wholesale regulation see, e.g., Vogelsang (2003), Foros (2004), and De Bijl and Peitz (2007).

tion with respect to call termination between traditional fixed-line and IP-based networks. With interconnection between both networks, calls from one network to the other are delivered through an interconnection point, or gateway, often controlled by the traditional fixed-line network. In this case, the fixed-line operator meters calls and sets a termination charge to the VoIP provider for calls terminating in its network. Otherwise, calls to the VoIP provider are terminated on the Internet, where costs of providing access are significantly lower than in traditional fixed-line networks (Monopolkommission 2006, p.25). Apart from this cost-asymmetry, other asymmetries can be observed in telecommunications markets, e.g., asymmetries in size of the customer base of providers.

The ability to take advantage of lower termination costs for VoIP providers depends on the regulatory regime. In May 2009, the European Commission (EU Commission 2009a) issued a “Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU” which sets out its views on how national regulators in Europe should approach this issue in the future. The recommendation basically is (i) to set termination charges to the long-run incremental cost level, and (ii) to require reciprocity with networks. In addition the European Commission recommends (iii) to adopt “bill-and-keep” (i.e. zero termination charges), which would effectively abolish termination charges. Each of these alternatives is considered in the European Commission’s recommendation (see in particular EU Commission (2009b, p.29)), where it is noted that, “a significant reduction of termination rates from current levels might create appropriate incentives for voluntary inter-operator agreements and consequently Bill and Keep type arrangements could evolve naturally”.

Given the observed asymmetries between telecommunications providers, the question arises whether all providers should be regulated in the same way or if some other regulation is more adequate. To answer this question, an analytical model based on the seminal model of Laffont et al. (1998a, b) introduces two asymmetries between telecommunications providers: A demand-side advantage in favor of the traditional fixed-line incumbent mirrors market structures in most European countries where the traditional fixed-line incumbent captures a larger subscriber base than its rivals. Additionally, a cost-side advantage is in favor of the fixed-line provider’s rival, which operates at lower termination cost. Hence,

the model is on competition between telecommunications providers which exhibit demand- and cost-side asymmetries, and is especially, but not exclusively, relevant for competition between traditional fixed-line and VoIP providers.

These terms of regulation have been designed for fixed and mobile networks, where asymmetric termination costs are less of an issue. The broadly recommended approach of setting termination charges to long-run incremental costs would have as consequence that the low cost network (e.g. a VoIP network) has to pay higher termination charges for call termination in the high cost network (e.g. a fixed-line network), than it otherwise receives for call termination in its network. This seems to be in contradiction with efforts to enhance market entry in the concentrated market of fixed-line telephony. An optimal regulation has to account for several kinds of asymmetries in telecommunications markets.

An asymmetry in termination costs has hardly been addressed in the literature and serves as the main innovation of this paper. The present model analyzes, whether to deviate from the recommended cost-based regulation approach and allow the low cost network to charge a markup on its termination cost. In a model of a pure demand-side asymmetry between telecommunications providers, Peitz (2005) shows that this is unambiguously beneficial for the respective provider. The present model can generalize his results and show that this conclusion is sensitive to a symmetry of termination costs. If one considers asymmetric termination costs, it can be shown that a unilateral markup on the termination cost of the low cost provider can even be to the detriment of the low cost network and to the benefit of the high cost network. This result is due to a cost-saving effect. If termination costs are sufficiently asymmetric, the high cost network has an incentive to terminate calls in the low cost network (off-net). To enhance the number of off-net calls it reduces its retail price and thereby, captures market shares from the low cost network. This (positive or negative) effect of regulation on providers' market share is new and basically determines the effect of regulation on providers' profits. In models of a pure demand-side asymmetry, the asymmetry affects subscribers' decision to subscribe to either provider, but, once subscribed, calling demand is unaffected by the asymmetry. Now, in these models, asymmetric regulation has no (local) effect on market shares which yields very clear-cut results concerning the effect of regulation on providers and subscribers. Since an additional supply-

side asymmetry directly affects subscribers' calling patterns, these results become ambiguous. Although the low cost network earns a higher termination revenue per rival consumer in the interconnection market, it may lose profits in the retail market. The total effect on profits depends on the extent of the asymmetry of termination costs and competition in the retail market.

Interestingly, if providers can discriminate between on-net and off-net prices, it can be shown that asymmetric regulation has no local effect on market shares, independent of any demand- and supply-side asymmetry. This restores the result of the previous literature even if one considers asymmetric termination costs. The low cost provider locally benefits from an increase in its termination charge and the high-cost provider suffers. Hence, the model predicts some testable results: Without price discrimination between on-net and off-net calls a low cost network may suffer from a markup on its termination costs, whereas with price discrimination it always benefits. The opposite holds for a high cost provider.

In the second part, in line with the European Commission's proposal, the model imposes reciprocity of termination charges for providers, which has also been considered by Carter and Wright (1999, 2003) in a model of a pure demand-side asymmetry. It can be shown that if the asymmetries between providers are sufficiently large, both providers prefer cost based regulation to the costs of the high cost network. If providers can discriminate between on-net and off-net prices for calls, reciprocal regulation of termination charges does not affect equilibrium profits for any supply-side symmetry. For any demand-side symmetry, the low cost provider benefits from regulation and the high cost provider suffers. Thereby, the model is able to justify reciprocal termination charges, even in the presence of cost asymmetries.

The chapter is in line with the wide literature on interconnection terms between telecommunications networks such as Armstrong (1998) and Laffont et al. (1998a, b), which focus on mobile communications.⁴ Asymmetries in network size have also been addressed by Gans and King (2001) who show that networks maximize joint profits by setting off-net prices below the efficient level and therefore termination rates below the true cost of termination. Dewenter and Haucap

⁴For an overview on the literature see Armstrong (2002) and for aspects on call externalities and network effects Harbord and Pagnozzi (2010)).

(2005) also analyze mobile termination rates when networks are of asymmetric size. They show that a mobile network's termination charge is the higher the smaller the network's size and that asymmetric regulation of only the larger network will induce the smaller networks to increase their termination rates. They support their results by empirical evidence. Hoernig (2009) calibrates a model of competition between an arbitrary number of telecommunications networks in the presence of tariff-mediated network externalities, call externalities, and cost and surplus asymmetries. He shows that a reduction in the mobile-to-mobile termination rate still mitigates network effects, and hence relaxes competition between mobile networks for market shares, the reduction in competition may or may not be sufficient to reduce consumer surplus in equilibrium, and it is less likely to do so the more significant call externalities are, and the larger the number of competing networks. Harbord and Hoernig (2010) run simulations based on the model of Hoernig (2009) to show that a "bill-and-keep" regime increases social welfare, consumer surplus, and networks' profits. First research on competition between traditional fixed-line and VoIP networks is conducted by De Bijl and Peitz (2009). As the fixed-line incumbent also controls the IP network, it also has the opportunity to offer IP-based service, so their model deals with endogenous consumer migration between both technologies.

The rest of the chapter is organized as follows: Section 4.2 provides the base model. Section 4.3 allows for raising the VoIP termination charge above marginal cost. Section 4.4 discusses the effect of reciprocity of termination charges for both networks. Section 4.5 allows providers to discriminate between on-net and off-net prices. Section 4.6 concludes.

4.2 The Model

Across Europe former state-owned incumbent fixed-line operators compete with alternative telecommunications providers. In the present model, it is assumed that a fixed-line provider (firm 1) competes with an entrant (firm 2), which operates at lower termination costs. Henceforth, this provider is labeled as a VoIP provider, although, it could be any provider which operates at lower termination costs than an established incumbent network. The providers compete for customers in the

retail market. VoIP customers completely substitute the fixed-line service. The VoIP provider needs access to an IP based network to offer voice services. To abstract from any regulatory issues on access regulation at the wholesale level and to focus on termination charges between networks, all costs and charges at the wholesale level are set to zero.⁵ The VoIP provider may use local loop unbundling to reach end users, which means that the VoIP provider makes use of the incumbent network through so called “bitstream access”. Hence, the framework captures “naked DSL” a service provision in which the VoIP provider provides a broadband Internet connection based on DSL by leasing only the broadband part of the frequency spectrum of the copper wire. The model follows Laffont et al. (1998a). It assumes that both networks are interconnected and provide full local coverage.

4.2.1 Cost Structure

For calls from the VoIP network to the traditional fixed-line operator the VoIP provider has to pay a termination charge of a_1 . For calls to the VoIP provider the traditional fixed-line network has to pay a termination charge of a_2 . It is assumed that termination charges are set by a regulator prior to competition in the retail market.

The networks incur a marginal cost c_i per minute for originating and terminating a call, so total marginal costs of a call are assumed to be $2c_i$, where the model abstracts from any additional costs, e.g. transmission costs. Since the VoIP network provides its service on the Internet, its costs are assumed to be lower than on fixed-line, hence $c_2 < c_1$. As De Bijl and Peitz (2009) state the “true” marginal costs of electronic communications are virtually zero.⁶ Also the German Monopolies Commission states that there should be no termination costs on IP based networks in general (Monopolkommission 2006). The model analyzes two regulatory regimes. In the first part, it evaluates the effects of a marginal increase of the VoIP provider’s termination charge above its marginal costs. In the second part it analyzes the effects of a marginal decrease of a reciprocal termination

⁵For issues on wholesale regulation in telecommunications markets see, e.g., Foros (2004).

⁶Nevertheless, in practice, operators allocate fixed costs to traffic, and hence may partly treat these costs as marginal costs when setting prices.

charge below the costs of the fixed-line incumbent.

4.2.2 Demand Structure

Consider a market where an incumbent fixed-line provider has a larger installed subscriber base than a VoIP provider, which has recently entered the market. To model the demand-side asymmetry the present model follows the framework of Carter and Wright (2003). The utility derived by a consumer for subscribing to either network i is given as

$$U_i = v_0 + \theta_i + u(q(p_i)), \quad (4.1)$$

where $q(p_i)$ is the number of calls placed on network i , depending on the price p_i . v_0 represents a fixed surplus (“option value”) from being connected to either network and is assumed sufficiently large so that all subscribers choose to be connected to a network. Subscribers receive a network specific benefit of subscribing to network i of

$$\theta_1 = \frac{\beta}{2\sigma} + \frac{1-x}{2\sigma}$$

and

$$\theta_2 = \frac{x}{2\sigma}.$$

Customers are endowed with a value of x drawn from a uniform distribution on the $[0, 1]$ interval, with the networks 1 and 2 located at either end of the interval. The parameter σ expresses the degree of substitution between both providers, where lower values correspond to a lower degree, so that providers can charge higher prices without losing all their market shares. Hence, σ can be interpreted to reflect the degree of competition in the market, with higher values corresponding to more intense competition.

As in the models of Carter and Wright (1999, 2003) the present model introduces an incumbency advantage of $\beta > 0$. An incumbency advantage results from a variety of factors. It might capture reputation effects of an established network, whereas there is uncertainty about the quality and service of the new network. Alternatively, it can proxy for switching costs (see De Bijl and Peitz (2002)) due to consumers’ inertia or due to technical reasons. In either case it is assumed

that the initial advantage is such that the fixed-line network has a larger installed base, which mirrors present market structures in most fixed-line telecommunications markets in Europe. Given equal prices, the fixed-line network can attract more consumers than its rival, hence the VoIP provider has to offset the fixed-line network's advantage by undercutting the fixed-line network's tariff.

Given that all consumers' marginal willingness to pay for calls is the same and known, networks can do no better than offering two-part tariffs. Each network charges a per-minute price p_i and a fixed fee F_i . Therefore, the two-part tariff is given as $T_i(q) = F_i + p_i q(p_i)$.

The function

$$v(p_i) = \max_q \{u(q) - p_i q\}$$

denotes the indirect utility derived from making calls at a price p , so $v'(q) \equiv -q(p)$ gives the associated demand function. For example, a linear demand function of $q(p) = 1 - p$ is represented by an indirect utility of $v(p) = \frac{1}{2}(1 - p)^2$. A consumer's net surplus of belonging to network i is $\omega_i = v(p_i) - F_i$. Subscribers are assumed to be identical in terms of their demand for calls to other subscribers.

Solving for the indifferent consumer with $U_1 = U_2$, the market share of the fixed-line provider is

$$s_1 = \frac{1}{2} + \frac{\beta}{2} + \sigma(\omega_1 - \omega_2) \quad (4.2)$$

and $s_2 = 1 - s_1$ for the VoIP provider.

4.3 Asymmetric Regulation

In the following analysis the VoIP provider may charge a termination fee above marginal costs.⁷ This assumption captures the policy concerns about call termination from fixed-line to VoIP networks. For calls terminated in the Internet termination costs are generally assumed to be lower than in fixed-line networks. Now, with cost based regulation the VoIP provider receives less for calls from rival subscribers than it pays for calls, which are terminated in the traditional fixed-line

⁷In a different model setup De Bijl and Peitz (2009) analyze the effects of charging termination fees at the fixed-line network, assuming bill-and-keep pricing at the VoIP network.

network. Hence, a relevant policy question is whether to allow VoIP networks to charge a termination fee above their marginal costs of termination.

Since market shares s_i are directly determined by the net surplus ω_i , it is more convenient to consider networks to compete over p_i and ω_i rather than in p_i and F_i . Substituting $F_i = v(p_i) - \omega_i$ the profit function of provider i is denoted as

$$\Pi_i = s_i(p_i - 2c_i)q(p_i) + s_i(v(p_i) - \omega_i) + s_i s_j ((a_i - c_i)q(p_j) - (a_j - c_i)q(p_i)). \quad (4.3)$$

The first two parts denote the profits in the retail market due to per-minute prices and fixed fees. Calling patterns are assumed to be balanced, with a share of $s_i s_j$ requiring interconnection.⁸ The third part represents the profit in the interconnection market. Provider i charges a termination rate of a_i , but incurs costs of c_i for rival subscribers' calls terminated in its network. Otherwise, for off-net calls by fellow subscribers the provider has to pay a termination charge of a_j but saves the termination costs.

The first order conditions for network i with respect to p_i and ω_i are

$$\frac{\partial \Pi_i}{\partial p_i} = s_i(q(p_i) + (p_i - 2c_i)q'(p_i)) + s_i v'(p_i) + s_i s_j c_i q'(p_i) = 0$$

and

$$\frac{\partial \Pi_i}{\partial \omega_i} = s_i((p_i - 2c_i)q(p_i) + (v(p_i) - \omega_i)) + (s_j - s_i)((a_i - c_i)q(p_j) - (a_j - c_j)q(p_i)) - s_i = 0,$$

where $q'_i = \frac{dq(p_i)}{dp}$. Using $v'(q) \equiv -q(p)$, the FOCs with respect to p_i yield equilibrium prices corresponding to “the perceived marginal costs” of a call of

$$p_i^* = 2c_i + s_j^*(a_j - c_i), \quad (4.4)$$

which is the standard result in the symmetric setup of Laffont et al. (1998a)

⁸This is the standard assumption in the literature (see, e.g., Laffont et al. (1998a) or Valletti and Cambini (2005)). Gabrielsen and Vagstad (2008) deviate and assume that people tend to place more calls in “calling clubs” i.e. to family and friends, independent of the market share of the providers.

and asymmetric setups of Carter and Wright (2003), Peitz (2005) and Valletti and Cambini (2005). By setting prices equal to the perceived marginal costs the networks can extract consumers' surplus by the fixed fee. The providers incur costs of $2c_i$ for originating and terminating calls on-net but save costs of $s_j c_i$ for calls terminated off-net. Rearranging $F_i = v(p_i) - \omega_i$, the fixed fee at the equilibrium per-minute price is given as

$$F_i^* = \frac{s_i^*}{\sigma} - s_i^*(a_j - c_i)q(p_i^*) + (s_i^* - s_j^*)(a_i - c_i)q(p_j^*). \quad (4.5)$$

A first insight into the effects of increasing termination charges can be gained by inspection of equations (4.4) and (4.5). An increase of termination charge a_j only directly affects the per-minute price of the rival firm i but is offset by a reduction in its fixed fee. The total effect on profit is ambiguous and depends on the asymmetry between operators. The first order effect of allowing the VoIP provider to charge a termination fee $a_2 > c_2$ is straightforward. It increases the marginal cost of a call for the traditional fixed-line network and thus the per-minute price p_1 . As the termination fee on the VoIP network pushes prices for customers of the fixed-line network, this implies a lower indirect utility from calls. At the margin this effect is equal to $-\frac{\partial p_1}{\partial a_2}q(p_1)$. Given lower indirect utility of calls, the fixed-line network lowers the fixed fee by the second term in equation (4.5) of $s_1^*(a_2 - c_1)q(p_1)$. Observe now from the equilibrium tariff of

$$T_i^* = \frac{s_i^*}{\sigma} + (s_i^* - s_j^*)(a_j - c_i)q(p_j^*) \quad (4.6)$$

that for equal market shares $s_1 = s_2$ both effects just offset each other, leading to a neutral result on market shares, as net surplus of calls ω_i is unaffected. This does not hold any longer for asymmetric termination costs, which is shown in the following section.

4.3.1 Subscribers' Net Surplus

Each provider sets its per-minute price equal to the perceived marginal cost and, thus, makes no profit from the amount of off-net and on-net traffic by fellow subscribers. The only source of income stems from subscription and inbound calls

from rival subscribers. Accordingly, each operator makes a profit in terms of net surplus of

$$\Pi_i^* = s_i^*(v(p_i^*) - \omega_i^*) + s_i^* s_j^*(a_j - c_i)q(p_j^*). \quad (4.7)$$

Proposition 4.1. *For symmetric termination costs subscribers of both networks benefit from a marginal increase of the VoIP provider's termination charge. For asymmetric termination costs net utilities may increase or decrease. Subscribers of both networks will likely benefit if providers are not too differentiated and termination costs are not too asymmetric.*

The complete technical proof is relegated to Appendix 4.A and goes along the line originated by Peitz (2005) and relies on applying results on supermodular games and comparative static analysis. Assume a larger installed base of the fixed-line network, i.e. $s_1 > s_2$. The first-order conditions of $\frac{\partial \Pi_i}{\partial \omega_i} = 0$ at equilibrium per-minute prices define the best-response functions in terms of net utilities for each provider, labeled as pseudo best-response functions. Providers offer pseudo best-response functions that are either strategic complements or substitutes, depending on the degree of competition between providers and the difference in termination costs. The cross derivative of the fixed-line provider's pseudo best-response function is denoted as

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial \omega_2} \Big|_{a_i=c_i} = \sigma - 2\sigma^2(c_2 - c_1)q(p_1^*) + \sigma^2(c_2 - c_1)^2 s_1^* q' \leq 0.$$

This implies that the traditional fixed-line network's pseudo best-response function is upwards sloping if providers are hardly differentiated and the difference in termination costs ($c_1 - c_2$) is not too large. An increase in the VoIP termination charge a_2 shifts the pseudo best-response function outwards, as

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial a_2} \Big|_{a_i=c_i} = \sigma(s_1^* - s_2^*)q(p_1^*) + s_1^* s_2^* \sigma(c_2 - c_1)q' > 0.$$

This term is strictly positive for $s_1^* > s_2^*$, $c_2 < c_1$, and $q' < 0$ which has been assumed.

Consider the VoIP provider's profit. Applying same technique, we obtain that

$$\frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial \omega_1} \Big|_{a_i=c_i} = \sigma - 2\sigma^2(c_1 - c_2)q(p_2^*) + \sigma^2(c_1 - c_2)^2 s_2^* q' \leq 0.$$

A marginal increase of the VoIP termination charge a_2 shift the function outwards as

$$\frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial a_2} \Big|_{a_i=c_i} = \sigma(s_1^* - s_2^*)q(p_1^*) + s_1^* s_2^* \sigma(c_2 - c_1)q' > 0.$$

The intuition is as follows. Consider the incumbent operator. As already stated by Peitz (2005) due to the larger termination charge it has to pay, it has an incentive to decrease the number of calls to the entrant in order to keep its perceived marginal costs low. The number is maximal for an equal split of the market, hence, the incumbent has an incentive to increase its subscribers' net surplus to increase its market share. However, to the contrary, it also has an incentive to increase the number calls to the rival's network. This is due to a cost-saving effect. The incumbent could save its higher costs by terminating calls in the entrant's network and thus, also has an incentive to increase the number of calls to the entrant's network.

Also the entrant has countervailing incentives. Clearly, on the one hand, the entrant has an incentive to increase the number of incoming calls to obtain higher revenues from incoming calls given rival's demand for calls and therefore offers a higher net surplus to its consumers. However, slightly reducing the net surplus reduces the amount of incoming calls and thereby, reduces the rival's cost-saving effect and increases rival's per-minute price. In turn, the net utility from calling on the incumbent's side decreases as well, competition on net surplus becomes less intense and the entrant may capture the remaining net surplus via the fixed fee.

4.3.2 Market Shares

After substitution of $\omega_i = v(p_i) - F_i$ in equation (4.2), the market share of firm 2 in equilibrium is

$$s_2^* = \frac{1}{2} - \frac{\beta}{6} - \frac{\sigma}{3} \left((v(p_1^*) - v(p_2^*) + s_2^* q(p_1^*)(a_2 - c_2) + s_1^* q(p_1^*)(c_2 - c_1) - s_1^* q(p_2^*)(a_1 - c_1) + s_2^* q(p_2^*)(c_2 - c_1)) \right). \quad (4.8)$$

Inserting equilibrium per-minute prices and total differentiation of equation (4.8) (locally around cost-based regulation of $a_i = c_i$) yields:

$$\frac{ds_2^*}{da_2}\bigg|_{a_i=c_i} = \frac{q' s_1^* s_2^* (c_2 - c_1)}{2(c_1 - c_2)(q(p_2^*) - q(p_1^*)) - (c_2 - c_1)^2 q' - \frac{3}{\sigma}} \quad (4.9)$$

and of $\frac{ds_1^*}{da_2}\bigg|_{a_i=c_i} = -\frac{ds_2^*}{da_2}\bigg|_{a_i=c_i}$ for the traditional fixed-line provider. Hence, there is a local effect on market shares for any asymmetry in termination costs ($c_1 \neq c_2$). Given that $c_2 < c_1$ the numerator is positive, as $q' < 0$. The sign of $\frac{ds_2}{da_2}$ is thus determined by the sign of the denominator.

Proposition 4.2. *For symmetric termination costs there is no local effect on market shares. For asymmetric termination costs an increase of the VoIP provider's termination charge has a positive local effect on its market share if i) the degree of substitution between both networks is sufficiently low (i.e., σ is sufficiently large), ii) if termination costs are sufficiently asymmetric, and iii) the demand for calls is sufficiently inelastic.*

Proof. See Appendix 4.A. □

Example 1: To illustrate the above propositions assume an indirect utility of calls of $v(p_i) = \frac{1}{2} \frac{(A-p_i)^2}{2b}$ for $A, b > 0$, which leads to a linear demand of calls of $q(p_i) = \frac{A-p_i}{b}$ and set $A = b = 1$. From evaluation of equation (4.9) at cost-based regulation it follows that there is a positive effect on the VoIP market share if

$$(c_1 - c_2)^2 > \frac{1}{\sigma}. \quad (4.10)$$

Given that providers are hardly differentiated, i.e., competition is intense, and given that termination costs are sufficiently asymmetric, an increase of the VoIP termination charge has a positive local effect on its market share. Otherwise, if competition is sufficiently soft, this may be reversed. The intuition behind the result is as follows: The fixed-line provider suffers from higher termination charges at the VoIP network. Therefore, it is in its interest to decrease the outflow of calls. As the per-minute prices are set to marginal cost, a larger termination fee directly increases those. Hence, the fixed-line network can only attract subscribers by lowering the fixed fee. Due to the intense competition, the VoIP provider in turn

sets a lower fixed fee itself in order not to lose subscribers in the retail market. Otherwise, for less intense competition, subscribers are less flexible and so the VoIP provider responds less fiercely to a decreasing fixed-line network's fixed fee in order to obtain a higher profit in the interconnection market. Therefore, both providers balance their profits in both the retail and the interconnection market.

4.3.3 Profits

Since providers set per-minute prices equal to perceived marginal cost, the equilibrium profits are denoted by equation (4.7). Since regulation affects market shares, it affects both the retail market (the first part of equation (4.7)), and the interconnection market (the second part of the equation). Differentiation of the profit functions with respect to a_2 (locally around cost-based regulation of $a_i = c_i$), yields

$$\frac{\partial \Pi_1^*}{\partial a_2} \Big|_{a_i=c_i} = 2s_1^* \frac{ds_1^*}{da_2} \left(\frac{1}{\sigma} + (c_1 - c_2)q(p_1^*) \right) + s_1^{*2} \left((c_1 - c_2)q' \frac{dp_1^*}{da_2} - q(p_1^*) \right) \quad (4.11)$$

and

$$\frac{\partial \Pi_2^*}{\partial a_2} \Big|_{a_i=c_i} = 2s_2^* \frac{ds_2^*}{da_2} \left(\frac{1}{\sigma} - (c_1 - c_2)q(p_2^*) \right) + s_2^{*2} \left(q(p_1^*) - (c_1 - c_2)q' \frac{dp_2^*}{da_2} \right). \quad (4.12)$$

Proposition 4.3. *With symmetric termination costs a marginal increase of the VoIP provider's termination charge positively (negatively) affects the profit of the VoIP provider (fixed-line provider) locally around cost-based regulation. With asymmetric termination costs this may be reversed, so both providers may benefit or suffer. If competition becomes too intense both providers prefer cost-based regulation of termination charges.*

Given symmetric termination costs of $c_1 = c_2$ it has been shown in equation (4.9) that there is no local effect on market shares, hence $\frac{ds_i^*}{da_2} \Big|_{a_i=c_i} = 0$. Applying the neutrality of market shares simplifies the effect of a marginal increase of the

VoIP termination charge on providers' profits denoted as

$$\frac{\partial \Pi_1^*}{\partial a_2} \Big|_{c_1=c_2} = -s_1^{*2} q(p_1) < 0$$

and

$$\frac{\partial \Pi_2^*}{\partial a_2} \Big|_{c_1=c_2} = s_2^{*2} q(p_1) > 0.$$

This confirms the non-neutrality result on profits obtained by Peitz (2005) in a model of demand-side asymmetry and by Kocsis (2007) in a model of supply-side asymmetry for symmetric termination costs. However, in the present model the cost asymmetry additionally affects calling patterns, so the effect on profits is less straightforward and the results of Peitz (2005) and Kocsis (2007) may be reversed. The VoIP provider may suffer and the traditional fixed-line provider may benefit from a markup on the VoIP provider's termination cost.

Let us decompose the effects on profits in the retail and in the interconnection market and assume the VoIP provider captures market shares from the fixed-line provider, i.e. $\frac{ds_2^*}{da_2} > 0$. An increase in the termination fee above marginal termination cost of the VoIP provider affects i) the per-minute profit of rival subscribers making off-net calls ($a_i - c_i$), ii) the demand for off-net calls per rival subscriber ($q(p_j^*)$), and iii) the total amount of off-net calls ($s_i^* s_j^*$). Obviously, a termination markup increases the per-minute profit per rival subscriber unit. Calling patterns are assumed to be balanced. Starting from the asymmetric situation of $s_2 < s_1$, an increase in s_2 increases the number of off-net calls, which is maximized at $s_1 = s_2$. Both effects are to the benefit of the VoIP provider. Total interconnection profit is determined by $s_i^* s_j^* (a_i - c_i) q(p_j^*)$. Hence, it is further necessary to determine the impact on rival subscriber's demand, given as $\frac{dq(p_i^*)}{da_2} = q' \frac{dp_i^*}{da_2}$, with $q' < 0$. It holds that

$$\frac{\partial p_1^*}{\partial a_2} \Big|_{a_i=c_i} = s_2^* - (c_1 - c_2) \frac{ds_2^*}{da_2} \leq 0.$$

Thus the effect on rival subscribers' demand is ad hoc unclear. If the difference in termination costs is large the incumbent has an incentive to push the demand for off-net calls to save its termination costs and thereby, to decrease its per-minute price. Otherwise, if the VoIP provider's subscriber base is too large, an increase in

the VoIP provider's termination charge may be to the detriment of its termination profit. This is due to providers' perceived marginal costs. If the VoIP provider's subscriber base is sufficiently large, there are many off-net calls. Now, an increase in a_2 has a larger impact on rival's per-minute prices for a larger VoIP provider's market share. Given the difference in termination costs, the fixed-line provider increase its per-minute prices for a larger market share of the VoIP provider, reducing the demand of the fixed-line subscribers which may overturn the cost-saving effect. This cost-saving effect is new and not present in the current literature. The extent of this cost-saving effect essentially determines many of the results.

Let us now consider the retail market. It follows from equation (4.7) that the effect of a termination markup of the VoIP provider's retail profit is determined by market shares and the fixed fee, determined by subscribers' net surplus as $F_i = v(p_i) - \omega_i$. Assume again that the VoIP provider's market share is increasing in a_2 . Locally evaluating the derivative of the fixed fee with respect to the termination fee of the VoIP provider (around cost-based termination charges) yields

$$\frac{\partial F_2^*}{\partial a_2} \Big|_{a_i=c_i} = \frac{ds_2^*}{da_2} \left(\frac{1}{\sigma} - (c_1 - c_2)q(p_2^*) - (c_1 - c_2)q' \right) - (s_1^* - s_2^*)q(p_1^*).$$

It has been stated above that for symmetric termination cost subscribers' net surplus increases. Hence, since market share are locally unaffected for $c_i = c_j$, fixed fees decrease, leading to lower profits in the retail market. Otherwise, for asymmetric termination costs, the fixed fee may increase or decrease. If providers are sufficiently differentiated (σ is small) the VoIP provider will likely benefit in the retail market, otherwise it may be harmed. Notice that the fixed-line provider compensates its subscribers for paying higher per-minute prices by increasing subscribers' net surplus. In order not to lose market shares, the VoIP provider has to respond by offering a higher net surplus itself. If providers are hardly differentiated, competition on net surplus is intense. Otherwise, if they are sufficiently differentiated, competition is relatively weak and the VoIP provider responds less fiercely to the fixed-line provider and can maintain a larger fixed fee. The effects in the retail and interconnection market may be countervailing, leading to a non-monotone relationship between the termination charge and profits. This will be illustrated in example 2.

Consider the effects for the fixed-line provider. Notably, as per-minute prices are set equal to perceived marginal cost, an increase of a_2 does not affect the interconnection profit of equation (4.7) locally around $a_1 = c_1$. So the local effect on total profit is given as

$$\frac{\partial \Pi_1^*}{\partial a_2} \Big|_{a_i=c_i} = \frac{ds_1^*}{da_2} F_1 + s_1^* \frac{\partial F_1^*}{\partial a_2}.$$

Remember that the fixed-line provider may offer a higher net surplus to its subscribers in response to an increase in a_2 . In order to determine the effect on the fixed fee it is necessary to additionally determine the effect on the indirect utility from making calls, as $F_i = v(p_i) - \omega_i$. Given the indirect utility $v(p_i)$ the fixed fee is the lower the higher the net utility ω_i . The effect on the indirect utility from making calls is affected by the per-minute price, which may increase or decrease in a_2 as $\frac{\partial p_1^*}{\partial a_2} \Big|_{a_i=c_i} = s_2^* - (c_1 - c_2) \frac{ds_2^*}{da_2} \leq 0$. Now if competition is sufficiently soft, it follows that $\frac{ds_2^*}{da_2} > 0$, and the per-minute price for fixed-line customers decrease. The fixed-line provider saves the higher termination cost on its network for every call terminated in the VoIP network. For $s_2 < s_1$ an increase in the VoIP provider's market share increases the number of off-net calls, which is maximized at $s_2 = s_1$. Now, the perceived marginal cost is the lower the higher the VoIP provider's market share. It can even be in the interest of the fixed-line provider to give up market share to the rival. This enables the fixed-line provider to increase the indirect utility and set a higher fixed fee to remaining subscribers. This positive effect on indirect utility vanishes if termination costs become symmetric. This positive effect holds if the share of off-net calls, determined by rival's market share is small, otherwise for large s_2 the total loss in market shares might become too large compared to the cost saving effect. Thus, the effects on profits crucially depend on the demand- and supply-side asymmetry and on the degree of competition in the market.

The following example illustrates that both positive and negative effects on profits are possible for both providers and the relationship between profits and the VoIP provider's termination charge is non-monotone for a more global deviation from cost-based regulation.

Example 2: Consider a linear demand of $q(p) = 1 - p_i$ and set parameters

at $a_1 = c_1 = 0.5$ and $c_2 = 0$. Table 4.2 illustrates the impact of a small increase of the VoIP provider's termination charge from $a_2 = 0$ to $a_2 = 0.05$ on profits and market shares, depending on the degree of competition and the traditional fixed-line provider's initial advantage, which determines the installed providers' subscriber base.

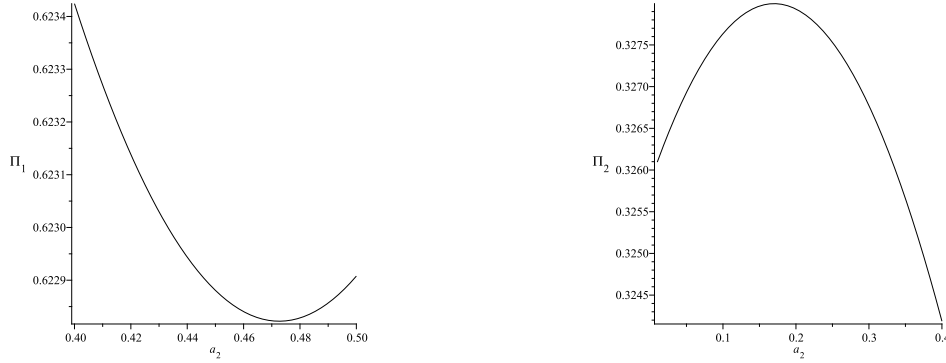
Table 4.1: Impact of a marginal increase of the VoIP termination charge (a_2) on market shares and profits.

	$\sigma = 0.01$		$\sigma = 0.1$		$\sigma = 0.5$	
	$\beta = 1$	$\beta = 4$	$\beta = 1$	$\beta = 4$	$\beta = 1$	$\beta = 4$
Δs_2	-0.03 %	+0.40 %	-0.04 %	-0.19 %	-0.14 %	-0.22 %
$\Delta \Pi_1$	+0.20 %	-0.10 %	-0.14 %	-0.01 %	-0.77 %	-0.22 %
$\Delta \Pi_2$	-0.05 %	+0.80 %	+0.02 %	-0.31 %	+0.34 %	-0.18 %

An increase in the termination charge is not necessarily beneficial for the VoIP provider and not necessarily detrimental for the traditional fixed-line provider. If competition is very soft ($\sigma = 0.01$) and the fixed-line incumbency advantage is large ($\beta = 4$), the VoIP provider benefits in terms of market shares and profits, whereas the fixed-line provider loses. Otherwise, if the VoIP installed base is already sufficiently large (i.e., $\beta = 1$), this is reversed. Given competition is intense and the VoIP installed base is sufficiently small, both providers prefer cost-based regulation, as an increase of the VoIP provider's termination charge is to the detriment of both providers' profits.

Figure 4.1 plots the profit functions of the VoIP provider for a larger deviation from cost-based regulation in the above example for $\sigma = 0.5$ and $\beta = 1$. The VoIP provider prefers an above, but close to marginal cost termination charge, whereas the traditional fixed-line provider prefers the VoIP provider to be regulated at marginal costs. To conclude, there are opposing effects a regulatory authority has to consider when regulating termination charges for VoIP networks. Regulation of termination fees may have a non-monotone effect on profits for asymmetric termination costs. This reverses the results of Peitz (2005) and Kocsis (2007).⁹ If termination costs become more symmetric, the market share effect

⁹Kocsis (2007) also considers asymmetric termination costs, but obtains similar results as Peitz



Fixed-line provider's profit.

VoIP provider's profit.

Figure 4.1: Providers' profits depending on a_2 .

becomes less effective, moving towards to the results of the previous literature, otherwise for a more dominant market share effect, their results less likely hold.

4.4 Reciprocal Regulation

For fixed-line networks the European Commission proposes to set termination charges on a reciprocal basis. With mobile telecommunications the European Commission allows for temporary higher termination charges for entrants until they have reached an efficient size of firm. In the fixed-line telecommunications markets, though, the European Commission does not propose any temporary asymmetries of termination charges. Any asymmetries have to be explicitly justified to the national regulatory authorities. Communications providers shall set the same termination charge as the fixed-line network to ensure efficient market entry and to avoid price squeezing vis-à-vis smaller operators. According to the

(2005). Her model implicitly assumes that providers set termination charges at different stages of the game: At a first stage the more efficient firm sets its termination charge, assuming that the less efficient provider is regulated to marginal costs at the second stage. Instead, the present chapter assumes that termination charges are set simultaneously. This contradicts her results.

European Commission entrants would not have any significant disadvantages in cost as they would primarily offer services in regional conurbations and may lease access to the incumbents' networks. The European Commission states that an entrant may not face any disadvantages in costs, but does not consider that it might face advantages.

The following section analyzes the effects of reciprocity of termination charges, $a_1 = a_2 = a$, in the previous model of cost-asymmetries. Since "bill-and-keep" pricing is proposed in the long run, the model analyzes the effect of marginally decreasing the reciprocal termination charge below the fixed-line network's costs.

For reciprocal termination charges equilibrium per-minute-prices are set to

$$p_i^* = 2c_i + s_j^*(a - c_i). \quad (4.13)$$

4.4.1 Subscribers' Net Surplus

Considering reciprocal termination fees it can be shown that subscribers may be again adversely affected by regulation. The technical proof goes along the line of section 4.3.1 and is relegated to Appendix 4.A.

Proposition 4.4. *For symmetric termination costs there is no local effect on subscribers' net utilities. Otherwise, for asymmetric termination costs, locally decreasing the reciprocal termination charge below the costs of the fixed-line provider is unambiguously beneficial for fixed-line subscribers. VoIP subscribers may benefit or suffer.*

Proof. See Appendix 4.A. □

Since termination costs are set reciprocally, the incumbent faces the same termination cost for on-net and off-net termination, thus, unlike with asymmetric regulation, there is no cost-saving opportunity of off-net call termination any longer. Since the incumbent faces an access deficit, it has an unambiguous incentive to reduce the number of off-net calls. As the number of off-net calls is determined by the market shares, the incumbent should increase the net utility to the subscribers in order to increase its market share and to reduce the number of off-net calls. The entrant still has countervailing incentives. On the one hand, since $a = c_1 > c_2$,

it benefits from interconnection of rival customers, thus it also has an incentive to increase the amount of incoming calls by increasing the net utility for its customers. On the other hand, it faces higher termination costs for off-net than for on-net calls, thus, it has an incentive to reduce the amount of off-net calls by decreasing the net utility for its customers. Thus, the effect on entrant's subscribers depends on the cost difference. If entrants termination costs are sufficiently low compared to the incumbent's cost, entrant's subscribers are harmed, otherwise, if costs become more symmetric they benefit.

4.4.2 Market Shares

The equilibrium market shares with reciprocal termination charges is given as

$$s_2^* = \frac{1}{2} - \frac{\beta}{6} - \frac{\sigma}{3} \left((v(p_1^*) - v(p_2^*) + s_2^* q(p_1^*)(a - c_2) + s_1^* q(p_1^*)(c_2 - c_1) - s_1^* q(p_2^*)(a - c_1) + s_2^* q(p_2^*)(c_2 - c_1)) \right) \quad (4.14)$$

for the VoIP provider and $s_1 = 1 - s_2$ for the fixed-line provider. By total differentiation of equation (4.14) with respect to a locally around cost-based regulation of the fixed-line network ($a = c_1$) it follows that

$$\frac{ds_2^*}{da} \Big|_{a=c_1} = \frac{(c_1 - c_2)(s_2^{*2} - 2s_1^* s_2^*)q'}{2(c_1 - c_2)(q(p_2^*) - q(p_1^*)) - (c_1 - c_2)^2 s_2^* q' - \frac{3}{\sigma}}. \quad (4.15)$$

Proposition 4.5. *For symmetric termination costs there is no local effect on market shares. Otherwise, for asymmetric termination costs, a marginal decrease of the reciprocal termination charge below the cost of the fixed-line network increases the VoIP provider's market share if i) providers are sufficiently differentiated, ii) the difference in termination costs is not too large, and iii) the VoIP provider's market share is not too large.*

The analysis shows that the “neutrality result” on market shares by Carter and Wright (2003) only holds for symmetric termination costs. Otherwise, there is a local effect of regulation on market shares, determined by the sign of the denominator. Comparison with equation (4.9) shows that the VoIP network qualitatively has to consider the same effects as with asymmetric termination charges. With

asymmetric termination charges the fixed-line provider could save its higher termination costs by terminating calls in the VoIP network. As with asymmetric termination charges ($\frac{\partial p_1^*}{\partial a_2}|_{a_i=c_i} = s_2^* - (c_1 - c_2)\frac{ds_2^*}{da_2}$) the fixed-line provider offers a higher net surplus to its subscribers. Given symmetric termination charges there is no cost saving and the positive effect on fixed-line subscriber's indirect utility vanishes. Now, if providers are sufficiently differentiated, i.e., σ is small, the VoIP provider will likely gain market shares. The fixed-line provider has to offset the advantage in termination costs of the VoIP provider by reducing the fixed fee, but if subscribers find it costly to switch this does not offset the higher per-minute price.

Example 3: Consider a linear demand of $q(p_i) = 1 - p_i$ again. The VoIP provider gains market shares by reducing the reciprocal termination charge below the cost of the traditional fixed-line network, i.e. $\frac{ds_2^*}{da}|_{a=c_1} < 0$ if

$$(c_1 - c_2)^2 < \frac{3}{\sigma} \frac{1}{(2 + 3s_2^*)}. \quad (4.16)$$

This holds if the VoIP provider's initial cost-advantage is sufficiently low, competition in the market is sufficiently soft, and the VoIP provider's market share is sufficiently small. Consider from the per-minute price of the fixed-line provider of $p_1^* = 2c_1 + s_2^*(a - c_1)$ that a reciprocal termination charge of $a < c_1$ decreases the price and thus increases the indirect utility of calls $v(p_1^*)$. Given a larger market share of the VoIP provider this effect is intensified and the VoIP provider has to offset the increase of fixed-line subscribers' net surplus in order not to lose market shares.

4.4.3 Profits

For symmetric termination costs a marginal reduction of the reciprocal termination charge does not affect providers' profits. This no longer holds for asymmetric termination costs. From the previous section it follows that providers can both gain or lose market shares in response to a marginal reduction of the reciprocal termination charge below costs of the fixed-line network. Then, both providers' profits may be positively or negatively affected. The effect on providers' profit

crucially depends on the degree of competition in the market and the demand- and supply-side asymmetry.

Proposition 4.6. *For symmetric termination costs a marginal reduction of the reciprocal termination charge does not affect providers' profits. For asymmetric termination costs providers can both gain or suffer. If competition is sufficiently soft a marginal reduction of the reciprocal termination charge is generally to the detriment of the fixed-line provider and to the benefit of the VoIP provider. If competition is intense and the demand-side asymmetry is sufficiently large, the fixed-line provider may benefit. Both providers prefer cost-based regulation at termination costs of the fixed-line provider if competition is intense and the asymmetries are sufficiently large.*

Proof. See Appendix 4.A. □

Consider the effects for the VoIP provider in both the interconnection and the retail market. Marginally decreasing the reciprocal termination charge induces countervailing effects in the interconnection market, where the termination charge affects i) the per-minute profit per rival subscriber ($a - c_2$), ii) the total off-net traffic by rival subscribers ($q(p_1^*)$), and iii) the amount of off-net traffic ($s_1^* s_2^*$). The first effect is clearly negative. The second effect is positive. Marginally reducing the termination fee leads to a decrease in the fixed-line provider's per-minute price, notably $\frac{\partial p_1^*}{\partial a}|_{a=c_1} = s_2^* > 0$. From $q' < 0$ it follows that off-net traffic per fixed-line subscriber is increasing, which is to the benefit of the VoIP provider as long as $a > c_2$. Total off-net traffic ($s_1^* s_2^* q(p_1^*)$) depends on the sign of the market shares effect. Given soft competition, the VoIP provider gains market shares, and thus, the number of off-net traffic is increasing for any $s_2 < s_1$. Hence, the total effect on interconnection profit is ambiguous.

Consider the effects in the retail market. The effect on retail profit is determined by the fixed fee, given by

$$F_2^* = v(p_2^*) - \omega_2^*.$$

The effect on the fixed fee is determined by the indirect utility from making calls and the subscribers' net utility. Notice from section 4.1. that the fixed-

line provider offers a larger net surplus to its subscribers. This implies a tendency towards a lower fixed fee for the VoIP provider, too, in order not to lose (too much) market share. However, a marginal reduction of the reciprocal termination charge decreases the per-minute price for VoIP provider, if the provider gains market shares, as $\frac{\partial p_2^*}{\partial a} = -\frac{ds_2^*}{da}(c_1 - c_2) + s_1^* > 0$ for $\frac{ds_2^*}{da} < 0$. The per-minute price decreases, as, on the one hand, the termination charge decreases and, on the other, hand fewer calls are terminated off-net. This translates into a larger indirect utility from marking calls and, thus, to an opposing effect on the fixed fee.

Now, the effect on total profit is ambiguous. Suppose competition is sufficiently soft, i.e., σ is low, so that according to condition (4.15) the market share of the VoIP provider is increasing, i.e. $\frac{ds_2^*}{da} < 0$. In this case, effects on the retail market are relatively weak and the positive effects in the interconnection markets dominate. For more intense competition the reduction in fixed fees to gain market share can become too large, so that total profit is decreasing. This especially holds for a large demand-side asymmetry, so that the VoIP provider has a small installed subscriber base. In this case relatively few calls are terminated in its network and a marginal benefit from interconnection becomes relatively unimportant for total profits. Thus, a gain in market shares is not necessarily sufficient for the profit to increase.

Let us consider competition to be intense, so that the VoIP provider loses market share. This may not necessarily profit reducing either. For any $s_2 < s_1$ the VoIP network has a net outflow of calls to the fixed-line network and pays a per-minute price of a for every call. A reduction of a decreases the price the VoIP provider has to pay, but also the total number of off-net calls. The two effects oppose each other. Given that the provider initially captures only a small installed subscriber base the demand effect is negligible so that the provider is harmed. Given a larger subscriber base the demand effect becomes more important and the VoIP provider may benefit although it loses market shares. In total, positive as well as negative effect are possible, which is shown in example 4 below. More generally, the VoIP provider will likely benefit from a reduction of the reciprocal termination charge. The effects on profits seem to be more clear-cut than with asymmetric regulation, as illustrated in figure 4.2.

Consider the profit of the fixed-line provider. It will be shown in Appendix

4.A. that whenever its market share is decreasing, its total profit is decreasing. Note that fixed line subscribers' net surplus is unambiguously increasing. Hence, if market shares are not increasing, the fixed fee and thus the retail profit is decreasing. In the interconnection market it faces a loss per rival subscriber. If the fixed-line provider gives market shares to the rival, total off-net traffic of a VoIP provider increases, leading to a larger loss from interconnection. Moreover, since $\frac{\partial p_2^*}{\partial a}|_{a=c_1} = s_1^* + (c_1 - c_2) \frac{ds_1^*}{da} > 0$ for $\frac{ds_1^*}{da} > 0$ VoIP subscribers' calling demand increases, leading to loss in the interconnection market, too, which leads total profit to decrease.

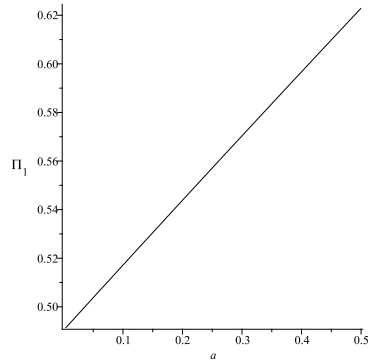
Otherwise, for increasing markets shares the fixed-line provider may benefit. Decompose the effects of the retail and the interconnection market. The effect in the interconnection market depends on the effects on the revenue per rival subscriber and total off-net traffic. Clearly, as termination fees are regulated below the costs of the fixed-line provider there is an unambiguous loss from interconnection of $s_1^* s_2^* q(p_2^*)$ per rival subscriber. Starting from the asymmetric situation of $s_1 > s_2$, off-net traffic to the fixed-line network is reduced. The effect on the demand for off-net calls depends on the fixed-line provider's market share, as $\frac{\partial p_2^*}{\partial a}|_{a=c_1} = s_1^* + (c_1 - c_2) \frac{ds_1^*}{da} \leq 0$. Consider $\frac{ds_1^*}{da} < 0$, so the fixed-line provider gains market shares. The per-minute price of the VoIP provider will increase if s_1 is sufficiently low, i.e. the demand-side asymmetry is sufficiently low. This benefits the fixed-line network as VoIP total off-net traffic, and thus, the loss from interconnection is reduced. Otherwise, for a higher s_1 the per-minute price of VoIP subscribers might decrease, so subscribers' demand for calls is increasing, which in turn harms the fixed-line network. Now, the total effect on the fixed-line profit depends on the demand-asymmetry. For a large asymmetry it may be harmed, for lower values it benefits.

Example 4: Consider a linear demand of calls of $q(p_i) = \frac{A-p_i}{b}$ and set $A = 2, b = 5, c_1 = 0.5$, and $c_2 = 0$. The following table illustrates the sign of the marginal derivatives of providers' profits and the VoIP provider's market share, depending on the degree of competition and on the fixed-line provider's initial advantage.

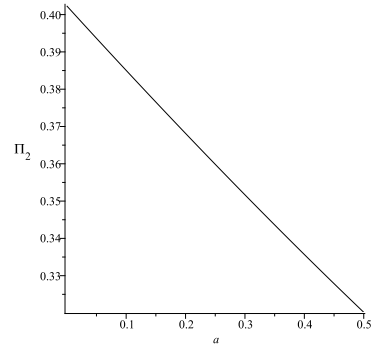
A positive sign indicates that the variable is decreasing in response to a reduction of the reciprocal termination charge.

Table 4.2: Impact of a marginal decrease of the reciprocal termination charge (a) on market shares and profits.

	$\sigma = 0.01$		$\sigma = 0.5$		$\sigma = 0.95$	
	$\beta = 1$	$\beta = 4$	$\beta = 1$	$\beta = 4$	$\beta = 1$	$\beta = 4$
$\frac{ds_2^*}{da} \big _{a=c_1}$	-	-	-	-	-	-
$\frac{d\Pi_1^*}{da} \big _{a=c_1}$	+	+	+	+	-	+
$\frac{d\Pi_2^*}{da} \big _{a=c_1}$	-	-	-	-	-	+



Fixed-line provider's profit.



VoIP provider's profit.

Figure 4.2: Providers' profits depending on a .

In this example the VoIP provider gains market share and profit, whereas the fixed-line provider is harmed by a reduction of the reciprocal termination charge. Only if competition is very intense and the fixed-line advantage very high, both providers suffer from a marginal decrease of the reciprocal termination charge. In this case the VoIP provider captures a small installed subscriber base, so interconnection is relatively unimportant for total profits. If competition in the retail market is intense, competition on net surplus is intense. As the fixed-line subscribers' net surplus is increasing in a marginal reduction of the reciprocal termination charge, the VoIP provider has to offset the increase, in order to be compet-

itive at the retail level. If competition becomes too intense, both providers would prefer keeping the reciprocal termination charge at the cost level of the traditional fixed-line provider, which is in line with Carter and Wright (2003).

Also the global effect on profits seem to be very clear-cut, which is shown in figure 4.2.¹⁰ A decrease of the reciprocal termination charge is beneficial for the VoIP provider and detrimental for the fixed-line provider. In this sense, a reduction of the reciprocal termination charge towards a “bill-and-keep” regime of zero termination charges may serve as an instrument to encourage market entry into the fixed-line telecommunications market.

4.5 Price Discrimination

The following section allows providers to charge different prices for calls terminated on the subscriber’s network (“on-net”) and for those terminated on the rival’s network (“off-net”). Denote provider i ’s on-net price as p_i and its off-net price as $\hat{p}_i$. If a provider’s market share is s_i , its subscribers make a fraction s_i of their calls on-net and the remaining $1 - s_i$ calls off-net. Then, subscribers’ net surplus $\omega(p_i, \hat{p}_i)$ is

$$\omega(p_i, \hat{p}_i) = s_i v(p_i) + s_j v(\hat{p}_i) - F_i. \quad (4.17)$$

Following the analysis of section 4.2, solving for the indifferent subscriber yields a market share for the fixed-line provider of

$$s_1 = \frac{1}{2} + \frac{\beta}{2} + \sigma(\omega(p_1, \hat{p}_1) - \omega(p_2, \hat{p}_2)) \quad (4.18)$$

and of $s_2 = 1 - s_1$ for the VoIP provider.

¹⁰Parameter values are set to: $A = 1, b = 1, \sigma = 0.5, \beta = 1, c_1 = 0.5$, and $c_2 = 0$.

4.5.1 Asymmetric Regulation

Provider i 's profit is denoted as

$$\begin{aligned} \Pi_i = & s_i(s_i(p_i - 2c_i)q(p_i) + s_j(\hat{p}_i - c_i - a_j)q(\hat{p}_i)) \\ & + s_i(s_i v(p_i) + s_j v(\hat{p}_i) - \omega(p_i, \hat{p}_i)) + s_i s_j (a_i - c_i) q(\hat{p}_j). \end{aligned} \quad (4.19)$$

The first two parts denote the profit in the retail market from setting on-net and off-net per-minute prices net the costs of calls. The third part denotes the profit from the fixed fee. The fourth part denotes the income in the interconnection market.

By solving $\frac{\partial \Pi_i}{\partial p_i} = 0$ and $\frac{\partial \Pi_i}{\partial \hat{p}_i} = 0$ providers set per-minute prices equal to the true marginal costs, i.e.

$$p_i^* = 2c_i \quad (4.20)$$

and

$$\hat{p}_i^* = c_i + a_j. \quad (4.21)$$

Without price discrimination, the first-order conditions with respect to call prices weights the optimal per-minute prices with price discrimination of equations (4.20) and (4.21) by their market shares, which gives equation (4.4). Since termination costs differ for both providers, a uniform per-minute price is the average of marginal on-net and off-net costs, which reflects a weighted average of true marginal costs.

The equilibrium fixed fee is set to

$$F_i^* = \frac{s_i^*}{\sigma} + s_i^*(v(\hat{p}_i^*) - v(p_i^*)) + (s_i^* - s_j^*)(a_i - c_i)q(\hat{p}_j^*). \quad (4.22)$$

If providers are unable to discriminate between on-net and off-net prices, the analysis of section 4.3 explores that both providers' market shares are positively or negatively locally affected by a marginal increase in the VoIP provider's termination charge a_2 above marginal costs. However, if providers can price discriminate it can be shown that market shares are locally unaffected, i.e.

$$\frac{ds_i^*}{da_2}|_{a_i=c_i} = 0. \quad (4.23)$$

This restores the result of Carter and Wright (2003) and Peitz (2005) in a model with cost-asymmetries and price discrimination. At the point of cost-based regulation, equilibrium market shares do not respond to an increase in the VoIP provider's termination fee, independent of any asymmetry in size or termination costs. With price discrimination regulation of termination fees leaves on-net per-minute prices (locally) unaffected. As in the models of Carter and Wright (2003) and Peitz (2005) the asymmetries only determine the decision to subscribe to either network, but once subscribed, the asymmetry does not affect subscribers' calling demand.

A termination markup generates income from inbound calls from rival subscribers for the VoIP provider. Locally around cost-based regulation, the VoIP provider benefits from a marginal increase in its termination charge. Otherwise, the fixed-line provider has to pay a higher termination charge for outbound calls, and hence, it suffers from the increase. Technically,

$$\frac{\partial \Pi_1^*}{\partial a_2}|_{a_i=c_i} = -s_1^{*2} q(\hat{p}_1^*) < 0 \quad (4.24)$$

and

$$\frac{\partial \Pi_2^*}{\partial a_2}|_{a_i=c_i} = s_2^{*2} q(\hat{p}_2^*) > 0. \quad (4.25)$$

Proposition 4.7. *If providers can discriminate between on-net and off-net prices for calls, a marginal increase in the VoIP provider's termination charge does not affect equilibrium market shares (locally around cost-based regulation). At this point, a marginal increase in the VoIP provider's termination charge gives rise to higher (lower) profits for the VoIP (fixed-line) provider. This holds independent of any demand- and supply-side asymmetry.*

Proof. See Appendix 4.A. □

Hence, price discrimination can restore the results of the previous literature in a model of asymmetric termination costs.

4.5.2 Reciprocal Regulation

Now consider that providers set a reciprocal termination charge of a . Providers set an on-net price of

$$p_i^* = 2c_i \quad (4.26)$$

and an off-net price of

$$\hat{p}_i^* = c_i + a. \quad (4.27)$$

The equilibrium fixed fee is denoted as

$$F_i^* = \frac{s_i^*}{\sigma} + s_i^* (v(\hat{p}_i^*) - v(p_i^*)) + (s_i^* - s_j^*) (a - c_i) q(\hat{p}_j^*). \quad (4.28)$$

Consider the effect of a marginal decrease of the reciprocal termination charge below the costs of the fixed-line provider on the market shares, given as

$$\left. \frac{ds_2^*}{da} \right|_{a=c_1} = \frac{(s_2^* - s_1^*)(c_1 - c_2)q(\hat{p}_1)'}{2((c_2 - c_1)q(\hat{p}_1^*) - v(\hat{p}_1^*) - v(p_1^*) + v(\hat{p}_2^*) - v(p_2^*)) - \frac{3}{\sigma}}. \quad (4.29)$$

Hence, in the case of a reciprocal termination charge, the effects on market shares depends on both the demand- and the supply-side asymmetry. For symmetric market shares or symmetric termination cost market shares do not locally respond to a marginal decrease of the reciprocal termination charge below the marginal cost of the fixed-line provider. Otherwise, for both a demand- and supply side asymmetry, market shares do locally respond. Interestingly, with price discrimination, the neutrality result on market shares can also be restored with asymmetric termination costs. Compare the market share equations in the regime of reciprocal regulation without price discrimination (4.14) and with price discrimination (4.29). Observe that without price discrimination only symmetric termination costs suffice a neutral effect on market shares, whereas with price discrimination symmetric termination costs or symmetric market shares are sufficient. With price discrimination regulation of termination charges only affects providers' off-net but not the on-net prices. With nondiscriminatory pricing, the uniform per-minute price weights on-net and off-net prices with market shares of the providers, so also the on-net part of the nondiscriminatory price is affected by regulation. Observe from the per-minute prices of equations (4.13) and (4.27)

that with non-discriminatory pricing the per-minute prices of providers are only identical with both a demand- and a supply-side symmetry, whereas with discriminatory pricing they are identical for a supply-side symmetry, independent of any demand-side asymmetry.

Now, observe from equation (4.17) that subscribers' net surplus is an average of surplus from on-net and off-net calls. With price discrimination the surplus from on-net calls remains unaffected. The marginal effect on surplus is determined by the effects on net-surplus from off-net calls and the adjustment of the fixed fee. If providers can price discriminate, they can extract every extra surplus by adjusting the fixed fee accordingly. Compare equations (4.17) and equation (4.28). It holds that the marginal effect on net surplus is given by $\frac{\partial \omega(p_i, \hat{p}_i)}{\partial a} = s_j \frac{\partial v(\hat{p}_i^*)}{\partial a} - s_i \frac{\partial v(\hat{p}_i^*)}{\partial a} - (s_i^* - s_j^*)(a - c_i)q(\hat{p}_j^*)'$. For symmetric market shares any extra surplus is perfectly passed-through into the fixed fee. Thus, there is no effect on net surplus and accordingly no effect on market shares, independent of any supply-side asymmetry. If market shares differ, the pass-through is imperfect, so also the net surplus of calls is affected. Then, again, the market share effect depends on the extent of the supply-side asymmetry. However, if providers are not able to discriminate in prices, they can not perfectly extract the surplus from on-net and off-net calls, they only extract an average surplus from calls in general and the pass-through into the fixed fee is only partial.

Proposition 4.8. *If providers can discriminate between on-net and off-net prices for calls, a marginal decrease of the reciprocal termination charge does not affect equilibrium market shares (locally around cost-based regulation), given a demand- or a supply-side symmetry.*

The first order conditions of the profit functions with respect to a marginal decrease of the reciprocal termination charge are denoted as

$$\frac{\partial \Pi_1^*}{\partial a} \Big|_{a=c_1} = 2 \frac{ds_1^*}{da} s_1^* \left(\frac{1}{\sigma} + v(\hat{p}_1^*) - v(p_1^*) \right) + s_1^{*2} (q(\hat{p}_2^*) - q(\hat{p}_1^*))$$

and

$$\begin{aligned} \frac{\partial \Pi_2^*}{\partial a} \Big|_{a=c_1} &= 2 \frac{ds_2^*}{da} s_2^* \left(\frac{1}{\sigma} + v(\hat{p}_2^*) - v(p_2^*) + (c_1 - c_2)q(\hat{p}_1^*) \right) \\ &\quad + s_2^{*2} (q(\hat{p}_1^*) - q(\hat{p}_2^*) - (c_1 - c_2)q'). \end{aligned}$$

As has been stated above, market shares are locally unaffected for any demand- or supply-side symmetry. However, observe that profit are unaffected only for a supply-side symmetry, but not for a demand side symmetry. Given a supply-side symmetry of $c_1 = c_2$ providers' profits are locally unaffected by regulation, i.e. $\frac{\partial \Pi_i^*}{\partial a} \Big|_{a=c_1} = 0$. This directly follows from the neutral market share effect and the fact that on-net and off-net prices are identical for both providers. The total effect on profits then depends on the net traffic of off-net calls (inbound calls from rival subscribers vs. outbound calls from fellow subscribers). If cost are identical, it directly follows that $q(\hat{p}_2^*) = q(\hat{p}_1^*)$ and regulation has no (local) effect on profits. In this case the reduction in interconnection profit from rival off-net calls is just balanced by the reduction in the payment for off-net calls by fellow subscribers. Otherwise, if costs differ, the fixed-line provider is locally harmed by regulation and the VoIP provider locally benefits. In case of a cost asymmetry, VoIP customers place more off-net calls than fixed-line customers, i.e. $q(\hat{p}_2^*) > q(\hat{p}_1^*)$. Thus, even for symmetric market shares, the fixed-line provider terminates more off-net traffic than the VoIP provider (which is even intensified if market shares are asymmetric). Hence, it faces a net deficit from interconnection, whereas the VoIP provider earns a net profit from interconnection (at least locally if the reciprocal termination charge is not even set below its marginal costs).

Proposition 4.9. *If providers can discriminate between on-net and off-net prices for calls, a marginal decrease of the reciprocal termination charge does not affect equilibrium profits for any supply-side symmetry. For any demand-side symmetry, the fixed-line (VoIP) provider's profit locally decreases (increases).*

4.6 Conclusion

This chapter has explored the ramification of interconnection terms in telecommunications networks with asymmetries in termination costs. Traditional fixed-line networks usually face a positive marginal cost of terminating calls, whereas for calls terminated in IP networks, the termination cost should generally be lower and close to zero. In its “Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU” the European Commission recently set out its views on how national regulators in Europe should approach termination charges in the future. The present chapter has discussed whether these terms of regulation, originally designed for fixed-line networks, should be applied in the presence of asymmetries of termination costs between networks. With the proposed cost-based regulation, a VoIP network will receive less for rival calls terminated on its network, than it has to pay for calls by fellow subscribers terminated in the fixed-line network. This does not seem to be in line with efforts to encourage market entry of alternative telecommunications providers in the market of fixed line telephony.

Thus it is a relevant policy question, whether to deviate from the cost-based regulation in VoIP networks and allow for termination fees above marginal cost. The model shows that unilaterally increasing the VoIP provider’s termination charge may or may not increase its profit, as feedback effects into market shares have to be taken into account. A unilateral increase in the termination charge of the VoIP network increases the marginal cost for the traditional fixed-line network, which increases its per-minute price, which in turn decreases the demand for calls. This has adverse consequences for total interconnection profit, which may decrease by deviating from cost-based regulation. Hence, regulation of termination charges has an effect on calling patterns and market shares.

An increase in the VoIP provider’s termination charge has an impact on net surplus of both providers’ subscribers. The fixed-line network compensates the increase in per-minute prices by lowering fixed fees for their subscribers. This may even lead the fixed-line provider’s market share to increase in response to the higher marginal termination cost it faces. This will be to the detriment of efforts to enable VoIP providers to catch up with traditional fixed-line providers.

The European Commission generally favors reciprocal termination charges for fixed-line networks. Hence, in a second step, the chapter has analyzed the effects of reciprocity in termination charges. The model shows that fixed-line subscribers benefit from a marginal reduction of the reciprocal termination fee, whereas VoIP subscriber may or may not benefit, depending on the degree of substitution of providers and the difference in termination costs. The local effects on providers' profits are also ambiguous but more clear-cut than with an unilateral increase of the VoIP termination charge. For larger deviations from cost-based regulation the fixed-line provider more generally suffers from a decrease of the reciprocal termination charge, whereas the VoIP provider more generally benefits. The model can justify reciprocal termination charges even in the presence of cost asymmetries.

If providers can discriminate between on-net and off-net prices, asymmetric regulation has no local effect on market shares, independent of a demand- and supply-side asymmetry. The VoIP provider locally benefits from an increase in its termination charge and the fixed-line provider suffers. This restores the result of the previous literature in a model of demand-and supply-side asymmetry. If providers can discriminate between on-net and off-net prices for calls, a marginal decrease of the reciprocal termination charge does not affect equilibrium profits for any supply-side symmetry. For any demand-side symmetry, the fixed-line provider is locally harmed, whereas the VoIP provider locally benefits from a marginal reduction of the reciprocal termination charge.

To conclude, a regulatory authority has to consider (positive or negative) feedback effects on market shares and on the demand for calls, when determining the most adequate regulation for fixed to VoIP interconnection.

4.A Appendix

Asymmetric Regulation

Proof. of Proposition 4.1:

Profit functions of both providers are given as

$$\Pi_1^* = s_1^*(p_1^* - 2c_1)q(p_1^*) + s_1(v(p_1^*) - \omega_1) + s_1^*s_2^* \{(a_1 - c_1)q(p_2^*) - (a_2 - c_1)q(p_1^*)\}$$

and

$$\Pi_2^* = s_2^*(p_2^* - 2c_2)q(p_2^*) + s_2(v(p_2^*) - \omega_2) + s_1^*s_2^* \{(a_2 - c_2)q(p_1^*) - (a_1 - c_1)q(p_2^*)\},$$

where market shares of $s_1 = \frac{1}{2} + \frac{\beta}{2} + \sigma(\omega_1 - \omega_2)$ and $s_2 = \frac{1}{2} - \frac{\beta}{2} + \sigma(\omega_2 - \omega_1)$ depend on consumer net surplus ω_i . Along its best-response function each operator sets per-minute prices to perceived marginal costs. Thus the only income source stems from subscription and off-net traffic, leading to profit in terms of net surplus of

$$\Pi_i^* = s_i^*(v(p_i^*) - \omega_i^*) + s_i^*s_j^*(a_i - c_i)q(p_j^*).$$

The first order condition of the fixed-line provider with respect to consumer net surplus ω_1 is given as

$$\frac{\partial \Pi_1^*}{\partial \omega_1} = \sigma(v_1^* - \omega_1^*) + s_1^* \left(\frac{\partial v_1^*}{\partial p_1} \frac{\partial p_1^*}{\partial \omega_1} - 1 \right) + (a_1 - c_1) (\sigma(s_2^* - s_1^*)q(p_2^*) + s_1^*s_2^* \frac{\partial q(p_2)}{\partial p_2} \frac{\partial p_2^*}{\partial \omega_1}).$$

For convenience label $v(p_i) = v_i$, $q(p_i) = q_i$, and $\frac{dq(p_i)}{dp_i} = q'_i$. Taking account for $\frac{\partial v_i}{\partial p_i} = -q_i$ and for per-minute prices of equation (4.4) it follows that

$$\frac{\partial \Pi_1^*}{\partial \omega_1} = \sigma(v_1^* - \omega_1^*) + s_1^* (\sigma q_1^* (a_2 - c_1) - 1) + \sigma(a_1 - c_1) ((s_2^* - s_1^*)q_2^* + s_1^*s_2^*q'(a_1 - c_2)).$$

The cross-derivative is

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial \omega_2} = \sigma \left(\frac{\partial v_1^*}{\partial p_1} \frac{\partial p_1^*}{\partial \omega_2} \right) + \sigma(a_2 - c_1) (-\sigma q_1^* + s_1^*q' \frac{\partial p_1^*}{\partial \omega_2}) + \sigma$$

which around cost-based regulation of termination charges simplifies to

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial \omega_2} \Big|_{a_i=c_i} = \sigma - 2\sigma^2(c_2 - c_1)q_1^* + \sigma^2(c_2 - c_1)^2s_1^*q',$$

which implies that the fixed-line network's pseudo best-response functions is up-

wards sloping if competition is not too weak and the difference in termination costs $(c_1 - c_2)$ is not too large. One obtains that an increase in the VoIP termination charge a_2 shifts the pseudo best-response function outwards, as

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1^* \partial a_2} = \sigma \left(\frac{\partial v_1^*}{\partial p_1} \frac{\partial p_1^*}{\partial a_2} \right) + s_1 \sigma((a_2 - c_1) q' \frac{\partial p_1^*}{\partial a_2} + q_1)$$

which reduces to

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1^* \partial a_2} \Big|_{a_i=c_i} = \sigma(s_1^* - s_2^*) q_1^* + s_1^* s_2^* \sigma(c_2 - c_1) q' > 0.$$

This term is strictly positive for $s_1 > s_2$ and $c_2 < c_1$, which has been assumed.

Consider the VoIP provider's profit. Applying same technique, the marginal profit is

$$\frac{\partial \Pi_2^*}{\partial \omega_2} = \sigma(v_2^* - \omega_2^*) + s_2^* (\sigma q_2^* (a_1 - c_2) - 1) + \sigma(a_2 - c_2) ((s_1^* - s_2^*) q_1^* + s_1^* s_2^* q' (a_2 - c_1)).$$

The cross derivative is denoted as

$$\frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial \omega_1} \Big|_{a_i=c_i} = \sigma - 2\sigma^2(c_1 - c_2) q_2^* + \sigma^2(c_1 - c_2)^2 s_2^* q'.$$

The shift of the pseudo-best response function in the termination charge is denoted as

$$\begin{aligned} \frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial a_2} &= \sigma \left(\frac{\partial v_1^*}{\partial p_2} \frac{\partial p_2^*}{\partial a_2} \right) + \sigma s_2^* (a_1 - c_2) q' \frac{\partial p_2^*}{\partial a_2} + \sigma(s_1^* - s_2^*) q_1^* + s_1^* s_2^* q' \sigma(a_2 - c_1) \\ &\quad + \sigma(a_2 - c_2) ((s_1^* - s_2^*) q_1^* + s_1^* s_2^* q'). \end{aligned}$$

As per-minute prices are only affected by rival's termination charges it follows that $\frac{\partial p_2^*}{\partial a_2} = 0$ and thus

$$\frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial a_2} \Big|_{a_i=c_i} = \sigma(s_1^* - s_2^*) q_1^* + s_1^* s_2^* \sigma(c_2 - c_1) q' > 0.$$

Hence, also the VoIP provider's pseudo best-response is shifted outwards. For identical termination costs, effects of both providers' pseudo best-response func-

tion are positive. This confirms the neutrality result on market shares for symmetric termination costs. $\square$

Proof. of Proposition 4.2:

Total differentiation of equation (4.8) locally around cost-based regulation of $a_i = c_i$ leads to

$$\frac{ds_2^*}{da_2}\bigg|_{a_i=c_i} = -\frac{\sigma}{3} \left\{ \frac{\partial v(p_1^*)}{\partial p_1} \frac{\partial p_1^*}{\partial a_2} - \frac{\partial v(p_2^*)}{\partial p_2} \frac{\partial p_2^*}{\partial a_2} + s_2^* q_1^* + (c_2 - c_1) \left(\frac{\partial s_1^*}{\partial a_2} a_1 + s_1^* q_1' \frac{\partial p_1^*}{\partial a_2} + \frac{\partial s_2^*}{\partial a_2} q_2^* + s_2^* q_2' \frac{\partial p_2^*}{\partial a_2} \right) \right\}.$$

Using $\frac{ds_1}{da_2} = -\frac{ds_2}{da_2}$, $v'(p_i) = -q_i$, inserting optimal per-minute prices and rearranging yields that

$$\frac{ds_2^*}{da_2}\bigg|_{a_i=c_i} = \frac{q' s_1^* s_2^* (c_2 - c_1)}{2(c_1 - c_2)(q_2^* - q_1^*) - (c_2 - c_1)^2 (s_1^* q_1' + s_2^* q_2') - \frac{3}{\sigma}}.$$

$\square$

Reciprocal Regulation

Proof. of Proposition 4.4:

To show that subscribers benefit from a marginal decrease of the reciprocal termination charge apply the same steps as in the proof of proposition 4.1. First consider the fixed-line provider's marginal profit of

$$\frac{\partial \Pi_1^*}{\partial \omega_1} = \sigma(v_1^* - \omega_1^*) + s_1(\sigma q_1^*(a - c_1) - 1) + \sigma(a - c_1)((s_2^* - s_1^*)q_2^* + s_1^* s_2^* q'(a - c_2)).$$

The cross derivative is denoted as

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial \omega_2} = \sigma - 2\sigma^2(a - c_1)q_1^*,$$

where at $a = c_1$ it holds that

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial \omega_2} \Big|_{a=c_1} = \sigma > 0.$$

A marginal decrease of the reciprocal termination charge shifts the fixed-line network's pseudo best-response function outwards as

$$\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial a} = \sigma(s_1^* - s_2^*)(q_1^* - q_2^*) + \sigma(c_1 - c_2)s_1^*s_2^*q' < 0.$$

First, for $a = c_1$ and from

$$\text{sign}(q_2^* - q_1^*)|_{c_1=c_2} = \text{sign}(p_1^* - p_2^*)|_{a=c_1} = (c_1 - c_2)(2 - s_1^*) = 0.$$

follows that $\frac{\partial^2 \Pi_1^*}{\partial \omega_1 \partial a} = 0$. Otherwise, for $c_1 > c_2$ the second part is negative, since $q'_i < 0$. The sign of the first part is determined by $\text{sign}(q_1^* - q_2^*) = \text{sign}(p_2^* - p_1^*)$. At $a = c_1$ it holds that $\text{sign}(p_2^* - p_1^*) = (c_2 - c_1)(2 + s_2^*) < 0$. From this it follows that the term is clearly negative and the pseudo best-response functions shifts outwards.

Applying same technique for the VoIP provider it follows that

$$\frac{\partial \Pi_2^*}{\partial \omega_2} = \sigma(v_2^* - \omega_2^*) + s_2^*(\sigma q_2^*(a - c_2) - 1) + \sigma(a - c_2)((s_1^* - s_2^*)q_1^* + s_1^*s_2^*q'(a - c_1)).$$

The cross derivative is given as

$$\frac{\partial \Pi_2^*}{\partial \omega_2 \partial \omega_1} \Big|_{a=c_1} = \sigma + 2\sigma^2(c_1 - c_2)(q_1^* - q_2^*) \leq 0$$

which again follows from $\text{sign}(q_1^* - q_2^*) = \text{sign}(c_2 - c_1)(2 + s_2^*) < 0$ and $c_1 > c_2$.

The pseudo best-response function is shifted outwards, as

$$\begin{aligned} \frac{\partial^2 \Pi_2^*}{\partial \omega_2 \partial a} \Big|_{a=c_1} &= \sigma(s_1^* - s_2^*)(q_1^* - q_2^*) + s_1^*s_2^*\sigma(c_1 - c_2)q' \\ &\quad + \sigma(c_1 - c_2)((s_1^* - s_2^*)q'_1s_2^* + s_1^*s_2^*q') < 0, \end{aligned}$$

which holds for $s_1 > s_2$. □

Proof. of Proposition 4.5:

The VoIP provider's market share with reciprocal access regulation is given as

$$s_2^* = \frac{1}{2} - \frac{\beta}{6} - \frac{\sigma}{3} (v_1^* - v_2^* + s_2^* q_1^* (a - c_2) - s_1^* q_2^* (a - c_1) + (c_2 - c_1)(s_1^* q_1^* + s_2^* q_2^*)).$$

Total differentiation of $\frac{ds_2^*}{da}$ yields

$$\frac{ds_2^*}{da} \Big|_{a=c_1} = -\frac{\sigma}{3} \left\{ \begin{aligned} & \frac{dv_1^*}{dp_1} \frac{dp_1^*}{da} - \frac{dv_2^*}{dp_2} \frac{dp_2^*}{da} + (a - c_2)(s_2^{*'} q_1^* + s_2^* q_1' \frac{dp_1^*}{da}) + s_2^* q_1^* - \\ & (a - c_1)(s_1^{*'} q_2^* + s_1^* q_2' \frac{dp_2^*}{da}) - s_1^* q_2^* + (c_2 - c_1)(s_1^{*'} q_1^* + s_1^* q_1' \frac{dp_1^*}{da}) \\ & + s_2^{*'} q_2^* + s_2^* q_2' \frac{dp_2^*}{da} \end{aligned} \right\}.$$

Using $v'(p) \equiv -q(p)$, $\frac{ds_i}{da} = -\frac{ds_j}{da}$ and evaluation locally around $a = c_1$, this reduces to

$$\frac{ds_2^*}{da} = \frac{(c_1 - c_2)q'(s_2^{*2} - 2s_1^* s_2^*)}{2(c_1 - c_2)(q_2^* - q_1^*) - (c_1 - c_2)^2 s_2^* q' - \frac{3}{\sigma}}.$$

As $c_1 > c_2$, $s_1 > s_2$ and $q' < 0$ the numerator is always positive, so the sign of $\frac{ds_2^*}{da}$ is determined by the denominator. $\square$

Proof. of proposition 4.6:

The effect on total profits is decomposed in effects in the retail market and in the interconnection market as

$$\Pi_i^* = s_i^* F_i^* + s_i^* s_j^* (a - c_i) q(p_j^*).$$

Total resulting effects on profits are depicted by evaluating the derivatives of the profit functions with respect to a marginal change in the reciprocal termination charge locally around $a_1 = c_1$. Consider the marginal change of the fixed-line network's profit of

$$\frac{\partial \Pi_1^*}{\partial a} \Big|_{a=c_1} = s_1^* \left(\frac{2}{\sigma} \frac{ds_1^*}{da} + s_1^* (q(p_2^*) - q(p_1^*)) \right)$$

and of

$$\frac{\partial \Pi_2^*}{\partial a} \Big|_{a=c_1} = 2s_2^* \frac{ds_2^*}{da} \left(\frac{1}{\sigma} + (c_1 - c_2)(q(p_1^*) - q(p(p_2^*))) \right) + s_2^{*2}(q(p_1^*) - q(p_2^*) + (c_1 - c_2)(q's_2^* - q's_1^*) + (c_1 - c_2)^2 \frac{ds_2^*}{da})$$

for the VoIP provider.

Remind from equation (4.10) that there is no local effect on market shares for symmetric termination cost. Secondly notice that $(q_2^* - q_1^*)|_{a=c_1} = \text{sign}(p_1^* - p_2^*) = (c_1 - c_2)(2 - s_1^*) = 0$ for $c_1 = c_2$. From both follows that

$$\frac{\partial \Pi_i^*}{\partial a} \Big|_{c_1=c_2} = 0.$$

□

Price Discrimination

Providers set optimal on-net prices, off-net prices and the fixed fee by maximizing the profit function of equation (4.19) with respect to p_i , $\hat{p}_i$, and $\omega(p_i, \hat{p}_i)$.

From

$$\frac{\partial \Pi_i}{\partial p_i} = s_i(s_i q_i + s_i(p_i - 2c_i)q_i') + s_i^2 v_i' = 0$$

and using $v_i' = -q_i$ follows that

$$p_i^* = 2c_i.$$

By solving

$$\frac{\partial \Pi_i}{\partial \hat{p}_i} = s_i s_j \hat{q}_i + s_i s_j (\hat{p}_i - c_i - a_j) \hat{q}_i' + s_i s_j \hat{v}_i' = 0$$

follows that

$$\hat{p}_i^* = c_i + a_j.$$

To derive the optimal fixed fee it is again convenient to consider providers to compete on net-surplus rather than on the fixed fee directly. From evaluation the

FOC at equilibrium per-minute prices it follows that

$$\frac{\partial \Pi_i}{\partial \omega_i} = \sigma(s_i v_i + s_j \hat{v}_i - \omega_i) + s_i(\sigma(v_i - \hat{v}_i) - 1) + \sigma(a_i - c_i) \hat{q}_i (s_i - s_j).$$

From setting this equal to zero it follows that the optimal net-surplus is given as

$$2s_i v_i + (s_i - s_j) \hat{v}_i - \frac{s_i}{\sigma} + (a_i - c_i)(s_j - s_i) \hat{q}_i.$$

After re-substituting $F_i = s_i v_i + s_j \hat{v}_i - \omega_i$ follows that

$$F_i^* = \frac{s_i^*}{\sigma} + s_i^*(\hat{v}_i^* - v_i^*) + (s_i^* - s_j^*)(a_i - c_i) \hat{q}_i^*.$$

Proof. of proposition 4.9:

The equilibrium market share of the fixed-line provider implicitly determined by

$$s_1^* = \frac{1}{2} + \frac{\beta}{6} + \frac{\sigma}{3} (2(s_1^* v_1^* - s_2 v_2^*) + (s_2^* - s_1^*)(\hat{v}_1^* + \hat{v}_2^* + (a_1 - c_1) \hat{q}_2^* + (a_2 - c_2) \hat{q}_1^*))$$

and by $s_2 = 1 - s_1$ for the VoIP provider.

Total differentiation locally around cost-based regulation yields

$$\begin{aligned} \frac{ds_1^*}{da_2} \Big|_{a_i=c_i} &= \frac{\sigma}{3} \left(2 \left(\frac{ds_1^*}{da_2} v_1^* - \frac{ds_2^*}{da_2} v_2^* \right) + \left(\frac{ds_2^*}{da_2} - \frac{ds_1^*}{da_2} \right) (\hat{v}_1^* + \hat{v}_2^*) \right. \\ &\quad \left. + (s_2^* - s_1^*) \left(\frac{\partial \hat{v}_1^*}{\partial p_1^*} \frac{\partial p_1^*}{\partial a_2} + \hat{q}_1^* \right) \right). \end{aligned}$$

After rearranging and using $\frac{dv_i}{dp_i} = -q_i$ follows that

$$\frac{ds_1^*}{da_2} \Big|_{a_i=c_i} = \frac{(s_2^* - s_1^*)(\hat{q}_1^* - \hat{q}_1^*)}{\frac{3}{\sigma} - 2(v_1^* - \hat{v}_1^* + v_2^* - \hat{v}_2^*)}.$$

Hence, it follows that

$$\frac{ds_1^*}{da_2} \Big|_{a_i=c_i} = -\frac{ds_2^*}{da_2} \Big|_{a_i=c_i} = 0.$$

Since equilibrium per-minute prices are set equal to the marginal cost, providers earn profits from the fixed fee and inbound calls from rival subscribers, leading to profits of

$$\Pi_1^* = \frac{s_1^{2*}}{\sigma} + s_1^{2*}(\hat{v}_1^* - v_1^* + (a_1 - c_1)\hat{q}_2^*).$$

The FOC with respect to a_2 yields

$$\begin{aligned} \frac{\partial \Pi_1^*}{\partial a_2} \Big|_{a_i=c_i} &= \frac{ds_1^*}{da_2} \left(\frac{2}{\sigma} + 2s_1^*(\hat{v}_1^* - v_1^* + (a_1 - c_1)\hat{q}_2^*) \right) \\ &+ s_1^2 \left(\frac{\partial \hat{v}_1}{\partial \hat{p}_1} \frac{\partial \hat{p}_1^*}{\partial a_2} - \frac{\partial v_1}{\partial p_1} \frac{\partial p_1^*}{\partial a_2} + (a_1 - c_1) \frac{\partial q}{\partial p_2} \frac{\partial p_2^*}{\partial a_2} \right). \end{aligned}$$

Since $\frac{ds_i^*}{da_2} = 0$ and only the off-net price $\hat{p}_1$ responds to a_2 it follows that

$$\frac{\partial \Pi_1^*}{\partial a_2} \Big|_{a_i=c_i} = -s_1^2 \hat{q}_1 < 0.$$

The VoIP provider's profit is denoted as

$$\Pi_2 = \frac{s_2^{2*}}{\sigma} + s_2^{2*}(\hat{v}_2^* - v_2^* + (a_2 - c_2)\hat{q}_1^*).$$

Since per-minute prices and market shares do not (locally) respond to a_2 it simply follows that

$$\frac{\partial \Pi_2^*}{\partial a_2} \Big|_{a_i=c_i} = s_2^{*2} \hat{q}_1 > 0.$$

□

Chapter 5

Roaming and Investments in the Mobile Internet Market

5.1 Introduction

The new generation of mobile phones, the so called smartphones, not only offer mobile telecommunications services, but a variety of other services. The most important service is certainly access to the Internet while being mobile. The growth rates in term of revenues from mobile data traffic in 2010 compared to 2009 vary from 8.1 % in Germany, 16.7 % in France to 25.3 % in the US.¹ To meet the growing demand for third generation (3G) services, mobile network operators (MNOs) have to build up capacities to improve the utility of existing services or to provide new services. A main improvement compared to second generation (2G) networks is to increase the speed of interconnection and to decrease the download time.

In the absence of full market coverage operators can agree to share their infrastructure (roaming agreements). This especially holds when customers travel abroad because the home provider does not normally operate in another country. For providing the roaming services, the foreign network operator charges the home operator a wholesale price (usually a charge per minute of use) and the home operator passes this additional cost on to the customer with a markup.

In 2006, the European Commission assessed that both the average roaming

¹www.bitkom.org/files/documents/BITKOM-Praesentation_PK_Mobile_World_11_02_2010.pdf

retail and wholesale prices were unjustifiably high. The European Commission estimated that the per-minute costs of an outgoing roaming call are approximately 0.2 Euro, while the wholesale prices are on average about 0.75 Euro and retail prices are roughly 1.10 Euro. Hence, the wholesale prices are estimated to amount roughly 4 times the costs for originating, transmitting and termination of outgoing roaming calls. The roaming regulation for voice communications entered into force in June 2007, so European consumers are paying 70 % less to make and receive voice calls while traveling in the European Union. However, the prices for sending text messages abroad or using data roaming services have remained significantly high. Hence, in 2008 the European Commission imposed price caps for all roaming services, voice roaming, text message roaming, and data roaming. These price caps are sequentially tightened. From 01 July 2010 the European regulation, among other obligations, imposed the following caps: Prices for mobile roaming calls are reduced with a maximum tariff of 0.39 Euro per minute for calls made and 0.15 Euro per minute for calls received; The maximum wholesale prices for data roaming fall from 1 Euro to 0.80 Euro per MB (EU Commission 2010).

Despite of international roaming, there is also national roaming within a country, which is in the focus of this chapter. In the recent auction of spectrum licenses in Germany in May 2010, Royal KPN NA's E-Plus unit failed to secure spectrum in the coveted high-end band in Germany, which mainly can be used to provide wireless Internet services. E-Plus said it will buy network access from competitors to keep its mobile-phone service in the country going. It would be open to cooperation with rivals in Germany, after it became the only one of four mobile-phone operators to not win spectrum in the 800-megahertz band. The unit of the Dutch company said it will approach competitors about "white spots", or areas where it has no coverage, and will seek network use from rivals at the "right price". The need for national roaming may also stem from a lack of spare capacities in peak times. There might be temporary congestion, e.g., due to heavy downloading by fellow subscribers, so networks may buy spare capacities of the rival. With 3G networks the available capacity for data transmission can be allocated in a more dynamic way than with 2G networks, so the customer may be given the free capacity of the rival network. Capacity constraints will very likely be intensified in the next years, since multimedia content requires significantly larger capacities

than voice or text messages. An email is normally between 1 and 50 KB, a page of an online newspaper can be 100 KB or more. The download of a song requires 2 to 5 MBs of data.

Given reciprocal roaming, investments in the networks do not only affect one's own subscribers' willingness to pay but also rival subscribers' willingness to pay. Hence, reciprocal roaming induces an externality (spillover effect), as rival subscribers benefit from better quality or other services offered by the rival network. Given the existing knowledge about investment spillovers (d'Aspremont and Jacquemin (1988) and Kamien et al. (1992)) there is a heated debate whether a regulator should allow MNOs to coordinate their investment decision. Moreover, it is still far from clear if and how to regulate national roaming charges. On the one hand, national roaming can provide a full coverage of services for subscribers. But on the other hand, networks may reduce competition in the retail market by coordinating on high reciprocal wholesale prices and decrease their investments in the infrastructure, which Valletti and Cambini (2005) show. The effect of wholesale prices on competition is extensively debated in the literature of voice telephony but is hardly addressed with data services. The present model aims to shed some light on these questions. It compares the regime of regulating roaming charges to the long-run incremental cost of providing mobile Internet access to regimes of below- and above-cost charges. Additionally, regulation is compared to a regime where MNOs freely set the reciprocal roaming charge. It shows that investment incentives are adversely affected by the regimes of roaming charge regulation. MNOs' incentive to invest crucially depends on three conditions: i) on the regime of roaming charge regulation, ii) on the choice of whether to allow MNOs to semi-collude over investments, and iii) on the extent of the investment spillover. Both roaming charges above and below cost can lead to under- and overinvestments from a welfare perspective.

The recent literature discusses the regulatory concerns under this two-way network competition in telecommunications markets, as networks may use an access charge as an instrument of tacit collusion because of a "raise-each-other's-cost" effect (see Armstrong (1998) and Laffont et al. (1998a)). Following Fabrizi and Wertlen (2008) it should be stressed, though, that interconnection agreements within the mobile Internet services do not have the same nature as interconnec-

tion agreements between voice telecommunications operators. With voice telephony, interconnection refers to enabling end-to-end users telecommunications traffic, which thus involves the origination of a given traffic within a network, its transportation, and its termination either in the same or the rival network. The theoretical literature and regulatory authorities usually address issues concerning the termination fee, networks charge each other. Roaming with 3G services instead refers to the access of the unilateral service by the rival network, origination and termination. The present model addresses two kinds of network effects. In addition to two-way access prices, the model introduces an additional one-way network effect of roaming agreements among networks.

In an extension to the base model, MNOs are able to endogenously determine the degree of the roaming quality. It will be shown that independent of the roaming charge, MNOs choose maximal quality when they semi-collude over investment levels. Although, when MNOs compete on investments, the choice of roaming quality depends on the roaming charge. MNOs set a higher roaming quality, the higher the roaming charge. A regulator might face a dilemma as for below cost roaming charges, MNOs set higher investment levels but a lower roaming quality. Otherwise, for above cost charges, MNOs set a better roaming quality but lower investment levels.

Recent research on roaming in the mobile Internet market is conducted by Fabrizio and Wertlen (2008). Their focus is on optimal market coverage given roaming agreements among networks, whereas the present focus is on investment, given spillovers due to roaming agreements. The present model is in line with Valletti and Cambini (2005), who analyze voice communications providers' incentives to invest given different regulatory regimes. In their model, networks tend to underinvest in quality, which is exacerbated if they can negotiate reciprocal termination charges above cost. The present model builds on a model of Foros et al. (2002), who analyze demand-spillovers due to voice roaming and semi-collusion in the mobile telecommunications market. However, they abstract from any wholesale pricing and regulation of roaming charges. They show that under collusion over investments, firms' and a welfare maximizing regulator's interest coincide, whereas with non-cooperative investments, firms even overinvest. The present model extends the model of Foros et al. (2002) by analyzing data traffic

and by incorporating the roaming market and different regulatory regimes.

The chapter is organized as follows: Section 5.2 describes the base model. Section 5.3 solves the equilibrium in the retail market, whereas section 5.4 analyzes incentives to invest given different roaming charge regulatory regimes. Section 5.5 compares the outcomes with two welfare benchmarks. Section 5.6 provides an extension of the base model, where MNOs choose the roaming quality. Section 5.7 concludes.

5.2 The Base Model

The model analyzes MNOs' incentives to invest in their facilities, where networks may semi-collude over investments, given different regulatory regimes of roaming charge regulation. The following timing is assumed:

Stage 1: MNOs pay a (negotiated or regulated) roaming charge a to each other.

Stage 2: MNOs choose the investment levels x non-cooperatively or jointly.

Stage 3: MNOs compete à la Cournot in the retail market.

The choice whether the networks cooperate when determining their investment levels will depend on whether it would be approved by the competition authorities.² The choices at stage 2 are fairly similar to those in the seminal models of R&D spillovers of d'Aspremont and Jacquemin (1988) and Kamien et al. (1992). They analyze cost-reducing spillovers, whereas the present model analyzes demand-enhancing spillovers.

Like Foros et al. (2002), Foros (2004), and Nitsche and Wiethaus (2011) the present model assumes Cournot competition in the downstream market, which seems reasonable since the networks face technological and physical constraints in spectrum capacity, e.g. in the 3G-system. Moreover, MNOs must choose capacity levels, which are either build or rented in both the backbone or the access network, prior to competition in the downstream market (see Foros (2004) for mo-

²By the block exception of Article 101 (3) of the European Treaty, agreements which contribute to improving the production or distribution of goods or to promoting technical or economic progress while allowing consumers a fair share of the resulting benefit will be approved.

bile telecommunications networks or Crémer et al. (2000) for fixed-line telecommunications networks). The presence of roaming agreements between MNOs is an indicator that networks face capacity constraints.

The optimal roaming charge assumes that roaming charges are set before investments take place. Clearly, a regulator may not credibly commit *ex ante* to regulated roaming charges before investment decisions of the networks are taken. However, without commitment a regulator may want to change roaming charges *ex post*. In this case, the optimal roaming charge would take investments as given. The common regulatory system of long run incremental cost is clearly designed to take investments consideration of networks into account. Moreover, given appropriate legal and regulatory institutions, commitment should be less of a problem.

5.2.1 Demand Side

When MNO i invests in its infrastructure this does not only affect the quality of the own service but the perceived quality of the rival MNO j due to the roaming policy. With congestion or in uncovered areas, connection to the Internet is provided by rival MNOs and hence, investments in the facilities do not only benefit fellow subscribers but also rival subscribers. Following the model of Foros et al. (2002), the total quality offered to consumers by MNO i can be written as

$$v_i = v + x_i + \beta x_j, \quad (5.1)$$

where v is an exogenous quality of the networks. The variable x_i represents the investment undertaken by MNO i and x_j the investment decision by the rival. There is an exogenous spillover parameter $\beta \in [0, 1]$, which indicates the impact of the investment by MNO j onto the demand of MNO i . The spillover effect exerts a one-way network effect from the investing network to the competitor. In an extension of the base model, MNOs are allowed to endogenously choose the degree of the spillover.

The inverse demand faced by MNO i is given by:

$$p_i = v_i - q_i - q_j, \quad (5.2)$$

where p_i indicates the subscription fee (e.g. a monthly fee) and q_i the quantity (e.g. the spectrum licenses). With spillovers, investment in the infrastructure of MNO i increases the willingness to pay for both MNOs.

5.2.2 Supply Side

Assume a linear marginal cost of providing mobile Internet services of $c < v$. MNOs pay each other a reciprocal roaming charge a whenever a subscriber of MNO i demands access into the net of MNO j . Due to the reciprocity, the roaming charge exerts a two-way externality on the providers. This roaming charge might be either regulated or negotiated by the networks. Finally, each network incurs a convex cost of investments of $I(x_i) = \frac{1}{2}\delta x_i^2$, where δ is a scale parameter of investment costs, which is assumed to be sufficiently large to allow for stable equilibria:

Assumption: $\delta > \max\left[\frac{1}{2}\frac{(1+\alpha)^2(1+\beta)^2}{1+2\alpha}, \frac{2}{9}(1+\alpha)(5+5\beta^2-8\beta)\right]$.

The critical values are derived below. Without this assumption there might be an escalation of investments.

5.3 Retail Market

In the third and last stage the networks compete à la Cournot in the retail market given a fixed roaming charge and investment decisions of the previous stages. The MNOs solve

$$\max_{q_i} = \pi_i - I(x_i),$$

with

$$\pi_i = (p_i - c)q_i + \alpha[(p_i - a)q_i + (a - c)q_j]. \quad (5.3)$$

The profit consists of three components: (1) the net revenue from serving fellow subscribers whenever they demand access within their network; (2) the revenue when the fellow customers demand access in the rival's network, net of the

payment of the roaming charge a ; (3) the revenue from serving rival customers demanding access into the own net. The parameter α indicates the share of roaming in the market.³

Equilibrium quantities⁴ are obtained as

$$q_i^* = \frac{1}{3} \frac{(v - c) + \alpha(v - a) + (1 + \alpha)[(2 - \beta)x_i - (1 - 2\beta)x_j]}{1 + \alpha}. \quad (5.4)$$

Inserting equilibrium quantities into the demand function of equation (5.2) yields an equilibrium subscription price of

$$p_i^* = \frac{1}{3} \frac{(1 + \alpha)v + 2(\alpha a + c) + (1 + \alpha)[(2 - \beta)x_i - (1 - 2\beta)x_j]}{1 + \alpha}. \quad (5.5)$$

Observe that the equilibrium retail quantity is decreasing in the reciprocal roaming charge a , i.e. $\frac{\partial q_i}{\partial a} < 0$. By increasing the cost of roaming, MNOs will decrease their quantity supplied to increase the price in the retail market. Hence, there will be an incentive to collude over the roaming charge to decrease quantities and increase profits. This is in line with the early literature on mobile communications (Laffont et al. (1998a), Armstrong (1998), and Carter and Wright (1999)), which show that wholesale prices serve as a device to reach the collusive outcome at the retail level when networks compete in linear prices. By coordinating on high access prices, networks can achieve monopoly prices and do not bear any burden from high access prices if call traffic is symmetric.⁵

³Like in the models of Gans and King (2000), Dewenter and Haucap (2005), Gabrielsen and Vagstad (2008), and Harbord and Hoernig (2010) it is assumed that the share of off-net traffic (i.e. roaming) is exogenously given and symmetric for both MNOs. In the models of Laffont et al. (1998a) and Valletti and Cambini (2005) the share of off-net traffic is determined by the market shares.

⁴The second order condition of $\frac{\partial^2 \Pi_i}{\partial q_i^2} = -2(1 + \alpha) < 0$ is always fulfilled.

⁵With non-linear tariffs (e.g. two-part tariffs) the problem of tacit collusion via access prices is reduced, since an increase in the linear price is compensated by a reduction of the fixed fee (Armstrong (1998) and Laffont et al. (1998a)). Another strand of literature shows that networks may wish to coordinate on access prices below marginal costs if networks compete with two-part tariffs and price discriminate between on-net and off-net calls (Gans and King 2001), or demand for subscription is elastic (Dessein 2003). If not only the carrier but also the receiver benefits from calls Hermalin and Katz (2010) provide theoretical arguments for both access pricing above and below costs. Harbord and Pagnozzi (2010) provide a comprehensive overview on the literature about cost-based and below-cost regulation.

Equation (5.4) shows that the retail quantity is unambiguously increasing in the own investment level, where there is a positive externality of own investments on rival's quantity for sufficiently large spillover values of $\beta > 0.5$, i.e.

$$\frac{\partial q_i}{\partial x_i} > 0$$

and

$$\left. \begin{array}{l} \frac{\partial q_i}{\partial x_j} < 0 \\ \frac{\partial q_i}{\partial x_j} > 0 \end{array} \right\} \begin{array}{l} \text{for } \beta < 0.5 \\ \text{for } \beta > 0.5. \end{array}$$

Given the quantity expansion of the rival, MNOs face two countervailing effects. Due to the Cournot structure it would be a best response to decrease the own quantity. But this negative market share effect is opposed by a general increase in total profits, as investments positively shift the demand curves of both networks. Now, it depends on the relative magnitude of both effects. Given that the investment spillover is sufficiently strong, the increase in total profits dominates the loss in market shares, so $\frac{\partial q_i}{\partial x_j} > 0$. Otherwise, if the impact of rival's investment on the own demand curve is too low, the increase in total profits cannot compensate the loss in market shares.

5.4 Investments

Like in the seminal papers of d'Aspremont and Jacquemin (1988) and Kamien et al. (1992) the model analyzes investment decision where MNOs may semi-collude over investments. The present model incorporates an additional stage, where roaming charges are determined. The model compares three different regulatory regimes: Cost-based regulation, above-cost regulation, and below-cost regulation. These regimes are compared to a regime without regulation, where the networks jointly determine the roaming charge.

In the second stage MNOs determine their optimal investment level either non-cooperatively or jointly by maximizing individual profits Π_i or joint profits ($\hat{\Pi} =$

$\Pi_i + \Pi_j$) with respect to investment levels, where

$$\Pi_i = (1 + \alpha)q_i^*[(v_i - c) - q_i^* - q_j^*] - \alpha[(a - c)(q_i^* - q_j^*)] - \frac{1}{2}\delta x_i^2. \quad (5.6)$$

5.4.1 Cost-Based Roaming Charge

Suppose that the roaming charge is regulated to the marginal cost of providing mobile Internet services, i.e. $a = c$. At stage 2 networks maximize their profits of equation (5.3) either individually or jointly. If both networks set their investment levels non-cooperatively there exists a unique⁶ (and symmetric) solution satisfying $\frac{\partial \Pi_i}{\partial x_i} = 0$ at

$$x_i^*|_{a=c} = \frac{(1 + \alpha)(v - c)}{\frac{9}{2} \frac{\delta}{2 - \beta} - (1 + \alpha)(1 + \beta)}. \quad (5.7)$$

When both networks choose investments cooperatively, they maximize their joint profit $\hat{\Pi}$ with respect to x_i and x_j , which yields a unique⁷ equilibrium investment level of

$$\hat{x}_i|_{a=c} = \frac{(1 + \alpha)(v - c)}{\frac{9}{2} \frac{\delta}{1 + \beta} - (1 + \alpha)(1 + \beta)}, \quad (5.8)$$

where the asterisk indicates the non-cooperatively and the hat the jointly determined solution.

Proposition 5.1. *For large spillovers on investments of $\beta > 0.5$ semi-collusion over investments leads to higher investment levels than competition on investments, i.e.*

$$\left. \begin{aligned} \hat{x}_i|_{a=c} &< x_i^*|_{a=c} \\ \hat{x}_i|_{a=c} &> x_i^*|_{a=c} \end{aligned} \right\} \begin{aligned} &\text{for } \beta < 0.5 \\ &\text{for } \beta > 0.5. \end{aligned}$$

This result is equivalent to the results obtained by d'Aspremont and Jacquemin (1988), Kamien et al. (1992), and Foros et al. (2002).

⁶For the SOC to hold it has to be ensured that the costs of investments are sufficiently convex, i.e. $\delta > \bar{\delta} = \frac{2}{9}(1 + \alpha)(\beta - 2)^2$.

⁷In the cooperative setting, for the SOC to hold, it has to be assumed that $\delta > \hat{\delta} = \frac{2}{9}(1 + \alpha)(5 + 5\beta^2 - 8\beta)$. This constitutes the second part of the above assumption, as $\hat{\delta} > \bar{\delta}$.

Comparing the cross derivatives of the profit function with respect to the investment of the rival provides intuition. It can be shown that investments may be both strategic substitutes and complements. The cross derivative in the non-cooperative case is given as

$$\frac{\partial^2}{\partial x_i \partial x_j} \Pi_i = -\frac{2}{9}(1 + \alpha)(2\beta - 1)(\beta - 2),$$

whereas in the cooperative case it is given as

$$\frac{\partial^2}{\partial x_i \partial x_j} \hat{\Pi} = -\frac{4}{9}(1 + \alpha)(2\beta - 1)(\beta - 2).$$

Note that for values below the critical spillover value $\beta < 0.5$ investments are strategic substitutes, i.e. network i decreases its investments whenever network j increases its investment level. Otherwise they are strategic complements.

This result is equivalent to the results obtained by d'Aspremont and Jacquemin (1988), Kamien et al. (1992), and Foros et al. (2002). As already pointed out by them for values below the critical spillover value $\beta < 0.5$ investments are strategic substitutes, i.e. network i decreases its investments whenever network j increases its investment level. Otherwise they are strategic complements.

The intuition for this result is in line with the one given by Kamien et al. (1992). If the spillover effect is small, then the demand effect experienced by network j as a consequence of MNO i 's investment is not large enough, compared to the demand increase of MNO j , so that the investment of the rival leads the demand and thus profits to decrease. Otherwise, for sufficiently high spillovers all MNOs benefit because total equilibrium profits increase and the demand of the rival MNO does not decline significantly. At $\beta = \frac{1}{2}$ the opposing effects are just balanced.

5.4.2 Non-Cost-Based Roaming Charge

Roaming charges can only be set at costs if a regulator knows demand and cost parameters. Although some sophisticated engineering network models are available, it is contentious that in practice that a regulator can exactly set roaming

charges at costs. Similar arguments hold for setting roaming charges above or below costs, though, except the regulator favors a reciprocal roaming charge of zero (“bill-and-keep”).

Suppose the roaming charge is not regulated at costs. In the non-cooperative case MNOs set investment levels of

$$x_i^* = \frac{(1 + \alpha)(v - c) + \frac{\alpha}{2} \frac{8\beta - 7}{2 - \beta} (a - c)}{\frac{9}{2} \frac{\delta}{2 - \beta} - (1 + \alpha)(1 + \beta)}, \quad (5.9)$$

whereas in the cooperative case they set investment levels of

$$\hat{x}_i = \frac{(1 + \alpha)(v - c) + \frac{\alpha}{2} (a - c)}{\frac{9}{2} \frac{\delta}{1 + \beta} - (1 + \alpha)(1 + \beta)}. \quad (5.10)$$

When the roaming charge is regulated to the cost of providing mobile Internet service, MNOs do not take account of rival’s demand in the roaming market, as the profit in equation (5.6) simply reduces to $\Pi_i = (1 + \alpha)q_i^*[(v_i - c) - q_i^* - q_j^*] - \frac{1}{2}\delta x_i^2$. MNOs just balance the previously mentioned effects in the retail market. When incorporating roaming profits or deficits, though, MNOs have to take account of the induced demand of rival customers, which generates a profit or deficit from roaming depending on the regulatory regime.

Semi-Collusion over Investments

Consider MNOs semi-collude over setting investment levels. With $a \leq c$ they additionally earn revenues (or face a deficit) in the roaming market. In a symmetric equilibrium, MNOs set symmetric investment levels of x , which leads to retail prices of

$$p_i = \frac{1}{3} \frac{(1 + \alpha)v + 2(\alpha a + c) + (1 + \alpha)(1 + \beta)x}{1 + \alpha}. \quad (5.11)$$

Hence, the retail price is unambiguously increasing in investments, i.e. $\frac{\partial p_i}{\partial x} > 0$, as fellow subscribers’ willingness to pay for services is increased. In the roaming market MNOs gain a profit or loss per rival customer depending on whether the roaming charge is regulated above or below costs. Now, if the roaming charge

is regulated above costs, there is a clear incentive to semi-collude over investments as revenues from both markets are increased. However, if MNOs face a loss from rival subscribers, there are opposing effects. Setting higher investments benefits fellow subscribers in the retail market, leading to higher retail prices. However, also rival subscribers' willingness to pay is increased, leading to more roaming and thus to a deficit from each rival subscriber. Now, if MNOs semi-collude over investments they will perfectly internalize the effect of their investment on rival's demand. Simply observe from equation (5.10) that investments are increasing if MNOs gain roaming income from rival subscribers ($a > c$) and are decreasing if they face a deficit from roaming ($a < c$), independent of the investment spillover β . Thus, results are very straightforward: Compared to a regime of cost-based regulation MNOs invest more if the roaming charge is regulated above costs and invest less when roaming charge is regulated below costs.

The joint investment level unambiguously increases in the profit from roaming per rival subscriber ($a - c$), whereas the non-cooperative equilibrium only increases for sufficiently large spillovers. Given spillovers above the critical spillover value of $\beta = 0.5$, semi-collusion always leads to larger investments than competition, as the numerator in equation (5.10) is always higher and the denominator always lower than in equation (5.9). This is obvious, as even without a markup on the costs MNOs set higher investment levels if $\beta > 0.5$, which has been stated in proposition 5.1. Now, with a markup MNOs have an additional source of profit from the roaming market. Given a markup of $a - c$ this result will even be true for lower investment spillovers than $\beta = 0.5$.

Competitive Investments

Consider MNOs determine investment levels non-cooperatively. In this case MNOs do not take account of the effect of their investment on rival's demand. Observe from equation (5.9) that this may lead to reversed effects than with semi-collusion. For any investment spillover of $\beta < \frac{7}{8}$ MNOs invest less when the roaming charge is regulated above costs and invest more when the roaming charge is regulated below costs. This confirms the result obtained by Valletti and Cambini (2005)

in a model of competition with linear prices⁸ if investment spillovers are not too large. In their model networks increase (decrease) investment levels when roaming charges are regulated below (above) costs. As previously stated, investment decisions are strategic substitutes given sufficiently low spillovers, i.e. $\frac{\partial x_i}{\partial x_j} < 0$. Thus, an increase of investments pushes the own demand and due to the Cournot-effect generally leads to a decrease of rival's demand. Although income from roaming per rival subscriber increases, total roaming profit is reduced. Otherwise, for sufficiently large investment spillovers of $\beta > \frac{7}{8}$ the Cournot-effect is dominated by the increase of total equilibrium profits, so investment turn to be strategic complements, i.e. $\frac{\partial x_i}{\partial x_j} > 0$. Given sufficiently large investment spillovers, the result of Valletti and Cambini (2005) is now reversed and competing MNOs also decrease investment levels for below costs regulation.⁹

The effects are summarized in the following proposition:

Proposition 5.2. *With competitive investment levels, MNOs increase (decrease) investment levels for below (above) cost regulation of roaming charges if the investment spillover is not too large. Otherwise, if $\beta > \frac{7}{8}$, this result is reversed. With semi-collusion over investments MNOs generally increase (decrease) investment levels for above (below) cost regulation, independent of the extent of the investment spillover.*

Figure 5.1 illustrates this proposition assuming a roaming charge of zero.¹⁰ The solid line plots the non-cooperatively determined investment levels and the dashed line shows the collusively determined one. Given sufficiently high spillovers ($\beta > 0.65$) semi-collusion over investments will lead to higher levels than competition.

5.4.3 Negotiation on Roaming Charge

The previous proposition shows that there is an incentive for MNOs to set the roaming charge above costs. Assume now, that the roaming charge is not regulated, but networks jointly set the reciprocal roaming charge at stage 1.

⁸Valletti and Cambini (2005) model competition with two-part-tariffs.

⁹They do not consider investment spillovers, technically, they set $\beta = 0$.

¹⁰The other parameters are set to: $\alpha = 0.25$; $c = 1$; $\delta = 3$; $v = 2$.

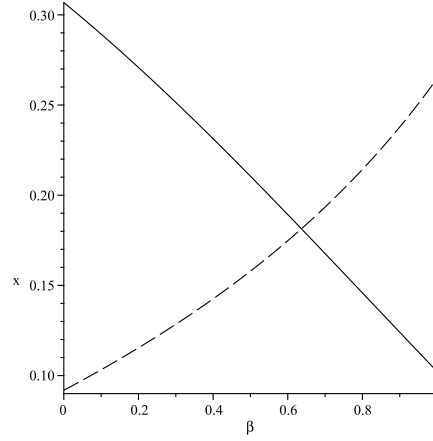


Figure 5.1: Competitive vs. collusive investment levels.

In the case they additionally semi-collude over investment levels at stage 2 the profit maximizing roaming charge¹¹ is given as

$$\hat{a} = \frac{\delta((1 + \alpha)v + c(3\alpha - 1)) - \alpha c(1 + \alpha)(1 + \beta)^2}{\alpha(4\delta - (1 + \alpha)(1 + \beta)^2)}. \quad (5.12)$$

In the case they compete on investments the optimal roaming charge is rather cumbersome and not provided here. However, one can show that MNOs will also set an optimal roaming above marginal costs of providing mobile Internet services, leading to the following proposition:

Proposition 5.3. *In a symmetric equilibrium, MNOs will generally negotiate a reciprocal roaming charge above costs.*

Proof. See Appendix 5.A. □

MNOs use the roaming charge to raise each other's costs and thus the price at the retail level, as equation (5.5) indicates. Inserting this jointly determined

¹¹The SOC of $\frac{\partial^2 \hat{\Pi}}{\partial a^2} < 0$ holds for $\delta > \tilde{\delta} = \frac{1}{4}(1 + \beta)^2(1 + \alpha)$, which holds given the restriction on δ .

roaming charge into equation (5.12) yields an equilibrium investment level of

$$\hat{x}_i|_{\hat{a}} = \frac{(1 + \alpha)(v - c)}{4\frac{\delta}{1+\beta} - (1 + \alpha)(1 + \beta)}. \quad (5.13)$$

As previously stated, MNOs will increase investments in a semi-collusion equilibrium if the roaming charge is set above costs. Obviously, if they further jointly determine the roaming charge, they set a roaming charge above costs and so their profit maximizing investment level is given by equation (5.13). With semi-collusion over investments, MNOs are able to internalize the entire gain of investment levels.

Otherwise, with competition on investments, MNOs have an incentive to invest less. To do so, they also set the roaming charge above costs but, in contrast to semi-collusion over investments, they decrease investment level given an investment spillover of $\beta < \frac{7}{8}$. Consider that a is set above costs. Taking the investment of the rival MNO j as given, MNO i is more reluctant to invest. If it would invest more it captures demand from its rival. Observe from the profit function of equation (5.3) that this in turn reduces the benefit of an increase of the roaming charge. By agreeing on a common markup above cost, MNOs commit not to fight over costly investments, which also Valletti and Cambini (2005) stated. Otherwise, if the investment spillover is sufficiently large, i.e. $\beta > \frac{7}{8}$, both MNOs relatively symmetrically benefit from rival's investment and the effect of the increase in subscribers' willingness to pay dominates the business-stealing effect. In this case, MNOs have an incentive to increase investment levels and also set $a > c$.

The above analysis implies that roaming charge regulation has a strong impact on MNOs' incentives to invest. Given that it is in the interest of a regulator to encourage investments, which will be shown is the case, then the authorities have to take account of both spillovers on investment and roaming charge regulation. The following summarizes the previous findings:

- Roaming charge regulated at costs:

$$\left. \begin{array}{l} x^* > \hat{x} \\ x^* < \hat{x} \end{array} \right\} \begin{array}{l} \text{if } \beta < 0.5 \\ \text{if } \beta > 0.5 \end{array}$$

- Roaming charge regulated above costs:

$$\left. \begin{array}{l} x^* > \hat{x} \\ x^* < \hat{x} \end{array} \right\} \begin{array}{l} \text{if } \beta < \tilde{\beta} \text{ and } a - c \text{ sufficiently small} \\ \text{if } \beta > \tilde{\beta} \text{ and } a - c \text{ sufficiently large} \end{array}$$

- Roaming charge regulated below costs:

$$\left. \begin{array}{l} x^* > \hat{x} \\ x^* < \hat{x} \end{array} \right\} \begin{array}{l} \text{if } \beta < \bar{\beta} \\ \text{if } \beta > \bar{\beta} \end{array}$$

where $\tilde{\beta} < \bar{\beta}$ are critical spillover values depending on the other parameters of the model. Thus, if the roaming charge is regulated above costs the critical spillover value leading to more investments with semi-collusion is lower than the critical spillover value if the roaming charge is regulated below costs.

5.5 Welfare Benchmark

The discussion above implies an important influence of roaming charges on MNOs' incentives to invest. As shown above, if networks were left unregulated, they would naturally agree on above-costs reciprocal roaming charges to raise their retail price. Ad hoc, the effect of collusion over roaming charges on welfare is ambiguous. On the one hand, MNOs use the roaming charge to raise retail prices at the detriment of consumers, but on the other hand, they set may set larger investment levels, which in turn benefits consumers. Both effects have to be balanced in a welfare analysis, which will be done in the following section. The question is how a benevolent social planner would ideally set investment levels and roaming charges.

Define total welfare as

$$W = CS + \Pi_1 + \Pi_2 \quad (5.14)$$

i.e. the sum of consumers' surplus and networks' profits. As both MNOs are symmetric and the inverse demand functions are linear with identical slopes, consumers' surplus can be written as

$$CS = \frac{(q_1 + q_2)^2}{2}. \quad (5.15)$$

Consumers' surplus is thus determined by the quantities q in the retail market. In the symmetric environment MNOs set quantities in equilibrium of

$$q_i^* = \frac{1}{3} \frac{(v - c) + \alpha(v - a) + (1 + \alpha)(1 + \beta)x}{1 + \alpha}. \quad (5.16)$$

Thus, equilibrium investment levels positively affect consumers' surplus. The negative effect on retail prices is compensated by the increase of total demand due to enhanced investments. This simplifies the welfare analysis with respect to collusion in the investment stage and on roaming charges. Whenever semi-collusion raises retail quantities it should be preferred from a welfare perspective, as collusion naturally also increases MNOs' profits. To evaluate the effects of collusion, the outcomes are compared to two benchmark cases, where a welfare maximizing regulator may set investments and/ or the roaming charge.

5.5.1 Control over Investments and Roaming Charge

Taking into account MNOs' profits, due to the convexity of investments cost, there is a welfare maximizing investment level¹² which solves $\frac{\partial W}{\partial x_i} = 0$ given as

$$x^w = \frac{(2 + \alpha)(v - c) - \frac{\alpha(1 - \alpha)}{2(1 + \alpha)}(a - c)}{\frac{9}{2} \frac{\delta}{1 + \beta} - (2 + \alpha)(1 + \beta)}. \quad (5.17)$$

Proposition 5.4. *Consider a welfare maximizing social planner both controls the roaming charge and investment levels. It sets a roaming charge below the costs of providing mobile Internet services. For sufficiently large investment spillovers, it prefers a roaming charge of zero.*

Proof. See Appendix 5.A. □

There are also possible instances, where the social planner always prefers a zero roaming charge. However, it is unlikely in practice that a regulator may directly influence MNOs' investments. It seems to be more relevant that a regulator may indirectly affects MNOs' investment levels by only regulating the roaming charge.

¹²The SOC of $\frac{\partial^2 W}{\partial x_i^2} < 0$ holds for $\delta > \frac{1}{4}(1 + \beta)^2(1 + \alpha)$, which holds given the restriction on δ .

5.5.2 Control over Roaming Charge

Suppose that MNOs set investment levels (non-cooperatively or jointly) in the second stage and the regulator sets a roaming charge of in the first stage. The left picture of figure 5.2 plots the welfare optimal roaming charge with a low degree of the investment spillover ($\beta = 0.1$) in case MNOs compete on investment levels in the previous stage¹³. If the investment spillover is sufficiently small, welfare is maximized for a below cost but positive roaming charge. For larger investment spillovers a regulator generally favors a roaming charge of zero.

Since the exact marginal costs of providing mobile Internet services are hardly to calculate, it seems to be a practical solution to implement a bill-and-keep regime of zero charges, which the European Commission proposes in the long run for mobile voice-communications services. Since the nature of off-net voice and data traffic differs, the effects of such a bill-and-keep regulation is ad hoc unclear. The theoretic welfare optimal investment level with a roaming charge of zero, is given as

$$x^w(a = 0) = \frac{(2 + \alpha)(v - c) + \frac{\alpha}{2} \frac{(1-\alpha)}{(1+\alpha)} c}{\frac{9}{2} \frac{\delta}{1+\beta} - (2 + \alpha)(1 + \beta)}. \quad (5.18)$$

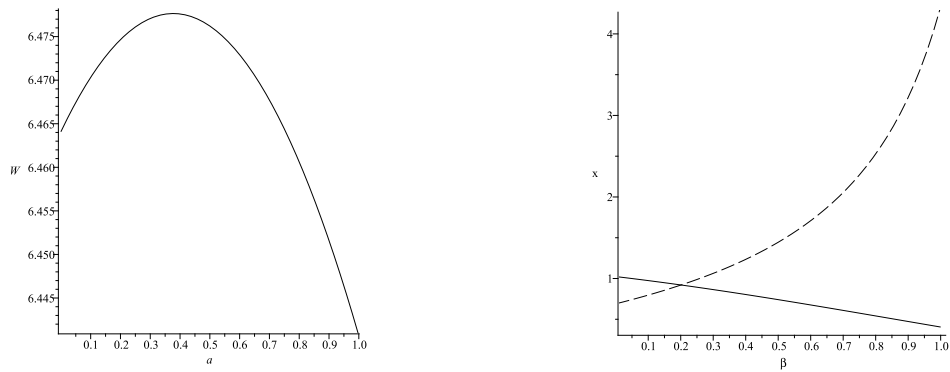
Comparison of the jointly and competitively determined investment levels of equations (5.9) and (5.10) clearly shows that roaming charge regulation to marginal costs, i.e. $a = c$, leads to underprovision in the present model, as $x^w > \hat{x}_{x^*}$. A roaming charge of zero will further decrease investments in the semi-collusive equilibrium, which leads to underprovision of investments from a welfare perspective.

However, if MNOs compete on investment levels, a roaming charge below marginal costs induce MNOs to increase their investment levels, given that the investment spillover is not too large ($\beta < \frac{7}{8}$). From a welfare perspective, a zero roaming charge regime may both lead to over- and underprovision if MNOs compete on investments as the right picture of figure 5.2 indicates. The solid line plots the competitive investment level of equation (5.9) and the dashed line the welfare optimal investment level of equation (5.17). For sufficiently low investment spillovers, there might even be overinvestment from a welfare perspective if

¹³Parameter values in both pictures are set to $v = 4$, $\delta = 3$, $c = 1$, and $\alpha = 0.5$.

MNOs determine their investments competitively, otherwise there is also underprovision of investments.

Proposition 5.5. *Consider a social planner controls the roaming charge but not investment levels. A regulator widely favors below cost roaming charges. A roaming charge of zero leads to underprovision of investment levels if MNOs semi-collude over investments, whereas it may lead to under- or even overprovision of investments if MNOs compete on investment levels.*



Welfare depending on the roaming charge.

Competitive vs. welfare optimal investment levels.

Figure 5.2: Roaming charge and welfare.

For low investment spillovers, MNOs' investments hardly affect rival consumers' willingness to pay. The positive effect on total demand and profit becomes relatively weak compared to the negative market share effect. As competition for market shares becomes relatively more important, this leads MNOs to engage in a "race for investment" which may even lead to overinvestment from a welfare perspective.

The different regimes of cooperative and non-cooperative determination of investments demand a careful regulation of the roaming charge to reach welfare

preferred investment levels. With competition on investments in network infrastructure, a roaming charge below marginal costs widely encourage investments, where the opposite holds with semi-collusion over investments. Thus, a regulator may both set a roaming charge below and above costs to reach an investment level, that is preferred from a welfare perspective.

5.6 Extension: Roaming Quality

In an extension of the base model, MNOs may additionally choose the optimal roaming quality. Like in the model of Foros et al. (2002) the choice of roaming quality is determined endogenously by setting the degree of the investment spillover β . Since a regulator can credibly commit on the regulatory regime, the roaming quality is chosen after regulation is announced and before infrastructure investment takes place. It will be determined how the different regimes of roaming charge regulation affect quality decisions. To restrict the number of possible cases it is assumed that both infrastructure investments and roaming quality are either determined cooperatively or non-cooperatively instead of a mixture of both decisions.¹⁴

5.6.1 Competition on Roaming Quality

Inserting the optimal retail quantity of equation (5.4) into the profit function of equation (5.3) yields the equilibrium retail profit, depending on the investment levels at the previous stage of

$$\Pi(x) = \frac{1}{9(1+\alpha)} [(v-c) + (1+\alpha)(1+\beta)x + \alpha(v-a)]^2 + 3\alpha(a-c)[(v-c) + \alpha(v-a) + (1+\alpha)(1+\beta)x] - I(x). \quad (5.19)$$

Suppose MNOs compete on setting their investment level. Differentiation with

¹⁴It seems reasonable to assume that whenever MNOs semi-collude over investments they will additionally semi-collude over the roaming quality and vice versa.

respect to β implicitly determines the choice of the optimal roaming quality by

$$\frac{\partial \Pi^*}{\partial \beta} = \frac{2}{9}[(1 + \beta)x^* + \frac{(v-c)+\alpha(v-a)}{1+\alpha}](1 + \beta)(\frac{\partial x^*}{\partial \beta} + \frac{x^*}{1+\alpha}) + \frac{3}{9}\alpha(a - c)(1 + \beta)(\frac{\partial x^*}{\partial \beta} + \frac{x^*}{1+\alpha}) - \delta \frac{\partial x^*}{\partial \beta}. \quad (5.20)$$

To determine the optimal choice of β consider how infrastructure investments are affected.

Differentiation of equation (5.9) yields

$$\frac{\partial x^*}{\partial \beta} = - \underbrace{\frac{(1 + \alpha)(v - c)[\frac{9}{2} \frac{\delta}{(2 - \beta)^2} - (1 + \alpha)]}{\frac{9}{2} \frac{\delta}{(2 - \beta)^2} - (1 + \alpha)^2}}_{<0} - (a - c) \underbrace{\frac{2\alpha[(1 + \alpha)(8\beta - 14\beta + 23) - 36\delta]}{[2(1 + \alpha)(1 + \beta)(\beta - 2) + 9\delta]^2}}_{\leq 0}. \quad (5.21)$$

Since investment costs are assumed to be sufficiently convex (δ is large), the first part of the equation is negative whereas the sign of the second part depends on the regime of the roaming charge regulation. For $a \leq c$ the second part is also negative, whereas it turns positive for a markup on marginal costs of $a > c$. In this case it depends on the level of the markup if the second positive effect outweighs the negative first one, so investments might increase in the roaming quality. In either case, investment levels are higher the higher the roaming charge. Hence, the regime of regulation determines MNOs' choice of the roaming quality. Simple observation of equation (5.20) shows that the impact on investment levels determines the optimal choice of the roaming quality.

Proposition 5.6. *Consider investment levels and the roaming quality are determined non-cooperatively. Investment levels are decreasing in the quality of roaming for a roaming charge at or below costs, whereas investments may increase for a sufficiently high markup. MNOs choose a higher roaming quality, the higher the regulated roaming charge.*

The exact choice of the roaming quality depends on the convexity of the cost function. If MNOs face a deficit from roaming there are less incentives to increase the roaming quality. Being regulated below the cost of providing services MNOs face a deficit from roaming per rival subscriber. Now, an increase in the roaming quality increases the amount of roaming, and in turn the loss from roaming. The only incentive to increase the quality of roaming is due to the increase in the

willingness to pay of fellow subscribers. Otherwise, if MNOs sufficiently benefit from roaming, they may even choose the maximal roaming quality. In case of a markup on costs they both benefit from an increased willingness to pay of fellow and rival subscribers. Consider for example parameter values of $v = 3$, $\delta = 4$, $c = 1$, and $\alpha = 0.25$. With a roaming charge of zero MNOs set a roaming quality of $\beta = 0.89$, with cost-based regulation they set $\beta = 0.975$, whereas they would set the maximal roaming quality of $\beta = 1$ for a 20 % markup on the costs.

5.6.2 Collusion over Roaming Quality

Consider MNOs semi-collude over investment levels and the quality of roaming. Simple observation of equation (5.10) shows that the infrastructure investment levels are unambiguously increasing in the roaming quality, independent of the type of roaming charge regulation. Contrary to competition on investment, the incentives to invest are higher the higher the roaming quality.

MNOs maximize their equilibrium profit with respect to the roaming quality, which results in

$$\frac{\partial \hat{\Pi}}{\partial \beta} = \frac{2\delta(1 + \beta)(2(1 + \alpha)(v - c) + \alpha(a - c))^2}{(2(1 + \beta)^2(1 + \alpha) - 9\delta)^2}. \quad (5.22)$$

Proposition 5.7. *Consider MNOs semi-collude over investment levels and the roaming quality. Investment levels are increasing in the roaming quality and MNOs always choose the maximal roaming quality, independent of the regulatory regime.*

Simply observe that the derivative is increasing over the interval of $\beta \in [0, 1]$. This is in line with the model of Foros et al. (2002). The equilibrium roaming quality corresponds to the maximal one, which holds independent of regulation.¹⁵ Again, when colluding, MNOs are able to internalize the roaming externality on individual profits. Otherwise, if MNOs compete on investments and roaming quality, they are not able to capture the entire gain of their investment as part of the gain is captured by the rival. This leads to the incentive to set a lower roaming

¹⁵Foros et al. (2002) do not consider wholesale pricing.

quality. Now, if a regulatory authority wishes to enhance investments and the quality of spillovers it might face a dilemma. As previously shown, competing MNOs increase investment levels for a roaming charge below cost (if spillovers are not too large), although in this case they set a lower roaming quality. Otherwise, for roaming charges above costs they set a better roaming quality, but set lower investment levels. With colluding MNOs, though, this dilemma is not present, as they always set the best roaming quality.

5.7 Conclusion

This chapter has analyzed mobile network operators' (MNOs') incentives to invest in their network facilities given investment spillovers and regulation of the roaming charge. Due to the widespread use of smartphones in recent years, MNOs have to invest in their facilities to meet the growing demand for 3G services. Now, if a MNO invests in its facilities, this does not only affect the willingness to pay for fellow subscribers, but due to the roaming agreement the willingness to pay of rival subscribers for the rival MNO. Hence, roaming agreements induce a demand-side investment spillover.

Today, it is a relevant policy question, whether MNOs should be allowed to semi-collude in the investment stage and if and how to regulate roaming charges. The present model shows that coordination on the investment decision is welfare enhancing for sufficiently high levels of investment spillovers, which is in line of the results of the seminal papers of d'Aspremont and Jacquemin (1988) and Kamien et al. (1992). The results imply that the incentives to invest depend on three components: i) the regime of roaming charge regulation, ii) on the choice whether to allow MNOs to semi-collude over investment levels, and iii) on the extent of the investment spillover.

Regulation of roaming charges affect MNOs' investment incentives. A regulator has to care if investments are determined non-cooperatively or jointly. This crucially affects the "right" roaming charge regulation, as roaming charges below or above costs may lead to reversed effects in both regimes. Generally, investment levels are decreasing for a roaming charge regulation below cost if MNOs semi-collude over investments, whereas they are increasing if MNOs non-cooperatively

determine their choices, given that the investment spillover is not too large. A social planner who both controls roaming charges and investment levels largely prefers a roaming charge of zero. Otherwise, if a social planner only regulates the roaming charge, a charge of zero decreases investments and welfare if MNOs semi-collude over investments and may lead to over- and underprovision of investments from a social welfare perspective if MNOs compete on investment levels.

In an extension of the base model, MNOs are additionally able to determine the roaming quality. They will choose maximal quality whenever they semi-collude over investments and quality. However, if MNOs compete on investments and the roaming quality, the social planner might face a dilemma. For below cost charges MNOs increase investment levels but decrease the roaming quality, whereas for above cost charges they decrease investment levels but increase the roaming quality.

To conclude, regulatory authorities have to take investment spillovers into account when evaluating the effects of collusion and setting the roaming charge in the mobile Internet market. Assessing the investment spillovers correctly is a tough task for the authorities. But there will likely be a positive correlation between investment spillovers and total roaming in the market. Given sufficient roaming in the market semi-collusion over investments will likely be welfare improving.

5.A Appendix

Proof. of Proposition 5.3:

Consider MNOs semi-collude over investment levels. They negotiate a roaming charge of equation (5.12). It follows that $\hat{a} > c$ for $v > c$ and $\delta > \frac{1}{4}(1 + \beta)^2(1 + \alpha)$, which both has been assumed.

In the case MNOs compete on investment levels, they set a roaming charge which solves $\frac{\partial \hat{\Pi}}{\partial a} = 0$. The roaming charge is rather cumbersome and not provided here. However, one can show that it also holds that $a^* > c$ if $v > c$. It follows that $a^* > c$ for $v > c$ and $\delta > \underline{\delta} = \frac{2}{9}(23\beta - 17\beta^2 - 5)(1 + \alpha)$. This holds given the restriction on δ . $\square$

Proof. of Proposition 5.4:

A welfare maximizing social planner sets an optimal roaming charge by solving $\frac{\partial W}{\partial a} = 0$, which yields

$$a^w = \frac{\delta(v - c) + \alpha[c(1 + \alpha)^2(1 + \beta)^2 - \delta(\alpha(3c + v) + 2c)]}{\alpha[(1 + \alpha)^2(1 + \beta)^2 - \delta(4\alpha + 2)]}.$$

The SOC of $\frac{\partial^2 W}{\partial a^2} < 0$ is ensured given that $\delta > \frac{1}{2} \frac{(1+\alpha)^2(1+\beta)^2}{1+2\alpha}$, which constitutes the first part of the restriction on δ .

For $a^w < c$ the social planner sets a roaming charge below costs. This condition holds for $\delta(1 - \alpha)(1 + \alpha)(v - c) > 0$ which is always true for $v > c$.

From

$$\frac{\partial a^w}{\partial \beta} = -\frac{2(v - c)(1 - \alpha)\delta(1 + \beta)(1 + \alpha)^3}{(\alpha(1 + \alpha)^2(1 + \beta)^2 - 2\delta(1 - 2\alpha))^2} < 0$$

follows that the welfare maximizing social planner decreases the roaming charge for a larger investment spillover. $\square$

Chapter 6

Conclusion

The following chapter summarizes the main findings and discusses further research directions.

Part I of the present thesis deals with competition and regulation in broadcasting markets. Chapter 2, entitled **Getting Beer During Commercials: Adverse Effects of Ad-Avoidance**, considers the impact of ad-avoidance technologies on competition in broadcasting markets. If advertising is largely avoided, the value of placing adverts decreases for advertisers, and, in turn, the broadcasters' ability to earn profits is reduced. A theoretical model shows that viewers' ad-avoidance behavior has a different impact on free-to-air and pay-TV broadcasters. In the free-to-air regime, broadcasters are generally hurt if viewers have better opportunities to avoid advertising messages. This, in turn, leads to a fewer number of channels that can survive in the market. However, with pay-TV, broadcasters are less affected as they can compensate any loss in revenue from advertising by increasing subscription prices accordingly. In this sense the chapter provides a rationale for a new form of advertising: Product placements. Broadcasters tend to increasingly respond to ad-avoidance behavior by placing products in the editorial content, which has been generally liberalized according to the European Commission's Audiovisual Media Service Directive. Advertising messages are bundled with the editorial content. Hence, this new form of advertising is hard to avoid by viewers and may cause an adverse effect of ad-avoidance of viewers. If viewers intensively avoid traditional advertising breaks they may be annoyed

even more by product placements. It is left for future research to explicitly model viewers' attitude towards product placements. As placed products are, or at least should be, related to the editorial content, this may have a different impact on viewers. Viewers who enjoy the content may be less affected than those who like the program less. Technically, this could be modeled by introducing a distribution over viewers' attitude to advertising. Then, advertisers who cause more nuisance to viewers could be charged more than those, who cause less nuisance to viewers.

Chapter 3, entitled **Regulating Advertising in the Presence of Public Service Broadcasting**, discusses the effects of a regulation of advertising time on broadcasting channels. The Audiovisual Media Services Directive restricts the amount of television advertising. Usually, national regulators impose a stricter regulation for their public service broadcasters. A theoretical model analyzes the effects of restricting advertising on commercial and public service broadcasting channels. If both kinds of broadcasters are subject to the same restriction, this may even benefit the broadcasters as the advertising level may move towards a collusive equilibrium. If the restriction only applies to the public service broadcaster, this may benefit or harm the commercial rival. On the one hand, given ad-avoidance of viewers, the commercial channel gives away market shares to the public service broadcaster. But on the other hand, due to the limited advertising level of the public service broadcaster, the advertising price rises and the commercial channel gains market power in the advertising market. If this positive price effect in the advertising market is sufficiently strong, the commercial rival benefits from a restriction of advertising time. This chapter analyzes competition between free-to-air and public service broadcasters. Given the knowledge about pass-through effects on pay-TV broadcasters of chapter 2, a natural extension is to analyze whether and how pay-TV channels are affected by regulation of advertising times. The present chapter focuses on the effects of regulation on advertisers and broadcasters. A welfare analysis of the effects on viewers is left for future research. Ad averse viewers benefit from lower advertising levels but may not watch the program which fits best their preferences, i.e. technically, transportation costs might increase. This may lead to an ambiguous effect on consumer welfare. A sophisticated welfare analysis has to account for the impact on all interest groups, namely broadcasters, recipients, and advertisers, which are differently affected.

Part II of this thesis covers competition and regulation in telecommunications markets. Chapter 4, entitled **Fixed to VoIP Interconnection: Regulation with Asymmetric Termination Cost**, deals with the interconnection of fixed-line and IP-based networks, so called Voice over IP (VoIP). A major difference between IP-based and fixed-line networks stems from the asymmetry in termination costs. Termination costs in electronic networks are significantly lower than in fixed-line networks. The European Commission basically proposes two regimes of regulating termination charges: i) Cost-based regulation and ii) reciprocal regulation at the termination cost of the incumbent fixed-line network. An analytical model explores the effects of marginally deviating from both regimes. In a direct effect, a deviation affects marginal costs and thus per-minute prices. This, in turn, induces indirect effects on subscribers' utilities, which may benefit from higher termination charges. It turns out that the VoIP provider does not necessarily benefit from a markup on its termination cost and the fixed-line provider is not generally harmed from a termination deficit. If competition becomes too intense both providers prefer cost-based regulation. Furthermore, the model can justify a reciprocal termination charge, even in the presence of cost differences. The model of this chapter abstracts from any issues on wholesale competition and isolates effects of regulation of termination charges. In practise, incumbent networks may strategically respond to market entry of alternative providers. The analysis of entry decisions are left for future research.

Chapter 5, entitled **Roaming and Investments in the Mobile Internet Market**, covers another recent technology in telecommunications markets: The mobile Internet. To meet the growing demand for mobile data traffic, mobile network operators (MNOs) have to invest in their network facilities. In the presence of roaming agreements, infrastructure investments induce externalities (spillovers) on the rival provider. Comparable to chapter 4, this chapter discusses different regulatory regimes of roaming charges. An analytical model shows that both roaming charges above and below costs can enhance investments, depending on whether MNOs compete or semi-collude over the investment decision. If they semi-collude, a roaming charge above the marginal cost of providing mobile Internet services induces larger investment levels. However, if firms compete on investment levels, a roaming charge below the marginal cost enhances investments,

if the externality is not too large. A welfare maximizing social planner controlling both the roaming charge and investment levels prefers “bill-and-keep” pricing, otherwise, if the planner is unable to control investment levels, a roaming charge of zero will both lead to under- and overinvestment from a welfare perspective. This chapter is a first starting point to analyze competition in the mobile Internet market. The model could be extended in several directions. The base model fixes the amount of roaming. A possible extension is to relate the amount of roaming to the market shares of the providers to account for the probability of roaming in style of chapter 4. Furthermore, MNOs might additionally price discriminate between home and roaming traffic and allow operators to set two-part tariffs. It is observable in practice that subscribers often choose a flat fee for voice and data services - although, this may not always be an optimal choice. Valletti and Cambini (2005) find similar results in a related model with two part tariffs in the mobile communications market. Networks increase (decrease) investment levels for below (above) termination charges. It is left for future research whether this holds in the presence of investment externalities.

This thesis covers regulatory issues in two markets: Media and telecommunications markets. Throughout the last years one can observe a convergence of market borders. Phone calls are placed in the Internet and the Internet is available on phones. This convergence may open new interesting aspects for the academic literature and for policy makers in regulatory authorities, taking account for diminishing borders of the two markets.

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