Competition and Regulation in Telecommunications Markets

Paul de Bijl
with Martin Peitz

CPB Netherlands Bureau for Economic Policy Analysis, The Hague, November 2000

CPB Netherlands Bureau for Economic Policy Analysis
Van Stolkweg 14
P.O. Box 80510
2508 GM The Hague, The Netherlands

Telephone +31 70 33 83 380
Telefax +31 70 33 83 350

ISBN 90-5833-052-4

Contents

CD-ROM with Mathematica notebooks and simulation results (a limited amount is separately available on request).

Preface

Opta, the independent post and telecommunications authority in the Netherlands, has asked CPB to undertake a study on competition and regulations in the market for telecommunications. This study fits into CPB’s growing interest in ICT markets, as demonstrated by earlier publications: *Competition in communication and information services: Opportunities and obstacles* (CPB, 1997), *Auctions and precautions: overbidding in spectrum auctions and its possible impact* (CPB Working Paper 127, 2000), and the chapter "The renewing economy" in CPB’s Central Economic Plan of 2000.

The transition from a monopoly to competition can be difficult, especially in situations where technology and infrastructure are crucial, such as in telecommunications. This study explores how policy and regulation can stimulate competition in the market for fixed voice telephony, while explicitly taking consumers’ benefits into account. Several regulatory instruments are examined in a wide range of situations of market entry, such as facilities-based entry, local loop unbundling, and Carrier Select-based competition.

The study was conducted by Paul de Bijl, under the stimulating guidance and supervision of Marcel Canoy (both at the Regulation & Competition unit). Martin Peitz (University of Frankfurt) provided important contributions to the study, in particular in the modelling, programming and economic expertise. Thanks to efforts of Eric Bartelsman (formerly at CPB), Marcel Canoy, and Jos Huigen (Opta), the project was ignited. The support and input by Marcel have been of vital importance for the project.

We wish to thank the members of the advisory committee for discussing and commenting on the research in various stages of the projectPeter Alexiadis (Squire, Sanders & Dempsey), Jens Arnbak (Opta), Eric Bartelsman (Ministry of Economic Affairs, Free University Amsterdam), Eric van Damme (CentER, Tilburg University), Ad Driedonks (DGTP, Ministry of Transport, Public Works and Water Management), and Casper van Ewijk (CPB). Frank Verboven (University of Antwerp) provided valuable economic expertise. The support and comments throughout the project by various colleagues at CPB and people at Opta are highly appreciated. Finally, the help of CPB’s IT staff and Kathy Schuitemaker is kindly acknowledged. The project was financed by Opta.

Henk Don
Director, CPB Netherlands Bureau for Economic Policy Analysis

Executive summary

Opta, the independent telecommunications and postal services authority in the Netherlands, has asked CPB to carry out a study on regulation of telecommunications markets, in particular of the market for (national) fixed voice telephony. The purpose is to increase the knowledge of and insight into the nature of competition and entry in the phase towards mature competition, and the effects of specific regulatory instruments on competition, market structure and consumers' surplus. The central question is:

How should one design policy and regulation with the purpose of stimulating competition in markets for fixed voice telephony, while ensuring that consumers benefit from entry, and operators have sufficient incentives to be active on the market?

This question is addressed in a range of different situations, using recent insights from the theory of industrial organization (applied game theory) and computer simulation. The tools of game theory are crucial to understand the incentives of market players who behave strategically, especially in complex market environments such as telecommunications. This is a conceptual study (based on a stylized, but empirically calibrated, description of the market) that does not forecast or describe actual behavior by market players. We are interested in understanding how regulatory instruments can stimulate competition in such a way that consumers benefit from it.

This study examines, within the context of a market dominated by an incumbent operator, three types of entry:[1]

- facilities-based competition: entry by an operator building its own infrastructure;
- direct access through "local loop unbundling": entry by an operator leasing local connections from the incumbent;
- indirect access through "Carrier Select": entry by an operator with "originating access" to the incumbent's customers.

For each mode of entry, we focus on wholesale prices (e.g. access fees) and retail prices. By comparing how regulation affects an entrant's profits in different entry situations, we also discuss how policy and regulation affect an entrant's incentives to invest in infrastructure. It is beyond the scope of this study to address the general pros and cons of sector-specific regulation and general competition policy. For the sake of exposition, throughout this study we implicitly assume that sector-specific regulation

[1] See the glossary for an explanation of terminology.

(instead of ex post competition policy) deals with access prices, price cap regulation, local loop unbundling, etc.

Besides the introductory chapter 1, this report consists of three parts:

Part I:Analytical framework
This part provides an introduction to the telecommunications industry (chapter 2), the economic literature on competition in telecommunications (chapter 3), and describes the analytical framework of the study (chapters 4-5). Chapter 2 can be skipped by readers familiar with telecommunications and policy. Chapters 4 and 5 can be skipped by readers who are not interested in the mathematical details of the models.

Part II: Results
This part can be read independently of part I. It contains the results of the simulations, discusses and interprets the outcomes, and draws conclusions relevant for regulation and competition policy. Chapter 6 analyzes facilities-based competition, local-loop unbundling-based competition, and Carrier Select-based competition. In each of these entry modes, the most relevant wholesale prices are examined, such as terminating access prices, lease price of the incumbent's local line, and originating access price in the case of Carrier Select.

Whereas in the models of chapter 6, the operators compete by choosing two-part tariffs, chapter 7 explores the following alternative pricing structures: flat fees, linear prices, and non-uniform prices (operators differentiate between on-net and off-net per-minute prices). In each of these situations we zoom in on the role of terminating access prices. As a special application, we discuss competition between a fixed and a mobile operator, and the role of relatively high fixed-mobile interconnection fees.

In the models of chapters 6 and 7, consumers are assumed to be homogeneous. Chapter 8 analyzes situation with heterogeneous customers. In particular, it is assumed that there are two types of customers, namely residential and business customers. The cases that are examined in chapter 8 are: (1) the entrant targets the business segment only, with a customer access network for business customers; (2) the entrant targets the business segment with a customer access network for business customers and targets the residential segment by leasing the incumbent's local lines; (3) the entrant targets the business segment with a customer access network for business customers and targets the residential segment through Carrier Select.

Part III: Policy implications
This part can be read independently of parts I and II. It recapitulates the implications for policy and regulation derived in part II, and discusses them from a broader viewpoint. Policy implications are based on maximization of consumers' surplus, with due care for the speed of entry and the entrant's incentives to enter. It is outside the scope of this

study to discuss: (1) sector-specific regulation versus general competition policy, and (2) the pros and cons of facilities-based and other types of competition.

The main policy implications are summarized below (for the sake of exposition, there is some overlap). Chapter 9 contains some more, detailed conclusions for policy and clarifications. We remark that for the purposes of this conceptual study, the economic intuitions behind these implications, derived in part II, are at least as important as the implications themselves.

1. Regulation of retail prices

- A general principle is that in market segments where the incumbent is a monopolist or substantially outweighs competitors in terms of market power, regulation of the incumbent's retail prices (per-minute price and/or subscription fee) is necessary.

2. Cost-based wholesale prices

- When competition in situations of facilities-based competition or local loop unbundling is mature, then terminating access prices should be reciprocal and cost-based.
- In situations of local loop unbundling, the lease price of the local loop should be cost-based (a supplementary markup may be needed for recovery of fixed investment costs).
- In situations of Carrier-Select-based entry, the originating access price should be cost-based (a supplementary markup may be needed for recovery of fixed investment costs). The growth in traffic caused by internet access via local telephony, making the effects of a "price squeeze" worse for entrants, reinforces the case for a cost-based originating access price.

3. Wholesale prices above cost

- In the early stages of competition it may be optimal to allow only the entrant to include a markup in the terminating access price.

4. Dynamic regulatory principles: retail and wholesale prices conditional on maturity of competition

- Price cap regulation of the incumbent's retail prices is typically useful in the early stages of competition, when entrants are too small to discipline the incumbent. Price caps should be carefully balanced: entrants experience downward price pressure as well from price caps, reducing their profits and incentives to invest.
- In addition to point 3 above: as the market matures, reciprocal and cost-based terminating access prices are optimal.

- Early announcement of regulatory principles, and commitment to the announced principles over time, is vital: regulatory uncertainty can reduce firms' incentives to invest.

5. Quality and congestion of Carrier Select services

- Insufficient capacity to interconnect with the incumbent's network directly harms users of Carrier Select services (they experience a quality degradation), and may indirectly harm all consumers (as the intensity of competition is reduced). A price cap on the incumbent's per-minute price can reduce the harm to consumers.
- Capacity shortages may hamper the growth of Carrier Select operators: as they try to gain market share (e.g., by competing in prices) they generate more traffic, which aggravates the capacity problem.

6. Incentives to build a customer access network

- Tighter price caps for the incumbent's retail prices result in more downward pressure on the prices of an entrant, making entry less profitable. Hence, in the short run there is a tradeoff between maximizing consumers' surplus and stimulating entry.
- Carrier Select-based entry can be stimulated in the short run by setting the incumbent's originating access price equal to marginal cost (a supplementary markup may be needed for recovery of fixed investment costs), and by eliminating any shortages in interconnection capacity in the incumbent's network.
- Unbundling-based entry can be stimulated in the short run by setting the lease price of the local loop equal to the fixed cost of a connection (a supplementary markup may be needed for recovery of fixed investment costs).
- Stimulating Carrier Select-based entry and local loop unbundling may be optimal in the short run, because of the importance of building market share. Over time, facilities-based entry can be stimulated by making Carrier Select-based entry and local loop unbundling less attractive for entrants, e.g., by gradually increasing the relevant wholesale prices that they have to pay.
- Early announcement of regulatory principles, and commitment to the announced principles over time, is vital: regulatory uncertainty can reduce firms' incentives to invest in infrastructure.

Chapter 1. Introduction

1.1. Purpose

Opta, the independent telecommunications and postal services authority in the Netherlands, has asked CPB to carry out a study on regulation of telecommunications markets, in particular of the market for (national) fixed voice telephony.[2] The purpose is to increase the knowledge of and insight into entry and the nature of competition in the phase towards mature competition, and the effects of specific regulatory instruments on competition, market structure and surplus. This report contains the findings of the research.

Generally speaking, the goal of public policy is to create conditions in order to achieve allocative and dynamic efficiency, resulting in efficient production, efficient pricing and the highest benefits for consumers and producers.[3] Dynamic efficiency denotes maximizing the "size of the pie" in the medium to long run, through product and process innovations. The pie is understood to mean total surplus in the market (also called welfare), that is, the sum of producers and consumers surplus. Allocative or static efficiency entails dividing the pie such that the pieces end up with those who value them most. In some cases, efficiency is maximized under the restriction that everyone gets a fair share, for instance by making arrangements that prevent firms from abusing monopoly power.

It is often said that efficiency is obtained by competition on a "level playing field." In the telecommunications sector, the playing field is tilted as a result of the dominant position of the former national monopolist. Creating a level playing field – which seems a reasonable policy goal for the long run – presents a substantial challenge to policy makers and regulators. However, one should not rule out the possibility of tilting the playing field to the other side in the short run, if it facilitates the transition to competition and it is in the interest of consumers.

According to Bergman et al. (1998, ch. 10), the major regulatory issues that determine the overall development of market structures in the telecommunications and related information industries are: the conditions of: (i) access to essential facilities, in particular residential access to key content, (ii) network interconnection, and (iii)

[2] Although other segments (e.g., mobile) are growing, the market for national fixed telephony is still big. The relative size of the segment of fixed telephony (PSTN and ISDN) in the Netherlands was 64% in 1998, expected to be 52% in 2002 (other segments include mobile, ATM, and leased lines). The relative size of national fixed telephony was 49% in 1997, expected to be 43% in 2002 (other segments: international and fixed-to-mobile). Source: IDC (1999).

[3] See, for instance, the Dutch policy agenda on communications networks (DGTP, 2000b).

ownership of technologies, infrastructures and essential facilities. Current regulation mainly applies to the conditions of access, interconnection, and network interoperability.

Arguably, competition in most telecommunications markets has not yet fully matured, and these issues are still very relevant. In European markets for fixed telephony, for instance, competition has not led to a widespread use of alternative infrastructures (Cave and Prosperetti, 2000a). In the early stages of competition, three types of instruments are needed to constrain the former monopolist (Cave and Prosperetti). First, control of retail prices, in order to protect consumers from abuse of market power. Second, control of access prices, to give entrants access to end-users. Third, universal service obligation, to protect consumers in less densely populated areas of the country.

In this study, we examine, within the context of a market that is dominated by an incumbent operator:[4]

- facilities-based competition: entry by an operator building its own infrastructure;
- direct access through "local loop unbundling": entry by an operator leasing local connections from the incumbent;
- indirect access through "Carrier Select": entry by an operator with originating access to the incumbent's customers.

In all situations, we concentrate on regulation of wholesale prices (e.g., terminating and originating access prices), and competition in (or regulation of) retail prices. We will make some specific assumptions about the entrant's network and ways of access to the incumbent's network, about the nature of price competition between the operators, and the nature of consumer demand. Doing so allows us to zoom into specific situations and address questions that are relevant within the situation at hand.

The central question of this study can be summarized as follows:

How should one design policy and regulation with the purpose of stimulating competition in markets for fixed voice telephony, thereby ensuring that consumers benefit from entry, and operators have sufficient incentives to be active on the market?

A related question is how policy and regulation affect an entrant's incentives to invest in infrastructure. That issue will also be addressed, by comparing an entrant's additional profits that can be obtained by building its own infrastructure, under different regulatory regimes.

[4] See chapter 2, or the glossary of terms, for an explanation of terminology.

1.2 Focus

We will now discuss the focus of the analysis in more detail. The difficulty to exactly define the markets for telecommunications networks and services obviously is a handicap (see Bergman et al., 1998, ch. 8). One of the reasons of this difficulty is that the technological constraints that define the boundaries of telecommunications markets are changing all the time. While it is obvious that technological change is having a drastic impact on the industry, the need still exists to design optimal regulation and policy that can deal with competition problems in the *current* situation of entry in markets of "traditional" fixed voice telephony. We therefore restrict ourselves to markets for national fixed voice telephony.[5]

Many telecommunications operators are multinational multi-product firms, offering not only national fixed voice telephony, but also international telephony, mobile telephony, data services, and so on. Broadening the market definition to take this into account is not helpful for the analysis. In fact, it would make a sensible analysis virtually impossible. The reader should keep in mind that the models used in the study are stylized and do not reflect the true scale of activities of firms.

Throughout this study, three major types of regulatory instruments are subject to detailed analysis:

- control of wholesale prices associated with network interconnection, access, and local lines (terminating access prices, originating access prices, and lease price of incumbent's local lines);
- control of the incumbent's retail prices (price caps);[6]
- specific rulings (e.g. whether or not to allow price differentiation, price discrimination, local loop unbundling etc.).

Control of wholesale and retail prices is analyzed by examining tradeoffs related to their levels. Specific rulings can, in general, be described as "yes/no"-decisions, which of course also involve tradeoffs. Examples of such decisions are: whether to force the incumbent to give the entrant access to end-users (for instance through local loop

[5] Nevertheless, we expect that some insights may also be relevant for other situations, for instance mobile telephony (see e.g. section 7.4.4 on fixed-mobile interconnection). Also, the way of modeling competition in network industries may turn out to be relevant for other network industries, such as energy.

[6] We will focus on retail price control by using price caps. An alternative is "cost-plus" or rate-of-return regulation, which is generally viewed as a low-powered incentive scheme in the sense that it gives firms weak incentives to reduce costs.

unbundling), to allow operators to differentiate prices for on-net and off-net calls, to allow operators to discriminate between different types of customers, etc.

Box 1.2.1: Sector-specific regulation versus competition policy

It is beyond the scope of this study to address

(i) the general pros and cons of sector-specific regulation and general competition policy;
(ii) the pros and cons of implementing or enforcing a specific policy measure through regulation or competition policy.

For the sake of exposition, throughout this study we implicitly assume that sector-specific regulation (instead of ex post competition policy) deals with access prices, price cap regulation, local loop unbundling, etc.

A central problem in the literature on one-way access concerns the optimal level of mark-ups under linear pricing, since marginal-cost pricing conflicts with viability. Our analysis focuses on the strategic effects of access prices in situations of two-way access, that is, network interconnection. Moreover, in the analysis of Carrier Select-based competition, where the incumbent's local loop can be viewed as an essential facility, we abstract from feasibility problems of marginal-cost pricing, since we consider a two-part price structure. With two-part tariffs, the incumbent can use its subscription fee to recover the fixed cost of the local loop.

This report complements the recent book by Laffont and Tirole (2000). While their book presents the central ideas that have emerged in the economics literature, this study delivers more applied and down-to-earth results, all related to market entry. The analysis of access prices in this study is complementary to theories that analyze ways to recover fixed costs of infrastructure in an efficient way. See for instance Laffont and Tirole (2000, chapters 3-4) and Valletti and Estache (1999) for overviews and discussions of the theoretical issues related to access pricing in situations of essential facilities and one-way access.

Beyond the scope of this study, there are many questions which are related to, for instance, the objectives of policy, the benefits of network competition versus services competition, the speed of liberalization, public versus private ownership, the design of a regulatory structure, and equity considerations. For a recent analysis on such broader issues in a European context, we refer to Bergman et al. (1998, ch. 4), and Cave and Prosperetti (2000a). Van Damme (2000) analyzes in detail the question whether competition in the customer access network is necessary for effective competition in telecommunications. Our report complements these recent policy studies. Finally, universal service obligation is not analyzed in this study. For more on this topic, see Laffont and Tirole (2000, chapter 6), Cave and Prosperetti (2000a), and Choné et al. (2000).

1.3. Methodology

Game theory and industrial organization

In situations where a relatively small number of firms compete, a sensible analysis of firm behavior and market structure should involve the strategic interaction between firms. Game theory is the mathematical analysis of rational behavior in situations where one firm's profits depend on what other firms do, that is, where outcomes are interdependent.

In itself, game theory is not a theory of firm behavior and market structure, but a set of logical tools that constrain and shape arguments about strategic interaction among firms. A formal model produces:[7]

- an "audit trail," documenting a coherent explanation for certain phenomena;
- a system of logic that helps to recognize flawed reasoning;
- a common language and framework for analysis.

Game theory is particularly useful to analyze the telecommunications industry, which is more complex than many regular product markets. At first sight, it may seem that a telecom operator just sells communication services at a certain price and underlying cost. However, sales volume not only contributes to an operator's revenues and costs, but may also generate traffic between operators. Traffic that goes from one operator's network to another generates access payments between the firms. Therefore the cost and profit structures of an operator are not straightforward. By using a formal model, it becomes easier to understand the operators' incentive structure.

[7] Saloner (1994, p. 192-193). For more on the growing importance of game theory as a useful tool for strategy and analysis, see e.g. Rumelt, Schendel and Teece (1994, especially the contributions by Camerer, Postrel, and Saloner), Brandenburger and Nalebuff (1996), and Day and Reibstein (1997).

Box 1.3.1. Possibilities and limitations of game-theoretic models in telecommunications

Competition in telecommunications is more complex than in many other industries, because of the presence of communications networks. Realized market shares not only contribute to profits because customers buy services, they also determine the volume of voice traffic between customers, that is, on and between the networks.

Given the complexity of strategic interaction, it is difficult to assess how policy and regulation affect competitive strategy, profitability, and consumer benefits. The theory of industrial organization, supported by formal tools of modern game theory, is necessary to comprehend the mechanics of competition in telecommunications. Game theory provides the discipline to address complex questions in a careful and logical way. It helps to sharpen one's intuition, and provides new perspectives of looking at problems that may seem impenetrable. At present, there are no alternative methods available that can deliver similarly detailed and refined insights.

The other side of the coin is that game theory cannot provide models that describe reality in complete detail. Therefore, the tools of modern game theory are not powerful enough to make precise or quantitative predictions about real-world cases (neither can other theories) – but then, the goal of this study is to understand telecommunications markets, not to make forecasts. Indeed, analyzing strategic interaction in telecommunications markets requires us to solve puzzles in which many pieces are missing (such as the internal organization of operators, and negotiations between operators and large corporate customers). Hence, one should not rely merely on game-theoretic analysis, but complement it with empirical observations and expert opinion about the industry.

Summarizing, the tools of game theory are crucial to understand the incentives of market players who behave strategically. To be effective, policy and regulation must take this into account. Game theory is less useful for forecasting and describing actual behavior.

Benchmark model

Throughout the study, we analyze duopoly models, that is, models with two operators (always an incumbent and an entrant). By doing so, we follow the usual approach in economics to explore the simplest model that is able to generate interesting and relevant results. We will perform robustness checks to verify that the results do not critically depend on the simplifying assumptions that are made.

In models with three or more firms, additional assumptions are usually needed to keep the analysis tractable, which introduces other types of restrictions. This is certainly the case in telecommunications models, which, tend to be more complex than standard oligopoly models. Therefore, a duopoly model actually allow us to maintain a more satisfactory level of richness in terms of, for instance, price strategies, demand structure, and telecommunications infrastructure. Moreover, although the entrant is depicted as a single operator, it may represent a "competitive fringe" of several entrants.

As a starting point for the analysis, chapter 4 presents a concise model of facilities-based competition.[8] This model, depicting a one-shot or static game, has been made as simple as possible. There are good reasons for analyzing a stylized model. The purposes of the analysis in chapter 4 are to:

- provide a framework for more detailed, realistic and case-specific analysis;
- make the reader familiar with the type of assumptions needed to get meaningful results;
- explain the notion of an equilibrium;
- introduce and explain important economic indicators (in particular profits, consumer surplus, and welfare);
- develop a basic understanding of strategic interaction among operators and causal effects of parameter changes.

Overall, an examination of a simple, stylized model makes it easier to understand more realistic (but also more complex) models later on. We will then also depart from the static analysis by using the one-shot game as a building block for a dynamic model of competition.

The regulator is implicitly incorporated in the model by retail price caps and wholesale prices (e.g. access prices). Either because the regulator makes a decision before the operators decide on prices, or because the regulator approves a negotiated interconnection fee, the regulatory environment is given when competition starts. Accordingly, we assess regulatory instruments by describing the tradeoff that is involved with their application. For example, subjecting an incumbent to a tighter price cap may be beneficial for consumers in the short run, but make entry more difficult. By discussing such a tradeoff within the context of a specific entry situation (e.g., local-loop unbundling), the decision-making process of the regulator is implicitly taken into account.

More realistic analyses: adapting the benchmark model

To make the benchmark model more realistic, more realistic variants of the model are built to address specific situations, such as unbundling of the local loop, originating

[8] Here we discuss only the chapters related to methodology. Section 1.3 contains an overview of all the chapters.

access by using Carrier Select services, price cap regulation, and entry targeted at specific segments of the market. This is done in part II, chapters 6-8, of this report.

Also, the static model of competition between operators is repeated during a number of periods. This allows one to examine market dynamics, in particular the development of the entrant's market share over time.

Because of mathematical complexity, it is necessary to assume that the operators maximize per-period profits in the dynamic context. As argued in chapter 5, this assumption has a realistic content. When we present policy implications in part II, we discuss the extent of the dependence on this assumption.

We perform numerical simulations with Mathematica software. Thus, we can avoid making more assumptions that are needed to solve the models analytically. It is becoming more common in (especially applied) industrial organization to use numerical analysis.[9] It may even be the only way to solve problems of complex nature, such as the issues studied in this report.

To generate meaningful outcomes with the models, one has to calibrate them, thereby giving cost levels, utility and demand parameters the right order of magnitude. More specifically, calibration is important *not* because we want to forecast or describe actual behavior by market players – that is beyond the purpose of the models – but because we want to understand how regulatory instruments can stimulate entry in such a way that consumers benefit from competition. The numbers themselves, generated by the models, are not important.

To calibrate the models, we have used data from industry studies, public information, and expert opinion. Data on operational cost levels of operators was not available. Robustness exercises demonstrated that possible inaccuracies in the calibration are not important for the policy implications of the models (see also more elaborate discussion under the heading "Robustness" directly below). Thus, since this is not empirical study in which we try to estimate models, but instead a conceptual study of the mechanisms in the market, the lack of data does not discount the value of the generated insights.

Robustness

Since the models are stylized in nature, one has to check if the outcomes critically depend on the model specifications and assumptions. To do this, we look at three types of robustness:

[9] A recent example is Green (2000), who analyzes whether in utility markets, competition can succeed regulation when consumers face switching costs. Green develops a game-theoretic model that is solved numerically, with parameter values selected to depict the energy utilities in the UK.

- *Robustness to parameter changes within the model:*
  Checks performed by running the models under a variety of parameter constellations showed that the levels of cost and demand parameters in the models, if chosen within reasonable ranges, do not affect the policy implications in a qualitative way, although naturally there are quantitative changes.
- *Robustness to different model specifications:*
  Robustness can also be assessed by checking if different model specifications affect policy implications. To do this, not one model is analyzed, but a whole range of models, covering different network strategies (facilities-based entry, local-loop unbundling, Carrier Select-based entry), different pricing structures (two-part tariffs, flat fees, linear prices, termination-based price discrimination), and various modes of targeted entry (in a market with a residential and a business segment). In most cases, the policy implications are robust to different model specifications. In the summary of policy conclusions (chapter 9) demonstrates that the results are also quite robust to different model specifications.
- *Robustness to alternative assumptions:*
  Finally, an important robustness check is to assess how the results depend on the underlying assumptions of a model. In this study, various assumptions were needed to keep the analysis tractable. Therefore, by definition, this type of robustness has to be assessed by reasoning without a formal model. We will pay special attention to the assumptions that operators are myopic (i.e., they maximize per-period profits), that there is a single entrant, and that there is no network congestion (e.g. due to internet traffic). This type of robustness is assessed when we discuss the model results in chapters 6-8. In most cases, dropping the assumptions of the model either reinforces or hardly affects – and hence does not reverse – the policy implications.

1.4. Overview of report

At a glance
This report consists of three parts:

- part I provides an introduction to the telecommunications industry, the economic literature on competition in telecommunications, and describes the analytical framework of the study;
- part II contains the results of the simulations, discusses and interprets the outcomes, and draws conclusions relevant for regulation and competition policy;

- part III recapitulates the implications for policy and regulation, and discusses them from a broader viewpoint.

We have tried to make the policy implications, that are based on theoretical models and simulations, accessible to the reader who does not want to go into the details of the models. Therefore, in order to read parts II and III, it is not necessary to read part I. Similarly, to read part III, it is not necessary to read parts I and II.

Part I

Chapter 2 provides an introduction to telecommunications technology and the European telecommunications industry. The economic literature on competition in telecommunications is surveyed in chapter 3.

The next two chapters set up the analytical framework for the study. Chapter 4 describes and explains a simple model of competition between two operators, called the "benchmark model," which is about as simple as such a model can be. This chapter may useful to readers who are interested in the structure of the models, the underlying assumptions, and the way outcomes are derived. Chapter 5 describes how numerical simulations are carried out. It also contains information about the software that was used to do the simulations.

Part II

All the models in part II expand the benchmark model to examine a variety of dynamic entry situations. Chapter 6 contains the most basic models. It is perhaps the most important chapter of this part, because to discuss the results of chapters 7 and 8, the intuitions of chapter 6 will be recalled. Chapter 6 analyzes:

- section 6.2: facilities-based competition ("FBC");
- section 6.3: local-loop unbundling-based competition ("LLU");
- section 6.4: Carrier Select-based competition ("CSC").

In each of these entry modes, the most relevant wholesale prices are examined, such as terminating access prices, lease price of the incumbent's local line, and originating access price in the case of Carrier Select.

In section 6.5, we adopt a broader perspective by considering how regulation can influence the incentives of an entrant to choose for a particular entry strategy. In particular, in that section we discuss how a dynamic regulation rule can be helpful to create competition in the short run by giving an entrant easy access to the incumbent's network, and increase the entrant's incentives to build its own customer access network over time.

Whereas in the models of chapter 6, the operators compete by choosing two-part tariffs (consisting of subscription fees and per-minute prices), chapter 7 explores alternative pricing structures. These are:

- section 7.2: flat fees (the operators choose subscription fees only);
- section 7.3: linear prices (the operators do not charge subscription fees);
- section 7.4: non-uniform prices (in the sense that the operators differentiate between on-net and off-net per-minute prices).

In each of these situations we zoom in to the role of terminating access prices. Accordingly, the purpose of chapter 7 is twofold: first, to better understand the nature of price competition, and second, to address the role of access fees under different pricing structures. As a special application of the model of section 7.4, we discuss competition between a fixed and a mobile operator, and the role of relatively high fixed-mobile interconnection fees.

In the models of chapters 6 and 7, consumers are assumed to be homogeneous, that is, they all have identical demand and utility functions. Chapter 8 analyzes situation with heterogeneous customers. In particular, it is assumed that there are two types of customers, namely residential and business customers. The incumbent is supposed to serve both market segments, but the entrant may wish to target only one segment. The cases that are examined in chapter 8 are:

- section 8.2: the entrant targets the business segment only, with a customer access network for business customers (targeted FBC);
- section 8.3: the entrant targets the business segment with a customer access network for business customers and targets the residential segment while leasing the incumbent's local lines (combination of targeted FBC and LLU);
- section 8.4: the entrant targets the business segment with a customer access network for business customers and targets the residential segment through Carrier Select (combination of targeted FBC and CSC).

Section 8.1 discusses some examples of entrants in the Netherlands that inspired the models in sections 8.2-8.4. However, it is important to note that the players in the models should not be identified as specific companies in the real world, but it is interesting to demonstrate the relevance of the models.

Each of chapters 6, 7, and 8 concludes with implications for policy and regulations. Chapter 6 also contains a discussion about the entrant's incentives to build a customer access network, or to compete through unbundled access or Carrier Select.

Part III

Chapter 9 recapitulates the main policy implications, and discusses them from a broader point of view. Results of the different chapters are compared, so that a better sense of the robustness of the outcomes can be obtained. For a summary of the conclusions, see also the executive summary.

Supplement

A separate supplement (CD-ROM) to this report, which is available on request in a limited amount, contains Mathematica programs and detailed output of the numerical simulations.

PART I: ANALYTICAL FRAMEWORK

This part provides background information on telecommunications markets, discusses relevant literature, and presents a simple model of competition in telecommunications (on which the simulation models used in part II are based). It consists of four chapters:

Chapter 2:	An introduction to telecommunications markets.
Chapter 3:	A brief overview of recent, relevant literature in economics on competition in telecommunications.
Chapter 4:	A presentation of the benchmark model.
Chapter 5:	An explanation how the benchmark model will be used in part II to analyze competition in repeated periods.

The reader with a reasonable knowledge of telecommunications industries can skip chapter 2. To comprehend the policy implications and intuitions of the simulations in part II, it is not necessary to read chapters 3, 4 and 5.

Chapter 2. Telecommunications markets

2.1. Introduction

This chapter gives a brief overview of the telecommunications technology and industry. As the information in this chapter is of an introductory and descriptive nature, it aims at readers who are not too familiar with the industry. For more precise or more recent information, the reader may want to consult recent industry studies (see references at the end of this report). This chapter can be skipped by readers with a reasonable amount of knowledge about the telecommunications industry.

Section 2.2 describes the technology of fixed voice telephony, and provides a (modest) technical background to the models used in this report, by briefly describing the main elements of fixed telecommunications systems. Section 2.3 provides a brief introduction to EU telecommunications markets, which are characterized by the national-monopolist history and recent liberalitations.[10] This chapter is based on, among others, Cave and Valletti (2000b), European Commission (1999b), Glass (1997), Morgan Stanley Dean Witter (1999), Opta (1999), and Laffont and Tirole (2000).

2.2 Telecommunications technology

Circuit-switched telephony

A telecommunications network permits transmission of information (e.g. the sound of a voice, in the case of basic telephony) between terminal devices (e.g. telephones) of different parties. This is done by establishing a connection, by using a telecommunications network, between their devices.

A network consists of:

- **transmission systems**:
  the means by which information travels through the network, comprising the transmission medium (e.g. copper wire, co-axial cable, fibre optic cable, wireless radio transmission) and transmission interface equipment (used to convert one type of transmission to another, e.g. from copper wire to wireless).
- **switches** (or **exchanges**):
  the means by which temporary connections between the calling party and the receiving party are established.

[10] Descriptions of market developments in e.g. the US, New Zealand, and Australia can be found in Cave and Valletti (2000b) or Laffont and Tirole (2000).

- **signaling systems**:
  the means by which information about connections that are to be established are conveyed. Examples of information that is often conveyed by signaling systems are the phone number of the parties involved in the connection (especially the number of the called party), and the nature of the call (e.g. whether the call is toll-free).

The traditional telecommunications network that is used for voice telephony, that is, the "fixed" (i.e., wireline) network to which public consumers are connected, is often called the **Public Switched Telephone Network (PSTN)**. It consists of two partial networks, namely:

- **customer access network (CAN)**:
  the network connecting end-users' telephones and local switches (also called "local exchanges" or "central offices") to which end-users are connected. An important part of a CAN is the transmission medium between local switches and end-users, the **local line**; in many cases consisting of copper wire. A connection to an end-user, often called the "local loop," consists of a local line and a "line card" (a part of the local switch).
- **long-distance network:**
  The network enabling calls to be routed between local switches, possibly through several other exchanges called trunk exchanges. It is also known as the "trunk" or "backbone" portion of the network. Commonly used transmission mediums within the backbone are copper wire, coaxial cable, and fibre.

Because of the associated fixed cost, the local line – which is essential to reach end-users – is generally perceived as a bottleneck. This is especially true in the case of wireline local loops. The emergence of wireless technology may lower these fixed costs and alleviate the bottleneck problem.

The PSTN is a **circuit-switched network**, that is, each telephone call reserves an end-to-end physical circuit between the calling party and called party during a telephone call. For the duration of a call, this circuit is fully dedicated to that call and is not available to other users of the network.

For illustrative purposes, we briefly describe what happens in a network when a consumer makes a telephone call through the PSTN. Lifting the handset causes the telephone to send a signal to a local switch, prompting the switch to provide a dial tone to the telephone. The calling party dials a number, which is sent to the local switch. Next, a connection is established with the called party's local switch. If the parties are connected to different switches because they do not live in the same area, then the link is established through the backbone, possibly via one or more "trunk" switches (exchanges on a higher level in the hierarchy of the network). The called party's local switch sends a signal which causes his telephone to ring. If the called party is engaged, a signal is sent back, resulting in an "engaged" tone in the calling party's handset.

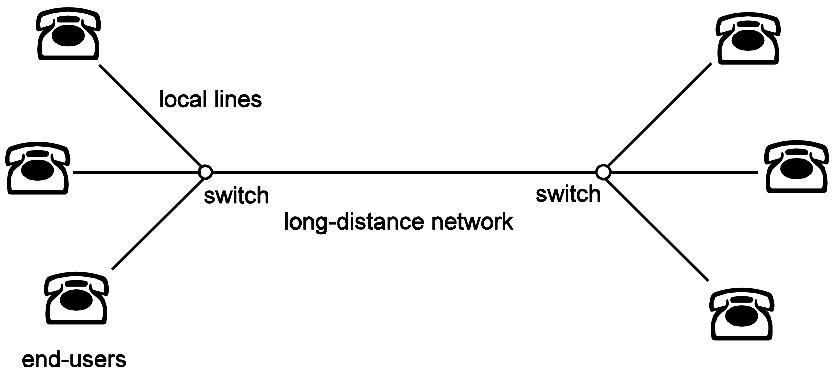

Figure 2.2.1. A telecommunications network

Other networks

Data networks, such as the internet, are **packet-switched networks**. Unlike PSTNs, they do not reserve a circuit between endpoints, but break up data into a large number of small packets. Each of the packets of a data file that is transmitted, may be routed differently to arrive at the same destination.

The different network structures of PSTN and packet-switching give rise to some important differences. A circuit-switched network consists of clear end-to-end paths, and is not very prone to delays. However, its overhead cost is high. A packet-switched network is more efficient in its use, but is much less immune to congestion.

The PSTN is called a fixed network because geographically fixed links (usually wires) connect the telephones to the core of the network. In the case of **mobile telephony**, telephones communicate with the network by using radio signals. Hence, a subscriber to a mobile network can travel around without losing his connection to the network, provided that he does not cross the borders of the area that is covered by the regional base stations (i.e., low power radio transmitters that communicate with the mobile handsets) of the network. The base stations are connected through a fixed network, possibly the backbone of the network that is also used for fixed telephony.

Network interconnection and access to end-users

Telephony offers maximum benefits to consumers if any user can call any other user. However, in a liberalized market it may happen that the calling party and called party do not subscribe to the same network. Then the networks must be linked so that a connection can indeed be established. This situation is commonly referred to as **network interconnection**. It is relevant for instance when there are competing networks in a market, for international telephony, and for calls between fixed and mobile networks.

The place at which interconnection takes place is commonly called **point of interconnect (POI)**. Typically, calls that require interconnection are carried on the calling's party's network as far as possible before being transferred the called party's network. By doing so, the calling party's operator will generally minimize the payments associated with using a rival operator's network.

An operator with only a small number of users directly connected to its network has an incentive to establish POIs in as many local switches of an operator with a complete network as possible, since this minimizes the portion of calls that have to be carried by the other operator. However, because of the cost and time needed to establish POIs, it may happen that there is only a small number of POIs, sometimes only one.

Some entrants in recently liberalized markets can reach none or only very few end-users, for instance because they have not (yet) built their own CAN. In such cases, they can use another operator's (typically the former national monopolist) CAN to have access to end-users. As an example, consider the situation in which there is an incumbent with an PSTN and an entrant with only a backbone. Then any calling party and called party are both connected to the incumbent's network, but the calling party may wish to carry the long-distance portion of the call over the entrant's network. In such situations, the entrant has to use the incumbent's CAN to provide

- **originating access**:
  the provision of a connection between the calling party and entrant's backbone;
- **terminating access**:
  the provision of a connection between the entrant's backbone and the called party.

Notice that network interconnection can be seen as a situation of two-way terminating access, that is, from one network to another and vice versa.

A usual way to establish originating access is **Carrier Select**, that is, consumers can choose which operator they want to carry a call by dialing a four digit code before the called party's telephone number. They keep their subscription to the incumbent, but pay the per-minute fees to the Carrier Select operator. Carrier Select is an example of "indirect access" to end-users.

One can consider voice telephony as a bundled service, consisting of local access and long-distance transportation. The possibilities to get access to end-users are greatly enhanced by separating the bundle, so that entrants that do not have a local access network are enabled to compete with the incumbent. This is called **local loop unbundling (LLU)**. Typically, if a regulator enforces LLU, entrants can lease the incumbent's local lines, and hence use the transmission medium to the customer in the incumbent's local loop. An unbundled local loop allows an entrant to operate its own transmission system to have direct access to consumers, who then can directly subscribe to the entrant. A common way of LLU is access to the main distribution frame ("MDF access"). Under MDF access, the local line and the linecard are unbundled. Hence an entrant can "plug in" by creating a link from its switch to the incumbent's MDF. Because of the possibility that consumers subscribe to the entrant, MDF access is an example of "direct access" to end-users.

The fees that operators have to pay to obtain originating or terminating access to other operators' networks are of large importance for the development of the market. The level of these access prices, as well as LLU and Carrier Select-based competition, are central in part II of this report.

2.3 The European telecommunications industry

General: EU industries

Since the 1980s, telecommunications industries are going through a period of fundamental change, ignited by privatization of national telcos, liberalization of national markets, technological innovations, and, at the European level, convergence of economic policy and institutional structures. From 1998 onwards, the markets for networks and services in almost all EU countries were liberalized. Market liberalizations have been accompanied by partial or full privatization of incumbent operators.

Historically, operators in Europe were state-owned, vertically integrated monopolists. Because of the large fixed cost of building a network, telecommunications networks providing voice telephony were viewed as natural monopolies. Technological change and innovation have generated new transmission systems and decreased the cost of building infrastructure. Therefore, the idea of a natural monopoly is no longer seen as valid. Moreover, the current view is that public ownership does not provide strong incentives to decrease costs, resulting in inefficiencies. Therefore, most operators have been or are subject to plans to be privatized. For instance, the former national incumbent's in the UK, Italy and Spain are fully privately owned, while the Dutch former monopolist is still partly in public ownership.

Market liberalizations have caused large scale entry by all sorts of network operators and providers of telecommunications services. The rules of competition are being changed rapidly by these entrants, who are not hampered by possibly obsolete infrastructure and associated cost structure, or by bureaucratic organizations and associated working practice. Hence, the former incumbents are facing a profound challenge to redefine their value propositions and strategies, and to reorganize their business practice.

The main strategies and tactics of incumbent operators to cope with the drastic changes in the industry are:

- internal restructuring to increase efficiency, flexilibity, quality of service, and responsiveness to customers' wishes;
- diversification (e.g. mobile telephony, internet access provision) and internationalization (e.g. foreign acquisitions, international alliances and mergers) to compensate for the expected loss of domestic market share in the market for fixed voice telephony;
- innovation (e.g. high-bandwidth transmission systems, intelligent applications in the network).

On the one hand, incumbent operators may still benefit from monopoly positions in some market segments (local telephony), and on the other hand, because of "universal service," they may be obliged to provide telephony services in remote areas, perhaps as a loss-making activity.

At present there are some alternatives for voice telephony through the incumbent operator's network. Mobile telephony is an obvious example. Another example is cable telephony. Nevertheless, since these alternatives are not yet widely available at competing prices, as long as we are in the transition to competition, it remains necessary to constrain the former monopolists (see Cave and Prosperetti, 2000a).

Among the new fixed-line players in the European market one can distinguish:

- **network operators**:
  operators that install and operate their own transmission systems to provide public telephony or network services.
- **service providers**:
  operators that offer services through mainly third party networks by leasing capacity;
- **resellers**:
  operators dealing exclusively with reselling (also known as call-back or calling card operators) or engaged only in marketing and billing activities.

In the member states of the European Union, the rules for liberalization and deregulation are formulated by the European Commission. Since these rules are relatively broad and general, the national regulatory agencies in the member states have a certain degree of discretion while implementing them. Moreover, the speed at which effective deregulation occurs is not the same for the different counties within the EU. Morgan Stanley Dean Witter (1999) views the regimes in the UK, Germany and the

Netherlands as strongly pro-competitive, the French regulatory authority as somewhat biased in favor of France Telecom. In Italy, regulation has come about only very recently.

The fundamentals of deregulation in the EU are defined in the Open Network Provision (ONP) framework. The ONP rules aim to ensure interconnection of networks, and to allow entrants access to various elements of networks of dominant operators at cost-based prices. In the language of the European Commission, a dominant operator is called an operator with "significant market power," and is usually defined by a market share above 25%. The incumbent operators naturally fall into this category.

The European Commission recently proposed a new framework with the purpose to accelerate the process of economic and structural reform in the EU by lowering access prices and reinforcing competition (the "Review" by European Commission, 1999a). According to the Commission, the European market is fragmented and dominated by incumbent operators, even though entry has been substantial and prices have decreased. While the existing framework was designed to cope with the transition to competition, the new framework seeks to reinforce competition, especially in market segments at the local level. Moreover, it must cater for the rapid technological change and unpredictability of telecommunications markets.

The Review identifies the following developments in the market:

- globalization (mergers, acquisitions and alliances at a European and global level);
- internet blurs the distinction between voice and data communication and may quickly overturn traditional market structures;
- communications technologies are being improved, resulting in lower costs and increased capacity of networks (driven by the computer industry);
- wireless applications are becoming more and more important;
- technologies within the media sector (e.g. digital TV and video on demand) are becoming more and more important.

In the Review, the Commission proposes a light regulatory approach for new services markets, while ensuring that market power is not abused by dominant firms. As competition matures, regulation can gradually be reduced. A central proposal is that the new framework would cover all electronic communications infrastructure and services (e.g. voice, data, TV, etc. transmitted through PSTN, internet, cable, wireless, etc.). The key policy proposals related that are relevant for voice telephony are the following:

- common principles for regulation of access and interconnection across all types of networks, so that entrants can compete with incumbent operators by using any transmission system, thereby minimizing bottleneck problems;

- high priority to establish competition in the local loop, either through existing networks (e.g. LLU) or new infrastructure (e.g. cable TV, wireless local loop);
- consistency across countries with respect to their regulatory regimes, and improved cooperation between the Commission and national regulators.

The first two points are related to the incumbent operators' strong market positions, especially in local markets. The last point is important in the light of globalization and also because regulatory regimes in member states display significant differences.

The Netherlands

Regulator Opta (the independent post and telecommunications authority) came into existence in August 1997. Its first activities concerned the allocation of costs for interconnection and special access, issues that arose in a conflict between KPN and Telfort. Van Damme (1999, ch. 5) contains an overview of developments in policy and regulation in the Netherlands since early 1997, the moment when ministerial guidelines on interconnection were published.

According to the European Commission (1999b), the following harmonization Directives have been substantially "transposed," that is (supposedly), implemented, by the Dutch *Telecommunicatiewet*, amendments, secondary legislation, and several additional Decrees:[11] ONP (Open Network Provision) Framework, Leased Lines, Universal Service Provision, Licensing, Interconnection, Numbering.

DGTP (2000b) summarizes the Dutch response to the ONP Review. It states, for example, that general competition policy will be sufficient as soon as the market functions in an effective way. It is the intention of the government to reach this situation as soon as possible.

The Dutch former "PTT," nowadays called KPN Telecom, was a state monopolist until the 1989, when it became a public limited liability company, although still fully owned by the state at that moment. The government sold 30% of its shares in 1994, and another 25% in 1995. When competition was introduced in the Dutch market in 1996 on the basis of the so-called "interim legislation," two operators, Enertel and Telfort obtained a license for national, fixed telecommunications infrastructure (Haffner, 2000). The Dutch market was completely liberalized in 1998 when the new Telecommunications Act came into force, in line with EU policy on liberalization.

Recently, KPN Telecom has been active with reorganizations, foreign acquisitions (in Eastern Europe), diversification (e.g. mobile telephony, internet provision, internet banking), and joint ventures (with US firm Qwest, building a pan-

[11] The Directive on data protection has been partially implemented, but additional secondary legislation concerning billing and unsolicited calls were under preparation when this report was written.

European, IP-based fibre network). Although entry in the Dutch market has been substantial, KPN has large market shares in several markets (e.g. in 1999: 80-95% in the markets for national telephony and for calls from fixed phones to mobile phones, 90-99% in the market for local telephony, and 85% in the consumer market for international telephony, according to Opta, 2000, p. 16).

Enertel, currently called Energis, was formed by Dutch energy companies. Currently a 100% daughter of Energis in the UK, it has a backbone of more than 1200 km in the Netherlands. It has two switches, located in Amsterdam and Rotterdam. It serves only the corporate market (by offering voice and data services, and internet access), although it can reach 70% of all Dutch households through interconnection. Energis has a cable link between the Netherlands and the UK on the bottom of the North Sea (source: DGTP, 2000a).

Telfort was formed by the Dutch Railways and British Telecom. Its infrastructure is based on the network alongside the main railways in the Netherlands, consisting of more than 1000 km glass fibre with a connection to BT's international network. The network has access to most of the business areas in the larger cities. Telfort is active in both the residential market (Carrier Select and mobile telephony) and corporate market (voice and data services, and internet access). It has not built a customer access network to serve the residential market (source: DGTP, 2000a).

There are several more important entrants in the Dutch market that operate a fixed network. Without trying to be complete, we will mention a couple of them.[12] Colt from the UK has built a backbone, four fibre "city rings" in Amsterdam and its surroundings, and one in Rotterdam. The aim is to connect the complete province of Noord-Holland to its backbone by 2001. GTS is an operator with a European backbone and a point of interconnection in Amsterdam. It took over the Dutch networks of Hermes Europe Railtel and Esprit, and is building a city ring in Amsterdam. MCI Worldcom has its own backbone and networks in Amsterdam and Rotterdam. It intends to build networks in The Hague and Utrecht as well. Another example is Versatel. In November 1999, Versatel had built more than 800 km fibre in the Benelux, including a ring between the major cities in the Netherlands. It is able to serve about 40% of the Dutch corporate market with local broadband access (DSL). Versatel is building a network of 2200 km, enabling the firm to seve more than 80% of the market (source: DGTP, 2000a).

There exist cable networks in the Netherlands that can facilitate local competition. An operator with a substantial number of connections in the Amsterdam area is Priority Telecom, previously known as A2000, and owned by UPC. However, most of the cable networks in the Netherlands have to be upgraded to allow for two-way

[12] The situations of targeted entry analyzed in chapter 8 were inspired by these types of examples in the Netherlands. See section 8.1.

communication. At present, KPN’s customer access network is an essential facility in most parts of the country, certainly with respect to residential customers and small businesses.

Chapter 3. Brief literature overview

3.1. Introduction

During the last three decades, economists have exerted a lot of effort to apply game-theoretic techniques to problems in industrial economics. The first primary text was Tirole (1988), providing a highly regarded overview of the theory of industrial organization. A more recent text book on the same topic is Cabral (2000).

The models in this report are all applications of the theory of industrial organization applied to telecommunications markets. As discussed in chapter 1, although models of industrial organization have their limitations just as other theories do, they impose discipline on the researcher to carefully define the boundaries of the problem at hand, and are unique in generating insight into complicated interactions and tradeoffs.

This chapter provides a brief overview of recent economic theory on competition between telecommunications operators. The reader who is interested in more details is referred to the original papers. The relation between the literature discussed in this chapter and the models used for the simulations, is that our models are based on this literature (especially the literature discussed in section 3.2).

It is beyond the purpose of this chapter to introduce the theory and its underlying intuitions to the reader. A good reference to the economic theory of telecommunications is the recent book by Laffont and Tirole (2000), which provides the reader with a synthesis of the most important publications in the field.

3.2. Competing telecommunications operators and network interconnection

The literature on the economic theory of network interconnection started with the papers of Armstrong (1998), Carter and Wright (1999), and Laffont, Rey and Tirole (1998a, b).[13] These papers have in common that they analyze unregulated competition between telecommunications operators whose networks are interconnected. They focus on the role of terminating access prices. The major part of the results are derived under linear pricing (i.e., the operators only charge per-minute prices and no subscription fees).

The models in these papers depict facilities-based competition, and have in common that:

- there are two competing operators, each with their own network;

[13] See Laffont, Rey and Tirole (1997) for an accessible paper that contains many of the results that were later published in Laffont, Rey and Tirole (1998a, b).

- the networks are horizontally differentiated, so that the operators have a certain degree of market power;
- the size of the market, that is, the total number of customers, is fixed;
- each customer chooses to subscribe to exactly one of the networks.

A central result of this literature is that if the operators compete in linear prices and there is sufficient product differentiation (i.e., competition is sufficiently imperfect), then an increase in the reciprocal terminating access price pushes up retail prices. Since traffic flows between the networks tend to be symmetric (because the firms are assumed to be identical), neither operator bears the burden from the high access prices to each other. Hence, the operators have an incentive to set the access price above the associated cost in order to realize profits above the "competitive" level (possibly up to the monopoly level).

The effect of the access price on retail prices is a form of the "double marginalization" problem.[14] This problem is best known from the situation of a non-integrated chain of monopolies (ranging from upstream to downstream, that is, from producers of basic inputs to intermediate goods to producers of the final good). Each monopolist maximizes its profits by adding its own margin above its cost level, thereby inflating the price of the final good. The problem is solved if all producers coordinate their pricing decisions, which occurs for instance in the case of a vertically integrated producer (all the producers are merged into a single firm). Therefore, negotiation instead of competitive setting of the access price may allow the operators to eliminate the double marginalization problem.

Perhaps the main conclusion of the seminal papers in the literature is that with linear pricing, the access price can be seen as an instrument of tacit collusion. This means that even if the operators do not form a cartel, they can actually collude over retail prices by negotiating a reciprocal terminating access price above the cost of access.

If the operators compete by choosing two-part tariffs (i.e., they charge subscription fees and per-minute prices), then the results change drastically. The central result is that per-minute prices in equilibrium are equal to average marginal costs, and any market power is exercised through subscription fees. Moreover, profit levels in equilibrium are now independent of the level of terminating access prices. Therefore, a striking difference with the linear pricing case is that the access price cannot be used as a collusive device. Laffont, Rey and Tirole (1998a) point out that this result may depend on the homogeneity of consumers' demand; in the more realistic case of heterogeneous consumers, intermediate outcomes may be possible. On this topic, see the discussion of Dessein (1999a, b) below.

[14] See Tirole (1988), p. 174-175.

Also on two-part pricing is Gans and King (1999), who analyze a situation in which the operators freely and independently choose terminating access prices. They show that in any symmetric Nash equilibrium, each operator will set its access price above the marginal cost of access, just as in the standard double marginalization result. If the operators negotiate on a reciprocal terminating access price to maximize their joint profits, however, they choose the access price below marginal cost. The intuition is that a negative markup softens price competition, and increases equilibrium profits. Gans and King argue that because of this collusive effect, “bill and keep” arrangements may be undesirable from consumers’ perspective: although it may reduce per-minute prices, it pushes up subscription fees.

A special topic in Laffont, Rey and Tirole (1998a) is entry (dropping the assumption that both operators have a full coverage network). Consider a situation in which the entrant initially has no network coverage, and must either (i) lease the local access network from the incumbent (unbundling-based entry), or (ii) build it itself (facilities-based entry). In both situation, the operators are assumed to compete in linear prices.

In case (i) the entrant has potentially the same network coverage as the incumbent, because it can lease any connection. The authors show that the socially optimal access price is below the traffic-dependent cost of the local loop, whereas the socially optimal lease price of the local loop is equal to the associated traffic-independent cost.

In case (ii) it is assumed that the entrant chooses a network coverage in the stage before the operators compete in prices. It is then shown that if the access price is close to the associated marginal cost (mandated by the regulator), the entrant underinvests in network coverage in order to soften price competition. Also, the entrant competes by undercutting the incumbent’s price. These results change if the access price is not mandated but results from negotiations between the operators. It may then happen that the incumbent delays indefinitely any agreement on interconnection in order to keep competition at bay. The entrant has an incentive to overinvest in network coverage, in order to be able to negotiate a more favorable interconnection agreement.

The articles discussed above have laid the fundaments for a micro-economic analysis of telecommunications markets. It is perhaps a pity that they pay more attention to linear prices than to two-part tariffs, given the widespread occurrence of the latter price structure in reality. A central result in this literature is the possibility of tacit collusion by setting the terminating access price above cost in the case of linear pricing, a result that does not hold under two-part tariffs and homogeneneity of demand.

Price discrimination based on call termination

Laffont, Rey and Tirole (1998b) analyze the situation in which operators are allowed to charge different per-minute prices for on-net and off-net calls.[15] Since they have to pay an access markup for off-net calls, they will want to set a higher price for this type of calls, in order to pass on the higher marginal cost to consumers.

First, assume that the operators compete in linear prices. A mark-up in the access price introduces a wedge between on-net and off-net prices based on the difference between perceived (i.e., including the access markup), but not true, marginal costs. Hence, price differentiation distorts consumers' marginal rate of substitution between on-net and off-net calls, and introduces a consumption inefficiency. This distortion can be avoided by imposing a cost-based access price, so that the operators do not have an incentive to differentiate per-minute prices. Since price competition may be intensified and the double marginalization problem may be alleviated, the consequences for welfare are ambiguous.

Second, consider competition in two-part tariffs. Again there is a consumption inefficiency, since per-minute prices reflect perceived, but not true, traffic-dependent costs. Moreover, the authors show that the operators have an incentive to agree on a reciprocal terminating access price equal to the marginal cost of access.

A final result of the paper is that with linear pricing, price discrimination by a dominant operator makes entry more difficult, and can even make entry impossible.

Gans and King (1999) demonstrate, in a model of price discrimination and two-art tariffs similar to Laffont, Rey and Tirole (1998b), that low (below cost) access prices can be used to soften price competition. The underlying idea is that a low access price reduces the incentive to attract additional customers.

The general conclusion is that price differentiation based on call determination is neither demand- nor cost-based, and hence distorts welfare. It may, however, result in more intense competition, and in the case of linear pricing, it may alleviate the double marginalization problem.

Heterogeneous demand

Another closer view on competition in two-part tariffs is provided by Dessein (1999a, b), who introduces heterogeneity in volume demand. This allows for two-part tariffs that can be used for second-degree price discrimination (the operators offer a menu of contracts to consumers so that they can implicitly discriminate between consumers of different types). Dessein focuses on possible collusive effects of the terminating access price. The results are ambiguous; they depend on assumptions about the calling patterns of different types of customers.

[15] Their 1997 article contains a summary of the main results.

While imposing that for equal per-minute prices, each consumer calls as much as he is being called ("balanced calling patterns"), Dessein (1999a) shows that the impact of the access price is ambiguous, that is, it may or may not lead to higher profits. Dessein (1999b) analyzes situations where calling patterns are unbalanced (e.g., "heavy" users call more than they are being called for equal per-minute prices). He shows that under two-part tariffs, there is no collusive effect of the access price, except if different types of consumers perceive the substitutability of networks differently. Intuitively, different types of consumers may react differently to differences in subscription fees, so that there is an endogenous selection of consumers. This may make collusion possible.

The mixed results suggest that it is difficult to prove tacit collusion in practice, especially in situations in which operators offer complex menus of contracts. Obviously, such menus cater, to a certain extent, to demand variety, but it seems legitimate to ask if they may also be used to obscure a low intensity of competition.

Local calls and long-distance calls

Carter and Wright (1999) consider various cases in which operators offer local calls and long-distance calls. In their setup, a local operator does not only provide local calls, but also local access for long-distance operators. Their focus is on the interaction between the local and long-distance markets, allowing for different degrees of asymmetry between operators. They analyze under what assumptions mandatory interconnection and reciprocal access prices make effective competition possible, without further regulation of retail prices or access prices. In particular, they show that two interconnected local operators will agree to cost-based access prices in the local market, and that competitive prices will also be provided in the downstream long-distance market, whether or not there are integrated firms operating in both the upstream and downstream markets.

More recent work

The survey in this chapter is not exhaustive. Recent work, some of it in progress, includes: Fabrizi (2000) on competition between a fixed and a mobile operator, Taylor (1999) on the marketing practice of offering subscribers enticements (e.g. a free phone in the market for mobile telephony) to switch suppliers, Wright (2000a) on competition between mobile operators, and Wright (2000b) on non-dominant network competition. On universal service obligation, see for instance Laffont and Tirole (2000, chapter 6), Cave and Prosperetti (2000a), and Choné et al. (2000).

3.3 Concluding remarks

The existing literature provides both the necessary tools as well as basic insights that are needed to better understand the nature of competition in telecommunications. At the same time, however, the level of abstraction of the models and outcomes does not necessarily facilitate application of the results to policy and regulation. Also, entry in telecommunications markets, and the associated asymmetry between an incumbent and an entrant, has not received the attention that it deserves, given its current importance. It is therefore useful to develop a more applied framework, while making use of existing theory, that can more directly address regulation and competition policy in the phase towards mature competition.

Box 3.3.1. Differences with existing literature

Most of the existing literature focuses on a static situation of mature, facilities-based competition, and the effects of terminating access prices on the nature of competition. A central question in the literature is whether an access markup can facilitate tacit collusion.

Our study is different from the main literature in the following ways:

- By introducing consumer switching costs, the size of market shares (in particular the incumbent's initial advantage) becomes relevant.
- By repeating the static game during a certain number of periods, dynamic competition can be simulated.
- We focus on several entry modes (facilities-based entry, local-loop unbundling, Carrier Select-based entry, and entry targeted to a specific segment of the market).
- The variety of entry modes allows us to examine a broader range of policy issues and regulatory instruments.

Chapter 4. Benchmark model

4.1. Introduction

This chapter presents a concise model of facilities-based competition between two operators. The model has been made as simple as possible. To make it more realistic, several assumptions will be dropped later, and detailed variants will be built to answer specific questions (see Chapter 1 for an overview of model variants). The purposes of setting up a simple model before doing simulations are:

- to provide a framework for more detailed, realistic and case-specific analysis;
- to make the reader familiar with the type of assumptions needed to get meaningful results;
- to explain the notion of an equilibrium;
- to introduce and explain important economic indicators (in particular profits, consumer surplus, and welfare);
- to develop a basic understanding of strategic interaction among operators and causal effects of parameter changes.

What kind of outcomes does the benchmark model, and also the simulation models in later chapters, generate? Solving the model results in a "Nash equilibrium," that is, the prices chosen by the operators in a situation of strategic interaction. Terminating access prices are exogenous, that is, before deriving the equilibrium outcome, one has to specify their levels (in later models also price caps, lease price of local loop, originating access price, etc. have to be specified). Accordingly, the main purpose of the model is to show how the equilibrium outcome depends on regulatory instruments. This allows one to compare outcomes for different levels of a certain instrument, so that conclusions about the optimal level can be drawn.

The benchmark model is similar in spirit to models analyzed in Laffont, Rey and Tirole (1998a, b), Armstrong (1998), and Carter and Wright (1999a). In each of these models, two operators compete by choosing prices. The main difference with those models is that the benchmark model incorporates initial market shares and switching costs. These elements allow us to explore situations in which one of the operators, the incumbent, initially has 100% market share, while its customers incur costs when they switch from the incumbent to an entrant.

In reality, there is more than one entrant active in telecommunications markets. Still, the benchmark model is very useful since it lays bare general mechanisms of competition, that are also present in markets with more than two players. A qualitative difference is that with more players, competition is (expectedly) more intense. Furthermore, in such a model one can consider the case in which different types of entrants are simultaneously active. However, to be able to analyze a model with more than one entrant, one has to make additional simplifying assumptions (because of the increased mathematical complexity). Doing so would reduce the richness of the outcomes that can be generated, without generating fundamentally different results. Therefore we have chosen to stick close to the models in the existing literature, and focus on the strategic interaction between an incumbent and an entrant only.

Section 4.2 presents the benchmark model. Section 4.3 explains the equilibrium notion that is used to solve the model. Section 4.4 presents and discusses selected analytical results.

4.2. Description of the benchmark model

In brief, the benchmark model depicts a situation of one-shot competition. It consists of the following stages:

- There is an incumbent who has an initial market share of 100%. There is a potential entrant, ready to compete. Each operator has a full-coverage network. Terminating access prices are given (e.g. set by the regulator).
- The incumbent and the entrant simultaneously and independently choose subscription fees and per-minute prices.
- Based on the operators' prices, consumers choose to keep their subscription to the incumbent or to switch to the entrant, so that new market shares are realized. Next, they make their phone calls. Realized profit levels are based on market shares, prices, costs of telephony, generated traffic on and between the networks, and the access payments between the operators.

We will now develop the model in full detail.

Operators, market shares and prices

There are 2 operators, an incumbent (operator 1) and an entrant (operator 2). Their initial market shares in volumes of customer base, denoted by φ_1^0 and φ_2^0, are given. By definition, $\varphi_1^0 + \varphi_2^0 = 1$. Typically, we assume that the incumbent starts with a market share $\varphi_1^0 = 100\%$.

Each operator has a full-coverage network that consists of a long-distance backbone, a local access network, and switches. Hence the model depicts facilities-based competition. The symmetry of the networks makes the exposition of a model as clear as possible.

To keep the model close to reality, the operators compete in **two-part tariffs**: each operator i chooses a price per minute p_i and a subscription fee m_i. Later, we will also look at linear prices, that is, the operators only choose per-minute prices.

Realized market shares are functions of prices p_1, p_2, m_1, and m_2. We want to capture, for instance, that if operator 1 increases its subscription fee, then operator 2's market share increases. This captures the essence of the strategic interaction between the firms. The market shares resulting from competition are denoted by $\varphi_1(p_1, p_2, m_1, m_2)$ and $\varphi_2(p_1, p_2, m_1, m_2)$. By definition, it must be that

$$\varphi_1(p_1, p_2, m_1, m_2) + \varphi_2(p_1, p_2, m_1, m_2) = 1.$$

We assume that all consumers will subscribe to one of the networks. This simplifies the analysis considerably. In a market where either price caps or competition guarantee that all consumers can afford telephony services, this assumption is relatively harmless.

Consumer demand

The size of the market is n, that is, there is a continuum of consumers with mass n. Consumers are homogeneous in the sense that they have identical utility and demand parameters, and also in the sense that operators cannot divide the market into different segments.

Given a price per minute equal to p_i, each individual consumer has a demand of $x(p_i)$ call minutes, and derives utility $u(x(p_i))$ from calling $x(p_i)$ minutes. The utility function is in money terms and satisfies $u'(x) > 0$ and $u''(x) < 0$ for all $x \geq 0$. We do not distinguish between local, regional and long-distance telephony.

Consumers maximize their utility. Hence, the optimal demand for call minutes x is chosen by maximizing $u(x) - x \cdot p$, so that the individual demand function $x(p)$ is derived from solving

$$u'(x) = p,$$

that is, a consumer will make less calls or make shorter calls when the per-minute price rises; he does not refrain from making calls.

Also, a consumer derives a fixed utility level u_i^0 from subscribing to network i, which may be interpreted as, for example,

- brand loyalty to operator i (in general stronger for an established incumbent than for new, initially small entrants);
- the quality of operator i's connection or network;
- having a telephone connection in the case of unforeseen events;
- receiving calls from family and friends.

This fixed utility u_i^0 from subscribing to a network also captures that consumers' demand for being connected to a network is inelastic. The total net utility of a subscriber to network i, who optimally chooses his calling time, is denoted by an indirect utility function $v_i(p_i, m_i)$. Assuming that utility levels are expressed in monetary units and can be added up, indirect utility can be written as:

$$v_i(p_i, m_i) = u_i^0 + u(x(p_i)) - p_i\, x(p_i) - m_i.$$

Using first-order conditions, it is easily shown that net utility is decreasing in prices:

$$\partial\, v_i(p_i, m_i) / \partial\, p_i = u'(x(p_i))\, x'(p_i) - p_i\, x'(p_i) - x(p_i) = -x(p_i) < 0;$$

$$\partial\, v_i(p_i, m_i) / \partial\, m_i = -1 < 0.$$

The following table presents a linear specification of the demand function, which will be used throughout this study.[16]

Table 4.2.1. Linear specification of individual demand

function	**description**	**specific form in example**
$u(x)$	utility from calling x minutes	$a\,x - ½\, b\, x^2$ where $a, b > 0$
u_i^0	fixed utility from a connection	given constant
$x(p_i)$	individual demand for call minutes	$(a - p) / b$
$v_i(p_i, m_i)$	total net utility	$u_i^0 + ½\,(p_i - a)^2 / b - m_i$
$\varepsilon(p_i)$	elasticity of demand	$-p_i / (a - p_i)$

Consumer switching costs

Consumers choose their subscription when they observe the operators' prices. The most straightforward way to model the subscription decision would be to have consumers choose the highest utility level among $v_1(p_1, m_1)$ and $v_2(p_2, m_2)$. The consequence would be that extremely small price differences (resulting in extremely small utility

[16] Doganoglu and Tauman (1996) also use a quadratic utility function, which results in a linear demand function for call minutes. An important benefit of this specification is that consumption is bounded if the per-minute price approaches zero. Laffont, Rey and Tirole (1998a, b) construct the demand function such that there is a constant price elasticity, resulting in unbounded consumption for small prices.

differences), would tilt the balance towards the operator offering the highest net utility. This operator would then instantaneously gain a market share of 100%. In reality, however, we do not observe such "bang-bang" outcomes. Instead, market shares exhibit a certain extent of stickiness, and change in a rather smooth fashion. In particular, capturing market share from a well-known, established firm requires great marketing efforts and substantially better price-quality combinations by new, small competitors.

In order to allow for a realistic transition of market shares over time, we introduce **consumer switching costs** (not to be confused with the costs of switches in networks). Suppose a certain consumer, identified by a parameter *s*, initially subscribes to network *i*. He will end his subscription and switch to operator *j* if and only if

$$v_j(p_j\,, m_j) - s > v_i(p_i\,, m_i),$$

where *s* is his cost of switching from one operator to another. Moreover, *s* is not the same for all consumers, but uniformly distributed on an interval $[0, s_{\max}\ \varphi_i^0\ ]$.

Parameter $s_{\max} > 0$ can be said to measure the level of competitiveness of the market. Later we will see how different values of this parameter affect competition.

The definition of the interval on which switching costs are uniformly distributed results in differentiability of profit functions, which will allow for straightforward derivation of equilibria. The economic interpretation of this specification of the switching cost interval is that:

- each operator's customer base ranges from consumers who are eager to switch (minimum switching cost $s = 0$) to consumers who need substantially lower prices to be encouraged to switch (maximum switching cost $s = s_{\max}\ \varphi_i^0$);
- all types in the range are equally likely (because of the uniform distribution);
- an operator with a larger initial market share φ_i^0 has relatively more customers with higher consumer switching costs (e.g. due to brand loyalty).

A recent, empirical study by Oftel (2000) confirms the validity of the switching costs assumption.That study reports that consumers vary with respect to switching. For example, among consumers making most use of competition are younger persons and larger households, and among those making least use of competition are older persons and small households. To a certain extent, these results can be explained by lower awareness of alternative suppliers. The main reason given by respondents for not switching was satisfaction with the current supplier, while the remainder gave reasons such as, for instance, that switching is too much hassle or disruption, that the reliability or quality of another supplier may not be as good, and that it is too difficult to work out which one is cheaper or better. Most consumers (about 67%) would be encouraged to switch if cheaper prices were offered.

Realized market shares

The customer switching costs introduced above affect the way market shares are realized. Let the operator's prices be given, and suppose that a certain customer of operator 1, who is characterized by switching cost parameter s_0, is indifferent between staying with firm 1 and switching to firm 2. Equivalently, s_0 satisfies

$$v_2(p_2, m_2) - s_0 = v_1(p_1, m_1).$$

Consequently,

- customers of operator 1 with $s \in [0, s_0]$ switch to operator 2;
- customers of operator 1 with $s \in [s_0, s_{max}\, \varphi_1^0]$ stay with operator 1;
- all customers of operator 2, that is, all $s \in [0, s_{max}\, \varphi_2^0]$, stay with operator 2.

Since $s_0 = v_2(p_2, m_2) - v_1(p_1, m_1)$, the fraction of firm 1's customer base that switches to operator 2 equals

$$(\, v_2(p_2, m_2) - v_1(p_1, m_1)\,) / (s_{max}\, \varphi_1^0).$$

Similarly, the fraction of its customer base that stays is equal to

$$[\, s_{max} * \varphi_1^0 - (\, v_2(p_2, m_2) - v_1(p_1, m_1)\,)\,] \;/\; (s_{max} * \varphi_1^0).$$

Therefore, operator 1's realized market share equals

$$\varphi_1 = \varphi_1^0 + (\, v_1(p_1, m_1) - v_2(p_2, m_2)\,) / s_{max}.$$

More generally, the realized market share of operator i is equal to:

$$\varphi_i = \varphi_i^0 + (\, v_i(p_i, m_i) - v_j(p_j, m_j)\,) / s_{max}.$$

Intuitively, an operator's market share increases if the operator offers a relatively larger level of net utility to consumers, and decreases otherwise. Recall that parameter s_{max} was earlier called a measure of the level of competitiveness of the market. One can observe that larger values of s_{max} make it more difficult to gain market share. In other words, in a relatively more competitive market, an entrant has to cut prices by less if it wants to capture a certain market share (compared to capturing that market share in a less competitive market).

One can show that the aggregate switching costs that are incurred by all consumers that switch are equal to

$$n\,(v_2(p_2\,,m_2) - v_1(p_1\,,m_1))^2\,/\,(2\,s_{max}).$$

Costs

To make assumptions about the cost structure of telecommunications networks, we will follow recent theory on competition in telecommunications (e.g. Laffont, Rey and Tirole, 1998a, b). One can distinguish between

- connection-independent fixed costs (traffic-independent; e.g. fixed costs of long-distance backbone);
- connection-dependent fixed costs (traffic-independent; e.g. the fixed cost of the local line);
- traffic-dependent costs (not fixed since they vary with traffic volumes).

Fixed costs are defined as any true fixed costs that have not been attributed to traffic. Fixed costs that are independent of the number of connections do not affect pricing decisions, although they are relevant for investment decisions. Connection-dependent fixed costs capture, for instance, the maintenance cost of local connections, and may also include investment costs that have to be recovered. These costs affect revenues per consumer and therefore pricing decisions. Operator *i*'s connection-dependent fixed cost is denoted by f_i.[17]

The "operational" or "technical" marginal cost of telephony calls is practically zero; it roughly equals the cost per time unit of the electricity that is needed to transmit signals through a network (or more precisely, the cost needed for transmission, switching and signaling systems). Moreover, it is in reality very difficult to measure these costs – firms often do not know marginal cost levels themselves. Still, operators typically may (partially) impute fixed costs to telephony traffic, enabling them to define a reference point for prices. This may happen despite the fact that these costs are either sunk once a network has been built or do not directly depend on traffic. Therefore we will define marginal costs as the costs that a sales/marketing department attributes to traffic when making pricing decisions, net of traffic-dependent access tariffs.

Costs which are also perceived as traffic-dependent costs are charges for interconnection and access. These charges are typically incurred on a per-minute basis.

[17] Although the cost structure of the customer access network is simplified to a considerable degree, our assumptions still capture the bottleneck nature of the local loop that is due to the fixed cost nature of the local line. See Cave and Valletti (2000b), for more details on the cost structure of the local loop that support our assumptions.

Total traffic-dependent costs are therefore to marginal costs plus traffic-dependent charges paid to other operators for interconnection and access.

We define fixed costs as any true fixed costs that have not yet been attributed to traffic. Since they are considered to be sunk when prices are chosen, they affect neither prices nor realized market shares. They do, however, affect profits and hence investment decisions in the model.

Some notation is needed to define the traffic-dependent (i.e., marginal) costs of telephone calls. Let c_{ik} denote operator *i*'s traffic-dependent cost per minute associated with a telephone call of type *k*. We will distinguish 3 types of telephone calls:

- **on-net calls**: calls that originate and terminate on a single network ($k = 1$);
- **off-net calls**: calls that terminate on the rival's network ($k = 2$);
- **incoming calls**: calls that originate on a rival network ($k = 3$).

In the literature it is typically assumed that the marginal cost of the local loop is the same for originating and terminating traffic, so that $c_{i1} - c_{i2} = c_{i3}$. We will follow this convention.

In the case of off-net calls and incoming calls, the operator of the network where the call originates pays a per-minute terminating access fee to the operator of the network where the call terminates. Terminating access fees paid to operator *i* are denoted by τ_i.[18]

We can summarize traffic-dependent costs as follows:

Table 4.2.2. Overview of traffic-dependent costs (per call minute)

specification	**operator 1**	**operator 2**
marginal cost of on-net calls	c_{11}	c_{21}
marginal cost of off-net calls	c_{12}	c_{22}
marginal cost of incoming calls	c_{13}	c_{23}
terminating access tariffs	τ_1	τ_2

[18] We abstract from differences local interconnection, single transit and double transit.

One can now write down the marginal costs and revenues for each type of telephone call.

Table 4.2.3. Marginal costs and revenues per call type (per call minute)

specification	**operator 1**	**operator 2**
on-net call (cost)	c_{11}	c_{21}
off-net call (cost)	$c_{12} + \tau_2$	$c_{22} + \tau_1$
incoming call (revenue)	$\tau_1 - c_{13}$	$\tau_2 - c_{23}$

Profit functions

Before profit functions can be derived, an assumption on calling patterns is needed. We assume that when a consumer makes a telephone call, the receiving consumer may be any other consumer with equal probability, whether or not he subscribes to the same network or another network than the originating consumer does. This implies that the numbers of on-net and off-net calls of an operator are proportionate to market shares ("isotropic calling patterns"). For instance, a volume of $\varphi_1\, x(p_1)$ call minutes originates on network 1. A fraction φ_1 of this volume terminates on network 1, and a fraction φ_2 terminates on network 2.

Using the assumption of isotropic calling patterns, revenues dependent and independent on traffic contribute to profits as shown in the following table.

Table 4.2.4. Profits of operator i ($i \neq j$; gross of fixed costs)

profits from	**level of profits**
on-net traffic	$n\, (\varphi_i)^2\, x(p_i)\, (p_i - c_{i1})$
off-net traffic	$n\, \varphi_i\, \varphi_j\, x(p_i)\, (p_i - c_{i2} - \tau_j)$
incoming traffic	$n\, \varphi_j\, \varphi_i\, x(p_j)\, (\tau_i - c_{i3})$
traffic-independent	$n\, \varphi_i\, (m_i - f_i)$

Operator *i*'s total profit level is equal to the sum of all the components in table 4.2.4:

$\Pi_i(p_1, p_2, m_1, m_2) =$ profits from on-net traffic
+ profits from off-net traffic
+ profits from incoming traffic
+ revenues from subscription fees
− per-period fixed cost of the local loop
− other fixed costs (not yet attributed to telephony traffic).

Notice that this is a function of both operators' prices, which reflects that the operators compete with each other (there is strategic interaction).

Surplus

The effects of competition and regulation can be evaluated by looking at:

- consumers' surplus;
- producers' surplus (total industry profits);
- welfare (total industry surplus, that is, the sum of consumers' surplus and producers' surplus).

It may sometimes be important to consider more than one measure of surplus, since one should not rule out the possibility that a regulatory measure increases welfare, but at the same time is detrimental to consumers' surplus.

Producers' surplus is equal to

$$PS \equiv \Pi_1(p_1, p_2, m_1, m_2) + \Pi_2(p_1, p_2, m_1, m_2).$$

Consumers' surplus is equal to the sum of net utilities of all consumers net of any switching costs incurred by consumers:

$$CS \equiv n\,\varphi_1\,v_1(p_1, m_1) + n\,\varphi_2\,v_2(p_2, m_2) - n\,(v_2(p_2, m_2) - v_1(p_1, m_1))^2 / (2\,s_{max}).$$

Notice that the incurred customer switching costs, calculated earlier, are taken into account in this formula. Welfare or total surplus in the market (net of incurred switching costs) equals

$$W \equiv PS + CS.$$

Box 4.2.1. Summary of benchmark model

The main assumptions of the benchmark model are:

- the operators compete by simulteneously setting prices in the retail market;
- the operators take the regulatory regime (e.g. terminating access prices) as given;
- each operator chooses prices to maximizes its profits (remark: profit functions take on-net and off-net traffic volumes into account);
- each consumer chooses a subscription and number of call minutes to maximize his net benefits;
- a consumer who wants to switch from one to the other operator, incurs a switching cost;

The sequence of moves in the game is:

$t = 0$: The following is given:
- initial market shares φ_1^0 and φ_2^0;
- terminating access prices τ_1 and τ_2 (either determined by the regulator or by negotiations between the operators).

$t = 1$: The operators simultaneously choose retail prices:
- operator 1 sets a per-minute price p_1 and a subscription fee m_1;
- operator 2 sets a per-minute price p_2 and a subscription fee m_2.

$t = 2$: Consumers observe retail prices and choose to subscribe to one of the networks. Next, they make their telephone calls.
The following are realized:
- market shares φ_1 and φ_2;
- profit levels $\Pi_1(p_1, p_2, m_1, m_2)$ and $\Pi_2(p_1, p_2, m_1, m_2)$;
- surplus levels *CS*, *PS*, and *W*.

4.3. Equilibrium notion

Nash equilibrium

The concept of a Nash equilibrium, which is explained below, is used to solve the model. More information about game theory and equilibrium notions can be found in, for instance, Fudenberg and Tirole (1991), and Gibbons (1992). We assume that the operators behave rationally, in the sense that each of them chooses prices to maximize profits. This is a standard assumption in this type of model. Without it, one could generate any type of outcome.

Equilibrium prices will be marked with a superscript "*." An equilibrium, called a Nash equilibrium in game theory, is defined by the following conditions:

- none of the operators has an incentive to change its prices given the other operator's prices, that is, prices $(p_1^*, p_2^*, m_1^*, m_2^*)$ are such that the first-order conditions are satisfied for both operators;
- given the operators' prices, consumers choose a network and a quantity of call minutes in order to maximize their net utility.

Notice that in a Nash equilibrium, each operator sets prices while taking as given the prices chosen by its rival firm. Formally, necessary conditions associated with each operator $i = 1, 2$ maximizing profits by choosing prices p_i and m_i, are the following *first-order conditions*:

$$\partial \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / \partial p_i = 0, \tag{2.1}$$

$$\partial \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / \partial m_i = 0.$$

To guarantee that we are dealing with a local maximum instead of a local minimum, the second-order conditions have to be checked as well for each operator $i = 1, 2$:[19]

$$\partial^2 \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / (\partial p_i)^2 < 0,$$

$$\partial^2 \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / (\partial m_i)^2 < 0,$$

$$(\partial^2 \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / (\partial p_i)^2) \cdot (\partial^2 \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / (\partial m_i)^2)$$

$$> (\partial^2 \Pi_i (p_1^*, p_2^*, m_1^*, m_2^*) / (\partial p_i \partial m_i))^2.$$

4.4. Preliminary results

Deriving a general analytical solution of the benchmark model turns out to be extremely complicated except in some very special parameter cases. We refer to Laffont, Rey and Tirole (1998a, b), Laffont and Tirole (1998), Armstrong (1998), and Carter and Wright

[19] See Chiang (1984) for more details on optimization.

(1999) for analytical solutions in models of competition in telecommunications that were the basis of the benchmark model.

Since we assume more asymmetry in the model than is done in the literature, we need to use numerical methods to obtain results (see chapter 5). In this section, we will deduce properties of equilibria without trying to get full or general analytical solutions.

Structure of Nash equilibrium prices
By manipulating and combining operator *i*'s first-order conditions (see equations (2.1)), one can show that optimal prices of operator *i*, when operator *j*'s prices are given, satisfy:

$$p_i^* = \varphi_i \; c_{i1} + \varphi_j \,(c_{i2} + \tau_j), \tag{2.2}$$

$$m_i^* = f_i + \varphi_i \; s_{\max} - \varphi_i \; x(p_i^*) \,(c_{i2} + \tau_j - c_{i1}) + (\varphi_i - \varphi_j)\, x(p_j^*) \,(\tau_i - c_{i3}). \tag{2.3}$$

Notice that (2.2) and (2.3) do not form an explicit solution, since market shares φ_1 and φ_2, and also demand $x(p)$, depend on prices.

A first observation that was made by Laffont and Tirole (1998) and also applies here, is that the operators each have two instruments (usage price and subscription fee), and therefore can "separate the building of market share from the generation of call volume" (p. 207). How this works can be explained by looking more closely at (2.2-2.3).

The interpretation of (2.2) is that an operator's optimal price strategy in a Nash equilibrium always involves choosing a price per minute equal to the operator's level of average marginal costs (also called "perceived" marginal costs in the literature). Given the traffic flows on and between the networks, the average marginal cost captures all traffic-dependent costs and payments that are incurred by that operator and that are directly affected by its prices. As a consequence, any market power is exercised – and fixed costs are recovered – solely through subscription fees. Notice that $s_{\max}$ has no direct effect on per-minute prices. (Intuitively, an operator's marginal costs relevant for its own pricing are the traffic-dependent costs associated with the traffic that its own customers generate. Incoming traffic, generated by its competitor's customers, cannot be directly affected by an operator and therefore does not contribute to its average marginal costs.)

The subscription fee in equilibrium (equality (2.3)) can be interpreted as the markup from market power, $\varphi_i \, s_{\max}$, plus the net marginal cost of adding a subscriber to the network, which is the rest of the expression.[20] Notice that an increase in $s_{\max}$, which

[20] See also Laffont et al. (1998a), proposition 7, p. 21.

can be interpreted as less intense competition, directly pushes subscription fees upwards (apart from possible indirect effects through market shares).

The intuition behind the structure of equilibrium prices strongly resembles optimal two-part tariff pricing by a monopolist. The classic example is an amusement park, where a two-part tariff can consists of an entry fee and a charge per ride inside the park. It is optimal for the park to capture consumer surplus through the entry fee, and set the price per ride equal to its marginal cost. Without a fixed fee, the monopoly price is above marginal cost, resulting in a loss of total surplus (the "dead-weight loss"). This is due to the fact that a price above marginal cost results in too little consumption, compared to the social optimum. Using a two-part tariff and setting the usage price equal to marginal cost allow the monopolist to create and capture maximal surplus. Now notice that in a situation where several firms compete by choosing prices, a firm can only gain market share by offering consumers a higher surplus than its competitors. This pressure forces firms to set the usage price equal to marginal cost. Market power (e.g. because of brand loyalty or customer switching costs) is then optimally exercised through fixed fees.

Suppose that access fees are reciprocal ($\tau \equiv \tau_1 = \tau_2$). Since we assumed that the marginal cost of the local loop is the same for originating and terminating traffic, that is, $c_{i1} - c_{i2} = c_{i3}$, equalities (2.2-2.3) boil down to

$$p_i^* = c_{i1} - \varphi_j \, (c_{i3} - \tau), \tag{2.4}$$

$$m_i^* = f_i + \varphi_i \; s_{\max} - [\, \varphi_i \; x(p_i^*) + (\varphi_j - \varphi_i) \, x(p_j^*) \,] \, (\tau - c_{i3}). \tag{2.5}$$

The equilibrium price structure is robust to different assumptions about the nature of competition. Let us mention here that the benchmark model is different from existing models because (i) initial market shares form the starting point of competition, and (ii) there are consumer switching costs (any insights pertaining to initial market shares are lost without these features). However, the outcome that per-minute prices in equilibrium are equal to average marginal costs, and that fixed fees are used to capture consumer surplus, is also obtained in other models. For instance, the result remains valid when networks are horizontally differentiated (Laffont, Rey and Tirole, 1998a) or when there is certain degree of substitutability between the networks (Armstrong, 1998).

Profit drivers

An interesting observation is that an operator that sets its per-minute price equal to average marginal cost, makes zero profits from the total amount of on-net and off-net traffic. Formally, one can show that $p_i^* = \varphi_i \;\, c_{i1} + \varphi_j \;\, (c_{i2} + \tau_j)$ is equivalent to

$$(\varphi_i)^2 \, x(p_i^*) \, (p_i^* - c_{i1}) \qquad\qquad + \varphi_i \;\, \varphi_j \;\, x(p_i^*) \, (p_i^* - c_{i2} - \tau_j) = 0$$

(profits from on-net traffic + profits from off-net traffic = 0).

A consequence of this observation is that in equilibrium, revenues from incoming traffic and revenues from subscription fees drive an operator's profit level. This result need not be true if one changes the assumptions that underlie the benchmark model, though.

Using the observation above, one can simplify equilibrium profits (under reciprocal access prices) as

$$\Pi_i\,(p_1^*, p_2^*, m_1^*, m_2^*) = n\,(\varphi_i^*)^2\,[s_{\max} + (\,x(\,p_j^*) - x(\,p_i^*)\,)\,(\tau - c_{i3})].$$

Equilibrium existence

We will now briefly address existence and uniqueness of an equilibrium. Suppose that the operators have identical marginal costs ($c_{1k} = c_{2k}$, k = 1, 2, 3), and let terminating access prices be reciprocal ($\tau \equiv \tau_1 = \tau_2$). It can be shown that if the potential lock-in effect is not too small (that is, $s_{\max}$ is sufficiently large) or the access price is sufficiently close to the marginal cost of the local loop (c_{13}), then there exists a unique equilibrium in which both operators have strictly positive market shares.[21]

It is very hard to analytically prove equilibrium existence in more general settings. In part II of this study, we will therefore use numerical methods to generate equilibrium outcomes, while checking the conditions that are necessary for a Nash equilibrium (the first- and second-order conditions).

Box 4.4.1. Insights of the benchmark model

[21] See Laffont, Rey and Tirole (1998a), who consider a completely symmetric model, which corresponds to the benchmark model if one assumes equal, initial market shares. By redefining $1/s_{\max}$ as the degree of substitutability of the networks, the symmetric equilibrium outcome above is identical to theirs. This suggests also that the price structure that is obtained is robust to changes in demand assumptions.

The benchmark model generates the following insights on static, facilities-based competition in two-part tariffs (similar to the basic results of the early literature discussed in chapter 3):

- In equilibrium, per-minute prices are equal to average marginal costs, while the operators use subscription fees to exercise market power.
- If the operators are symmetric, there exists a unique equilibrium in which both operators have strictly positive market shares.
- The reciprocal terminating access price cannot be used as an instrument of tacit collusion (contrary to the situation of competition in linear prices).

Chapter 5. Simulation

5.1. Introduction

To make the benchmark model more realistic, a dynamic element can be added. In this chapter, we explain how dynamics are introduced into the benchmark model. Put simply, the benchmark model is repeated during a certain number of periods, while after each period, initial market shares are updated by redefining them as the market shares realized in that period. Also, an observed outcome of the benchmark model, in which the entrant gained market share at an unrealistically high speed, is repaired by making a realistic assumption on the fixed utility levels of the operators.

Section 5.2 discusses how market dynamics are incorporated in the model. Section 5.3 explains the way that equilibria are calculated by using Mathematica software. Section 5.4 contains information about the way outcomes of the simulations will be represented in part II.

5.2 Incorporating market dynamics

Profit maximization

In a dynamic game, many outcomes are possible in general, depending of course on the assumptions of the game (e.g. finite versus infinite number of periods, equilibrium concept, equilibrium selection; see e.g. Fudenberg and Tirole, 1991). Also, given a specific set of assumptions, a dynamic game may have several outcomes, ranging from cut-throat competition in each period, to collusion during the complete course of the game. Such a range of outcomes can be completely compatible with dynamic optimization by the players in the game.

To keep the simulations tractable, we assume that in each period the operators maximize their per-period profits (net of investment costs), and consumers maximize per-period utility. This assumption is obviously restrictive. Ideally, one would want to incorporate that firms look much further ahead and maximize the discounted sum of per-period profits. Nevertheless, the assumption that operators are “myopic” is, to a certain extent, realistic. For instance, investors may be myopic in the sense that they require a fast recovery of investments (which can be done by designing approprate incentive schemes for managers). Also, a quick turnover of personnel at sales and marketing departments (where pricing decisions are taken) may make it difficult to implement long-term pricing strategies. More generally, managers who are responsible for tactical decisions often have a shorter time horizon than owners or investors of a firm, since incentives are not aligned.

Repeating the game

In the benchmark model, initial market shares strongly affect the outcome of competition. At the beginning of the game, initial market shares are given by $\varphi_1^0 = 1$ and $\varphi_2^0 = 0$. Let φ_i^t denote operator i's market share realized in period $t = 1, 2,...$ At the start of each period $t = 1, 2,...$, the operators take the market shares φ_i^{t-1} of the previous period as given. Hence, initial market shares are updated by defining the "new" initial share as φ_i^{t-1} in each period t. Moreover, we assume that consumer types are uncorrelated over time, so that in each period, switching costs for customers of operator i are uniformly distributed on the interval $[0, s_{max}\, \varphi_i^{t-1}]$.

The length of a single period in the model can be thought of as the minimum amount of time that operators need in order to adjust their prices. In reality in the market for fixed telephony, it may take about two months for a regulated operator to adapt its prices (one month to get approval from the regulator, and one month to implement the price change). Therefore it seems reasonable to think of a single period as a length of time of two months.

The effectiveness of various regulatory regimes will be assessed by considering the sum over the periods of producer surplus, consumer surplus, and welfare. To simplify matters without affecting the qualitative insights, the discount factor will be set at 1.

Track record of entrants

One can easily check numerically that in the benchmark model, the incumbent's realized market share after a single period of competition in equilibrium roughly equals 0.67 for many parameter cases (and that realized market shares converge toward 50-50 after more periods). This is because in the model, the entrant could offer equal utility levels as the incumbent. Hence, under price competition the entrant builds up market share quite fast. Actually, the operators in the benchmark model were "excessively symmetric," while in reality, entrants typically increase quality levels and range of services over time. In the simulations, we will try to preclude this rather extreme outcome by assuming that initially, the fixed utility level offered by the entrant is lower than the incumbent's, but it increases over time as the entrant. More precisely,

$$u_1^t = u_0,$$

$$u_2^t = u_0 \,\text{Min}\{(t - 1), k\} / k,$$

where u_0 is a given constant and k is the number of periods needed by an entrant to build a "track record" of quality. Notice that in the long run, both operators offer equal fixed utility levels.

An empirical survey among telecommunications users in the Netherlands by Bouwman, Hulsink and Van de Riet (1999) confirms the claim that entrants have a strong focus on gaining market share through pricing strategies, possibly to the detriment of quality. The authors refer to a presentation by GartnerGroup for the claim that it takes at least 24 months for entrants to build a serious track record. In the model, this corresponds to setting $k = 12$.

The assumption about the updating of traffic-independent utility levels does not affect the qualitative insights of the models. It is a means of smoothing out market shares, resulting in a more natural evolution of the market. Moreover, one can motivate the assumption by realistic concerns. A recent, empirical study by Oftel (2000) found that the main reason given by consumers for not switching to an alternative supplier was satisfaction with the current supplier, while price was the main factor that would encourage them to change suppliers. These results suggest that in the initial stages of competition, the incumbent operator offers the best value for money in the perception of consumers. In line with these empirical results, one can interpret utility level u_i^t as the utility derived from:

- services in addition to basic telephony (e.g. voice mail, information services); the entrant is able to develop and introduce more of such services over time;
- quality of service (e.g. accuracy of help desk, assistance with problems); the entrant is able to improve its quality over time, as it gains experience in serving consumers. Alternatively, if quality is an experience good and consumers are risk averse, it may gain a reputation for having a reliable network.
- network quality (e.g. quality of local connection, sound quality of voice telephony, capacity of switches). An entrant's network may not satisfy the same quality standards as the incumbent's network in the early stages of network rollout.

5.3 Calculation of equilibria

Software

The simulations were carried out on a personal computer equipped with a Pentium Pro processor (Intel), operating system Windows 95 (Microsoft), software package Mathematica version 4 (Wolfram Research, Inc.), and simulation programs developed in Mathematica. Some examples of literature on applications of Mathematica to economics are Froeb and Werden (1996), Huang and Crooke (1997), and Varian (1996). A recent review of the software is Shone (2000).

A supplementary CD-ROM, available on request in a limited distribution, contains the Mathematica documents with simulation output and programs. Readers with the CD but without access to Mathematica can use the application MathReader, which is a viewer for notebook documents created with Mathematica.[22]

Procedure
In each period, an equilibrium is derived by solving the system of first-order equations for that period. Since these equations contain polynomials of degree 3, numerical methods must be used to solve the system. To do so, we use the FindRoot procedure of Mathematica, which uses Newton's method if one starts the procedure with a single vector of starting values.[23]

If Newton's method converges to a candidate solution of the system of first-order equations, we check if it satisfies the second-order conditions. By examining candidate solutions for different starting values, and by plotting profit functions, one can assess with reasonable confidence whether a unique equilibrium has indeed been found. For all equilibrium outcomes presented in this report, second-order conditions have been verified. Uniqueness has been verified in some cases; one can be fairly confident that the presented outcomes are unique equilibria.

Notice that in order to use a numerical method, all parameters of the model must have numerical values. Appendices to the chapters in part II, that discuss the outcomes of the simulations, present and discuss the chosen parameter values. To calibrate the models, we have used industry studies, public information, and expert opinion. Data on operational cost levels of operators was not available. Robustness checks showed that the levels of cost and demand parameters in the models, as long as they are not too extreme, do not affect the policy implications in a qualitative way (although obviously the numbers in the model outcomes are affected if one changes parameters). Since this is not empirical study in which we try to estimate models, but instead a conceptual study of the mechanisms in the market, the lack of data does not discount the value of the generated insights.

[22] A free copy of this application can be downloaded at http://www.wolfram.com/products/mathreader/.

[23] See e.g. Burden and Faires (1988) for an explanation of Newton's method and a description of an algorithm that applies the method.

PART II: RESULTS

This part contains the simulation results. It consists of:

Chapter 6:	An analysis of three types of entry in a non-segmented market (i.e., homogeneous consumers).
Chapter 7:	An analysis of alternative tariff structures in a non-segmented market (flat fees, linear prices, and termination-based price discrimination).
Chapter 8:	An analysis of three types of targeted entry in a segmented market (residential customers and business customers).

Summary of notation used in part II (unless noted otherwise):

variable	**notation**	**unit**
subscription fees	m_1 and m_2	Euro-cents
per-minute prices	p_1 and p_2	Euro-cents
differentiated per-minute price for on-net calls	p_1^{on} and p_2^{on}	Euro-cents
differentiated per-minute prices for on-net calls	p_1^{off} and p_2^{off}	Euro-cents
entrant's prices for residential customers	p_2^{res} and m_2^{res}	Euro-cents
entrant's prices for business customers	p_2^{bus} and m_2^{bus}	Euro-cents
terminating access prices	τ_1 and τ_2	Euro-cents
originating access price	δ_1	Euro-cents
lease price of local loop	L	Euro-cents
probability of capacity shortage Carrier Select service	α	- ($0 \leq \alpha < 1$)
market shares	φ_1 and φ_2	%
profits	Π_1 and Π_2	million Euros
consumers' surplus, producers' surplus, and welfare	CS, PS, and W	million Euros

Chapter 6. Entry in a non-segmented market

6.1. Introduction

In this chapter, we assume that all consumers are identical, except with respect to consumer switching costs, and investigate the following entry situations:

- section 6.2: facilities-based competition (FBC);
- section 6.3: local-loop unbundling (LLU);
- section 6.4: Carrier Select-based competition (CSC).

Accordingly, we move from entry that requires the biggest investments by an entrant (FBC), to a situation in which entry by an operator with only a long-distance backbone is relatively easy (CSC). In each case, the regulatory instruments that apply in that situation are analyzed. By comparing these three situations, conclusions on entrants' incentives to invest in a network can be drawn.

The models in this chapter are more stylized than those that will be analyzed in chapters 7 and 8. Still, their importance should not be underestimated. By discussing and interpreting the outcomes of basic models, it will be easier to comprehend the results of the more realistic models in the next chapters. However, although conclusions for policy and regulation will be drawn from the results in this chapter, it is possible that some of the conclusions will not remain valid in the richer settings of chapters 7 and 8.

The FBC model depicts a very general situation of competition between operators that is not yet observed in reality, but will become relevant if entrants will have built local loops such that most consumers can choose between more than one operator with a local access network. Even though it is still uncertain if this will ever happen, a relevant question is how policy and regulation affects the likelihood that FBC will prevail.

Section 6.2 explores the role of reciprocal and asymmetric terminating access prices. In addition, price cap regulation by using a basket containing the incumbent's subscription fee and per-minute price is analyzed. Section 6.3 explores the role of the lease price of the incumbent's local line, and analyzes price cap regulation within an LLU context. Section 6.4 focuses on capacity shortages of the Carrier Select service, the way they interact with price caps, and also analyzes originating and terminating access prices are analyzed. Section 6.5 recapitulates implications for policy and regulation. Also, it discusses the incentives for network investment. An appendix contains the parameter values and discusses in more detail the model modifications.

Table 6.1.1. Summary of model differences.

	FBC (section 6.2)	**LLU (section 6.3)**	**CSC (section 6.4)**
entrant's network consist of:	- backbone - customer access network	- backbone	- backbone
entrant's way of access to end-users:	- direct access (consumers can subscribe) - terminating access (off-net calls)	- direct access (consumers can subscribe) - terminating access (off-net calls)	- indirect access (consumers cannot subscribe) - terminating access (all calls) - originating access (Carrier Select)
relevant wholesale prices:	- terminating access prices	- terminating access prices - line rental	- incumbent's terminating and originating access prices
other relevant details:			- possibility of capacity shortage of Carrier Select service

6.2. Facilities-based competition

6.2.1. Model

The competitive situation that is under investigation in this section requires the most extensive effort by an entrant, since it has to build a customer access network. The model used to analyze facilities-based entry is a repeated version of the benchmark model of chapter 4. Operator 2 can depict, for example:

- an entrant who builds a customer access network similar to the incumbent's network;
- a cable operator who upgrades its cable network to a two-way communication network;

- an entrant who uses new technology to build a customer access network that is quite different from the incumbent's network, but enables the firm to deliver similar services.

Expectedly, these types of entrants will have different cost structures. We assume here, at least as a starting point, that operator 2's network is similar to the incumbent's, and therefore has similar traffic-dependent cost levels.

In section 6.2.3, price cap regulation will be introduced. We will focus on price caps that are binding in a limited number of periods only. Indeed, when the market matures, retail price control should no longer be necessary to prevent the exploitation of market power by the incumbent, and to guarantee reasonable prices for consumers. However, this does not necessarily imply that price cap regulation is always needed in the early stages of competition.

Instead of looking at voice telephony as a bundled service, one can consider a regulatory basket containing:

- a connection to the incumbent's local access network (denote the corresponding weight in the basket by λ);
- the possibility to use the connection to make calls oneself (denote the corresponding weight by $1 - \lambda$).

Parameter λ can be interpreted as a weight, since per-minute prices and subscription fees are both expressed in cents.

The price cap on the basket is denoted by κ. A non-binding price cap will be denoted by the infinity symbol $\kappa = \infty$. In the model, the following restriction on prices is included:

$$\lambda\, p_1 + (1 - \lambda)\, m_1 \leq \kappa.$$

Notice that for $\lambda > 0$ and κ sufficiently small, operator 1 is subject to a joint price cap, while for $\lambda = 0$ and κ sufficiently small, operator 1 is subject to a price cap on the subscription fee only.

This joint price cap can be motivated as follows. Parameters λ and κ can be fixed by the regulator such that a consumer with a certain number of call minutes can enjoy his consumption at a regulated prices. For example, suppose a consumer is willing to pay 60 Euros for 1200 call minutes. The "participation constraint" of this consumer is: $1200\, p_1 + m_1 \leq 6000$, which can be rewritten as $(1200/1201)\, p_1 + (1/1201)\, m_1 \leq 6000/1201$. Accordingly, $\lambda = 1200/1201 \approx 1$, and $\kappa = 6000/1201 = 5.00$.

Weight λ can be used to finely adjust the price cap: increasing λ (for given κ) has a releasing effect on the price cap while the pressure on the subscription fee is reduced.

A “more stringent price cap” indicates a lower value for κ (for given λ), or a lower value of λ (for given κ).[24]

Table 6.2.1. Instruments of policy and regulation

instrument	**description**
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2
λ	weight in price cap operator 1
κ	total price cap operator 1

6.2.2. Terminating access prices

The most basic questions in a situation of competing operators, concerns the level of access prices. These questions include how high they should be, whether they should be reciprocal (i.e., symmetric), whether they should be regulated, and if yes, how. We will first address the height of terminating access prices. Regulation will be addressed in section 6.5.

Intuitively, one may expect that since the access price of one operator increases the other operator’s average marginal cost, operators of equal sizes and with equal market shares should be able to agree on reciprocal, cost-based access prices. Also, this seems to be efficient from a welfare point-of-view. The outcomes confirm this intuition, but also illustrate that in the early stages of competition, when the entrant is still small, the regulator may want to decide differently.

To start, consider the effects of an increase in the reciprocal terminating access price.

[24] An alternative way to define price caps is to use separate caps for the per-minute price and the subscription fee. In cases where our formulation is not optimal, it is dropped. For example, in the case of Carrier Select entry, the incumbent’s subscription fee is fixed and there is a price cap on the per-minute price is separately capped.

Table 6.2.2. Reciprocal terminating access prices / *short run*

$\tau_1 = \tau_2$	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	5.556	422.64	1.46	400.29	424.1	824.39
1.5	5.523	422.1	1.45	400.95	423.55	824.5
2	5.425	420.49	1.41	402.94	421.89	824.83

Table 6.2.3. Reciprocal terminating access prices / *long run* *

$\tau_1 = \tau_2$	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	49.807	119.37	117.54	610.14	236.91	847.05
1.5	49.806	119.37	117.54	610.01	236.91	846.92
2	49.804	119.38	117.53	609.62	236.91	846.53

* The “long run” is in period 15.

Table 6.2.4. Reciprocal terminating access prices / *aggregate over time*

$\tau_1 = \tau_2$	profits 1	profits 2	*CS*	*PS*	*W*
1	3602.06	799.54	7809.72	4401.06	12211.3
1.5	3600.43	799.19	7811.03	4399.62	12210.7
2	3595.5	798.15	7815.05	4393.65	12208.7

We will view access prices equal to marginal costs as the point of departure. Consider an increase in the reciprocal access price. One can make the following observations.

Short run:

The entrant’s market share is slightly reduced. There is a small, positive effect on consumers’ surplus. Both operators’ profits, and therefore also producers’ surplus, are reduced.

Long run:
The effects seem to be negligible. Consumers' surplus is slightly reduced, while profit levels and producers' surplus are hardly affected. Therefore, welfare is slightly reduced.

Aggregate over time:
Both operators' profits are reduced; the incumbent experiences a stronger decrease in profits. Because of the short-run effect, consumers' surplus increases. Overall the effect on welfare is negative but very small.

Intuition
In general, an operator wishes to increase its access price since (i) it results in higher profits (due to revenues from incoming traffic), and (ii) it raises the rival operator's cost, leading to a strategic advantage.

Terminating access revenues make competition more intense. Especially the entrant becomes a tougher competitor. The reason is that if an operator reduces its subscription fee to attract a consumer, it not only gains market share, but also attracts more calls from the other network to that consumer, which is profitable if there is an access markup. Hence a marginal consumer is especially valuable for an operator with a small market share.

From a welfare point-of-view, the best that can be done (the "first-best") is to set access prices equal to marginal costs. An increase in the reciprocal terminating access price leads to an increase of both operators' levels of traffic-dependent costs. Therefore, both operators' per-minute prices increase. Because consumers' demand for call minutes decreases, the operators have to reduce subscription fees. Initially, when the entrant is still small, the entrant reacts by much stronger price cut than the incumbent.

Overall, profits and producers' surplus are hardly affected by an increase in the reciprocal access price. In the short run though, when the entrant still has a small market share, consumers benefit from more intense competition. Also, lower switching costs are incurred since there is less consumer switching. Therefore, consumers' surplus increases initially.

Next, we consider non-reciprocal access prices.

Table 6.2.5. Non-reciprocal terminating access prices / *short run*

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	5.556	422.64	1.46	400.29	424.1	824.39
1	2	5.556	389.32	1.58	433.49	390.9	824.39
1	2	5.556	356.11	1.69	466.58	357.8	824.38
2	1	5.523	455.44	1.33	367.73	456.78	824.5
2	1	5.425	487.21	1.19	336.45	488.39	824.84

Table 6.2.6. Non-reciprocal terminating access prices / *long run*

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	49.807	119.37	117.54	610.14	236.91	847.05
1	2	49.821	110.02	126.76	610.21	236.78	846.99
1	2	49.861	100.83	135.88	610.09	236.71	846.8
2	1	49.793	128.74	108.33	609.92	237.07	846.99
2	1	49.751	138	99.28	609.51	237.28	846.79

Table 6.2.7. Non-reciprocal terminating access prices / *aggregate over time*

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	3602.06	799.54	7809.72	4401.06	12211.3
1	1.5	3319.18	862.3	8029.25	4181.48	12210.7
1	2	3039.44	924.46	8245.11	3963.9	12209
2	1	3883.58	736.53	7591.12	4620.11	12211.2
2	1	4160.25	674.05	7376.7	4834.3	12211

Again, we view access prices equal to marginal costs as the point of departure. Consider the effects of increase in entrant's terminating access price (while incumbent's terminating access price is cost-based).[25] One can make the following observations.

Short run:
The entrant's market share remains unaffected while its profits increase. The incumbent's profits are reduced. There is a strong positive effect on consumers' surplus and a strong negative effect on producers' surplus. The effect on welfare is negligible.

Long run:
The entrant's market share slightly increases while its profits increase substantially. The incumbent's profits are reduced. Moreover, the incumbent's profit reduction roughly equals the entrant's profit increase. The effects on consumers' surplus, producers' surplus, and welfare seem negligible (welfare is slightly reduced).

Aggregate over time:
The entrant's profits increase. The incumbent's profits decrease. There is a positive effect on consumers' surplus and a negative effect on producers' surplus. The effect on welfare seems negligible (welfare is slightly reduced).

Intuition
An increase in the entrant's terminating access price leads to an increase of the incumbent's level of traffic-dependent costs. Therefore the incumbent's per-minute price is increased. To remain competitive, the incumbent has to reduce its subscription fee, which triggers a cut in the entrant's subscription fee. Hence, in the short run consumers benefit from more intense competition. In the long run, when the operators are equally large in terms of market share, this effect vanishes. Notice that the short-term asymmetry is profitable for the entrant.

Robustness
Section 1.3 distinguished three types of robustness. Because this is the first time we discuss policy implications and their robustness, we do it more elaborately than in the rest of part II.

Concerning the first type of robustness, it was already mentioned in chapter 1 that for all models, the outcomes of the simulations are qualitatively robust to changes

[25] Note that the tables also depict situations reverse to those discussed above. An increase in the incumbent's terminating access price while entrant's terminating access price is cost-based is beneficial only for the incumbent. The entrant's market share and profits, and also consumers' surplus, are reduced. The lower welfare level in the long run seems to be a negligible effect.

in cost and demand parameters.[26] Robustness with respect to model specifications will be reported in chapter 9, where we compare the outcomes of the different models. We now turn to the third type of robustness check, namely, robustness to changes in underlying assumptions.

First, suppose that instead of per-period profit maximization, operators maximize the discounted sum of profits over time. In the light of the strategic importance of market shares, which is due to reputation effects and switching-cost induced loyalty, the operators put more weight on a large market share. This leads to more price pressure in general. At the beginning of the game, when the entrant starts with zero market share, the entrant has stronger incentives to cut prices than the incumbent. Presumably, the entrant will try to gain market share fast by cutting prices and revert to per-period profit maximization when its market share is substantial and the division of the market has stabilized.[27] In the short run therefore, more intense price competition is beneficial for consumers, and the entrant gains market share at a faster rate. The long-run implications of the model do not seem to change substantially, although competition may become more intense. The conclusion is that the importance of access price regulation might be less prominent in the short run, while long-run policy implications remain unchanged, at least qualitatively. There is an evident consequence for the time-dependent asymmetric access price regulation. Since the entrant's market share grows much faster, the regulator can switch to reciprocal access prices equal to costs at an earlier stage.

If the entrant competes aggressively for market share in the short run, the largest risk for consumers is perhaps that the entrant fails to deliver the promised quality.[28] It is generally outside the scope of a regulator to interfere if such problems arise, although monitoring the market and informing consumers about the risks that are involved seems appropriate. Also, since the delivery of a certain level of quality in telecommunications critically depends on market forecasts and capacity investments, a predictable regulatory environment is very helpful to the entrant and consumers. That is one of the reasons why it is so important that the regulator informs the market about its regulatory principles as soon as possible, and commits to it. Regulatory certainty will also reduce the risk that the entrant may go bankrupt (which harms the development of competition and therefore

[26] Many simulations were performed during the research stage of the project. For the sake of exposition, these are not reported here.

[27] We acknowledge but abstract from the possibility that under dynamic optimization, competition in the long may be more intense if firms give more priority to market shares. This abstraction does not seem to affect the conclusions of this discussion.

[28] Recently, there have been many complaints about the quality delivered by providers of broadband internet access. Typically in the market for internet access, firms want to grow very fast.

also consumers' surplus). Arguably, the risk of bankruptcy is higher if the entrant maximizes market share in the short run.

Second, suppose that there is more than one entrant. A likely effect is that the increased number of operators introduces more downward pressure on prices. Consumers typically benefit from increased competition, which at least at first sight suggests that the role of access price regulation becomes less prominent. However, more entry may lead to lower market shares and profits per entrant. In particular the reduced market shares may harm them, given the strategic importance of market shares (due to reputation and loyalty effects). Accordingly the incumbent can remain relatively large, compared to the situation with a single entrant, and its dominant position is maintained during a longer period of time. Hence it is now even more important to take entrants' market share and profits into account for the regulator. This enforces our earlier arguments related to access price regulation.

Third, consider the growing market for internet access. Perhaps the most pressing problem is that the growth in internet traffic may lead to network congestion at the points of interconnection with the incumbent's network. A possible consequence is that entrants, and also internet service providers (ISPs) using an entrant's network, are disadvantaged. Capacity problems can be circumvented by diverting internet traffic away from regular voice traffic on the incumbent's PSTN (for instance by using special phone numbers for internet access). Since this is a realistic policy option,[29] there are no indications that the growth in internet traffic will interfere with the earlier conclusions tailored to voice traffic (which doesn't experience the steep growth of the internet market). Interconnection fees paid by the incumbent to an entrant hosting an ISP are very important, however, since ISPs may financially depend on "kickbacks" paid out of these fees. This issue is outside the scope of this study.

Policy implications

Consumers' surplus is maximized over time if the entrant's access price is relatively large initially and tends towards its underlying cost level as the entrant gains market share. The incumbent's access price should be equal to cost throughout time. Access regulation of this type, which essentially does not affect how fast the entrant gains market share, initially skims the incumbent's profits, while increasing the entrant's profits, and hence its incentives to build local infrastructure.

[29] In the Netherlands, Opta intends to apply this option. See e.g. http://www.opta.nl.

6.2.3. Price cap regulation

In this section we consider a joint price cap on the incumbent's subscription fee and per-minute price, as was introduced in section 6.2.1. Recall that in section 6.2.2, without price cap regulation, the operators choose per-minute prices equal to their traffic-dependent costs, and use subscription fees to exercise market power. This result may no longer hold under price cap regulation. Intuitively, a price cap may make it impossible for the incumbent to choose the optimal (i.e., profit-maximizing best response) subscription fee, triggering a deviation by the entrant as well. Accordingly, the price structure observed in section 6.2.2 will be distorted, and expectedly, the operators will no longer set their per-minute prices at the marginal cost level.

Table 6.2.8. Price cap regulation / *short run*

λ	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	5.556	422.64	1.46	400.29	424.1	824.39
0	7500	4.072	414.34	0.79	414.01	415.12	829.14
0	6000	1.619	393.25	0.12	436.92	393.37	830.3
0	7500	4.19	415.12	0.83	412.92	415.96	828.87
0	6000	1.724	394.33	0.14	435.94	394.47	830.41
0.1	6000	2.739	404	0.36	426.43	404.36	830.79

Table 6.2.9. Price cap regulation / *long run*

λ	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	49.807	119.37	117.54	610.14	236.91	847.05
0	7500	49.807	119.37	117.54	610.14	236.91	847.05
0	6000	49.794	119.43	117.48	610.14	236.91	847.05
0	7500	49.807	119.37	117.54	610.14	236.91	847.05
0	6000	49.797	119.42	117.5	610.14	236.91	847.05
0.1	6000	49.807	119.37	117.54	610.14	236.91	847.05

Table 6.2.10. Price cap regulation / *aggregate over time*

λ	κ	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	3602.06	799.54	7809.7	4401.1	12211.3
0	7500	3597.8	793.38	7837.2	4391.2	12228.4
0	6000	3547.66	745.3	7965.1	4293	12258.1
0	7500	3598.6	794.49	7833.2	4393.1	12226.3
0	6000	3551.39	748.41	7958.1	4299.8	12257.9
0.1	6000	3579.66	773.77	7896.4	4353.4	12249.8

The following table complements the tables above. It tells us how long the considered price caps are binding.

Table 6.2.11. Periods in which price cap is binding

λ	κ	periods
0	∞	none
0	7500	1,...,5
0	6000	1,...,12
0	7500	1,...,5
0	6000	1,...,12
0.1	6000	1,...,9

Now consider the effects of more stringent price cap on incumbent's prices. We view the situation without binding price caps as a point of departure. One can make the following observations.

Short run:
The incumbent's profits, and the entrant's market share and profits, are strongly reduced. Hence producers' surplus decreases. Consumers' surplus and welfare increase.

Long run:
In the long run, the price cap is no longer binding. Over time, the entrant is able to recover from its initially lower market share. Given that the entrant remains active in the market, there is no harm in the long run.

Aggregate over time:
Both operators' profits, and hence producers' surplus, are reduced. There is a positive effect on consumers' surplus and welfare.

Intuition
As long as the incumbent's price cap is binding (lowering the incumbent's prices), the entrant indirectly experiences more downward pressure on its prices and is forced to reduce prices as well. Hence both operators suffer from the price cap, while the entrant gains market share much more slowly. However, consumers benefit from lower prices.

Robustness
Just as in section 6.2.2, we start by discussing the role of the assumption of myopic optimization. Recall that a dynamic entry strategy will put more weight on a large market share. Consequently, the entrant will try to gain market share faster by setting lower prices. This creates downward pressure on the incumbent's prices, so that the need for price cap regulation diminishes (given that the incumbent does not have captive customers in the model analyzed here; an assumption that is dropped in section 8.2). Suppose that the incumbent's prices are reduced, due to a tighter price cap. In order to reinforce its short-term aim to gain market share, the entrant has to reduce its prices further. As a consequence, price cap regulation makes entry less attractive. Summarizing, although one cannot conclude that the need for price cap regulation vanishes, one can argue that it is reduced, or that a price cap should be less tight.

Another assumption of the model is that there is a single entrant. If there are several entrants, market share and profits per entrant decrease, due to increased competition. Also the incumbent experiences more downward price pressure. Therefore, also in this case the conclusion is that price cap regulation can be softened to some extent.

One can learn from these robustness exercises on a more general level. If the entrant (or entrants) for some reason adopt a more aggressive stance in the short run, then (i) the incumbent experiences more downward pressure on its prices, and (ii) maintaining a tight price cap hurts the entrant more than before. Therefore, it makes sense to make price cap regulation less tight, to a certain extent. Overall, the general, qualitative policy implications are not affected.

Policy implications
In the short run, when the entrant is still too small to exert serious competitive pressure, price cap regulation is good for consumers' surplus. A drawback is that a price cap for the incumbent forces the entrant to decrease prices as well (even though the price cap is not binding for the entrant). A consequence is that the entrant's incentives to build a local network are weakened: price cap regulation makes entry less attractive. Summarizing, price cap regulation may be needed in the short run, but because of its strong impact on the entrant in the early phase of competition, it is important to set the levels of price caps correctly.

6.3. Local loop unbundling

6.3.1. Model

In the model, LLU depicts access to the local line through the main distribution frame (MDF), sometimes also denoted by "copper loop rental." This type of access is often considered as the most relevant type of access to stimulate competition.[30] Under MDF access, a connection to a customer of the incumbent, which consists of a local line (the connection to the customer up to and including the MDF) is unbundled. Hence an entrant can "plug in" by creating a link from its switch to the incumbent's MDF, allowing for access to the transmission medium in the local loop. This makes it possible for the entrant to operate its own transmission system to provide access, and to take over the incumbent's subscriber.

Some new notation is needed for the parameters associated with the components of connections to customers (see the appendix to this chapter for a more detailed explanation of these cost parameters). In particular, the entrant gets access to the "raw copper," but still has to provide a transmission system.[31] Hence it incurs a traffic-independent cost.

Table 6.3.1. Instruments of policy and regulation

instrument	**description**
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2
λ	weight in price cap operator 1
κ	total price cap operator 1
L	lease price of local line (line rental)

Unbundling of the local loop allows an entrant to take over subscribers from the incumbent while changing both operators' structure of connection-dependent, traffic-independent costs. We abstract from possible changes of the operators' traffic-dependent

[30] See e.g. Opta (1998, p. 19) and European Commission (2000a, b, c).

[31] Since we focus on basic voice telephony, we abstract from complications that arise if the entrant wishes to provide high-speed data services through an xDSL technology.

costs. Therefore terminating access prices play the same role in LLU as in FBC (see the previous section for an analysis of the role of access prices). Also, the model does not incorporate implementation issues (e.g. collocation) related to LLU (see Opta, 2000c, for an overview of open issues).

6.3.2. Lease price of local line

The central question in a situation of LLU is the level of the lease price of the incument’s local line. The higher it is, the larger is the traffic-independent cost of a connection incurred by the entrant. Therefore one expects that an increase in the lease price results in higher subscription fees. As long as no price caps are effective, per-minute prices are not influenced. Indeed, optimal per-minute prices are then equal to average marginal costs, which are not affected by the fixed cost of connections.

Table 6.3.2. Lease price of local line / *short run* *

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	5.556	422.64	1.46	400.29	424.1	824.39
2000	5.556	454.22	1.46	368.7	455.69	824.39
2400	5.556	485.81	1.46	337.12	487.27	824.39

* $\tau_1 = \tau_2 = 1$.

Table 6.3.3. Lease price of local line / *long run* *

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	49.807	119.37	117.54	610.14	236.91	847.05
2000	49.807	150.96	117.54	578.55	268.5	847.05
2400	49.807	182.55	117.54	546.96	300.09	847.05

* $\tau_1 = \tau_2 = 1$.

Table 6.3.4. Lease price of local line / *aggregate over time* *

L	profits 1	profits 2	*CS*	*PS*	*W*
1600	3602.06	799.54	7809.72	4401.06	12211.3
2000	4075.88	799.54	7335.9	4875.42	12211.3
2400	4549.7	799.54	6862.08	5349.24	12211.3

* $\tau_1 = \tau_2 = 1$.

Given a cost-based lease price as our point of departure, we consider the effects of an increase in the lease price of the incumbent’s local line. One can make the following observations.

Short run, long run, and aggregate over time:
The entrant’s profits and market share are not affected. The incumbent’s profits are strongly increased, so that producers’ surplus increases. Consumers’ surplus decreases, while welfare is not affected.

Intuition
Both operators' subscription fees are increased, each in the same order of magnitude as the increase of the lease price. Per-minute prices are not affected. The incumbent's profits increase because of the mark-up in the lease price. The entrant faces a higher traffic-independent input cost but is able to pass this on to consumers. Therefore, the entrant's profits are not affected. Hence, allowing the incumbent to include a mark-up in the lease price of the local line results in a "transfer" from consumers to the incumbent, without any change in the competitive landscape (i.e., market shares are not affected). In order to maximize consumers' surplus, the line rental should be cost-based.

Robustness
The fact that market shares are not affected in the model depends on the assumptions that all consumers have a sufficiently high willingness to pay, and an inelastic demand for a single connection. In reality, it may well be the case that the entrant's market share is reduced from a more disadvantageous cost position.

Consider again the role of the assumption of myopic optimization. Suppose that the entrant puts more weight on market share, especially in the early periods. The entrant tries to gain market share by setting lower prices, creating downward pressure on the incumbent's prices in the short run. Recall that in the model, market shares are not affected if the line rental increases. This result probably no longer holds here, because it directly depends on the operators' profit functions and mode of optimization. Instead, it may happen an increase of the lease price, as it increases the entrant's cost level, interferes with its strategy to gain market share fast, in the sense that its subscription fee increases, and it becomes more difficult to gain market share. Consumers face higher subscription fees.

If there are several entrants, one can argue along the same lines that a higher lease price of the incumbent's local loop marginalizes the entrants. While a formal analysis is needed to assess exactly how competition is affected, presumably in both situations a markup in the lease price hurts entrants as well as consumers, who have to pay higher subscription fees. Summarizing, both from the viewpoint of entrants and consumers, there should not be a markup in the line rental. This enforces the policy implication of the model.

So far, we have ignored the effects of the line rental on the entrant's incentives to invest in a customer access network. These will be discussed in section 6.5.4.

Policy implications
Taking the LLU situation as given and abstracting from the entrant's incentives to build its own local network, the lease price of the local loop should be equal to the fixed cost of the local line. See section 6.5.4 for a discussion of the entrant's incentives to invest in infrastructure.

6.3.3. Price cap regulation

In this section we consider a joint price cap on the incumbent's subscription fee and per-minute price (see also section 6.2.1). Just as in FBC, the structure of two-part tariffs where per-minute prices are equal to average marginal costs, is distorted, because of the downward pressure on subscription fees. To start with, we look at the effects of price cap regulation for a given line rental.

Table 6.3.5. Price cap regulation / *short run* *

λ	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	5.56	454.22	1.46	368.7	455.69	824.39
0	7500	3.44	441.37	0.56	388.3	441.93	830.23
0	8000	4.23	446.96	0.85	380.98	447.8	828.78
0	8500	5	451.5	1.18	373.84	452.68	826.53

* The lease price of local line is set at L = 2000. $\tau_1 = \tau_2 = 1$.

Table 6.3.6. Price cap regulation / *long run* *

λ	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	49.81	150.96	117.54	578.55	268.5	847.05
0	7500	49.81	150.96	117.54	578.55	268.5	847.05
0	8000	49.81	150.96	117.54	578.55	268.5	847.05
0	8500	49.81	150.96	117.54	578.55	268.5	847.05

* The lease price of local line is set at L = 2000. $\tau_1 = \tau_2 = 1$.

Table 6.3.7. Price cap regulation / *aggregate over time* *

λ	κ	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	4075.88	799.54	7335.9	4875.42	12211.3
0	7500	4065.33	786.03	7387.84	4851.36	12239.2
0	8000	4072.65	794.78	7358.3	4867.43	12225.7
0	8500	4075.42	798.66	7347.18	4874.07	12215.3

* The lease price of local line is set at L = 2000. $\tau_1 = \tau_2 = 1$.

We will only make a few brief comments. A price cap on operator 1's subscription fee plays the same role in LLU as in the FBC. However, the *level* of the price cap may need to be adjusted to account for the effects of a markup in the lease price of the local line. The effects of a given price cap regime and a mark-up in the line rental on an entrant's incentives to choose FBC or LLU entry are discussed in section 6.5.2.

It is also interesting to consider the effect of changes of the lease price given a certain price cap regime. Consider, for example, parameters $\kappa = 8000$ and $\lambda = 0$. Tables 6.3.8-6.3.9 depict outcomes in the short run and aggregate over time, The long-run outcomes remain unchanged, because the price cap is not binding in the long run (see table 6.3.6).

Table 6.3.8. Lease price of local line under price cap regime / *short run* *

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	4.846	419.08	1.11	406.85	420.2	827.04
2000	4.228	446.96	0.85	380.98	447.8	828.78
2400	3.599	474.16	0.61	355.23	474.78	830.01

* $\tau_1 = \tau_2 = 1$, $\kappa = 8000$, $\lambda = 0$.

Table 6.3.9. Lease price of local line under price cap regime / *aggregate over time* *

L	profits 1	profits 2	*CS*	*PS*	*W*
1600	3601.31	798.25	7817.22	4399.55	12216.8
2000	4072.65	794.78	7358.3	4867.43	12225.7
2400	4541.09	788.25	6907.13	5329.34	12236.5

* $\tau_1 = \tau_2 = 1$, $\kappa = 8000$, $\lambda = 0$.

The main observation is that the entrant is no longer able to pass on the markup in the line rental to consumers. One can easily see from the tables that, similar to the situation without price cap regulation, the line rental should be cost-based to maximize consumers' surplus. Moreover, price cap regulation can alleviate the detrimental effect on consumers' surplus of an increase of the line rental. The precautions on price cap regulation, discussed in section 6.2.3, also apply here.

6.4. Carrier Select and Carrier Preselect

6.4.1. Model

The setting is as follows (see the appendix of this chapter for the details of the model). Operator 2 only has a long-distance backbone.[32] To have access to end-users, it uses originating access via a Carrier Select or Preselect service (the difference between selecting an entrant on a per-call basis or one-and-for-always, is not relevant for the model).

Operator 1's originating access price is denoted by δ_1. Operator 2's traffic-dependent cost of its backbone is denoted by c_{24}.

A consumer selecting operator 2's network to carry his calls, keeps his subscription to the incumbent. Therefore, he can continue to enjoy the fixed utility of having a connection to operator 1's network. Still, since a consumer who wants to use the Carrier Select service has to register with the entrant, the assumption on consumer switching costs remains valid and plausible.

In reality, there is often limited interconnection capacity to provide Carrier Select services (see Opta, 2000). Suppose that there is a small probability, denoted by α, that a consumer who tries to make a call through Carrier Select, gets the "busy" tone, that is, he experiences that he does not get a connection although the called party is not engaged. If this happens, we assume that he uses his regular subscription to the incumbent's network to establish a connection.

We assume that α does not change over time, as the entrant gains market share. Arguably, in reality α increases over time, as the entrant generates more traffic. However, an argument against this is that the incumbent gradually is able to increase the interconnection capacity over time, thereby reducing α. A constant parameter α captures both tendencies.

Because all consumers subscribe to operator 1, the incumbent has an incentive to choose its subscription fee m_1 as high as possible. Therefore the regulator must put a cap on operator 1's subscription fee. We will actually assume that the subscription fee is fixed by the regulator (this is not restrictive since any price cap will be binding in the model). In addition, the regulator may use a price cap on operator 1's per-minute price. For simplicity, we assume that the incumbent's subscription fee is fixed by the regulator, while the cap on its per-minute price is denoted by κ:

$$p_1 \leq \kappa.$$

[32] Alternatively, one can assume that the entrant buys spare capacity from the incumbent. What matters is that the entrant's long-distance traffic dependent cost is substantially lower than the incumbent's, either due to discounts on the wholesale market, or to a higher efficiency level.

Table 6.4.1. Instruments of policy and regulation

instrument	**description**
m_1	regulated subscription fee
κ	price cap on p_1
τ_1	terminating access price charged by operator 1
δ_1	originating access price charged by operator 1

6.4.2. Capacity shortage of Carrier Select service

We start by looking at the effects of a capacity shortage. Intuitively, one expects that limited capacity harms the entrant as well as consumers, while it enables the incumbent to hold on to its strong position in the market. We will see, however, that the picture is not as simple as that.

A small warning is in place: in the model, a consumer who switches to the entrant but is unable to get a connection, can costlessly switch back to the incumbent (recall that they still subscribe to the incumbent's network). Therefore, by construction, a capacity shortage does not necessarily lead to a lower level of consumers' surplus. Obviously such outcomes should be understood within the framework of the model, since in reality, consumers who decide to switch will be dissatisfied if they do not get the quality that they expect. We have chosen not to incorporate consumers' irritation into the model.

Table 6.4.2. Capacity shortage of Carrier Select service / *short run* *

α	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	29.504	193.68	36.54	569.73	230.22	799.95
0.1	∞	27.964	218.48	39.55	528.1	258.03	786.13
0.2	∞	25.575	245.05	40.73	482.77	285.78	768.55
0	5	22.217	172.73	21.42	625.77	194.15	819.91
0.1	5	17.996	180.62	17.35	623.55	197.97	821.52
0.2	5	14.219	187.68	13.71	621.56	201.39	822.95

* $\tau_1 = \delta_1 = 1$.

Table 6.4.3. Capacity shortage of Carrier Select service / *long run* *

α	κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	50	121.66	94.42	611.82	216.08	827.9
0.1	∞	50	136.22	108.97	574.1	245.19	819.29
0.2	∞	50	152.04	124.79	529.58	276.83	806.41
0	5	49.33	122.02	92.25	614.1	214.26	828.36
0.1	5	39.957	139.55	74.72	614.09	214.27	828.36
0.2	5	31.571	155.23	59.04	614.09	214.27	828.36

* $\tau_1 = \delta_1 = 1$.

Table 6.4.4. Capacity shortage of Carrier Select service / *aggregate over time* *

α	κ	profits 1	profits 2	*CS*	*PS*	*W*
0	∞	1944.41	1313.78	9126.66	3258.19	12384.8
0.1	∞	2188.59	1505.03	8554.44	3693.62	12248.1
0.2	∞	2463.83	1699.82	7882.55	4163.65	12046.2
0	5	1947.21	1205.16	9268.77	3152.37	12421.1
0.1	5	2187.93	976.18	9257.82	3164.11	12421.9
0.2	5	2403.32	771.3	9248.02	3174.62	12422.6

* $\tau_1 = \delta_1 = 1$.

We view the situation without a capacity shortage and without a price cap on the incumbent's per-minute price as point of departure. Consider the effects of an decrease in capacity of the Carrier Select service. One can make the following observations.

Short run:

- Suppose the incumbent's per-minute price is not subject to a price cap ($\kappa = \infty$). Although the entrant's market share is negatively affected, both operators benefit in terms of profits. There is a strong negative effect on consumers' surplus, while welfare is reduced as well.
- Suppose the incumbent's per-minute price is subject to a price cap ($\kappa = 5$). Now only the incumbent benefits from the capacity shortage, while the entrant's market share and profits are substantially reduced. Consumers' surplus is slightly reduced, while producers' surplus slightly increases. There is a small positive effect on welfare.

Long run:

- Suppose the incumbent's per-minute price is not subject to a price cap ($\kappa = \infty$). The entrant's market share is not affected. Both operators benefit in terms of profits. There is a strong negative effect on consumers' surplus, while welfare is reduced as well.
- Suppose the incumbent's per-minute price is subject to a price cap ($\kappa = 5$). Now only the incumbent benefits from the capacity shortage, while the entrant's market share and profits are substantially reduced. The effects on producers' surplus, consumers' surplus and welfare are negligable.

Aggregate over time:

- Suppose the incumbent's per-minute price is not subject to a price cap ($\kappa = \infty$). Both operators benefit from the capacity shortage. Consumers' surplus and welfare are reduced.
- Suppose the incumbent's per-minute price is subject to a price cap ($\kappa = 5$). The incumbent benefits from the capacity shortage, while the entrant's profits are substantially reduced. Consumers' surplus is slightly reduced, while producers' surplus slightly increases. There is a small positive effect on welfare.

Intuition

Without a price cap, the incumbent benefits from the entrant's capacity problems. Therefore it can increase its per-minute price. Consequently, the price pressure faced by the entrant is reduced. Thus a capacity shortage softens price competition, resulting in a lower market share for the entrant (although it can catch up in the long run), and higher profits for both operators.

If there is a price cap on the incumbent's per-minute price, then competition is not softened due to a capacity shortage. Hence the entrant's profits decrease. Its market share also decreases. Recall that the positive effect on consumers' surplus in the long run is due to the fact that consumers can costlessly "switch back" to the incumbent if they experience a capacity shortage.

In order to maximize consumers' surplus, and taking into account that consumers will experience dissatisfaction from failed connections, the conclusion is that capacity shortages should be minimized. As long as there still is a capacity problem, price cap regulation can prevent the softening of price competition. It should be noticed, though, that the incumbent has strong incentives to maintain the capacity shortage.

Robustness

Concerning the assumption of myopic optimization, one can argue that the entrant initially is not very eager to put more weight on market share, relative to profits. This is an important difference with the FBC and LLU models of sections 6.2-6.3. To see this, notice that a price cut leads to a sharp increase in the volume of Carrier Select traffic. Thus, for a given, installed capacity to interconnect, the probability of getting no connection increases, and Carrier Select users experience a serious quality degradation. Therefore, by using an aggressive price strategy, the entrant actually bites in its own tail. Accordingly, the assumption that per-period profits are maximized, is compatible with a dynamic entry strategy.

If there is more than one entrant, the downward pressure on the per-minute price becomes stronger. Consequently, for a given, installed capacity to interconnect, the probability of getting no connection increases for Carrier Select users. The negative consequences for entrants' profits may be offset somewhat by the fact that the incumbent is then able to increase its per-minute price, somewhat reducing price pressure in the market. However, it seems unlikely that the entrants benefit from less intense competition. In particular, a large number of small entrants may maintain itself for a long time, since each single entrant finds it more difficult to build up a brand name and reputation. Small entrants have difficulty to get out of this vicious circle if the capacity problems are not resolved. Especially with more entrants, it is crucial to reduce the capacity shortage as soon as possible.

Also, if there are several entrants with rather unfavorable prospects to capture market share, an entrant has less to lose and may be willing to take higher risks. For instance, an entrant can undercut other entrants, trying to capture market share from its competitors (inducing them to exit the market), and hoping that the incumbent will increase capacity soon. However, since each entrant may argue along these lines, it is best to eliminate the capacity shortage as soon as possible.

In section 6.4.3, we discuss the effects on Carrier Select operators of price squeezes in the light of the observed growth in internet access traffic.

Policy implications
If the incumbent faces competition from an entrant that offers Carrier Select services to consumers, and if there is no downward pressure on the incumbent's subscription fee from other sources (e.g., competition in other market segments) the incumbent's subscription fee must be regulated. Capacity shortages that lead to failures in Carrier Select connections should be minimized to maximize consumers' surplus. As long as capacity problems are not yet solved, price cap regulation of the incumbent's per-minute price can reduce the harm to consumers. Insufficient interconnection capacity makes it difficult for entrants to gain market share and become strong competitors.

6.4.3. Originating and terminating access prices

For the sake of exposition, we will first try to assess the effects of access prices without possible distortions caused by a capacity shortage or a price cap on operator 1's per-minute price. Therefore, we start with the case in which $\alpha = 0$ and $\kappa = \infty$.

Expectedly, in a situation of CSC, the effects of access prices will diverge from the effects in situations of FBC and LLU. The reason is that an operator who only offers Carrier Select services, but does not own or lease local lines to have direct access to consumers, has to pay the entrant for access but does not receive any access revenues itself. Because of this asymmetry, only the entrant (and not the incumbent) suffers from high access prices.

In the robustness discussion, we will pay explicit attention to price squeezes in the light of growing internet access traffic (see also Opta, 2000b).

Table 6.4.5. Originating and terminating access prices / *short run*

δ_1	τ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	29.504	193.68	36.54	569.73	230.22	799.95
1	2	28.598	218.94	34.21	540.18	253.14	793.32
1	2	27.577	241.7	31.71	512.55	273.41	785.96
2	1	28.598	218.94	34.21	540.18	253.14	793.32
2	1	27.577	241.7	31.71	512.55	273.41	785.96
2	2	27.577	241.7	31.71	512.55	273.41	785.96
2	2	25.162	279.99	26.28	463.36	306.27	769.63

Table 6.4.6. Originating and terminating access prices / *long run*

δ_1	τ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	50	121.66	94.42	611.82	216.08	827.9
1	2	48.88	150.76	89.38	580.83	240.14	820.97
1	2	47.6	177.71	83.97	551.45	261.68	813.13
2	1	48.88	150.76	89.38	580.83	240.14	820.97
2	1	47.6	177.71	83.97	551.45	261.68	813.13
2	2	47.6	177.71	83.97	551.45	261.68	813.13
2	2	44.446	225.34	72.02	497.79	297.35	795.14

Table 6.4.7. Originating and terminating access prices / *aggregate over time*

δ_1	τ_1	profits 1	profits 2	*CS*	*PS*	*W*
1	1	1944.41	1313.78	9126.66	3258.19	12384.8
1	1.5	2376.11	1242.18	8662.62	3618.29	12280.9
1	2	2774.93	1165.4	8223.14	3940.33	12163.5
1.5	1	2376.11	1242.18	8662.62	3618.29	12280.9
2	1	2774.93	1165.4	8223.14	3940.33	12163.5
1.5	1.5	2774.93	1165.4	8223.14	3940.33	12163.5
2	2	3476.94	995.76	7421.89	4472.7	11894.6

Viewing cost-based access prices as our point of departure, we consider the effects of an increase in originating or terminating access price. First of all, an important observation is that in this model and under the current set of parameters, it is the sum of the access prices $\delta_1 + \tau_1$ which matters for the outcomes, not the separate levels. Furthermore, one can make the following observations.

Short run, long run, and aggregate over time:
The entrant's market share and profits decrease, while the incumbent's profits increase. Consumers' surplus is reduced and producers' surplus increases. Overall, welfare decreases.

Intuition
An increase in either access price of the incumbent increases the entrant's traffic-dependent cost. Consequently, each operator increases its per-minute price: the entrant's price increase is a direct consequence of the higher traffic-dependent cost, while the incumbent's price increase is a strategic reply to the entrant's price strategy. The incumbent's revenues from on-net calls as well as from incoming traffic increase, while the entrant's revenues from traffic decrease. In order to maximize consumers' surplus, originating and terminating access prices should be cost-based.

Robustness
Consider maximization of total profits over time. In particular, suppose that initially, especially the entrant puts more weight on market share, relative to short-term profits. Then, there are no indications that higher originating and terminating access prices are now good for consumers' surplus or the entrant. Access markups translate into higher prices for consumers, and the risk of bankruptcy increases for the entrant in the short run. Similar to section 6.2.2, the long-run implications of the model probably won't change substantially, although competition may become more intense due to the stronger focus on market shares.

Now consider the possibility that it is the *incumbent* that adopts a more aggressive strategy (in accordance with a dynamic strategy), putting more emphasis on maintaining its market share, or even preventing entry. We will argue that in a situation of Carrier Select-based competition, (i) a predatory strategy can be rational for the incumbent, and (ii) the growth in internet traffic through local telephony makes this a realistic danger.

Note that the entrant, at some point in time, has to start making positive profits to cover its fixed investment costs at some point in time. If this takes too long, the entrant may have to exit the market. In general, therefore, competition authorities have to watch out for predatory pricing by the incumbent. Assuming that straightforward predatory pricing is effectively prevented, we turn to a more subtle possibility for predatory behavior, based on price squeezes (see Opta, 2000b).

To see this, notice that even if a Carrier Select operator is more efficient than the incumbent, a high originating access price, creating a price squeeze if the incumbent's retail price is sufficiently low, can bring the entrant into trouble. Because Carrier Select operators have no customer access network, they cannot provide local telephony at a lower cost (and price) than the incumbent without incurring losses. Nevertheless, to be able to offer a complete range of services, they may choose to offer local calls at a competing price while incurring the associated losses.

Next, note that phone numbers for internet access are typically local numbers. Accordingly, because of the strong growth in the demand for internet access, more and more losses are imposed on Carrier Select entrants, who ultimately have to discourage their customers to use the Carrier Select service to dial internet access numbers. They may even advise their customers to use the incumbent's network for internet access, or increase their prices to a prohibitive level,[33] leading to a marginalization of entrants. In the light of the strategic importance of market shares (due to loyalty and reputation effects), the prospects of competition are then seriously damaged, not only in the market for internet access, but only in the market for local and long-distance voice telephony. The conclusion is that an access markup can be very harmful for entrants.

Notice that we have ignored the possibility that the originating price may be different for voice telephony (calls from one telephone to another) and internet access (calls that terminate at an ISP); however, this is not crucial here. The discussion above suggests that a markup in either access price harms entrants and their prospects to grow into significant competitors.

Finally, some remarks on the single-entrant assumption. If there is more than one entrant, the downward pressure on the per-minute price becomes stronger. Any access markup leads to higher per-minute prices, which is bad for consumers. Again it becomes more crucial for the viability of entry that there are no access markups. The policy implication of the analysis above concerning access prices seems to be quite robust.

So far we have ignored the effect of access prices on the entrant's incentives to build its own customer access network. These effects are discussed in section 6.5.4.

Policy implications

Taking the CSC situation as given and abstracting from the entrant's incentives to build its own local network, originating and terminating access prices should be cost-based. Not only from the viewpoint of consumers' surplus (access markups inflate retail prices), but also to prevent price squeezes that may marginalize Carrier Select entrants, especially in the light of the growth in (local) internet access traffic. See section 6.5.4 for a discussion on the entrant's incentives to invest in infrastructure.

To conclude this section, we briefly move to a situation that is closer to current reality (as a last robustness check). Consider the case in which $\alpha = 0.10$ and $\kappa = 5$, that is, the entrant has to cope with a significant capacity shortage, while the incumbent's per-minute price is subject to a price cap.

[33] In the Netherlands, Carrier Select operator Tele2 recently advised customers to use incumbent KPN Telecom's network, while operator One.Tel increased its price to prevent losses. See Financieele Dagblad, 19 October 2000, p.3.

Table 6.4.8. Originating and terminating access prices / *short run* *

δ_1	τ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	17.996	180.62	17.35	623.55	197.97	821.52
2	2	11.55	200.38	7.34	617.98	207.72	825.7
2	2	5.552	211.05	1.75	614.98	212.8	827.78

* $\alpha = 0.10$ and $\kappa = 5$.

Table 6.4.9. Originating and terminating access prices / *long run* *

δ_1	τ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	39.957	139.55	74.72	614.09	214.27	828.36
2	2	24.593	183.62	30.66	614.08	214.28	828.35
2	2	11.419	207.16	7.12	614.08	214.28	828.35

* $\alpha = 0.10$ and $\kappa = 5$.

Table 6.4.10. Originating and terminating access prices / *aggregate over time* *

δ_1	τ_1	profits 1	profits 2	*CS*	*PS*	*W*
1	1	2187.93	976.18	9257.82	3164.11	12421.9
1.5	1.5	2791.04	404.16	9228.81	3195.2	12424
2	2	3115.64	94.46	9214.94	3210.1	12425

* $\alpha = 0.10$ and $\kappa = 5$.

Again with cost-based access prices as our point of departure, consider the effects of an increase in originating or terminating access price. It is straightforward to see that similar to the previous case ($\alpha = 0$ and $\kappa = \infty$), originating and terminating access prices should be cost-based. Indeed, with an access markup, the entrant's market share and profits decrease dramatically, while consumers' surplus is reduced (especially in the short run).

6.5. Summary of implications for policy and regulation

6.5.1. Policy implications

In this section, conclusions for policy and regulation are drawn from the observations on the outcomes of the models earlier in this chapter. Policy implications are based on the criterion of maximizing consumers' surplus, while taking into account the entrant's profits and market share, and more generally, possible reductions of both operators' profit levels. The entrant's profit level is particularly important, as it gives an indication of the incentives to enter the market.

In the policy implications on access prices, we often refer to access prices equal to marginal cost. For simplicity, we abstract from a supplementary markup that may be needed if cost-based access prices prevent the incumbent from breaking even.

In this subsection, the entry strategy of the entrant is taken as given. Section 6.5.2 takes a broader perspective by considering how regulation can influence the incentives of an entrant to choose for a particular entry strategy. In particular, in that section we discuss how a dynamic regulation rule can be helpful to create competition in the short run by giving an entrant easy access to the incumbent's network, and increase the entrant's incentives to build its own customer access network over time.

Facilities-based competition
The following implications for policy and regulation are valid *given that there is entry that creates a situation of facilities-based competition*.

Terminating access prices

- In the short run, the entrant's profits and consumers' surplus can be increased by asymmetric regulation in which the incumbent's access price is equal to marginal cost, and the entrant's access price temporarily includes a markup. Then, consumers' surplus and the entrant's profits are increased. Although the speed of entry (measured by the entrant's market share) is not necessarily affected, the incentives to enter and build a customer access network become stronger. (Free negotiation of access prices between a large, dominant incumbent and a small entrant may not result in the desired outcome, so that regulation of access prices may be needed.)
- In a mature market, that is, when the operators are on a more equal footing, reciprocal and cost-based terminating access prices are best for both producers and consumers.
- Because optimal access prices change over time, it is important that the regulator announces at an early stage the regulatory principles and credibly commits to them.

- The moment at which regulation can switch from asymmetric regulation to reciprocal, cost-based access prices depends on the speed at which the entrant gains market share. If the entrant competes very aggressively in the early periods, resulting in faster growth, the switch can take place earlier than if the entrant "myopically" maximizes per-period profits.

Price cap regulation

- Price cap regulation implies a tradeoff between producers' surplus and consumers' surplus. A price cap for the incumbent decreases both operators' profit levels, while consumers benefit. Hence subjecting the incumbent to price cap regulation may be useful in the early stages of competition, although the entrant's short-run prospects seriously deteriorate. The reason is that, although a price cap meant for the incumbent need not be binding for an entrant, the latter operator experiences more downward pressure on its prices if the incumbent's prices are reduced.
- Price cap regulation can fade away if the entrant's market share has become substantial. Operators should be able to form expectations about the length of time that the regulation will apply. Early announcement of the principles adopted by the regulator, combined with credible commitment, is vital.
- The intensity of competition affects the optimal price cap level. If the disciplinary force of entry on the incumbent is stronger, for instance because the entrant tries to gain market share at a high speed, or because there is more than one entrant, then price cap regulation can be less tight.

Local loop unbundling

The following implications for policy and regulation are valid *given that there is a situation of local loop unbundling*.

Lease price of incumbent's local line

- The lease price of the incumbent's local line should be cost-based (i.e., as close as possible to the fixed cost of the local line), whether or not the incumbent's subscription fee is constrained by a price cap. Allowing the incumbent to include a mark-up in the line rental is beneficial only for the incumbent, while consumers' surplus is reduced.

Terminating access prices

- Similar to a situation of facilities-based entry.

Price cap regulation

- Price cap regulation has the same qualitative effects as in the case of facilities-based entry.

- The aggregate reduction of consumers' surplus due to a larger line rental is somewhat less strong if there is price cap regulation. Therefore, price cap regulation can, to some extent, reduce the detrimental effect on consumers' surplus of an increase of the line rental.

Carrier Select-based competition
The following implications for policy and regulation are valid *given that there is a situation of Carrier Select-based competition*.

Capacity shortage of Carrier Select service
- A capacity shortage of the Carrier Select service may soften price competition. It slows down the growth of the entrant's market share. The incumbent has strong incentives to maintain the capacity shortage. Taking into account that consumers will experience dissatisfaction from failed connections, capacity shortages should be minimized.
- Especially if there are several, small Carrier Select operators, it is crucial to reduce any capacity shortage as soon as possible. This is due to the fact that more competition among entrants, as it leads to more Carrier Select traffic, increases the probability of connection failures. Therefore, if there are capacity problems, the market has a tendency to remain in a state of a large number of marginal entrants.

Price cap regulation
- Since the incumbent faces no disciplining competitive force on its subscription fee, it should be regulated (if there is sufficient competition from other competitors as well, e.g. entrants with their own customer access network, or entrants that lease local lines, then this is not necessary).
- If there is a capacity shortage of the Carrier Select service, a price cap on the incumbent's per-minute price can prevent the softening of price competition.

Originating and terminating access prices
- In the short and long run, originating and terminating access prices should be cost-based (i.e., as close as possible to the traffic-dependent cost of the local line). The entrant is completely dependent on the incumbent's local loop if it wants to have access to end-users.
- The strong growth in the demand for internet access reinforces the need for a cost-based originating access price. The reason is that internet access usually takes places via local telephony, a loss-making service if Carrier Select operators have to pay a large originating access price ("price squeeze"). If consumers only make a small number of local calls using Carrier Select, the

incurred losses may be acceptable for the entrant. However, the sharp growth of internet traffic creates a strong imbalance.

6.5.2. Network investment

By comparing the outcomes of sections 6.2-6.4, one can draw conclusions about the entrant's incentives to roll out a customer access network. In particular, we will discuss how well the entrant is doing in terms of aggregate profits over time in the situations of:

- facilities-based competition (FBC), section 6.2;
- local-loop unbundling (LLU), section 6.3;
- "Carrier Select"-based competition (CSC), section 6.4.

Recall that in section 6.5.1, implications for policy and regulation were valid given a certain entry situation. However, if one compares the three entry situations in order to assess whether the possibilities to stimulate a specific type of entry, the implications for policy and regulation may be different.

The entrant's aggregate profits during the periods in which the operators compete, net of any fixed cost of investment associated with a particular entry strategy, give an indication of the entrant's incentives to choose that strategy and incur the associated investment cost. Reasonable values of these investment costs should reflect that the fixed cost of FBC-entry is much larger than the entry cost under LLU, which is in turn larger than the entry cost of a Carrier Select operator. Since it is difficult to calibrate the costs of investment for our models, we have not attached specific values to these cost levels. Instead, the relative attractiveness of an entrant's investment choices will be discussed qualitatively.

Within the framework of the models, it is in principle possible to obtain any outcome by conditional regulation. For example, if a regulator favors FBC over LLU, it can impose a tight price cap regime conditional on LLU entry taking place, while allowing higher prices under FBC entry. In reality, though, there is a large variety of entrants, so that FBC, LLU and CSC take place simultaneously. Therefore, conditional regulation may neither be feasible nor desirable. In the comparisons of different entry modes below, we will take this practical restriction into account.

FBC versus LLU

Terminating access prices play the same role in FBC as in LLU. Because in LLU, an increase in the lease price of the local line results in upward pressure on both the incumbent's as an entrant's subscription fee, we focus on the role of the lease price in combination with the possibility of a price cap on the incumbent's subscription fee. Consider two cases.

Case 1: the incumbent is not subject to price cap regulation. First, let the lease price of the incumbent's local line be equal or close to its fixed cost. Given the investment cost of building a customer access network, an entrant presumably prefers LLU above FBC. Second, suppose that the lease price of the incumbent's local line includes a mark-up. If the entrant can pass on the mark-up on the lease price to consumers by increasing its subscription fee, as we have seen in section 6.3.2, then again the balance is tilted towards LLU.

Case 2: the incumbent's subscription fee is subject to a price cap. Now, in a situation of LLU, we have seen (section 6.3.3) that an entrant may not be able to pass on a mark-up in the lease price of the local line to consumers, since in order to compete with the incumbent, it must undercut the incumbent's subscription fee.[34] Accordingly, a lease price above cost, in combination with a price cap regime, makes FBC relatively more attractive for an entrant, compared to LLU.

Cases 1 and 2 suggest that regulation can be used to gradually increase the entrant's incentives to build its own customer access network. Initially, the lease price of the local loop should be low. This allows the entrant to build up a customer base by leasing local loops. Price cap regulation (which may be desirable during the early periods) should not be too heavy, otherwise LLU becomes unattractive. Over time, one can allow the incumbent to gradually increase the line rental, which makes FBC more attractive for the entrant, relative to LLU.

In the model of section 6.3, it was assumed that LLU does not restrict the entrant in terms of quality or range of services that it can offer, compared to entry based on FBC. Therefore, given proper policy and regulation, it does not matter for consumers' surplus whether FBC or LLU occurs. In reality though, technological restriction imposed by the particular way in which local loops are unbundled, may hamper an entrant to offer innovative services over the network.

CSC versus FBC/LLU

Access prices play a different role in CSC than in FBC and LLU. The reason is that in CSC, only the incumbent charges an access price, while an entrant depends on the incumbent's local loop to have access to end-users. This dependency implies that terminating access prices above cost hurt a Carrier Select entrant more than they hurt an

[34] To see this, compare the results of sections 6.2.3 and 6.3.3.

entrant that owns or leases a customer access network. Consequently, a lenient policy on access prices, resulting in access markups, creates a bias away from CSC.

An obvious way to make either building or leasing local lines more attractive for the entrant compared to offering a Carrier Select service, is to have a high originating access price. Also, a price cap on the incumbent's per-minute price, while keeping capacity shortages of Carrier Select intact, creates a bias away from CSC.

If there are no capacity shortages, then CSC may result in the short run in a larger consumers' surplus than FBC or LLU. Hence it may be beneficial for consumers to stimulate CSC in the short run by enforcing a low originating access price, and eliminating capacity shortages of Carrier Select. Investments in network infrastructure can be encouraged in the longer run by allowing the incumbent to gradually increase the access price over time. Thus, offering Carrier Select services gradually becomes less attractive. At some point in time, FBC and LLU become may become more attractive. The tradeoff between FBC and LLU can be tilted towards FBC by gradually increasing the lease price of the local loop as well (as discussed above).

A.6. Appendix: Calibration and model adaptations

A.6.1. Parameters

The calibration procedure is based on realistic input values as much as possible, but it is unavoidable that it also contains some arbitrary elements. For instance, it is difficult to empirically measure the level of utility a consumer derives from calling. Obviously, this will quantitatively influence the numerical outcomes. Nevertheless, this is not important for the *qualitative* results and insights that are obtained.

Demand parameters

Estimations for the demand parameters can be obtained by taking the following information as a starting point: recently observed prices (see table A.6.1.1), and price elasticities (estimates are available; see table A.6.1.2), and some information about calling behavior (estimates available; see next paragraph).

In 1998, the "average person" called 3.86 (the call rate) times 3.37 (the call duration) = 13 call minutes per day (KPN Jaarverslag 1998). We assume that the call rate has increased with 3.9% per year, and the call duration with 3% per year (these numbers represent the actual growth from 1997 to 1998). Expectedly in 2000, the call rate is 4.2 and the call duration 3.57, resulting in 15 call minutes per day. Therefore in a period of two months (61 days), a rough estimate of average, individual demand is given by $x = 915$.

The following tables show how one can roughly calculate an average per-minute price ($p = 3.0$) and an average elasticity ($\varepsilon = -0.18$), that can be used to choose parameters a and b.

Table A.6.1.1. Per-minute prices in the Netherlands in February 2000 (NLG cents)

	local	national	
peak	5.6	11	75%** weighted average 7.44
off-peak	2.5*	6	25% weighted average 3.69
	66%*** weighted average 4.83	34% weighted average 9.75	overall weighted average 6.5 (3.0 Euro-cents)

* Actually the tariff is either 2 or 3 cents.
** By assumption (exact values are not crucial for the results).
*** KPN Concessierapportage 1998, p. 30.

Table A.6.1.2. Price elasticities of demand in the Netherlands (individual end-users)*

	local	national	
residential customers	− 0.14	− 0.34	50%** weighted average − 0.21
business customers (small/medium enterprices and corporate)	− 0.11	− 0.20	50% weighted average − 0.14
	66% weighted average − 0.13	34% weighted average − 0.27	weighted average − 0.18

* NERA (1999). Elasticities do not differ for on-net and off-net calls.
** By assumption (exact values are not crucial for the results).

In the models it is assumed that demand is given by $x = (a - p) / b$, which implies that the price elasticity is equal to $\varepsilon = - p / (a - p)$. Using these formulas, one can calculate:

- Step 1: $a = p\ (\varepsilon - 1) / \varepsilon = 3 * (-\ 1.18) / (-\ 0.18) = 20$.
- Step 2: $b = (a - p) / x = 17 / 915 = 0.019$.

Utility parameters u_1^0, u_2^0 and switching cost parameter s_{max} are of a more subjective nature, and are difficult to measure, let alone observe, in reality. Their values are based on experience obtained in test runs of the model.

The demand parameters that depict the Netherlands in 2000 are summarized in the following table.

Table A.6.1.3. Demand parameters

parameter	**estimate**	**source**
a	20 Euro-cents	see text
b	0.019 Euro-cents	see text
u^0	5 000 Euro-cents	experience in test runs
s_{max}	6 000 Euro-cents	experience in test runs
market size	7 897 000 customers	IDC (1999)

Cost parameters

Opta's BU-model generates the following approximations for KPN Telecom's "indirectly attributable costs," which can be seen as traffic-dependent costs:

Table A.6.1.4. Traffic-dependent costs

type of call	**traffic-dependent cost per minute**	**source**
local on-net (“BiBa”)	1.9 Euro-cents	BU model (Opta)
regional/national on-net (“BuBa”)	2.6 Euro-cents	BU model (Opta)
off-net	1.5 Euro-cents	BU model (Opta)
incoming	1.5 Euro-cents	BU model (Opta)

Given that the relative traffic volume of local calls is larger than the volume of regional/national calls, we will approximate the average cost by 2.0 cents. The average cost of any “interconnected” call, whether off-net or incoming, is 1.5 cents. Notice that these numbers do not satisfy the common assumption in the literature that $c_{i2} + c_{i3} = c_{i1}$ (an assumption also used for the benchmark model). This is possibly due to averaging. Since the models abstract from the distinction between local, regional and national calls, we will simplify the numbers and assume that $c_{i1} = 2$, $c_{i2} = 1$, and $c_{i3} = 1$, $i = 1, 2$.

The cost-oriented “BelBasis” subscription fee is NLG 34.60 per month, which includes a rate of return of 13.2%. Hence the incumbent’s underlying fixed cost of a connection in the customer access network per month is NLG 30.57 or Euro 14. Accordingly, $f_i = 2800$. A connection comprises:

- the local line (the part of the connection from the network termination point up to and including a share in the main distribution frame);
- the line card.

The traffic-independent cost associated with a local line of the incumbent roughly equals NLG 17.80, or Euro 8.00.

Cost parameters are summarized in the following table.

Table A.6.1.5. Assumptions on cost parameters

parameter	**value (Euro-cents)**
c_{11}	2
c_{12}	1
c_{13}	1
c_{21}	2
c_{22}	1
c_{23}	1
f_1	1600
f_2	1600

A.6.2 Facilities-based competition

Model without price caps

The model that depicts the game played by the operators in each period, is identical to the benchmark model of chapter 4. There are no structural changes in the model.

Price cap regulation

Basket of services contains the following services of the incumbent:

- a connection to its network;
- voice telephony.

Joint price cap on operator 1's subscription fee and per-minute price, defined by linear relation:

$$\lambda\, p_1 + (1 - \lambda)\, m_1 \leq \kappa, \text{ where } 0 \leq \lambda < 1.$$

A.6.3 Local loop unbundling

Operator 2 only has a long-distance backbone. To have access to end-users, it can lease operator 1's local line, while incurring a fixed cost for a linecard. A connection in the incumbent's customer access network comprises the local line and the line card. The associated fixed costs satisfy

$$f_1 = f_1^{\text{local-line}} + f_1^{\text{linecard}}.$$

If operator 2 rents a local line from the incumbent, a wire is diverted from the incumbent's local switch to a plant provided by operator 2, instead of to operator 1's main distribution frame. Hence operator 2 incurs a fixed cost f_2^{linecard}.

The lease price of operator 1's local line is denoted by L. Operator 1's traffic-independent revenues become:

$$n\,\varphi_1\,(m_1 - f_1) + n\,\varphi_2\,(L - f_1^{\text{local-line}}),$$

while operator 2's traffic-independent revenues become:

$$n\,\varphi_2\,(m_2 - L - f_2^{\text{linecard}}).$$

The remaining parts of the profit functions, that is, the revenues from on-net, off-net, and incoming calls, remain unchanged (see chapter 4).

Table A.6.3.1. Assumptions on cost parameters

parameter	**value**	**description**
$f_1^{\text{local-line}}$	1600	1's fixed cost of local line
f_2^{linecard}	1200	2's fixed cost of linecard (cost of co-locating)

A.6.4 Carrier Select-based competition

Operator 2 only has a long-distance backbone. To have access to end-users, it uses originating access via a Carrier Select service.[35] Operator 1's originating access price is denoted by δ_1. Operator 2's traffic-dependent cost of its backbone is denoted by c_{24}.

A consumer who selects operator 2's network to carry his calls, keeps his subscription to the incumbent. Therefore, he can continue to enjoy the fixed utility of having a connection to operator 1's network u_0^1.

By assumption, there is limited capacity to provide Carrier Select services. Suppose that there is a (small) probability α that a consumer who tries to make a call through Carrier Select, experiences that he does not get a connection, although the called party is not busy. If this happens, he uses his regular subscription to the incumbent's network to establish a connection, but does not cancel its registration with the entrant.

A consumer who wants to use Carrier Select has to register first with the operator that offers it. Hence it is reasonable to assume that a consumer switching cost is incurred by anyone who tries to use the Carrier Select service, irrespective of capacity overload.

A consumer who decides to use the Carrier Select service gets expected net benefits $(1 - \alpha)\ v_2(p_2, m_1) + \alpha\ v_1(p_1, m_1)$. Accordingly, a customer of operator 1 with switching cost parameter s compares $v_1(p_1, m_1)$ and $(1 - \alpha)\ v_2(p_2, m_1) + \alpha\ v_1(p_1, m_1) - s$. One can now define market shares after registration with the entrant has occurred but before calls are being made, as follows:

$$\varphi_1^{reg} = \varphi_1^0 + (1 - \alpha)\ (v_1(p_1, m_1) - v_2(p_2, m_1))\ /\ s_{max}, \text{ and}$$

$$\varphi_2^{reg} = \varphi_2^0 + (1 - \alpha)\ (v_2(p_2, m_1) - v_1(p_1, m_1))\ /\ s_{max}.$$

In these formulas, φ_1^0 and φ_2^0 denote previous-period market shares after registration and before calls are being made. Notice that the market shares that are stored in each period in the Mathematica notebooks, are the market shares after registration and before calls are being made.

The market shares that are used to calculate profits, consumers' surplus and welfare in each period in the Mathematica notebooks, are the market shares after calls have been made and possible capacity shortages have occurred. These market shares are defined by:

[35] Actually, the model may depict either Carrier Select or Carrier Preselect.

$$\varphi_1^{\text{after calls}} = \varphi_1^{\text{reg}} + \alpha\, \varphi_2^{\text{reg}}$$

$$= \varphi_1^{0} + (1 - \alpha)\, (v_1(p_1, m_1) - v_2(p_2, m_1)) / s_{\max}$$

$$+ \alpha\, (\varphi_2^{0} + (1 - \alpha)\, (v_2(p_2, m_1) - v_1(p_1, m_1)) / s_{\max})$$

$$\varphi_2^{\text{after calls}} = (1 - \alpha)\, \varphi_2^{\text{reg}}$$

$$= (1 - \alpha)\, (\varphi_2^{0} + (1 - \alpha)\, (v_2(p_2, m_1) - v_1(p_1, m_1)) / s_{\max})$$

Profit functions become:

$$\Pi_1 (p_1, p_2, m_1) = n\, \varphi_1^{\text{after calls}}\, x(p_1)\, (p_1 - c_{11}) + n\, \varphi_2^{\text{after calls}}\, x(p_2)\, (\delta_1 + \tau_1 - 2\, c_{13})$$

$$+ n\, (m_1 - f_1),$$

$$\Pi_2 (p_1, p_2, m_1) = n\;\; \varphi_2^{\text{after calls}}\, x(p_2)\, (p_2 - \delta_1 - \tau_1 - c_{24}).$$

Consumers’ surplus becomes:

$$CS \equiv n\, \varphi_1^{\text{after calls}}\, v_1(p_1, m_1) + n\, \varphi_2^{\text{after calls}}\, v_2(p_2, m_1)$$

$$- n\, ((1 - \alpha)\, (v_2(p_2, m_1) - v_1(p_1, m_1)))^2 / (2\, s_{\max}).$$

Table A.6.4.1. Assumptions

parameter	**value**	**description**
c_{24}	0	2’s marginal cost backbone
α	variable / fixed at 0.10	capacity shortage (probability)
m_1	fixed at 3145	1’s regulated subscription fee

Chapter 7. Alternative tariff structures in a non-segmented market

7.1. Introduction

Besides the two-part tariff structure analyzed in the previous chapter, there are more ways to price telecommunications connections and services. In the real world, this is perhaps illustrated best in the market for mobile telephony, where it is virtually impossible to keep track of all the different, available contracts. Important questions are therefore how tariff structures affect competition, and if alternative pricing structures have different policy implications. This chapter explores extensions on pricing structures.

We restrict ourselves to facilities-based competition and analyze the following tariff structures:

- section 7.2: flat fees (the operators compete by choosing subscription fees only);
- section 7.3: linear prices (the operators choose per-minute prices only);
- section 7.4: non-uniform prices (the operators differentiate per-minute prices for on-net calls and off-net calls), also called "price discrimination" or "price differentiation."

In each situation we zoom in to the role of terminating access prices. Accordingly, the purpose of this chapter is first, to better understand the nature of price competition, and second, to address the role of access fees. The appendix of chapter 8 (A.8.1) contains a related discussion of situations in which operators offer menus of contracts, that may consist of different types of pricing structures at the same time.

We will also discuss some additional topics, namely network congestion in the model with flat fees (section 7.2.2), network externalities in the model with non-uniform prices (section 7.4.2), asymmetry in allowing non-uniform prices (also section 7.4.2), and fixed-mobile competition as an interpretation of the model with non-uniform prices (section 7.4.3).

Table 7.1.1. Summary of model differences.

	flat fees **(section 7.2)**	**linear prices** **(section 7.3)**	**non-uniform prices** **(section 7.4)**
entrant's network consist of:	- backbone - customer access network	- backbone - customer access network	- backbone - customer access network
price structure	- operators choose subscription fees only - per-minute prices are zero	- operators choose per-minute prices only - subscription fees are zero	- operators choose different per-minute prices for on-net and off-net calls
relevant wholesale prices:	- terminating access prices	- terminating access prices	- terminating access prices
other relevant details:			- model can be used to address fixed-mobile interconnection

7.2 Flat fees

7.2.1. Model

The model is the same as the FBC-model of section 6.2, with one exception: the operators do not compete in two-part tariffs, but in flat fees. That is, consumers only pay subscription fees and get an unlimited amount of free call minutes. By imposing that

$$p_1 = p_2 = 0,$$

the same profit functions as before can be used. Accordingly, the operators compete by choosing subscription fees m_1 and m_2.

Table 7.2.1 . Instruments of policy and regulation

instrument	**description**
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2

7.2.2. Terminating access prices and comparison with two-part tariffs

With competition in flat fees, making telephone calls is too cheap, in the sense that traffic-dependent costs still have to be incurred by the operators. Therefore consumers' individual demand for call minutes will increase. Because of this distortion, one can expect that welfare will be reduced, compared to the two-part tariffs situation. Moreover, because subscribers can derive more utility from making calls, the operators will be able to increase subscription fees. It is not clear beforehand though, whether consumers will benefit overall.

To keep the presentation compact, we consider reciprocal and asymmetric terminating access prices simultaneously. In order to better understand the role of flat fees in the strategic interaction between the operators, we will also include a comparison with two-part tariffs.

Table 7.2.2. Price structure and terminating access prices / *short run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part*	1	1	5.56	422.64	1.46	400.3	424.1	824.39
2-part	2	2	5.52	422.1	1.45	401	423.6	824.5
2-part	1	2	5.56	389.32	1.58	433.5	390.9	824.39
flat	1	1	5.56	422.64	1.46	392	424.1	816.08
flat	2	2	5.56	422.64	1.46	392	424.1	816.08
flat	1	2	5.56	385.56	1.59	428.9	387.2	816.08

* Two-part tariffs (subscription fee and per-minute price).

Table 7.2.3. Price structure and terminating access prices / *long run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part	1	1	49.81	119.37	117.54	610.1	236.9	847.05
2-part	2	2	49.81	119.37	117.54	610	236.9	846.92
2-part	1	2	49.82	110.02	126.76	610.2	236.8	846.99
flat	1	1	49.81	119.37	117.54	601.8	236.9	838.74
flat	2	2	49.81	119.37	117.54	601.8	236.9	838.74
flat	1	2	49.81	108.9	127.85	602	236.8	838.74

Table 7.2.4. Price structure and terminating access prices / *aggregate over time*

prices	τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part	1	1	3602.06	799.54	7809.7	4401.1	12211.3
2-part	2	1.5	3600.43	799.19	7811	4399.6	12210.7
2-part	1	1.5	3319.18	862.3	8029.3	4181.5	12210.7
flat	1	1	3602.06	799.54	7685	4401.1	12086.6
flat	2	1.5	3602.06	799.54	7685	4401.1	12086.6
flat	1	1.5	3286.09	869.67	7930.9	4155.8	12086.6

We view cost-based access pricing as our point of departure, and discuss the effects of the access price in comparison with competition in two-part tariffs. Consider the effects of an increase of terminating access prices. One can make the following observations.

Short run, long run, and aggregate over time:
The operators' profit levels are hardly changed, and consumers' surplus is not affected, under flat fees if the reciprocal access price goes up, contrary to the situation with two-part tariffs. However, we will see later that each operator's composition of profits does change.

A non-reciprocal increase of the entrant's terminating access price, while keeping the incumbent's access price equal to cost, reduces the incumbent's profits, but is beneficial for the entrant's profits and consumers' surplus. Market shares are not affected. In the long run, the beneficial effect on consumers' surplus fades out.

Intuition
It is illustrative to look more closely at the prices chosen by the operators in an equilibrium:

Table 7.2.5. Prices in period 1

prices	τ_1	τ_2	p_1	p_2	m_1	m_2
2-part	1	1	2	2	8467	3133
2-part	1.5	1.5	2.03	2.47	8432	2685
2-part	1	1.5	2.03	2	8020	2713
flat	1	1	-	-	10572	5239
flat	1.5	1.5	-	-	10572	5239
flat	1	1.5	-	-	10104	4771

Recall, as the table above depicts, that with two-part pricing, an increase of the access price leads to higher per-minute prices (those prices are set at average marginal cost levels) and to lower subscription fees (making phone calls becomes more expensive, there is less surplus to extract from consumers).

With flat fees, the picture is different. A change in the level of terminating access prices directly affects traffic-dependent costs, but by definition, the operators cannot translate an increase in this cost into larger per-minute prices. Hence the question is how subscription fees are affected. To understand this, notice that the larger an operator's market share:

- the more revenues it receives from subscription fees (net of traffic-dependent costs of on-net calls made by its subscribers);
- the less access costs it incurs from off-net calls made by its subscribers (since less off-net calls are being made);
- the more access revenues it receives from incoming calls (since the subscribers of the rival operator make more off-net calls).

The following tables depict how the operators' total profits are composed:

Table 7.2.6. Profits operator 1 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
2-part	1	1	422.64	0	0	0	422.64
2-part	1.5	1.5	422.1	1.84	− 1.84	1.9	420.2
2-part	1	1.5	389.32	1.85	− 1.85	0	389.32
flat	1	1	422.64	−148.29	−8.72	0	579.65
flat	1.5	1.5	422.64	−148.29	−10.90	2.18	579.65
flat	1	1.5	385.56	−148.29	−10.90	0	544.76

Table 7.2.7. Profits operator 2 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
2-part	1	1	1.46	0	0	0	1.46
2-part	1.5	1.5	1.45	0.11	− 0.11	1.95	−0.50
2-part	1	1.5	1.58	0	0	1.96	− 0.38
flat	1	1	1.46	−0.51	−8.72	0	10.7
flat	1.5	1.5	1.46	−0.51	−10.90	2.18	10.7
flat	1	1.5	1.59	−0.51	−8.72	2.18	8.65

With reciprocal access prices, it turns out that the sum of net revenues from off-net calls and from incoming calls is equal for the incumbent and for the entrant. Therefore both operators have equally strong incentives to compete for market share. This is not true if the access prices are asymmetric, though. When only the entrant's access price is above cost:

- it is very unattractive for the incumbent to lose market share (less market share means more off-net calls but no gain in revenues from incoming calls);
- the entrant has a strong incentive to capture market share (less off-net calls and additional revenues from incoming calls).

As a consequence, competition in subscription fees becomes more intense in the first periods of the game. Consumers greatly benefit from the lower flat fees.

Robustness
Consider the situation in which the operators maximize total profits over time. Accordingly, they put more weight on a large market share, leading to more price pressure in general. More importantly, in the beginning of the game the entrant has stronger incentives to decrease its subscription fee than the incumbent, due to its smaller market share. Overall, the robustness discussion in section 6.2.2 still applies, taking into account that the operators now compete in subscription fees instead of two-part tariffs. Note also here that the regulator can fine-tune access price regulation by switching to cost-based reciprocal access prices at an earlier stage. Similarly, policy implications do not hinge on the assumption that there is a single entrant if the operators compete in flat fees.

The welfare-distorting nature of flat fees does not depend on the assumptions of myopic behavior and a single entrant.

The risk of network congestion, not included in the model, provides another argument against flat fees. Indeed, flat fees lead to a steep increase of the demand for call minutes; consumers who access internet through their telephone lines may even want to be on-net day and night. To see this, compare an individual consumer's demand under two-part tariffs and under flat fees. Suppose that with two-part tariffs, the per-minute price is equal to marginal cost, that is, $p = 2$. If the parameters of the individual demand function for call minutes, $x(p) = (a - p) / b$, are equal to $a = 20$ and $b = 0.019$, then the individual demand for call minutes is equal to $x(2) = 947$ minutes. With flat fees, $x(0) = 1053$ minutes. However, this comparison implicitly assumes that parameters a and b do not change in different regions of the demand function. If one views the linear demand function as a local approximation of a more complex demand curve, the parameters may very well change when the per-minute price goes to 0. Therefore it may be the case that $x(0)$ is much larger.

Policy implications
With a flat-fee pricing structure, the operators can no longer set per-minute prices at the efficient level of marginal, that is, average traffic-dependent, costs. Since calling minutes are free, consumers' demand for call minutes increases sharply, allowing the operators to set higher subscription fees than under two-part tariffs. Overall, a consumer's total benefits from having a subscription and making phone calls decrease, compared to the situation with two-part tariffs. The risk of network congestion provides an additional argument against flat fees.

The level of a reciprocal terminating access price is not relevant, except for the composition of the operators' profits. The reason is that since the sum of net revenues from off-net calls and from incoming calls is equal for the incumbent and for the entrant, so that the operators have equally strong incentives to compete for market share. A consequence is that with flat fees, the reciprocal access price is unlikely to facilitate tacit collusion.

Asymmetric regulation, allowing the entrant to set the access price above cost while keeping the incumbent's access price cost-based, has similar qualitative effects as in the situation with two-part tariffs. In particular, it leads to tougher price competition in the early stages of competition. Consumers' surplus is maximized over time if the entrant's access price is relatively large initially and tends towards its underlying cost level over time.

Both from the operators' and from consumers' point of view, the model does not provide arguments in favor of competition in flat fees. They may be in the operators' interest only in the short run, when market shares are still asymmetric, but only to a limited extent. The general picture is that flat fees are neutral for producers' surplus, while they reduce consumers' surplus (and therefore also welfare).

Price cap regulation

To conclude this section we demonstrate that a price cap on subscription fees has very strong effects if the operators compete in flat fees, stronger than in the case of two-part tariffs. This is due to the fact that flat fees lead to higher subscription fees. As an example, consider a price cap of κ = 10000. Simulations show that it is binding in periods 1-3 only. Still, it has a very strong effect on the entrant's market share and profit level in these early periods. The following table depicts period 1. One can observe that a price cap can offset the negative effect of flat fees on welfare.

Table 7.2.8. Price cap regulation / *short run*

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
∞	5.556	422.64	1.46	391.98	424.1	816.08
10000	0.789	399.16	0.03	436.43	399.19	835.61

7.3 Linear prices

7.3.1. Model

The model is the same as the FBC-model of section 6.2. However, the operators no longer compete in two-part tariffs, but in linear prices, that is, consumers only pay per-minute prices. We simply impose the following restriction:

$$m_1 = m_2 = 0.$$

Accordingly, the operators compete by choosing prices p_1 and p_2.

Table 7.3.1. Instruments of policy and regulation

instrument	**description**
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2

Remark
For technical reasons related to the possibility to generate feasible solutions (see appendix A.7.3), the assumption about the entrant's fixed utility level had to be modified. As a consequence the results (i.e., the numbers) cannot be compared with those of section 6.2. Therefore, we have included simulation results on two-part pricing based on this modified assumption, so that a direct comparison with two-part tariffs becomes possible.

7.3.2. Terminating access prices and comparison with two-part tariffs

The most interesting question is how terminating access prices affect retail prices. We know from chapter 6 that with two-part tariffs, higher access prices push up per-minute prices only to the extent of the associated increase of traffic-dependent costs, while leading to a downward pressure on subscription fees. We have seen that in the early stages of competition (when the entrant is still small), consumers benefit from the fact that competition becomes more intense, but in the long run, cost-based access prices are better for them.

With linear pricing, however, one can intuitively expect that higher access prices have a negative impact on consumers' surplus both in the short and in the long run, since there is no way that higher per-minute prices can be off-set by lower subscription fees. The following tables confirm this intuition. We note that the numerical results on two-part tariffs that are included, are different from those presented in section 6.2, because of the changed assumption on the fixed utility level offered by the entrant (see the remark in section 7.3.1).

Table 7.3.2. Price structure and terminating access prices / *short run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part*	1	1	19.44	307.47	17.91	474.3	325.4	799.71
2-part	2	2	19.42	307.23	17.9	474.6	325.1	799.7
2-part	1	2	19.45	283.32	19.32	497.1	302.6	799.69
linear	1	1	1.062	108.48	0.04	610.7	108.5	719.26
linear	2	2	0.309	110.26	0	606.6	110.3	716.83
linear	1	2	2.815	103.36	0.3	621.4	103.7	725.08

* Two-part tariffs (subscription fee and per-minute price).

Table 7.3.3. Price structure and terminating access prices / *long run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part	1	1	50	118.46	118.45	610.2	236.9	847.06
2-part	2	2	50	118.46	118.45	610	236.9	846.93
2-part	1	2	50.01	109.17	127.75	610.1	236.9	846.99
linear	1	1	49.85	47.79	47.1	657.6	94.6	752.23
linear	2	2	49.82	48.46	47.99	652.9	96.45	749.36
linear	1	2	51.28	40.89	54.84	654.8	95.74	750.49

Table 7.3.4. Price structure and terminating access prices / *aggregate over time*

prices	τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
2-part	1	1	2332.82	1404.93	8747.49	3737.8	12485.2
2-part	1.5	1.5	2332.5	1404.79	8746.25	3737.3	12483.5
2-part	1	1.5	2149.99	1515.15	8819.24	3665.1	12484.4
linear	1	1	1012.52	440.84	9653.37	1453.4	11106.7
linear	1.5	1.5	1039.13	442.58	9582.76	1481.7	11064.5
linear	1	1.5	907.24	527.38	9689.38	1434.6	11124

Consider the effects of an increase of terminating access prices. We view cost-based access pricing under linear pricing as our point of departure, and discuss the effects of the access price in comparison with competition in two-part tariffs. One can make the following observations.

Short run:
The incumbent's profits go up as a result from an increase in the reciprocal access price, but the entrant's profits go down. This is different from the situation with two-part tariffs, where both operators' profit levels decrease. Also different is that under linear pricing, consumers' surplus decreases.

Asymmetric access prices (such that only the entrant charges an access price above cost) under linear pricing strongly benefit both the entrant in terms of market share and profits, and consumers. This is similar to the situation with two-part tariffs.

Long run:
Both operators' profits increase, and consumers' surplus decreases, when the reciprocal terminating access price goes up. With two-part tariffs, profits are not affected.

Under linear pricing and also two-part pricing, the beneficial effect on consumers' surplus of a non-reciprocal increase of the entrant's terminating access price, fades out in the long run. It still reduces the incumbent's profits, and is beneficial for the entrant's profits and market share.

Aggregate over time:
The most important observation is that both operators' total profits increase when the reciprocal terminating access price increases, contrary to the situation with two-part tariffs.

Intuition
To develop our intuition, we take a closer look at the prices emerging from competition in the first period of the game:

Table 7.3.5. Prices in period 1

prices	τ_1	τ_2	p_1	p_2	m_1	m_2
2-part	1	1	2	2	7633	3967
2-part	1.5	1.5	2.1	2.4	7538	3587
2-part	1	1.5	2.1	2	7254	3679
linear	1	1	9.81	5.81	-	-
linear	1.5	1.5	9.91	5.94	-	-
linear	1	1.5	9.56	5.5	-	-

Recall from the analysis with two-part tariffs, as can also be seen in the table above, that an increase of the access price leads to higher per-minute prices (because those prices are set equal to costs) and to lower subscription fees (because there is less surplus to extract from consumers).

With linear prices, the picture changes. A rise in the level of terminating access prices still shows up in per-minute prices, but the increase cannot be off-set by lower subscription fees. The consequence is that a higher reciprocal access markup increases both operators' prices. Therefore the reciprocal access price can be seen as an instrument that may facilitate tacit collusion in the retail market.[36]

Generally speaking, since linear prices make it more difficult for operators to appropriate consumers' willingness to pay, they lead to a larger consumers' surplus. Also, increasing the per-minute price has the following consequences for an operator:[37]

- it decreases the operator's market share (*market share effect*);
- it increases the revenues from calls made by its customers *(retail revenue effect*);
- it increases net access revenues, since it decreases the access costs that have to be paid to the rival operator (*access revenue effect*).

The access revenue is the reason that the access price can be used to facilitate tacit collusion in the long run, when the entrant has gained market share. With competition

[36] This is one of the central results in the early literature such as Laffont, Rey and Tirole (1998a), discussed in chapter 3.

[37] See Laffont, Rey and Tirole (1997, 1998a).

in two-part tariffs, the access revenue effect is absent, so that there is no risk of collusion.

The following tables depict how the operators' total profits are composed. In these tables, the "revenues from subscriptions" under linear pricing are negative because it constitutes only the fixed costs of connections. With two-part tariffs, the subscription fees cover these costs. It is interesting to notice how access prices affect the composition of profits quite differently under the different pricing structures.

Table 7.3.6. Profits operator 1 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
2-part	1	1	307.47	0	0	0	307.47
2-part	1.5	1.5	307.23	4.69	− 4.69	5.72	301.51
2-part	1	1.5	283.32	4.7	−4.70	0	283.32
linear	1	1	108.48	323.77	3.48	0	−218.77
linear	1.5	1.5	110.26	329.65	0.96	0.09	−220.43
linear	1	1.5	103.36	309.86	8.38	0	−214.89

Table 7.3.7. Profits operator 2 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
2-part	1	1	17.91	0	0	0	17.91
2-part	1.5	1.5	17.9	1.11	−1.11	5.82	12.08
2-part	1	1.5	19.32	0	0	5.83	13.5
linear	1	1	0.04	0.03	2.36	0	−2.35
linear	1.5	1.5	0	0	0.62	0.07	−0.68
linear	1	1.5	0.3	0.17	5.77	0.59	−6.23

Robustness

Consider the situation in which the operators maximize total profits over time. Accordingly, they put more weight on a large market share, leading to more price pressure in general. More importantly, in the beginning of the game the entrant has stronger incentives to decrease its per-minute price than the incumbent, due to its smaller market share. Overall, the robustness discussion in section 6.2.2 still applies, taking into account that the operators now compete in linear prices instead of two-part tariffs. Policy implications still hold, but the regulator can switch to cost-based reciprocal access prices at an earlier stage. Similarly, policy implications do not crucially depend on the single-entrant assumption.

The welfare-distorting nature of linear prices does not depend on the assumptions of myopic behavior and a single entrant. The risk of network congestion, that provided an argument against flat fees, plays a much less prominent role with linear prices than with two-part tariffs or with flat fees. This is due to the inflated per-minute prices.

Policy implications

Linear pricing does not reflect the two-part nature of demand, consisting of the demand for a connection and the demand for call minutes. Linear pricing is harmful for both operators, but consumers benefit from it. Overall, the general picture is that linear prices reduce total surplus in the market.

In the long run, when the entrant has gained size, the reciprocal terminating access price can be used to facilitate tacit collusion. The reason is that per-minute prices increase when the access price increases, while this increase cannot be offset by more intense competition in subscription fees. By setting the access price above cost, the operators mutually raise the rival's cost level, and generate higher profits.

Asymmetric regulation, allowing only the entrant to set the access price above cost, has the same qualitative effects as in the situation with two-part tariffs. In particular, it leads to tougher price competition in the early stages of competition. Consumers' surplus is maximized over time if the entrant's access price is relatively large initially and tends towards its underlying cost level over time.

7.4 Non-uniform prices (termination-based price discrimination)

7.4.1. Model

In this section we explore the model while allowing the operators to set different per-minute prices for on-net and off-net calls. Accordingly, per-minute prices no longer need to be uniform, but can be chosen differently for different services. In the literature, non-uniform pricing is often called termination-based price discrimination.[38]

In many countries, the Netherlands included, fixed-line subscribers pay different prices for calls that remain on the incumbent operator's network and calls to a mobile operator. Therefore the model in this section may also be used to depict entry in the market for voice telephony by a mobile operator. Indeed, competition between a fixed and a mobile operator is also a form of facilities-based competition, since both types of operators have complete facilities to reach end-users.

Per-minute prices for on-net and off-net calls will be denoted by p_i^{on} and p_i^{off}, respectively. There is no change with regard to subscription fees: as in chapter 6, the operators set fixed fees m_1 and m_2.

Table 7.4.1. New variables

variable	**description**
p_i^{on}	operator *i*'s per-minute price for on-net calls
p_i^{off}	operator *i*'s per-minute price for off-net calls

We assume that the need to call a certain person is an exogenous event: nature (or chance) determines whom a consumer wants to communicate with, as a random drawing out of the complete population of consumers. The probabilities that the called party subscribes to the same or the other network are proportionate to the operators' market shares. Given that a consumer has chosen whom to call, we want to capture that if $p_i^{\text{off}} > p_i^{\text{on}}$, an off-net call will be shorter than an on-net call, or equivalently, that less

[38] See Laffont, Rey and Tirole (1998b). Price discrimination usually means that different units of the same good are sold at different prices (e.g. to different consumers or to the same consumers at different moments). Arguably, on-net and off-net calls can be viewed as *different* services, just as it may make sense to consider railway trips to different destinations as non-identical goods. We will use non-uniform pricing, price discrimination, and price differentiation interchangably.

off-net calls will be made. Since the demand function is decreasing in the per-minute price, it follows that $x(p_i^{\text{off}}) < x(p_i^{\text{on}})$.[39]

Table 7.4.2. Instruments of policy and regulation

instrument	**description**
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2

7.4.2. Terminating access prices and comparison with two-part tariffs

Before presenting simulation results, we discuss the possible implications for welfare of non-uniform prices. Recall that in the FBC-model of chapter 6, per-minute prices in equilibrium were set at perceived or average marginal costs. With non-uniform pricing, on-net and off-net prices can be set *exactly* at marginal cost levels of on-net and off-net calls, respectively. Indeed, in an equilibrium per-minute prices satisfy

$p_i^{\text{on}} = c_{i1}$, and

$p_i^{\text{off}} = c_{i2} + \tau_j$.

Appendix A.7.4 provides more background to this result. Notice that for access prices equal to marginal cost, it follows that $p_i^{\text{off}} = p_i^{\text{on}}$, so that the outcome of the model will be equivalent to the results under uniform pricing (see section 6.2).

Another observation is that price differentiation distorts subscribers' individual demand for call minutes. Although an access markup does increase an operator's perceived cost of off-net calls, there is no efficiency-related reason to differentiate prices. Under uniform pricing, consumers ignore the artificial difference – due to an access markup – between an operator's private costs of on-net and off-net calls. With non-uniform pricing, consumers do not ignore such cost differences. Neither is there a demand-based reason for termination-based prices, since a consumer's preference to make a phone call does not depend on the identity of the called party's network.

[39] With this specification, a consumer is supposed to know whether the called party is on-net or off-net. In some situations, such as competition between a fixed and a mobile operator, this information may be inferred from the called party's phone number.

The question then is: do non-uniform prices therefore reduce welfare? Since the market already was in a situation of imperfect competition, and therefore a second-best outcome, this is not necessarily the case. Typically, the effects of adding a distortion in a second-best world are ambiguous and therefore difficult to predict.

Table 7.4.3. Price structure and terminating access prices / *short run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
uniform	1	1	5.556	422.64	1.46	400.3	424.1	824.39
uniform	2	2	5.523	422.1	1.45	401	423.6	824.5
uniform	1	2	5.556	389.32	1.58	433.5	390.9	824.39
differ.	1	1	5.556	422.64	1.46	400.3	424.1	824.39
differ.	2	2	3.05	410.2	0.41	424.2	410.6	834.76
differ.	1	2	5.67	388.79	1.52	433.6	390.3	823.88

Table 7.4.4. Price structure and terminating access prices / *long run*

prices	τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
uniform	1	1	49.81	119.37	117.54	610.1	236.9	847.05
uniform	2	2	49.81	119.37	117.54	610	236.9	846.92
uniform	1	2	49.82	110.02	126.76	610.2	236.8	846.99
differ.	1	1	49.81	119.37	117.54	610.1	236.9	847.05
differ.	2	2	49.75	110.22	108	628.6	218.2	846.79
differ.	1	2	51.81	101.48	127.03	618.4	228.5	846.92

Table 7.4.5. Price structure and terminating access prices / *aggregate over time*

prices	τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
uniform	1	1	3602.06	799.54	7809.72	4401.06	12211.3
uniform	2	2	3600.43	799.19	7811.03	4399.62	12210.7
uniform	1	2	3319.18	862.3	8029.25	4181.48	12210.7
differ.	1	1	3602.06	799.54	7809.72	4401.06	12211.3
differ.	2	2	3496.17	690.6	8086.37	4186.77	12273.1
differ.	1	2	3230.4	861.14	8100.88	4091.54	12192.4

Consider the effects of an increase of terminating access prices. Cost-based access prices in a situation of price differentiation is our point of departure, and we discuss the effects of the access price in comparison with competition in two-part tariffs. One can make the following observations.

Short run, long run, and aggregate over time:
Both operators' profits go down when the reciprocal access price increases, similar to the situation with two-part tariffs in the short run. Consumers' surplus increases. Notice, however, that some of the effects of a reciprocal access markup are intensified under non-uniform pricing.

Asymmetric access prices such that only the entrant charges an access price above cost, benefit both the entrant (in terms of market share and profits) and consumers, again similar to the situation with two-part tariffs.

Intuition
It is helpful to take a closer look at equilibrium prices, and compare them with the outcomes under uniform two-part tariffs.

Table 7.4.6. Prices in period 1

prices	τ_1	τ_2	p_1^{on}	p_1^{off}	p_2^{on}	p_2^{off}	m_1	m_2
uniform	1	1	2		2		8467	3133
uniform	1.5	1.5	2.03		2.47		8432	2685
uniform	1	1.5	2.03		2		8020	2713
differ.	1	1	2	2	2	2	8467	3133
differ.	1.5	1.5	2	2.5	2	2.5	8144	2522
differ.	1	1.5	2	2.5	2	2	8019	2705

Just as in the case of uniform pricing, an access markup makes competition more intense. The table shows that non-uniform pricing results in even tougher competition for market share (there is more downward pressure on subscription fees).

Let's also take a look at the composition of the operators' profits.

Table 7.4.7. Profits operator 1 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
uniform	1	1	422.64	0	0	0	422.64
uniform	1.5	1.5	422.1	1.84	− 1.84	1.9	420.2
uniform	1	1.5	389.32	1.85	− 1.85	0	389.32
differ.	1	1	422.64	0	0	0	422.64
differ.	1.5	1.5	410.2	0	0	1.08	409.12
differ.	1	1.5	388.79	0	0	0	388.79

Table 7.4.8. Profits operator 2 in period 1

prices	τ_1	τ_2	total	on-net	off-net	incoming	subscr.
uniform	1	1	1.46	0	0	0	1.46
uniform	1.5	1.5	1.45	0.11	− 0.11	1.95	−0.50
uniform	1	1.5	1.58	0	0	1.96	− 0.38
differ.	1	1	1.46	0	0	0	1.46
differ.	1.5	1.5	0.41	0	0	1.08	− 0.67
differ.	1	1.5	1.52	0	0	1.95	−0.42

If per-minute prices can be differentiated, then the operators' revenues from on-net calls and off-net calls vanish, not because consumers stop making calls, but because prices are exactly equal to cost levels. As a result, the net revenues from traffic generated by an operator's own customers are reduced to zero. However, an access markup still generates positive revenues from incoming voice traffic.

Robustness
An important assumption was that we ignore network effects. However, notice that if operator *i* faces a terminating access price above costs, then $p_i^{off} > p_i^{on}$, so that a subscriber of network *i* derives more benefits if operator *i*'s customer base increases.

Accordingly, price differentiation creates "tariff-mediated" network externalities.[40] Therefore, if consumers could coordinate their subscription decisions, they have an incentive to join the same network. The resulting market power (because of consumer switching costs) could then lead to a price increase by the operator with the large customer base.

A result from the literature on network externalities is that coordination problems may result in a multiplicity of equilibria, depending on consumers' beliefs about other consumers' subscription decisions. Relating this insight to our model, one may actually observe advertisements that advocate the benefits – due to lower on-net prices – of subscribing with a group of people together. Such advertisements are usually aimed at corporate market segments, where centralized decision making facilitates coordination. However, it seems unlikely that consumers are able to coordinate on a larger scale than say, companies, families, and circles of friends.[41] Therefore, assuming away possibilities for coordination does not seem particularly harmful.

Also from a more technical point of view, it seems safe to ignore coordination problems in our model. We refer to Laffont, Rey and Tirole (1998b, section 3), who argue that by imposing a stability requirement, one can safely ignore this multiplicity of equilibria. As before, we restrict the analysis to shared-market equilibria (which are stable in the sense of Laffont et al.) that can be derived from the usual first-order conditions and the market share formula above.

We do not want to claim that tariff-mediated network externalities are not relevant. Some mobile operators implicity use the argument of network externalities in advertisements aimed at enterprises, stating that it is in the interest of an organization that all its employees subscribe to the same operator. Indeed, since fixed-to-mobile interconnection charges are often very high, the importance of network effect is likely to be larger.

We have also explored the model in a situation where only the entrant is allowed to differentiate per-minute prices of on-net and off-net calls. Accordingly, the incumbent chooses a uniform per-minute price p_1, and the entrant chooses prices p_2^{on} and p_2^{off}. Simulation results (not reported here) were qualitatively equivalent, and quantitatively roughly similar, to the situation where both operators set non-uniform prices. A quantitative difference was that for a higher reciprocal access price, the incumbent is in the short run worse off if it cannot differentiate prices, but in the long run it is better off. The entrant is better off both in the short and long run in terms of profits, but worse off

[40] Network externalities exist when the utility derived from consuming a certain good increases with the number of other consumers that buy the same or a compatible good (see Tirole, 1988, for an overview of the seminal literature).

[41] Internet may facilitate coordination on a large scale, but as far as we know, this hasn't happened yet.

in terms of market share. Moreover, consumers' surplus is slightly larger in the short run, but substantially lower in the long run (also if we consider an access markup for the entrant only). These results seem to confirm our earlier conclusion that in a situation of facilities-based entry, there does not seem to be an argument in favor of allowing only the entrant to differentiate per-minute prices.

The ambiguous welfare-implications of termination-based price discrimination do not depend on the assumptions of myopic behavior and a single entrant. Neither do they affect the implications for access price regulation in a qualitatively way.

Policy implications

Overall, from the viewpoint of consumers' surplus and welfare, there does not seem to be a strong case against or in favor of allowing non-uniform pricing. Given the ambiguous implications for social welfare of price differentiation in general, this confirms our expectation expressed at the beginning of this sub-section. A caveat is that reciprocal access prices above costs hurt the entrant much more than before. This may be a reason to forbid the operators to compete with termination-based per-minute prices.

Consumers and the entrant are better off if in the beginning, the entrant's access price is relatively large initially. In a mature market, that is, in the long run when the operators are equally big, this still holds, but reciprocal and cost-based terminating access prices are then best for total surplus.

7.4.3. Fixed-mobile competition

In its infancy years, mobile telephony was not considered to be a substitute for fixed telephony. The average owner of a mobile phone in the early days was probably a businessman, who was using it as a complement to the telephone in the office while on the road. Nowadays, it is becoming more and more common to switch from a fixed subscription to a mobile subscription. Therefore fixed and mobile telephony are becoming closer substitutes, so that fixed and mobile operators find themselves in a situation of competition with each other.

In situations of competition between a fixed and a mobile operator, one may sometimes observe that the fixed operator has to set a terminating access price close to the associated cost level, whereas the unregulated mobile operator is free to choose a much higher access price. This so-called fixed-mobile access price may even be excessively high, compared to the cost of providing terminating access to the fixed operator.

Using the model of non-uniform pricing, we will briefly zoom into such a situation, assuming that operator 1 is the fixed operator, and operator 2 the mobile operator. Since a mobile operator's network also reaches its end-users, just as a fixed operator does with a local access network, we can use the model to make some observations. Because fixed and mobile networks have quite different cost structures, which we do not take into account here, we will not go to deep in the analysis.

Parameter τ_2 is the so-called "fixed-mobile interconnection tariff." We assume that the access price charged by the fixed operator is equal to cost, that is, $\tau_1 = 1.0$. This may be due to asymmetric regulation. We will look at more extreme increases of the mobile operator's access price, τ_2 (the fixed-mobile interconnection tariff), than in section 7.4.2.

Table 7.4.9. Instruments of policy and regulation

instrument	**description**
τ_1	mobile-to-fixed terminating access price charged by operator 1
τ_2	fixed-to-mobile terminating access price charged by operator 2

Table 7.4.10. Fixed-mobile interconnection tariff / *short run**

τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	5.556	422.64	1.46	400.29	424.1	824.39
2	5.719	356.52	1.54	465.53	358.07	823.59
5	4.198	190.73	0.78	637.22	191.51	828.72

* $\tau_1 = 1$.

Table 7.4.11. Fixed-mobile interconnection tariff / *long run**

τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	49.807	119.37	117.54	610.14	236.91	847.05
2	53.921	85.16	137.16	624.22	222.32	846.54
5	70.842	17.67	221.1	601.4	238.77	840.17

* $\tau_1 = 1$.

Table 7.4.12. Fixed-mobile interconnection tariff / *aggregate over time**

τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	3602.06	799.54	7809.72	4401.06	12211.3
2	2883.68	925.03	8362.65	3808.72	12171.4
5	1265.98	1384.43	9356.91	2650.41	12007.3

* $\tau_1 = 1$.

It is interesting to take a close look at the prices that emerge when a mobile operator starts competing with a fixed incumbent operator.

Table 7.4.13. Prices in period 1

τ_2	p_1^{on}	p_1^{off}	p_2^{on}	p_2^{off}	m_1	m_2
1	2	2	2	2	8467	3133
2	2	3	2	2	7589	2298
5	2	6	2	2	5321	211

One can see that a large access markup of the mobile operator inflates the fixed operator's off-net price. Also, it leads to tougher competition for market share. Notice in particular that the mobile operator's subscription fee is set below the fixed cost of a connection: mobile phone users are subsidized to take a mobile subscription in the early stages of competition. Thus the model provides an explanation for the real-life observation that mobile entrants give away phones for free to new subscribers.

High fixed-mobile interconnection fees are detrimental to the fixed operator's profits. Although in the short run, when the fixed operator still has a large market share, the mobile operator does not benefit from an access markup, in the longer run it is extremely profitable for the mobile operator.

In reality it is almost always the case that the fixed incumbent operator is also one of the suppliers of mobile telephony services. Therefore one should not conclude from the results that the fixed operator is always harmed by high fixed-mobile interconnection tariffs.

7.5. Summary of implications for policy and regulation

In this section, we recapitulate the conclusions for policy and regulation of the previous sections.

Flat fees

The following implications for policy and regulation are valid *given a situation of facilities-based entry*.

- The overall picture is that flat fees distort welfare, since they do not reflect consumers' elastic demand for call minutes and the associated traffic-dependent cost. Recall that two-part tariffs reflect on the one hand consumers' demand for connections and for call minutes, and on the other hand the cost structure of telephony (fixed costs in combination with traffic-dependent costs).

- If the capacity of switches and points of interconnection is limited, flat fees may generate too much traffic compared to the capacity of the network. Accordingly there may be a risk of network congestion.
- In the short run, the entrant's profits and consumers' surplus can be increased by asymmetric regulation in which the incumbent's access price is equal to marginal cost and the entrant's access price includes a markup. In a mature market, that is, in the long run when the operators are equally big, reciprocal and cost-based terminating access prices are best for both producers and consumers (similar to situation with two-part tariffs).

Linear prices
The following implications for policy and regulation are valid *given a situation of facilities-based entry*.

- The overall picture is that linear prices are welfare-distorting, since they do not reflect consumers' inelastic demand for a connection and the associated fixed, traffic-independent cost of a connection. Recall that two-part tariffs reflect on the one hand consumers' demand for connections and for call minutes, and on the other hand the cost structure of telephony (fixed costs in combination with traffic-dependent costs).
- In a mature market, a reciprocal terminating access price may be used to facilitate tacit collusion in the retail market. The risk of collusion can be eliminated by imposing a cost-based access price in the long run.
- In the short run, the entrant's profits and consumers' surplus can be increased by asymmetric regulation in which the incumbent's access price is equal to marginal cost and the entrant's access price includes a markup. In a mature market, that is, in the long run when the operators are equally big, reciprocal and cost-based terminating access prices are best for both producers and consumers (similar to situation with two-part tariffs).

Non-uniform prices
The following implications for policy and regulation are valid *given a situation of facilities-based entry*.

- Looking at consumers' surplus and welfare, there does not seem to be a strong case against, or in favor of, non-uniform pricing. This is due to the ambiguous welfare implications of price differentiation in general. A warning is that a reciprocal access markup reduces the entrant's profits more than under uniform pricing.
- In the short run, the entrant's profits and consumers' surplus can be increased by asymmetric regulation in which the incumbent's access price is equal to

marginal cost, and the entrant's access price includes a markup. In a mature market, that is, in the long run when the operators are equally big, this still holds but reciprocal and cost-based terminating access prices are then best for total surplus.

- The model does not suggest arguments in favor of allowing only the entrant to differentiate per-minute prices.

Fixed-mobile competition

The following implications for policy and regulation are valid *given a situation of entry of a mobile operator with its own network*.

- In the short run, when the mobile operator still has a very small market share, consumers benefit from the mobile entrant's access markup, but in the longer run, consumers' surplus is reduced for large access markups. Although in the short run, when the fixed operator still has a large market share, the mobile operator does not benefit from an access markup, in the longer run it is extremely profitable for the mobile operator.
- A large fixed-mobile interconnection tariff inflates the fixed operator's off-net per-minute price. Also, it leads to tougher competition for market share, and may lead to the mobile operator subsidizing new customers in the early stages of competition. High fixed-mobile interconnection fees are detrimental to the fixed operator's profits.

A.7. Appendix: Calibration and model adaptations

A.7.2. Flat fees

The model is solved by setting per-minute prices equal to zero, and having the operators choose only subscription fees. The parameters are the same as those used in section 6.2.

Table A.7.2.1. Profits of operator *i* ($i \neq j$; gross of fixed costs)

profits from	**level of profits**
on-net traffic	$- n\,(\varphi_i)^2\, x(0)\, c_{i1}$
off-net traffic	$- n\, \varphi_i\, \varphi_j\, x(0)\, (c_{i2} + \tau_j)$
incoming traffic	$n\, \varphi_j\, \varphi_i\, x(0)\, (\tau_i - c_{i3})$
traffic-independent	$n\, \varphi_i\, (m_i - f_i)$

A.7.3. Linear prices

The model is solved by setting subscription fees equal to zero, and having the operators choose only per-minute prices. The parameters are the same as those used in section 6.2, but we have to change an assumption. Trial simulations showed that given the set of original parameters, the entrant is unable to capture market share from the incumbent. Therefore the parameters used in chapter 6 do not generate feasible outcomes in the model of section 7.3. The solution to this problem is to make the entrant a stronger player, relative the weak starting position as postulated in section 5.2. To do this, we assume only in section 7.3 that the fixed utility level offered by the entrant does not start at zero in the first period, but at half the level of the incumbent's utility of a connection:

$$u_2^t = u_0 \text{ Min}\{(t + 5), k\} / k.$$

Accordingly, the entrant initially can offer a relatively larger fixed utility to consumers than before, and is therefore in a better position to gain market share. Notice that numerical results cannot be compared with those of chapter 6. Therefore we have included simulation results on two-part tariffs by using the new assumption on the fixed utility level.

Table A.7.3.1. Profits of operator *i* ($i \neq j$; gross of fixed costs)

profits from	**level of profits**
on-net traffic	$n\,(\varphi_i)^2\,x(\,p_i\,)\,(p_i - c_{i1})$
off-net traffic	$n\,\varphi_i\,\varphi_j\;x(\,p_i\,)\,(p_i - c_{i2} - \tau_j)$
incoming traffic	$n\,\varphi_j\,\varphi_i\;\;x(\,p_j\,)\,(\tau_i - c_{i3})$
traffic-independent	$-\,n\,\varphi_i\;f_i$

A.7.4. Non-uniform prices

The parameters are the same as those used in section 6.2, but we have to make additional assumptions on calling behavior. The per-minute prices of on-net and off-net calls are denoted by p_i^{on} and p_i^{off}, respectively.

The individual demand for call minutes of a subscriber to network *i* is determined as follows:

1. with probability φ_i he wants to call someone who subscribes to the same network (resulting in an on-net call), and with probability $1-\varphi_i$, he wants to call someone on the other network (resulting in an off-net call);
2. the actual length of the call is determined by the individual demand function $x(p)$, and is therefore equal to $x(p_i^{on})$ or $x(p_i^{off})$, respectively.

Notice that we do not explicitly separate the demand for on-net calls from the demand for off-net calls. Instead, it seems realistic to postulate that at some moment a consumer experiences the need to call a certain person, independent of whether that person is on the same network or not, and independent of per-minute prices. Next, depending on the associated per-minute price, the consumer determines the actual length of the call. Summarizing, consumers naturally take into account price differences between on-net and off-net calls, but the need to call somebody arises independently of the network the called party subscribes to.

The indirect utility from subscribing to network *i* is equal to

$$\varphi_i\, v_i\,(p_i^{on}, m_i) + (1-\varphi_i)\, v_i\,(p_i^{off}, m_i).$$

This is the same demand specification as in Laffont, Rey and Tirole (1998b, see their definition of variable net surplus in equation (1), p. 42).

The realized market share of operator *i* is implicitly defined as follows, where $i \neq j$:

$\varphi_i = \varphi_i^0 +$

$[\ \varphi_i\, v_i\,(p_i^{\text{on}}, m_i) + \varphi_j\, v_i\,(p_i^{\text{off}}, m_i) - (\ \varphi_j\, v_j\,(p_j^{\text{on}}, m_j) + \varphi_i\, v_j\,(p_j^{\text{off}}, m_j))\ ] \,/\, s_{\max}.$

Market shares φ_1 and φ_2 are now derived in a straightforward way, namely from solving the system of linear equations consisting of implicit market share defitions for $i = 1, 2$.

Table A.7.4.1 depicts the composition of profit functions.

Table A.7.4.1. Profits of operator *i* ($i \neq j$; gross of fixed costs)

profits from	**level of profits**
on-net traffic	$n\ (\varphi_i)^2\ x(\ p_i^{\text{on}})\ (p_i^{\text{on}} - c_{i1})$
off-net traffic	$n\ \varphi_i\ \varphi_j\ \ x(\ p_i^{\text{off}})\ (p_i^{\text{off}} - c_{i2} - \tau_j)$
incoming traffic	$n\ \varphi_j\ \varphi_i\ \ x(\ p_j^{\text{off}})\ (\tau_i - c_{i3})$
traffic-independent	$n\ \varphi_i\ (m_i - f_i)$

One can show (see Laffont, Rey and Tirole, 1998b, proposition 5) that without price cap regulation, per-minute prices in equilibrium are equal to marginal costs, that is,

$p_i^{\text{on}} = c_{i1},$

$p_i^{\text{off}} = c_{i2} + \tau_j.$

This result applies also to our model. Moreover, Laffont et al. show that profits in equilibrium are bounded above by the profit levels under uniform pricing, and profits are equal to profit levels under uniform pricing only if $\tau_i = \tau_j = 0$.

Chapter 8. Targeted entry in a segmented market

8.1. Introduction

In this chapter, consumers are assumed to be heterogeneous. We distinguish two types of customers, which allows us to incorporate targeted entry in the models. For example, an entrant may wish to serve business customers only. Another entrant may wish to target the total market, but build a customer access network for business customers only, while serving residential customers through local loop unbundling or Carrier Select service.

Throughout this chapter, we interpret the two types as residential customers and business customers. This is done mainly for illustrative purposes and ease of exposition; other interpretations of the types are also possible.

In principle, the models allow that residential customers and business customers are different with respect to individual demand and price elasticity, consumer switching costs, and the constant utility derived from having a network connection. However, instead of focusing on parameter differences, we focus on targeted entry, which is, in our view, a more important policy issue.

The following entry situations are investigated:[42]

- section 8.2: the entrant targets the business segment only, with a customer access network for business customers (targeted FBC);
- section 8.3: the entrant targets the business segment with a customer access network for business customers, and targets the residential segment while leasing the incumbent's local lines (combination of targeted FBC and LLU);
- section 8.4: the entrant targets the business segment with a customer access network for business customers, and targets the residential segment through Carrier Select (combination of targeted FBC and CSC).

The targeted entry situation comes much closer to the real world than the models analyzed in chapter 6. While the players in the models should not be identified as specific companies in the real world – but the models are too stylized to justify that – it is interesting to discuss some examples, with the purpose to demonstrate the relevance of the models. First, consider targeted FBC, the topic of section 8.2. Versatel in the Netherlands is an example of an operator with a network consisting of city rings connecting the largest cities and business centers in the Benelux, and a customer access

[42] FBC = facilities-based competition; LLU = local loop unbundling-based competition; CSC = Carrier Select-based competition. See also section 6.1.

network that connects customers along its Benelux network. Moreover, Versatel's network will not be confined to the "Randstad" only;[43] the intention is to connect several medium-sized cities ranging from Alkmaar and Groningen in the North of the country, to Heerlen in the very South.[44] MCI Worldcom follows a similar strategy in the Netherlands.

An example of an operator targeting both the business and residential market is Telfort in the Netherlands. Residential customers can connect to its backbone by using a Carrier Select service, while large business can directly connect to the network. This type of entry is similar to the combination of targeted FBC and CSC, the topic of section 8.4.[45] In the near future, an operator such as Telfort may consider to lease local loops from KPN Telecom, instead of offering Carrier Select services, in order to reach residential customers. That would lead to a situation of targeted FBC and LLU, which is the topic of section 8.3.

Many of the outcomes in this chapter closely resemble the results of chapter 6. Indeed, the analysis based on models with heterogeneous customers can be seen as robustness checks of the models with homogeneous customers.

Table 8.1.1 summarizes the differences between the models analyzed in this chapter.

[43] The Randstad consists of the four major cities in the Netherlands (Amsterdam, Utrecht, The Hague, and Utrecht).

[44] See http://www.versatel.nl/network.htm (consulted October 2000).

[45] See http://www.telfort.nl (consulted October 2000).

Table 8.1.1. Summary of model differences.

	targeted FBC (section 8.2)	**targeted FBC and LLU (section 8.3)**	**targeted FBC and CSC (section 8.4)**
entrant's network consist of:	- backbone - customer access network for business segment	- backbone - customer access network for business segment	- backbone - customer access network for business segment
entrant's way of access to residential end-users:	- entrant does not serve residential users	- direct access (consumers can subscribe) - terminating access (off-net calls)	- indirect access (consumers cannot subscribe) - terminating access (all calls) - originating access (Carrier Select)
entrant's way of access to business end-users:	- direct access (consumers can subscribe) - terminating access (off-net calls)	- direct access (consumers can subscribe) - terminating access (off-net calls)	- direct access (consumers can subscribe) - terminating access (off-net calls)
relevant wholesale prices:	- terminating access prices	- terminating access prices - line rental	- incumbent's terminating and originating access prices

8.2 Targeted facilities-based entry

8.2.1. Model

Compared to the benchmark model, there are now two market segments. Type-specific variables will be denoted by adding superscripts "res" and "bus" to parameters and variables, denoting respectively "residential" and "business" customers. We assume that the business segment is relatively small compared to the residential segment (see appendix A.8.2).

The entrant competes with the incumbent only in the business segment. Accordingly, in the residential segment we have by definition that

φ_1^{res} = 100% in all periods.

Market shares in the business segment, φ_1^{bus} and φ_2^{bus}, are well defined, in the same manner as they were defined in the model with homogeneous consumers. Total market shares φ_1 and φ_2, that is, the operators' market shares in the total market, are weighted averages of market shares in the two segments, weighted by the size of the segments.

As before, calling patterns are assumed to be isotropic (see also chapter 4). In the models with homogeneous consumers, this meant that the volumes of on-net and off-net traffic are proportionate to market shares. With heterogeneous customers, the assumption not only applies to market shares, but also to relative sizes of the two market segments. Simply stated, a customer of any type has an equal statistical probability of calling another customer of any type and subscribing to any operator. Notice that the incumbent only has to pay a terminating access price to the incumbent if one of its customers calls a business customer of the entrant, as the latter operator does not have any residential customers..

Throughout the body of the chapter, we assume that the incumbent is not allowed to price discriminate. The entrant is allowed to price discriminate (this becomes only relevant in sections 8.3 and 8.4, where the entrant targets more than one segment). Accordingly, the incumbent chooses prices p_1 and m_1, and the entrant sets p_2^{res}, p_2^{bus}, m_2^{res}, and m_2^{bus}. This assumption reflects a situation of asymmetric regulation, in which only the incumbent, as an operator with a dominant position, is subject to certain rules.[46]

The following table summarizes the policy instruments that we will be focusing on.

[46] For the sake of exposition, we ignore the possibility that asymmetric regulation is lifted as soon as the two operators are roughly equal players, or that the entrant becomes subject to similar type of regulation if its market share gets sufficiently large..

Table 8.2.1. Instruments of policy and regulation

instrument	**description**
p_1	fixed per-minute price operator 1
m_1	fixed subscription fee operator 1
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2

8.2.2. Retail price regulation

In this section we address the situation in which the entrant targets only the business segment, and leaves the residential segment to the incumbent operator. We start by discussing the case in which the incumbent's retail prices are not regulated, only to show that regulation is needed if the monopoly segment of the market is sufficiently large or attractive for the incumbent. Next, we look in detail at the case of retail price regulation. Throughout, the incumbent is not allowed to set different prices for the two segments.

Retail price regulation is necessary

To start with, we take a closer look at the incumbent's behavior in the monopoly segment of the market. Suppose that the incumbent is free to set its prices. Without a maximum on its subscription fee, the incumbent operator has a strong incentive to raise it up to the monopoly level, although the resulting loss of profits in the business segment acts, to some extent, as a counteracting force. However, if the business segment is too small, its counteracting power is insufficient. In that case the incumbent "gives away" the business segment to the entrant, who quickly gains a market share of 100%.

Simulations showed that the entrant's market share in the business market grows very fast. See the table below for an example of simulation results under standard parameter values. The incumbent sets the subscription fee at the maximum level that is possible (e.g. the monopoly level of the residential market, or the level imposed by a price cap), effectively milking the residential segment and leaving the corporate segment to the entrant.

Table 8.2.2. Market share of the entrant in business market (example)

period	φ_2^{bus}
0 (before entry)	0%
1	59%
2	91%
from 3 onwards	100%

Because the incumbent's subscription fee is relatively high, the entrant hardly faces any price pressure in the corporate market. This phenomenon is sometimes called "cherry picking." It does not occur if the incumbent is allowed to price discriminate between residential and business customers. Indeed, price discrimination allows the incumbent to decrease its subscription fee for corporate customers, m_1^{bus}, to a more competitive level. The situation in the business segment then resembles competition in a market with homogeneous customers. The incumbent charges monopoly prices in the residential market.

The occurrence of cherry-picking depends on the size or attractiveness of the monopolized market segment. If the entrant targets the much larger *residential* market instead of the business market, then simulations confirm that the incumbent does not monopolize the corporate market while leaving the residential segment to the entrant. Hence, if the incumbent operator faces no entry in a sufficiently large (i.e., attractive) segment of the market, regulation of its retail prices is necessary.

Policy implications

If the incumbent faces no competition in a sufficiently large or attractive segment of the market, then regulation of the incumbent's retail prices is necessary.

Without price regulation, the incumbent will monopolize the market where no entry occurs and leave the other segment to the entrant. Since the incumbent cannot price discriminate between residential and business customers, the entrant hardly faces any price pressure and can raise its subscription fee ("cherry picking"). It may then be desirable to regulate the entrant's retail prices. Note that if there is more than one entrant in the business market, then competition may reduce prices and to prevent cherry picking.

Allowing the incumbent to price discriminate prevents cherry-picking, but does not take away the need to regulate the incumbent's prices in the captive segment, that is, the segment where no entry occurs.

Asymmetric retail price regulation

Because of the observations above, we will now move to another set-up of the game, in which the incumbent is subject to retail price regulation. In particular, we assume that the incumbent's per-minute price and subscription fee are fixed by the regulator. For the interpretation of the outcomes of the model, however, this does not matter, as long as we keep in mind that in some cases, a price cap is equivalent, while in other cases, in may be necessary to check that the incumbent's prices are not too low.

Expectedly, if the incumbent's prices are too low, entry will be difficult, or perhaps even impossible. We will indeed see that in the beginning, entry is facilitated by preventing the incumbent from exerting strong price pressure that would keep the entrant out of the market.

The following three tables depict the total market. Next, the outcomes for the separate markets are given.

Table 8.2.3. Effects of price regulation of incumbent, total market / *short run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	0.183	402.01	0.01	444.31	402.02	846.33
2	8000	0.366	409.14	0.03	436.43	409.17	845.6
2	8500	1.281	444.36	0.35	397.11	444.72	841.82
2.5	8000	1.221	441.56	0.32	399.69	441.88	841.56
2	**	1.281	444.36	0.35	397.11	444.72	841.82

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.4. Effects of price regulation of incumbent, total market / *long run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	18.283	329.11	72.13	445.8	401.24	847.04
2	8000	18.649	334.06	75.05	437.93	409.11	847.04
2	8500	20.479	357.95	90.5	398.6	448.44	847.04
2.5	8000	20.358	356.01	89.44	401.19	445.44	846.63
2	**	16.823	308.72	61.07	477.25	369.79	847.04

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.5. Effects of price regulation of incumbent, total market / *aggregate over time**

p_1	m_1	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	5466.32	412.63	6700.7	5879	12579.7
2	8000	5552.47	435.37	6583.7	5987.8	12571.6
2	8500	5971.05	560.58	5999.2	6531.6	12530.8
2.5	8000	5937.23	551.75	6037.6	6489	12526.6
2	**	5424.1	359.74	6774.2	5783.8	12558

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.6. Effects of price regulation of incumbent, res. market / *short run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	-	314.31	-	346.75	314.31	661.06
2	8000	-	320.48	-	340.59	320.48	661.06
2	8500	-	351.29	-	309.77	351.29	661.06
2.5	8000	-	348.86	-	311.8	348.86	660.66
2	**	-	351.29	-	309.77	351.29	661.06

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.7. Effects of price regulation of incumbent, res. market / *long run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	-	314.31	-	346.75	314.31	661.06
2	8000	-	320.48	-	340.59	320.48	661.06
2	8500	-	351.29	-	309.77	351.29	661.06
2.5	8000	-	348.86	-	311.8	348.86	660.66
2	**	-	289.66	-	371.4	289.66	661.06

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.8. Effects of price regulation of incumbent, res. market / *aggregate over time**

p_1	m_1	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	4714.7	-	5201.3	4714.7	9915.94
2	8000	4807.14	-	5108.8	4807.1	9915.94
2	8500	5269.37	-	4646.6	5269.4	9915.94
2.5	8000	5232.87	-	4677	5232.9	9909.86
2	**	4653.07	-	5262.9	4653.1	9915.94

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.9. Effects of price regulation of incumbent, business market / *short run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	0.833	87.7	0.01	97.56	87.7	185.27
2	8000	1.667	88.67	0.03	95.84	88.69	184.54
2	8500	5.833	93.07	0.35	87.33	93.43	180.76
2.5	8000	5.559	92.7	0.32	87.89	93.02	180.91
2	**	5.833	93.07	0.35	87.33	93.43	180.76

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.10. Effects of price regulation of incumbent, business market / *long run**

p_1	m_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	83.264	14.8	72.13	99.05	86.93	185.98
2	8000	84.931	13.89	75.05	97.34	88.63	185.98
2	8500	93.264	6.66	90.5	88.83	97.15	185.98
2.5	8000	92.716	7.15	89.44	89.39	96.59	185.97
2	**	76.614	19.06	61.07	105.85	80.13	185.98

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

Table 8.2.11. Effects of price regulation of incumbent, business market / *aggregate over time**

p_1	m_1	profits 1	profits 2	*CS*	*PS*	*W*
2	7900	751.63	412.63	1499.5	1164.3	2663.73
2	8000	745.33	435.37	1474.9	1180.7	2655.61
2	8500	701.68	560.58	1352.6	1262.3	2614.85
2.5	8000	704.36	551.75	1360.6	1256.1	2616.72
2	**	771.03	359.74	1511.3	1130.8	2642.05

* $\tau_1 = \tau_2 = 1$.
** Periods 1-5: m_1=8500, and periods 6-15: m_1=7500.

One can make the following observations related to regulation of the incumbent's prices.

Short run, long run, and aggregate over time:
Unsurprisingly, the higher the incumbent's prices are, the higher are its profits in the residential segment and the lower is residential consumers' surplus. The same picture emerges in the business segment, where the entrant benefits also from reduced pressure on prices. Consumers' surplus of business customers is reduced.

Notice that if the incumbent's prices are set too low, the entrant cannot capture any market share, while its profits are strongly reduced. This effect is particularly strong in the short run.

Intuition
Regulation of the incumbent's prices is necessary because of the incumbent's monopoly position in the residential market, which is a large and attractive segment. However, allowing the incumbent to charge high prices directly softens the entrant's best-response price strategy in the business segment. Therefore, both operators benefit to the detriment of consumers. Also, forcing the incumbent to set low prices makes entry in the business segment more difficult, if not impossible.

Accordingly, lenient regulation may be needed in early periods, but in the longer run, it is optimal to impose a tighter price cap (assuming that there is no further entry). This can be seen in the last row of the tables, where the regulator sets prices according to a dynamic rule:

- in early periods, the incumbent's subscription fee is allowed to be relatively high (in the example it is set at $m_1 =$ 8500 in periods 1-5);
- in later periods, it is reduced (in the example it is set at m_1 = 7500 in periods 6-15).

This type of retail price regulation, which is "indulgent" in the early periods of competition, does the best job from the point of view of maximization of consumers' surplus. In the early phase of competition, entry is made more attractive, and in the longer run, the focus is on consumers' benefits.

Robustness
Recall that the incumbent has a strong incentive to milk the attractive residential market, and leave the corporate market to the entrant. Therefore, it is relatively easy for the entrant to quickly gain a large market share. Therefore, if the operators maximize the sum of profits over time, an optimal entry strategy probably resembles the strategy based on myopic optimization. If the entrant sets its prices more aggressively in the short run (just as in the robustness discussion of section 6.2.2), it seems unlikely that this would

discipline the incumbent to the extent that retail price regulation can be withdrawn, given the attractiveness of the captive segment.

The same argument applies if there is not a single entrant but several ones, leading to lower prices in the business segment. Also, if there are several entrants in the business market, it may not be necessary to reduce the incumbent's retail prices in the longer run (although regulation may remain necessary). Evidently, a dynamic price cap rule that gradually becomes more tight, cannot hurt if more intense competition disciplines the incumbent. Beforehand though, it is typically unclear if the competitive pressure from entrants will be sufficiently intense. Therefore, announcing a dynamic price cap rule when the market is opened for competitors, is also recommended if there are several entrants in the business segment.

Finally, consider the growth in internet traffic (see also the robustness discussion in section 6.2.2). Since a large part of this growth is realized in the residential sector, the attractiveness of the incumbent's captive segment sharply increases. Relatively, this may further weaken the disciplinary force of competition in the smaller market segment, which is in support of the arguments for the policy implications on regulation of the incumbent's retail prices.

Policy implications

In order to make entry not too difficult, the incumbent's prices should not be too low, especially in the short run. However, when the entrant has captured substantial market share in the business segment, lenient regulation of the incumbent's prices is harmful for consumers and no longer necessary. To do so, under the assumption that the market structure does not change, the incumbent's prices can be reduced gradually over time, for instance by means of a tighter price cap. In a changing market structure, especially if there is more entry, this may not be needed.

8.2.3. Terminating access prices

We will now look at the effects of changes in terminating access prices. A difference with the model of chapter 6 is that now the incumbent's retail prices are regulated, so that it cannot adapt its prices in reaction to changes in access prices. Therefore some results may change, compared to the model with homogeneous consumers. We will see, however, that the main policy implications remain the same.

Table 8.2.12. Effects of price regulation of incumbent, total market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	0.366	409.14	0.03	436.43	409.17	845.6
1.5	1.5	0.378	409.09	0.03	436.43	409.12	845.55
1	1.5	1.212	405.22	0.32	436.57	405.54	842.11

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.13. Effects of price regulation of incumbent, total market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	18.649	334.06	75.05	437.93	409.11	847.04
1.5	1.5	18.658	333.9	75.15	437.93	409.05	846.98
1	1.5	19.724	323.73	85.4	437.92	409.13	847.04

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.14. Effects of price regulation of incumbent, total market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	5552.47	435.37	6583.7	5987.8	12571.6
1.5	1.5	5550.4	436.39	6583.8	5986.8	12570.5
1	1.5	5420.43	529.2	6588.2	5949.6	12537.8

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.15. Effects of price regulation of incumbent, res. market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	-	320.48	-	340.59	320.48	661.06
1.5	1.5	-	320.47	-	340.59	320.47	661.06
1	1.5	-	320.12	-	340.59	320.12	660.71

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.16. Effects of price regulation of incumbent, res. market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	-	320.48	-	340.59	320.48	661.06
1.5	1.5	-	320.35	-	340.59	320.35	660.94
1	1.5	-	314.72	-	340.59	314.72	655.31

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.17. Effects of price regulation of incumbent, res. market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	4807.14	-	5108.8	4807.1	9915.94
1.5	1.5	4806.1	-	5108.8	4806.1	9914.91
1	1.5	4758.39	-	5108.8	4758.4	9867.19

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.18. Effects of price regulation of incumbent, business market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	1.667	88.67	0.03	95.84	88.69	184.54
1.5	1.5	1.721	88.62	0.03	95.84	88.65	184.49
1	1.5	5.518	85.1	0.32	95.99	85.42	181.41

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.19. Effects of price regulation of incumbent, business market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	84.931	13.89	75.05	97.34	88.63	185.98
1.5	1.5	84.973	13.55	75.15	97.34	88.7	186.04
1	1.5	89.826	9.01	85.4	97.33	94.41	191.74

* p_1 = 2.0 and m_1 = 8000.

Table 8.2.20. Effects of price regulation of incumbent, business market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	745.33	435.37	1474.9	1180.7	2655.61
1.5	1.5	744.29	436.39	1475	1180.7	2655.64
1	1.5	662.04	529.2	1479.4	1191.2	2670.61

* p_1 = 2.0 and m_1 = 8000.

The effects of a reciprocal access markup are very small, as also observed in chapter 6. Consider therefore an asymmetric increase in the entrant's terminating access price.

Short run
The most important effect in the business market is a strong increase in the entrant's market share and profits, while the incumbent's profits are slightly reduced. Other effects are rather small. Business consumers' surplus slightly increases, and welfare in the business segment slightly decreases. Producers' surplus is reduced. The effects in the residential market are negligible.

Long run
In the long run, the entrant still benefits in terms of market share and profits. The incumbent's profits, though, are reduced much more than in the short run. Business consumers' surplus remains roughly constant, while welfare increases. In the residential segment, the incumbent's profits are reduced, consumers' surplus is not affected, and welfare is reduced. Total consumers' surplus and welfare remain roughly constant.

Aggregate over time
Business consumers' surplus and welfare increase. Residential consumers' surplus is not affected, and welfare decreases. Total consumers' surplus increases, but total welfare decreases.

Intuition
The existence of a regulated monopoly segment, connected to the competitive business segment through traffic with another segment, somewhat distorts previous intuitions. In particular, the incumbent's residential profits in the long run are reduced because of decreased access revenues from incoming calls. Also, now the incumbent cannot react with its prices to an increase in traffic-dependent costs if it faces a larger access price charged by the entrant.

Robustness
Because of the incumbent's captive segment, entry in the business segment is relatively easy. Presumably therefore, a dynamic entry strategy resembles per-period profit maximization (see the discussion on robustness earlier in this section). Nevertheless, suppose that the entrant sets its prices more aggressively in the short run (just as in the robustness discussion of section 6.2.2). In the short run, corporate customers benefit from lower prices, while the entrant gains market share in the business segment at an even faster rate. Although competition for business customers may become somewhat more intense, the large captive segment is still there, which makes the incumbent a soft competitor in the business segment. Hence, the long-run implications of the model do

not seem to change in a substantial way. Overall, the importance of access price regulation is perhaps less prominent in the short run (especially since consumers' surplus is hardly affected by access markups). However, the arguments in favor of access prices equal to costs in the long run are not affected. Some fine-tuning may be needed, though. Since the entrant's market share grows faster, the regulator can switch to reciprocal, cost-based access prices at an earlier moment.

A similar argument applies if there is not a single entrant but several ones, leading to lower prices in the business segment. The fact that this leads to lower market shares and profits per entrant, which marginalizes their position, suggests that it is still important to allow only entrants to charge an access markup. This is especially true since in early periods, the bulk of incoming traffic on their networks originates from the incumbent's network, and the bulk of traffic originating on their networks terminates on the incumbent's network.

Policy implications

Allowing the entrant to set a relatively high access price in the beginning, and setting the incumbent's access price equal to cost, strongly increases the entrant's market share and profits. Since the effects on residential and business consumers' surplus seem negligible, it makes sense to adopt total welfare (aggregate over time) as the relevant policy criterion. Welfare is maximized by setting symmetric access prices equal to cost, both in the long and short run. Hence, asymmetric access price regulation (allowing only the entrant an access markup, and only in the short run), only is called for if the purpose is to stimulate entry.

8.3. Combined facilities-based and LLU-based entry

8.3.1. Model

The model is adapted to capture that the entrant targets both market segments, but serves customers in the two segments in different ways:

- it builds a customer access network for corporate customers;
- it serves residential customers through local loop unbundling.

Furthermore, only the entrant is allowed to price discriminate between residential and corporate customers. Accordingly, the incumbent chooses prices p_1 and m_1, and the entrant sets p_2^{res}, p_2^{bus}, m_2^{res}, and m_2^{bus}. (Type-specific variables are denoted by adding superscripts "res" and "bus" to parameters and variables, denoting respectively "residential" and "business" customers.)

The entrant may have good reasons for building local loops for one segment only. For instance, in general the cost of building a local access network for residential customers is much higher than building one for business customers (due to economies of scope in the cost of building the network).

A major difference with the model of section 8.2 is that the operators now compete in both market segments. Thus, both φ_2^{res} and φ_2^{bus} can take any value between 0 and 100%. Market shares in each segment are defined similarly to the model with homogeneous consumers. Total market shares φ_1 and φ_2, that is, the operators' market shares in the total market, are weighted averages of market shares in the two segments, weighted by the size of the segments.

Calling patterns are assumed to be isotropic (see also chapter 4). This means that a customer of any type has an equal probability of calling another customer of any type and subscribing to any operator.

The following table summarizes the policy instrument that we will be focusing on. The role of terminating access prices is similar to the previous section, so that we can restrict our attention to the level of the line rental.

Table 8.3.1. Instruments of policy and regulation

instrument	**description**
L	lease price of local line (line rental)

8.3.2. Lease price of the local loop

Since the entrant targets both segments, there does not seem to be a risk of cherry-picking. Closer inspection of the prices in equilibrium outcomes will confirm that it does indeed not occur. We start with the case in which the incumbent's prices are not regulated.

We will first explore the role of the lease price of the incumbent's local line. Given the insights developed in Chapter 6, we expect that an increase of the lease price will push up the entrant's subscription fee for residential customers m_2^{res}, but not necessarily its subscription fee for corporate customers m_2^{bus}. Also, since its larger traffic-independent cost makes the entrant less competitive, the incumbent will be able to raise its subscription fee. There will probably be no effect on per-minute prices, because local loop unbundling has, in principle, no impact on traffic-dependent costs in the model.

The outcomes for the total market, as well as for the two segments, are depicted below.

Table 8.3.2. Lease price of local line in total market / *short run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	5.556	422.64	1.46	400.29	424.1	824.39
2000	5.556	447.11	1.55	375.69	448.66	824.35
2400	5.556	471.22	1.82	351.17	473.04	824.21

* $\tau_1 = \tau_2 = 1$.

Table 8.3.3. Lease price of local line in total market / *long run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	49.807	119.37	117.54	610.14	236.91	847.05
2000	49.807	143.66	117.9	585.49	261.57	847.05
2400	49.807	167.23	118.99	560.84	286.22	847.05

* $\tau_1 = \tau_2 = 1$.

Table 8.3.4. Lease price of local line in total market / *aggregate over time**

L	profits 1	profits 2	*CS*	*PS*	*W*
1600	3602.06	799.54	7809.72	4401.6	12211.3
2000	3966.79	804.35	7440.12	4771.14	12211.3
2400	4321.41	818.79	7070.88	5140.2	12211.1

* $\tau_1 = \tau_2 = 1$.

Table 8.3.5. Lease price of local line in residential market / *short run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	5.556	329.84	1.14	312.4	330.98	643.37
2000	4.824	351.89	0.86	293.02	352.75	645.77
2400	4.092	373.87	0.62	273.66	374.49	648.15

* $\tau_1 = \tau_2 = 1$.

Table 8.3.6. Lease price of local line in residential market / *long run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	49.807	93.16	91.73	476.17	184.89	661.06
2000	48.343	117.73	86.42	456.91	204.15	661.06
2400	46.88	142.15	81.27	437.65	223.41	661.06

* $\tau_1 = \tau_2 = 1$.

Table 8.3.7. Lease price of local line in residential market / *aggregate over time**

L	profits 1	profits 2	*CS*	*PS*	*W*
1600	2811.13	623.98	6094.88	3435.11	9529.99
2000	3174.9	576.88	5803.64	3751.78	9555.42
2400	3536.45	531.89	5512.48	4068.34	9580.82

* $\tau_1 = \tau_2 = 1$.

Table 8.3.8. Lease price of local line in business market / *short run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	5.556	92.8	0.32	87.9	93.12	181.02
2000	8.157	95.22	0.69	82.67	95.91	178.58
2400	10.758	97.35	1.2	77.51	98.55	176.07

* $\tau_1 = \tau_2 = 1$.

Table 8.3.9. Lease price of local line in business market / *long run**

L	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1600	49.807	26.21	25.81	133.97	52.02	185.99
2000	55.01	25.93	31.48	128.58	57.41	185.99
2400	60.212	25.09	37.72	123.19	62.81	185.99

* $\tau_1 = \tau_2 = 1$.

Table 8.3.10. Lease price of local line in business market / *aggregate over time**

L	profits 1	profits 2	*CS*	*PS*	*W*
1600	790.93	175.56	1714.83	966.49	2681.32
2000	791.89	227.47	1636.48	1019.36	2655.84
2400	784.96	286.89	1558.4	1071.86	2630.25

* $\tau_1 = \tau_2 = 1$.

Consider an increase in the lease price of the local loop L.

Short run
The entrant's market share in the residential market is reduced, but it increases in the business market. Its total market share does not change. The incumbent's profits increase in both segments. The entrant's profits decrease in the residential segment, but increase in the business segment. Consumers' surplus decreases in both segments. Producers' surplus goes up in both segments. Residential welfare increases, but business welfare decreases. Total welfare decreases slightly.

Long run
The changes in market shares are similar to those in the short run. The incumbent's profits still increase in the residential segment, but now decrease in the business segment. For the entrant it is the other way around. Consumers' surplus decreases in both segments. Producers' surplus goes up in both segments. Welfare remains constant in both segments.

Aggregate over time
The incumbent's profits in the business segment go up slightly for a moderate increase in the line rental, but decrease for larger markups. Its total profits increase over the whole range, though. Welfare in the residential market increases, whereas it decreases in the business market.Total welfare is is slightly reduced for a sufficiently large increase in the line rental.

Intuition
The entrant's profits decrease in the residential market, where it faces a higher connection-dependent fixed cost, due to the higher line rental. However, the entrant benefits in the business market, where it builds its own local access network and can benefit from higher prices. The reason is that it experiences less price pressure from the incumbent. Notice also the shift in the entrant's market shares: an increase in the line rental leads to a larger business market share, and a smaller residential market share.

The following table illustrates how in the short run, an increase in the line rental softens price competition in subscription fees, without influencing per-minute pricing. The reason is that the entrant faces a higher fixed cost in the residential market, which inflates its subscription fee for residential customers. The incumbent reacts by increasing its uniform subscription fee, triggering the entrant to raise the fixed fee for business customers as well. Notice that the entrant opts for price discrimination with regard to the subscription fee, as soon as it faces a markup in the line rental. The intuition is that it perceives different fixed costs in the two market segments. In particular, each of its fixed fees increase when leasing the local loop becomes more expensive, but the fee for residential customers m_2^{res} increases most.

Table 8.3.11. Prices in period 1

L	p_1	p_2^{res}	p_2^{bus}	m_1	m_2^{res}	m_2^{bus}
1600	2	2	2	8467	3133	3133
2000	2	2	2	8779	3489	3289
2400	2	2	2	9091	3846	3446

In the long run, depicted in the following table, the entrant still differentiates its subscription fees, although it does not show up in the table due to rounding off. Most importantly, an increase in the line rental increases the entrant's connection-dependent (or fixed) cost level and raises the entrant's subscription fee for residential customers. Accordingly the incumbent can raise its subscription fee as well, which in turn triggers a soft response by the entrant in the business market (see also the earlier explanation).

Table 8.3.12. Prices in period 15

L	p_1	p_2^{res}	p_2^{bus}	m_1	m_2^{res}	m_2^{bus}
1600	2	2	2	5812	5788	5788
2000	2	2	2	6124	6101	6101
2400	2	2	2	6436	6413	6413

Robustness

First of all, consider the assumption that only the entrant can differentiate its prices. Dropping this assumption and assuming that the incumbent can also differentiate its prices, an increase in the line rental no longer softens price competition in the business market. Just as in section 6.3, however, residential consumers face higher subscription fees if the line rental increases. Therefore, the lease price should be equal to the fixed cost of a local connection.

Do the policy implications change if the operators maximized total profits over time, or if there are several entrants? Concerning the first assumption, there are no indications that the results are not robust. In particular, the general arguments in the robustness discussions in chapter 6 still apply; a new element is that depending on the level of the lease price, the entrant may shift its relative priorities between the two segments. For example, a higher line rental leads to a stronger growth of its business market share, and a slower growth of its residential market share, due to the change in relative attractiveness of the segments. The presence of heterogeneous customers does not seem to affect the intuitions developed in chapter 6. Therefore, the short-term weight in the entrant's strategy on gaining market share does not seem to reverse policy implications.

Now consider the second assumption, and suppose that there is more than one entrant. Perhaps some of the entrants target only the residential segment, some only the business segment, and others target both segments. Clearly, the relative intensities of competition in the segments may be different, depending on the variety of entry strategies. Also, a markup in the lease price of the local loop directly harms (just as before) residential customers, and softens price competition in the business segment. Again, the arguments that support a cost-based lease price still apply.

Policy implications

The policy recommendation with regard to the lease price of the local line, delivered in Section 6.3.2, does not change: consumers' surplus of both types of customers is maximized if the line rental is equal to the underlying cost. The motivation is now even more compelling, though. The additional motivation is that the lease price of the local line, in combination with the fact that the incumbent cannot price discriminate, acts as an instrument of tacit collusion, since it softens competition in the business segment. Because of the risk of collusion through a joint agreement on a lease price markup, it makes sense to either closely monitor the operators' negotiations on the lease price, or to regulate it.

8.4. Combined facilities-based and Carrie Select-based entry

8.4.1. Model

The model is adapted to capture that the entrant targets both market segments, but serves customers in the two segments in different ways:

- it builds a customer access network for corporate customers;
- it serves residential customers through Carrier Select.

Furthermore, only the entrant is allowed to price discriminate between residential and corporate customers. Accordingly, the incumbent chooses prices p_1 and m_1, and the entrant sets p_2^{res}, p_2^{bus}, and m_2^{bus}. In the residential market, consumers using the entrant's Carrier Select service pay subscription fee m_1 to the incumbent. (Type-specific variables are denoted by adding superscripts "res" and "bus" to parameters and variables, denoting respectively "residential" and "business" customers.)

Similar to section 8.3 but different to section 8.2, both φ_2^{res} and φ_2^{bus} can take any value between 0 and 100%. Market shares in each segment are defined similarly to the model with homogeneous consumers. Total market shares φ_1 and φ_2, that is, the operators' market shares in the total market, are weighted averages of market shares in the two segments, weighted by the size of the segments.

Calling patterns are assumed to be isotropic (see also chapter 4). This means that a customer of any type has an equal probability of calling another customer of any type and subscribing to any operator.

To keep the model simple, we have not included the possibility of capacity shortages of the Carrier Select service, which was analyzed in section 6.4.2. In other words, we have set parameter $\alpha = 0$ (see appendix A.6.4 for more on α).

We will consider a price cap only on the incumbent's subscription fee, denoted by κ:

$$m_1 \leq \kappa.$$

Table 8.4.1. Instruments of policy and regulation

instrument	**description**
κ	price cap on m_1
τ_1	terminating access price charged by operator 1
τ_2	terminating access price charged by operator 2
δ_1	originating access price charged by operator 1

8.4.2. Asymmetric retail price regulation

Unregulated retail prices

Without a price cap on its subscription fee, or with "soft" price cap regulation, the incumbent operator has a strong incentive to raise it up to the monopoly level, although the resulting loss of profits in the business segment acts, to a certain extent, as a counteracting force. However, because of the large size of the residential segment, its counteracting power is insufficient, as we have also seen in section 8.2. There, the incumbent "gives away" the business segment to the entrant, who quickly captures the complete market segment.

Simulations (not reported here) showed that the entrant very rapidly gains market share in the business market. The incumbent has an incentive to set the subscription fee as high as possible (equal to either the monopoly level of the residential market or to a possible price cap on the subscription fee), in order to “milk” residential customers and leaving the corporate segment to the entrant.

This outcome does not occur if the incumbent is allowed to price discriminate between residential and business customers. Price discrimination enables the incumbent to decrease its subscription fee for corporate customers, m_1^{bus}, and effectively compete with the entrant in the business market.

The policy implication is that if the disciplinary force from entry is insufficient, then regulation of the incumbent’s retail prices is necessary. Without retail price regulation, the incumbent will monopolize one segment of the market and leave the other segment to the entrant.

Asymmetric retail price regulation

Given the observations above, we assume that the incumbent is subject to retail price regulation. In particular, there is a price cap, denoted by κ, on the incumbent’s subscription fee.

Table 8.4.2. Effects of price cap regulation, total market / *short run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	22.814	347.71	26.24	429.52	373.95	803.48
5500	22.941	380.97	25.27	396.51	406.24	802.75
6000	23.067	413.28	24.58	363.66	438.16	801.82

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.3. Effects of price cap regulation, total market / *long run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	48.758	230.22	109.35	495.94	339.56	835.5
5500	48.678	257.15	115.51	464.04	372.67	836.71
6000	48.616	282.84	122.81	432.18	405.65	837.83

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.4. Effects of price cap regulation, total market / *aggregate over time**

κ	profits 1	profits 2	*CS*	*PS*	*W*
5000	3972.64	1191.08	7176.34	5163.72	12340.1
5500	4421.25	1211.42	6696.5	5632.67	12329.2
6000	4852.19	1246.8	6217.86	6098.99	12316.9

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.5. Effects of price cap regulation, residential market / *short run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	28.123	263.12	26.08	338.36	289.19	627.55
5500	27.324	292.41	24.71	312.25	317.12	629.37
6000	26.524	321.59	23.37	286.19	344.96	631.15

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.6. Effects of price cap regulation, residential / *long run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	42.015	209.97	54.33	386.04	264.29	650.33
5500	40.01	240.43	49.78	361.07	290.21	651.28
6000	38.029	270.62	45.43	336.13	316.05	652.19

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.7. Effects of price cap regulation, residential market / *aggregate over time**

κ	profits 1	profits 2	*CS*	*PS*	*W*
5000	3232.56	882.13	5586.27	4114.69	9700.96
5500	3692.77	817.34	5206.95	4510.11	9717.06
6000	4149.35	754.94	4828.24	4904.28	9732.52

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.8. Effects of price cap regulation, business market / *short run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	3.945	84.6	0.16	91.17	84.76	175.92
5500	7.364	88.56	0.56	84.25	89.13	173.38
6000	10.78	92	1.21	77.47	93.21	170.67

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.9. Effects of price cap regulation, business market / *long run**

κ	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
5000	72.722	20.25	55.02	109.89	75.27	185.17
5500	79.486	16.73	65.73	102.96	82.46	185.42
6000	86.241	12.22	77.38	96.04	89.6	185.64

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Table 8.4.10. Effects of price cap regulation, business market / *aggregate over time**

κ	profits 1	profits 2	*CS*	*PS*	*W*
5000	740.08	308.95	1590.06	1049.03	2639.09
5500	728.48	394.09	1489.55	1122.56	2612.11
6000	702.85	491.86	1389.62	1194.71	2584.33

* $\tau_1 = \tau_2 = \delta_1 = 1$.

Concerning different levels of the price cap on the incumbent's subscription fee, one can make the following observations. Consider an increase of the level of the price cap on the incumbent's subscription fee.

Short run

The entrant's residential market share decreases, and its business market share increases. Profits of the incumbent increase in both segments. The entrant's profits decrease in the residential segment, but increase in the business segment. Consumers' surplus decreases, and producers' surplus increases, in both segments. Welfare in the residential segment slightly increases, but decreases in the business segment. Overall (in terms of total profits), the incumbent is better off and the entrant is worse off. Total consumers' surplus decreases, while total producers' surplus increases. Welfare is slightly reduced.

Long run

The long-run effects in the residential segment are the same as in the short run. In the business segment, though, the incumbent's profits now decrease, and welfare remains roughly constant (the effects on other indicators are similar to the short run effects). The entrant's total profits now increase. Other effects are similar to short-run effects.

Aggregate over time

We restrict attention to cases where short and long run effects have opposite signs. In the business segment of the market, the incumbent's aggregate profits decrease, and welfare decreases also. Total welfare decreases.

Intuition

The considered price caps on the incumbent's subscription fee are binding in all periods. Allowing the incumbent to charge a higher subscription fee directly affects residential consumers, since they have to pay the incumbent's subscription fee even if they use the Carrier Select service. Since the incumbent does not differentiate its prices, price competition in the business segment becomes less intense. Therefore, that soft price cap regulation not only hurts residential but also corporate customers.

Something that cannot be observed from the tables above is that the market share that the entrant initially gains in the residential market, is reduced again in the longer run. Also, the entrant takes over the incumbent in the corporate market. For example, in the case of price cap $\kappa = 5000$, the following picture emerges:

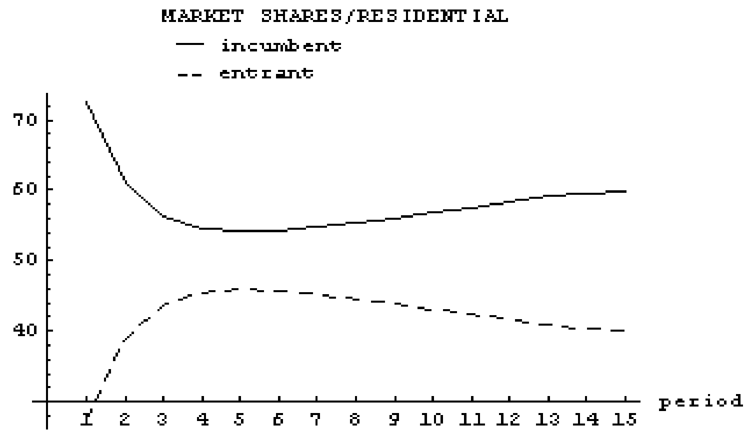

Figure 8.4.1. Residential market shares

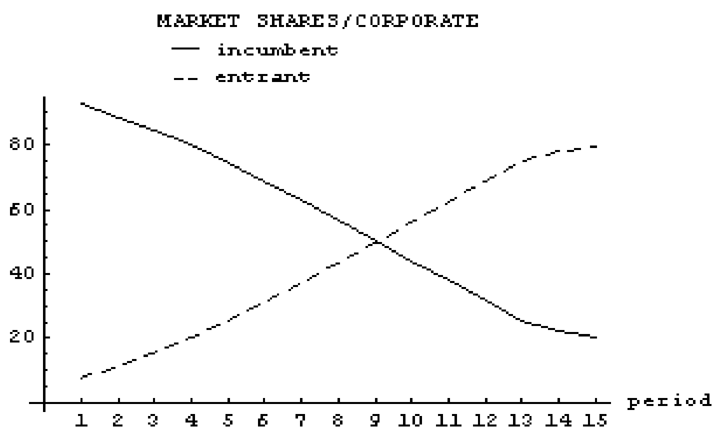

Figure 8.4.2. Business market shares.

Figures 8.4.1-8.4.2 can be explained as follows. In the short run, the incumbent hardly faces any competitive pressure from the entrant in the business segment, since the entrant initially offers a relative low fixed utility level to corporate users (see section 5.2). Since the incumbent cannot differentiate its prices, this softens the incumbent's overall stance (i.e., the incumbent charges a relatively high per-minute price). Consequently, it is relatively easy for the entrant to gain market share in the residential market. In the longer run, however, the entrant's fixed quality level offered to corporate users increases, which leads to a more aggressive response from the incumbent (i.e., the incumbent's undifferentiated per-minute price decreases more than if there was no corporate segment).

A simple exercise supports the above explanation. If one simulates competition under the assumption that $u_2^{t,\,\mathrm{bus}} = u_0$ in all periods t, that is, the entrant immediately offers the same fixed utility to corporate users as the incumbent, then one does not observe the decrease in the entrant's corporate market share in the longer run. See the following figure.

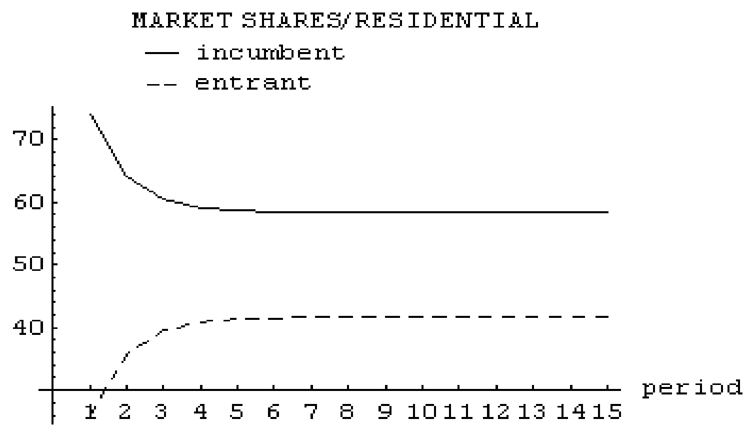

Figure 8.4.3. Residential market shares if $u_2^{t,\,\mathrm{bus}} = u_0$ in all periods t.

Robustness

Suppose that the operators maximize total profits over time. Hence, competition becomes somewhat more intense due to the bigger importance of market shares. This effect is particularly pronounced for the entrant in the beginning of the game: the entrant will try to gain market share faster by setting lower prices. The resulting downward price pressure on the incumbent may call for some fine-tuning of the price cap (in the sense of loosening it), but expectedly, the need for price cap regulation does not vanish.

Similarly, if there is more than one entrant, the incumbent faces more price pressure. Hence, price cap regulation can be softened to some extent. The presence of heterogeneous customers in combination with targeted entry does not seem to affect the intuitions developed in the previous chapter. Therefore, the presence of several entrants does not seem to reverse the policy implications of our analysis.

Policy implications

Because of the lack of competitive discipline, it is necessary to regulate the incumbent's subscription fee with a price cap or by fixing it directly (any reasonable price cap will be binding). The negative effect on the entrant's total, aggregate profits are negative, but relatively small. There is a tradeoff involved, though. To maximize consumers' surplus in both the residential and the business segment, both in the short and long run, the price cap on the subscription fee should be relatively tight. This encourages Carrier Select-based entry in the residential market. The other side of the coin is that a tighter price cap makes facilities-based entry in the business market becomes less attractive in the short run, but this drawback vanishes in the longer run, when the entrant is able to offer a higher quality level to business customers.

8.4.3 Originating access price

We now turn to the originating access price. Expectedly, it will play the roughly the same role as in section 6.4.

Table 8.4.11. Originating access price, total market / *short run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	22.814	347.71	26.24	429.52	373.95	803.48
1.5	22.034	367.43	23.53	406.2	390.96	797.16
2	21.19	385.06	21.03	384.36	406.08	790.44

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.12. Originating access price, total market / *long run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	48.758	230.22	109.35	495.94	339.56	835.5
1.5	47.748	250.21	110.84	470.8	361.06	831.86
2	46.672	268.14	112.99	446.73	381.12	827.85

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.13. Originating access price, total market / *aggregate over time**

δ_1	profits 1	profits 2	*CS*	*PS*	*W*
1	3972.64	1191.08	7176.34	5163.72	12340.1
1.5	4292.94	1149.57	6808.56	5442.5	12251.1
2	4580.96	1118.19	6458.08	5699.15	12157.2

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.14. Originating access price, residential market / *short run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	28.123	263.12	26.08	338.36	289.19	627.55
1.5	26.476	280.19	23.12	319.7	303.32	623.01
2	24.79	295.8	20.29	302.17	316.09	618.26

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.15. Originating access price, residential / *long run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	42.015	209.97	54.33	386.04	264.29	650.33
1.5	39.219	230.82	47.47	366.37	278.29	644.66
2	36.408	250.37	41.05	347.53	291.41	638.94

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.16. Originating access price, residential market / *aggregate over time**

δ_1	profits 1	profits 2	*CS*	*PS*	*W*
1	3232.56	882.13	5586.27	4114.69	9700.96
1.5	3540.29	775.9	5295.07	4316.18	9611.25
2	3828.05	675.7	5017.34	4503.76	9521.1

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.17. Originating access price, business market / *short run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	3.945	84.6	0.16	91.17	84.76	175.92
1.5	6.244	87.24	0.41	86.51	87.64	174.15
2	8.398	89.26	0.73	82.19	89.99	172.18

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.18. Originating access price, business market / *long run**

δ_1	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	72.722	20.25	55.02	109.89	75.27	185.17
1.5	78.049	19.39	63.38	104.43	82.77	187.2
2	83.152	17.77	71.94	99.2	89.71	188.91

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Table 8.4.19. Originating access price, business market / *aggregate over time**

δ_1	profits 1	profits 2	*CS*	*PS*	*W*
1	740.08	308.95	1590.06	1049.03	2639.09
1.5	752.65	373.67	1513.49	1126.32	2639.81
2	752.91	442.49	1440.73	1195.39	2636.13

* $\tau_1 = \tau_2 = 1$, $\kappa = 5000$.

Consider an increase of the originating access price.

Short run, long run, and aggregate over time:
In the residential market, the originating access price plays roughly the same role as in the analysis of section 6.4.3, where we analyzed Carrier Select based entry in an unsegmented market. In the business market, the picture looks different. An increase of the originating access price results in an increase of the entrant's market share and

profits, both in the short and long run. The incumbent's profits in the business market increase in the short run, but decrease in the long run. Business consumers' surplus is reduced in the short and in the long run. Welfare goes down in all cases, except in the long run in the business market.

Intuition

The price cap on the incumbent's subscription fee is binding in all situations. An increase in the originating access price increases the entrant's perceived marginal cost in the residential segment, and therefore also its per-minute price for residential customers. This allows the incumbent to increase its per-minute price as well. The spill-over effect in the business market is that competition becomes less intense, because the increase in the incumbent's undifferentiated per-minute price allows the entrant to increase its subscription fee for business customers. The incumbent, however, faces the price cap and cannot go along. Hence, not only residential consumers, but also business customers are harmed by a markup in the originating access price.

Robustness

The policy implication that the originating access price should be cost-based, does not critically depend on the assumptions of myopic profit maximization and the presence of a single entrant.

Consider the strong growth in internet traffic. Along the lines of the robustness discussion in section 6.4.3, it can be argued that if this growth is strong in the residential market, then a markup in the originating access fee reduces the entrant's profits in the residential segment. The reason is that the internet is typically accessed through local telephony, a service that is more costly for the entrant than the incumbent to provide. Therefore, the residential segment becomes relatively less attractive for the entrant, compared to the business segment. This effect is stronger if the originating access price is larger. The discussion above suggests that a markup in the originating access fee harms the entrant even more than without the internet-induced traffic growth.

Policy implications

The originating access price should be equal to marginal cost. A markup in the originating access price directly harms residential customers, who have to pay higher per-minute prices, and indirectly harms business customers, who experience softened price competition.

8.4.4 Terminating access prices

Finally, we take a brief look at the role of terminating access prices.

Table 8.4.20. Terminating access prices, total market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	22.814	347.71	26.24	429.52	373.95	803.48
1.5	1.5	22.015	368.52	23.68	405.05	392.2	797.25
1	1.5	22.892	344.43	25.73	432.82	370.16	802.98

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.21. Terminating access prices, total market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	48.758	230.22	109.35	495.94	339.56	835.5
1.5	1.5	48.021	251.23	110.56	469.82	361.79	831.61
1	1.5	48.835	227.31	114.37	493.57	341.68	835.25

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.22. Terminating access prices, total market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	3972.64	1191.1	7176.3	5163.7	12340.1
1.5	1.5	4309.23	1150.1	6792.1	5459.4	12251.5
1	1.5	3928.1	1216.1	7183.4	5144.2	12327.5

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.23. Terminating access prices, res. market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	28.123	263.12	26.08	338.36	289.19	627.55
1.5	1.5	26.63	280.58	23.44	318.86	304.02	622.88
1	1.5	27.668	262.2	25.37	340.75	287.57	628.31

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.24. Terminating access prices, res. market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	42.015	209.97	54.33	386.04	264.29	650.33
1.5	1.5	39.749	232.87	50	365.6	282.88	648.47
1	1.5	41.31	209.36	54.05	384.17	263.41	647.59

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.25. Terminating access prices, res. market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	3232.56	882.13	5586.3	4114.7	9700.96
1.5	1.5	3557.47	801.49	5282.8	4359	9641.79
1	1.5	3228.19	865.75	5589.8	4093.9	9683.75

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.26. Terminating access prices, business market / *short run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	3.945	84.6	0.16	91.17	84.76	175.92
1.5	1.5	5.61	87.94	0.24	86.19	88.19	174.37
1	1.5	5.918	82.23	0.37	92.07	82.6	174.67

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.27. Terminating access prices, business market / *long run**

τ_1	τ_2	φ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	72.722	20.25	55.02	109.89	75.27	185.17
1.5	1.5	77.418	18.35	60.56	104.22	78.91	183.14
1	1.5	75.584	17.95	60.32	109.4	78.27	187.66

* $\delta_1 = 1$, $\kappa = 5000$.

Table 8.4.28. Terminating access prices, business market / *aggregate over time**

τ_1	τ_2	profits 1	profits 2	*CS*	*PS*	*W*
1	1	740.08	308.95	1590.1	1049	2639.09
1.5	1.5	751.76	348.65	1509.3	1100.4	2609.72
1	1.5	699.91	350.3	1593.6	1050.2	2643.77

* $\delta_1 = 1$, $\kappa = 5000$.

One can see from the tables above that the entrant's direct benefits from an access markup are experienced in the business segment. That is the segment where the entrant is able to generate revenues from incoming traffic. Terminating access prices indirectly affect the entrant's profits in the residential market because of the effects on prices and traffic. As in previous models, access markups increase perceived marginal costs, and therefore also per-minute prices. This introduces pressure on, in this case, only the entrant's subscription fee. Similar to previous results, it is optimal to allow only the entrant to charge an access markup in the short run, and to impose cost-based access prices in the long run.

8.5. Summary of implications for policy and regulation

In this section, we recapitulate the conclusions for policy and regulation of the previous sections.

Targeted facilities-based entry

The following implications for policy and regulation are valid *given the assumed mode of entry (the entrant targets only the business segment in a situation of facilities-based competition, and leaves the larger, residential segment to the incumbent).*

Retail price regulation

- If the incumbent cannot price discriminate, then without price regulation, the incumbent will monopolize the residential market (given that it is sufficiently large or attractive) and leave the business segment to the entrant. The entrant hardly faces any price pressure and can raise its subscription fee in the business segment. Therefore, regulation of the incumbent's retail prices is not only necessary to protect residential consumers, but also in the interest of business customers.
- Allowing the incumbent to price discriminate prevents a division of the market, but does not take away the need to regulate the incumbent's prices in the residential segment.
- In order to make entry not too difficult or even impossible, the incumbent's prices should not be set too low initially. However, when the entrant has captured substantial market share in the business segment, lenient regulation of the incumbent's prices is harmful for consumers and no longer necessary. Therefore, it is best to reduce the incumbent's retail prices over time.

Terminating access prices

- Consumers' surplus is maximized over time if the entrant's access price is initially above cost and tends towards its underlying cost level as the entrant gains market share. Access regulation of this type, initially skims the incumbent's profits, while increasing the entrant's profits and market share in the business segment. In the long run, total consumers' surplus and welfare are maximized by setting both access prices equal to marginal costs.

Combined facilities-based and LLU-based entry

The following implications for policy and regulation are valid *given the assumed mode of entry (the entrant targets the business segment in a situation of facilities-based competition, and targets the residential segment by leasing the incumbent's local loop).*

- Consumers' surplus of both types of customers is maximized if the line rental is equal to the underlying cost. A markup in the line rental directly harms residential customers, who have to pay higher subscription fees, and indirectly harms business customers, who experience softened price competition.
- Because of the risk of implicit collusion through a joint agreement on a lease price markup, it is important to closely monitor the operators' negotiations on the lease price or to regulate it.
- The effect of softened price competition in the business segment does not occur if the incumbent is allowed to differentiate its prices. This does not affect the recommendation that the lease price of the local loop be equal to the fixed cost of a connection.

Combined facilities-based and Carrier Select-based entry

The following implications for policy and regulation are valid *given the assumed mode of entry (the entrant targets the business segment in a situation of facilities-based competition, and targets the residential segment through Carrier Select services)*.

Price cap regulation

- Because of insufficient competitive discipline, it is necessary to regulate the incumbent's subscription fee. In order to maximize consumers' surplus in both the residential and the business segment, both in the short and long run, the price cap on the subscription fee should be relatively tight. This encourages Carrier Select-based entry in the residential market, while the negative effect on the entrant's total, aggregate profits are, although negative, small.

Originating access price

- The originating access price should be equal to marginal cost. A markup in the originating access price directly harms residential customers, who have to pay higher per-minute prices, and indirectly harms business customers, who experience softened price competition.

Terminating access prices

- It is optimal to allow only the entrant to charge an access markup in the short run, and to impose cost-based access prices in the long run.

A.8. Appendix: Calibration and model adaptations

A.8.1. General

Because of technical limitations of the models, we abstract from situations in which an operator offers a menu of contracts of different types, which allows consumers to choose a contract that fits their calling behavior and preferences best. Within the context of the models of Chapters 6 and 7, this restriction is harmless, since consumers are homogeneous.

With heterogeneous customers, it makes perfect sense to try to address variety of demand with different pricing structures. Indeed, in the real world, price discrimination by using menus of contracts is widespread. It allows operators, even if they are unable to tell types of customers apart, to capture surplus by fine-tuning contracts aimed at different types. Typically, operators cannot distinguish between types, so that consumers can self-select the contract that they prefer. In the economic literature, this situation is often called "second-degree price discrimination."

A formal analysis of second-degree price discrimination is outside the scope of this study. In most parts of this chapter, we allow for price discrimination by the entrant while the entrant is able to tell residential and business customers apart. Offering a menu of contracts is then not necessary. Our interest does not lie, however, in price discrimination with the purpose of fine-tuning prices to demand, but in targeting certain segments with a more aggressive price strategy.

Let us briefly go back to second-degree price discrimination. A menu of contracts aimed at low-volume and high-volume callers may, for instance, consist of a contract with a flat fee and a contract with a linear price. For a sufficiently high subscription fee, the flat fee contract is selected by high-volume callers, and for a sufficiently high per-minute price, the linear price contract is chosen by low-demand callers. One type of consumer finds it then unattractive to select the contract aimed at the other type.

Second-degree price discrimination tends to be profitable for firms, while consumers need not benefit from it. Prices will be such that consumers with low demand derive less net benefits than consumers with high demand. The reason is that operators reduce the demand by low-demand consumers, in order to make it less tempting for high-demand consumers to choose the low-demand contract. Overall, the welfare effects are ambiguous.[47]

New parameters are the sizes of the market segments.

[47] See Tirole (1988, ch. 3).

Table A.8.1.1. Size of market segments*

parameter	estimate
market size residential segment	6 163 000 connections
market size business segment	1 734 000 connections
total market size (as before)	7 897 000 connections

* IDC (1999).

In all models, total market shares φ_1 and φ_2, that is, the operators' market shares in the total market, are weighted averages of market shares in the two segments, weighted by the size of the segments.

Similar to earlier chapters, calling patterns are assumed to be isotropic (see also chapter 4). With heterogeneous customers, the assumption not only applies to market shares, but also to relative sizes of the two market segments. Simply stated, a customer of any type has an equal statistical probability of calling another customer of any type and subscribing to any operator. Applying the assumption of isotropic calling patterns, all relevant traffic flows on and between the networks, and between market segments, are taken into account.

The reader who is interested in the exact specifications of the models used in this chapter, can consult the Mathematica notebooks (available on request).

A.8.2. Targeted facilities-based entry

The model of section 8.2 is based on the model of section 6.2, taking into account that there are two market segments. All parameters are the same as in Section 6.2. In the captive residential segment, by definition, φ_1^{res} = 100% in all periods.

In order to obtain feasible outcomes, the incumbent's prices must be regulated. A joint price cap did not succeed to generate feasible solutions. Therefore the incumbent's prices are fixed.

Simulations (not reported here) showed that if the incumbent's prices are fixed at levels that are relatively low, then no equilibrium is found by the Mathematica program. This does not seem to be merely a technical problem. A possible economic interpretation is that since the entrant initially does not have a track record of quality (see Section 5.2), it cannot choose a feasible entry strategy. As a consequence, a limited range of regulated prices has been looked at.

A.8.3 Combined facilities-based and LLU-based entry

The model of section 8.3 is a combination of the models of sections 6.2 and 6.3, taking into account the differences concerning local access between the two market segments. All relevant parameters are the same as in Section 6.3.

A.8.4 Combined facilities-based and Carrier Select-based entry

The model of section 8.4 is a combination of the models of sections 6.2 and 6.4, taking into account the differences concerning local access between the two market segments. All relevant parameters are the same as in Section 6.4.

PART III: POLICY IMPLICATIONS

This part recapitulates the policy implication of the simulation results presented in Part II, and concludes the report. It consists of one chapter.

Chapter 9. Conclusions

9.1. Introduction

In this chapter, we recapitulate the key insights that emerged from the analysis. As introduced in chapter 1, the central question of this study is:

How should one design policy and regulation with the purpose of stimulating competition in markets for fixed voice telephony, thereby ensuring that consumers benefit from entry, and operators have sufficient incentives to be active on the market?

This question was addressed in a range of different situations, using models from industrial organization and applied game theory. As argued in the introduction, the tools of game theory are crucial to understand the incentives of market players who behave strategically, especially in complex market environments such as telecommunications. Therefore, we have built a set of game-theoretic models that were used to examine the most important types of market entry.

To generate outcomes with the models that can be interpreted in a meaningful way, one has to calibrate them by giving cost levels, utility and demand parameters the right order of magnitude. The calibration is important *not* because we want to forecast or describe actual behavior by market players – that is beyond the purpose of the models – but because we want to know how the market functions. For instance, a commonly observed model outcome was that in the long run, an entrant gains a market share of 50%. We are not interested in the number itself (it is probably an inaccurate estimate in any case). What we are interested in, is how regulatory instruments can stimulate entry in such a way that consumers benefit from competition.

9.2. Implications for policy and regulation

Within a certain entry situation, such as facilities-based entry or local loop unbundling, there are several regulatory principles that depend on the development of competition, while others can be applied independent of the entrant's growth. Naturally, policy implications within a given entry situation may not remain valid if a regulator wishes to reverse the relative attractiveness of certain entry modes over time.

Economic theory does not provide a clear-cut answer to the question whether competition in services on a single network (by giving entrants access to an incumbent's local loop), or competition between several networks (facilities-based competition), is best for dynamic efficiency. It is outside the scope of this study to discuss the pros and cons of facilities-based and other types of competition (see Van Damme (1999) for an extensive study on this topic). Moreover, perhaps a *third* type of competition, which comes about by rolling out fibre to the house (which creates a new natural monopoly situation), is better in terms of dynamic efficiency.[48] Regulatory choices geared towards either services or infrastructure competition should not foreclose alternative, new possibilities. Nevertheless, for the sake of exposition we will discuss below how regulation can make facilities-based competition more or less attractive for an entrant, compared to leasing the incumbent's local loop or offering Carrier Select services.

We recapitulate the most important results in relation to a small number of central topics and regulatory principles. Box 9.2.1 highlights two assumptions that are helpful to clarify the exposition of the policy implications.

Box 9.2.1. Assumptions made for the sake of exposition.

- We discuss price cap regulation, access prices, etc., in terms of ex ante, sector-specific regulation. It may also be possible to let competition authorities deal ex post with abuse of market power, instead of imposing regulation beforehand. However, it is beyond the scope of this study to examine the pros and cons of sector-specific regulation and general competition policy.
- In relation to access prices, "cost-based" refers to access prices equal to marginal costs. In relation to the lease price of the local loop, it refers to a price equal to the per-period fixed cost of a local connection (e.g., the cost of connecting a customer). If cost-based prices prevent an incumbent operator from breaking even (e.g., because the cost of building a local network must be recovered), then allowing the incumbent to charge a supplementary markup may be necessary.

Regulation of retail prices

A general principle, which is well known, is that in market segments where the incumbent is a monopolist or has substantial market power, regulation of the **incumbent's retail prices** is necessary. It is shown to apply to several situations:

- If the monopolist faces no entry in a sufficiently attractive market segment, then regulation of the incumbent's prices is helpful to protect consumers from abuse of market power (e.g., via price caps). Also, if the incumbent is not allowed to price discriminate between market segments, entrants can "cherry pick" by

[48] Bartelsman and Canoy (2000).

targeting the smaller segment. Allowing the incumbent to price discriminate prevents cherry picking, but does not take away the need to protect captive consumers.

- If there are only Carrier Select operators in a certain market segment, and the incumbent faces no competitive pressure on its subscription fee, then regulation of the incumbent's prices is helpful to protect consumers from abuse of market power (e.g., via price caps).
- If an entrant builds local loops in the smaller market segment and offers Carrier Select services in the larger segment, a price cap on the incumbent's subscription fee is helpful to protect consumers from abuse of market power. Competition in subscription fees in the smaller segment does not result in enough pressure on the incumbent. The price cap should not be too tight, as a cap makes facilities-based entry in the smaller segment less attractive in the short run.

A more specific policy implication is the following. In situations of Carrier Select-based competition, as long as there are shortages in interconnection capacity, price cap regulation of the **incumbent's per-minute price** can reduce the harm from shortages to consumers (the potential harm to consumers is that a capacity shortage can soften price competition).

Cost-based wholesale prices

In a range of situations, it is optimal to impose cost-based wholesale prices (i.e., equal to the underlying marginal cost). We abstract from supplementary markups that may be needed if cost-based access prices prevent the incumbent from breaking even. Also, we do not discuss the implementation of cost-based prices, which can be complex because operators are better informed about their cost levels than regulators.[49]

Consider a situation where both incumbent and entrant receive terminating access fees for incoming calls, that is, the entrant either owns (facilities-based competition) or leases local loops (unbundling-based competition). When competition is mature, that is, the entrant has grown about as large as the incumbent, then consumers' surplus and welfare are maximized if **terminating access prices** are reciprocal and cost-based.

In situations of local loop unbundling, consumers' surplus is maximized if the **lease price of the local loop** is cost-based (i.e., equal to the traffic-independent or fixed cost of a local connection). This principle is valid independent of the maturity of

[49] For more on regulation if there is asymmetric information, see Laffont and Tirole (2000, chapter 2).

competition.[50] Also, if the lease price includes a markup, then price cap regulation of the incumbent's retail prices may alleviate the markup's detrimental effect on consumers' surplus. This is a fairly general result, which also holds in the targeted-entry model where an entrant builds local loops for one market segment, and leases them in another one. In such a situation of targeted entry, the lease price can act as an instrument of tacit collusion (an argument that reinforces the motivation to forbid a markup).

Consider a situation of Carrier-Select-based entry, and assume that the entrant is the only operator that has to pay, but does not receive, access revenues (e.g. because the entrant does not own or lease any local connections). Then, to maximize consumers' surplus and to make entry not unnecessarily difficult, **originating and terminating access prices** should be cost-based. This principle is valid independent of the maturity of competition.[51]

If an entrant builds local loops in the smaller market segment and offers Carrier Select services in the larger segment, then, to maximize consumers' surplus, the originating access price should be cost-based. A markup in the **originating access price** harms customers in both market segments. This principle is valid independent of the maturity of competition.[52]

The growth in traffic caused by internet access via local telephony reinforces the argument to impose a cost-based originating access price. Since the growth in internet traffic increases a Carrier Select operator's losses due to a high originating access price, the price squeeze between the perceived cost level and the incumbent's price (which they have to match or undercut) becomes a more pressing problem. Entrants may ultimately have to discourage their customers to use the Carrier Select service to dial internet access numbers. This leads to a marginalization of entrants. In the light of the strategic importance of market shares (due to loyalty and reputation effects), the prospects of competition are then seriously damaged.

Wholesale prices above cost

In the early stages of competition it may be optimal to introduce asymmetries in the market (see also below, "Dynamic regulatory principles"). In the short run in situations of facilities-based competition and local loop unbundling, that is, situations where both incumbent and entrant receive terminating access revenues, allowing only the entrant to charge an access markup is good for consumers' surplus. When only the **entrant's terminating access price** is above cost (and the incumbent's access fee is cost-based), consumers' surplus is maximized, while the entrant's profits and market share increase.

[50] An exception occurs if a regulator wants to influence the incentives to build new networks over time. See the discussion below on this topic.

[51] The previous footnote applies.

[52] The previous footnote applies.

There are no indications that markups in wholesale prices are good for consumers' surplus in the long run, that is, if competition is mature.

Dynamic regulatory principles

We will now combine some of the regulatory principles discussed above. Market developments over time may make it optimal to adopt **regulation that is conditional on the maturity of competition**. An indicator of the maturity of competition is formed by entrants' market shares.[53] As long as entrants are small, the incumbent, with a much larger market share, can usually outweigh them with its market power (e.g., because of consumer switching costs, reputation, and brand name recognition). It may then be helpful for the development of competition to give entrants a temporary advantage. When entrants have gained substantial market shares and can exert significant competitive pressure, the asymmetric advantage can be withdrawn.

To start, we discuss dynamic regulatory principles pertaining to the retail market. Price cap regulation of the **incumbent's retail prices** is typically useful to increase consumers' surplus in the early stage of competition, when entrants are too small to discipline the incumbent. A drawback of price cap regulation is that entrants usually experience downward price pressure as well, even though a price cap is not binding for them. This reduces an entrant's profits and its incentives to enter the market. Therefore, price caps should be carefully balanced if entrants are small. As soon as there is sufficient competitive pressure from entrants, for instance when a correctly chosen price cap ceases to be binding for the incumbent, it can be withdrawn.

In some situation, price caps should not be too tight. Suppose that the incumbent faces no entry in a sufficiently attractive market segment, so that the **incumbent's retail prices** must be regulated even if there is entry in a smaller segment. Suppose also that the incumbent cannot price discriminate between segments. In the short run, in order to make entry in the smaller segment not too difficult, price caps should not be too tight. In the longer run, if the entrant has gained substantial market share, and if the incumbent is still a monopolist in the larger segment, then it is optimal for consumers' surplus to tighten price cap regulation to a certain extent.

We now move to dynamic regulatory principles in wholesale markets. In situations of facilities-based competition and local loop unbundling, where incumbent and entrant receive terminating access revenues, the following type of regulation of **terminating access prices** maximizes consumers' surplus while increasing the entrant's short-term profits and market share. Initially (i.e., when the entrant has a small market share), only the entrant should be allowed to charge an access markup. As the market matures (i.e., when the entrant gains market share), it becomes optimal to impose

[53] We are not claiming that market shares are always good indicators of market power; sometimes they are not. See CPB (2000).

reciprocal, cost-based (equal to the marginal cost of access) terminating access prices. This is a fairly general result, which holds if operators compete in two-part tariffs, in flat fees, or in linear prices; if the operators can differentiate between on-net and off-net calls; if entry is aimed at the whole market or targeted at a segment; if an entrant builds local loops in one segment and offers Carrier Select services in another segment.

If a dynamic regulatory principle is applied, **early announcement of regulatory principles** and **commitment to the announced principles** over time are vital, since regulatory uncertainty is likely to reduce firms' incentives to invest.

Finally a remark on competition between a fixed and a mobile operator, which was analyzed in a model where operators can differentiate between per-minute prices for on-net calls and off-net calls. A very high **fixed-to-mobile interconnection fee** leads to tougher competition for market share: in the short run, the mobile operator may even set its subscription fee below cost (mobile phone users are subsidized with respect to the fixed fee). When the mobile operator is small, it does not yet benefit from a very high fixed-to-mobile interconnection fee, but in the longer run, it becomes extremely profitable (due to the growth of incoming traffic). Also, a large access markup of the mobile operator inflates the fixed operator's off-net per-minute price. Implications for consumers' surplus and welfare are ambiguous if the access markup is of a larger order of magnitude than the underlying cost.

Quality and congestion

Some policy implications pertain to quality of service of operators, such as the deterioration of the quality of a Carrier Select operator if the incumbent does not have enough interconnection capacity to handle the entrant's traffic.

At a general level, note that in the early stages of competition, entrants have small customer bases. Incumbent and entrants are not at an equal footing with the incumbent, who has market power because of consumer switching costs, a well recognized brand name and reputation. Also, an incumbent typically offers a higher level of service quality than newcomers in the market. Therefore, policy needs to take into account the risk that the incumbent abuses its dominant position in order to keep entrants small, preventing them from building up a brand name and reputation.

As an illustration, consider a situation of Carrier Select-based entry, and suppose that at a given moment in time, there is a given, but insufficient, installed capacity to interconnect with the incumbent's network. Then, if an entrant competes more aggressively by reducing its retail price (e.g., it wants to gain market share fast, or there is a large number of entrants), more Carrier Select traffic is generated. This leads to a larger probability that consumers get the "busy" tone due to insufficient capacity. Hence, a situation with small entrants may maintain itself for a long time, since entrants have difficulty to get out of this vicious circle.

In situations of Carrier Select-based competition, shortages in **interconnection capacity** should be eliminated. It directly harms users of Carrier Select services, since they experience a quality degradation, and it may indirectly harms all consumers, who may suffer from a reduced intensity of competition. As long as there are capacity problems, price cap regulation of the incumbent's per-minute price can reduce the harm to consumers.

Incentives to build a customer access network

In general, price cap regulation of the **incumbent's retail prices** affects the incentives for entry. Tighter price caps result in more downward pressure on the prices of an entrant, making entry less profitable. Hence, in the short run there is a tradeoff between maximizing consumers' surplus (when entrants are small and exert little competitive pressure on the incumbent), and facilitating entry (so that the moment when price cap regulation is no longer needed, is reached at an earlier stage).

Carrier Select-based entry can be stimulated in the short run by decreasing incumbent's **originating access price** (possibly down to marginal cost), and by eliminating any shortages in interconnection capacity in the incumbent's network. Similarly, unbundling-based entry can be stimulated in the short run by decreasing the **lease price of the local loop** (possibly down to the fixed cost of a connection). In both cases, the incentives to build a customer access network, and therefore the prospects for facilities-based competition, may be reduced (but only to a limited extent if it the regulatory measure is temporary). Still, because it is important that entrants can gain market share fast (see the discussion on quality above), stimulating Carrier Select-based entry and local loop unbundling may be optimal in the short run.

Over time, facilities-based entry can be stimulated by making other modes of entry relatively less attractive. For example, the lease price of the local loop, or the originating access price for Carrier Select services, can gradually be increased. Again, if such a dynamic regulatory principle is applied (e.g. a price cap that is gradually withdrawn as competition develops), **early announcement of regulatory principles** and **commitment to the announced principles** over time are vital. In particular in telecommunications, regulatory uncertainty can harm the development of infrastructure investment.

9.3. Concluding remarks

This study analyzed the impact of regulatory instruments on entry and consumers' surplus. We have seen that a balanced application of regulatory instruments, that takes the development of competition and the resulting competitive pressure on the incumbent into account, can increase the benefits for consumers, and can facilitate entry in the market. It can also provide a flexible framework for a wide range of future issues, such as the development of broadband services and fixed-mobile convergence.

The models used in the analysis sometimes yielded results that confirm basic intuition or current policy. This formalization of basic intuition is more important than it perhaps appears at first glance. Sometimes, namely, apparently intuitive outcomes turned out to be falsified and reversed by the models. This falsification is not easily achievable by other methods.

An attractive feature of the models is that they are sufficiently simple in nature to enable clear interpretations: they are not black boxes. Yet the models are far from trivial. Sophisticated software is needed to solve even the simplest of models, while the software also allows to solve more complex variants of the model. Also, simulation models make it possible to do "dry runs" to address a wide range of regulatory instruments and questions.

We strongly encourage researchers to use or build on these models and software for other policy questions, inside and outside the telecommunications world. There is ample scope to apply slightly modified versions of the models in other sectors. In particular this may be very useful for other utility sectors and markets with network externalities, such as markets for information goods and internet-related markets.

References

Economic literature

Armstrong, M. (1998), "Network interconnection in telecommunications," *Economic Journal*, Vol. 108, 545-564.

Bartelsman, E. and M. Canoy (2000), "De gesel van de vezel," *ESB*, Vol. 85, No. 4261, 19-21.

Bergman, L., C. Doyle, J. Gual, L. Hultkranz, D. Neven, L.-H. Röller, and L. Waverman (1998), *Europe's Network Industries: Conflicting Priorities*, Telecommunications, Monitoring European Deregulation 1, CEPR and SNS.

Boone, J. (2000), "Competition," mimeo, Tilburg University and CPB.

Brandenburger, A.M. and B.J. Nalebuff (1996), *Co-opetition*, Currency Doubleday.

Cabral (2000), L.M.B., *Introduction to Industrial Organization*, MIT Press.

Carter, M. and J. Wright (1999a), "Interconnection in network industries," *Review of Industrial Organization*, Vol. 14, 1-15.

Carter, M. and J. Wright (1999b), "Local and long-distance network competition," mimeo, University of Canterbury.

Cave, M. and L. Prosperetti (2000a), "The liberalisation of European telecommunications: a critical review and future progress," mimeo, Brunel University and University and Milan.

Cave, M. and T. Valletti (2000b), "Regulation and Competition in Telecommunications," in: G. Galli and J. Pelkmans (eds.), *Regulatory Reform and Competitiveness in Europe, II: Vertical Issues*, Edward Elgar.

Choné, P., L. Flochel, and A. Perrot (2000), "Universal service obligations and competition," *Information Economics and Policy*, Vol. 12, 249-259.

CPB (1997), *Competition in Communication and Information Services: Opportunities and obstacles*, Sdu Uitgevers, The Hague.

CPB (2000), "Publishers caught in the Web? Strategies, performance and public policy," Werkdocument No. 119, The Hague.

Day, G.S. and D.J. Reibstein (1997), *Wharton on Dynamic Competitive Strategy*, John Wiley & Sons, Inc.

De Fraja, G. and C. Waddams Price, "Regulation and access pricing: comparison of regulated regimes," Scottish Journal of Political Economy, Vol. 46, 1-16.

Dessein, W. (1999a), "Network Competition in Nonlinear Pricing," mimeo, ECARE, Université Libre de Bruxelles and GREMAQ, Université de Toulouse.

Dessein, W. (1999b), "Network Competition with Heterogeneous Calling Patterns," mimeo, ECARE, Université Libre de Bruxelles and GREMAQ, Université de Toulouse.

Doganoglu, T. and Y. Tauman (1996), "Network competition with reciprocal proportional access charge rules," SUNY at Stony Brook Discussion Paper DP96-01.

Fabrizi, S. (2000), "Competing telephony technologies: fixed versus mobile case," mimeo, GREMAQ (University of Toulouse) and University of Bologna.

Farrell, J. and M.L. Katz (1998), "Public policy and private investment in advanced telecommunications infrastructure," mimeo, University of California at Berkeley.

Fudenberg, D. and J. Tirole (1991), *Game Theory*, MIT Press.

Gans, J.S. and S.P. King (1999), "Using 'bill and keep' interconnect arrangements to soften network competition," mimeo, University of Melbourne.

Gibbons R. (1992), *A Primer in Game Theory,* Harvester Wheatsheaf.

Green, R. (2000), "Can competititon replace regulation for small utility consumers?", CEPR, Discussion Paper No. 2406.

Haffner, R.C.G. (2000), "Policy Issues in Telecommunications Reform: the Netherlands," in: OECD Proceedings, *Privatisation, Competition and Regulation*, Centre for Co-operation with Non-Members, OECD, p. 207-213.

Klemperer, P. (199.), Review of Economic Studies.

Laffont, J.J., P. Rey, and J. Tirole (1997), "Competition between telecommunications operators," *European Economic Review*, Vol. 41, 701-711.

Laffont, J.J., P. Rey, and J. Tirole (1998a), "Network competition: I. Overview and nondiscriminatory pricing," *RAND Journal of Economics*, Vol. 29, No. 1, 1-37.

Laffont, J.J., P. Rey, and J. Tirole (1998b), "Network competition: II. Price discrimination," *RAND Journal of Economics*, Vol. 29, No. 1, 38-56.

Laffont, J.J., and J. Tirole (1994), "Acces pricing and competition," *European Economic Review*, Vol. 38, 1673-1710.

Laffont, J.J., and J. Tirole (1996), "Creating competition through interconnection: theory and practice," *Journal of Regulatory Economics*, Vol. 10, 227-256.

Laffont, J.J., and J. Tirole (2000), *Competition in telecommunications*, MIT Press, Cambridge MA.

Mitchell, B.M., and I. Vogelsang (1991), *Telecommunications pricing: theory and practice*, Cambridge University Press, Cambridge.

Saloner, G. (1994), "Game Theory and Strategic Management: Contributions, Applications, and Limitations," in: R.P. Rumelt, D.E. Schendel, and D.J. Teece (eds.), *Fundamental Issues in Strategy: A Research Agenda*, Harvard Business School Press.

Valletti, T.M. and A. Estache (1999), "The Theory of Access Pricing: An Overview for Infrastructure Regulators," CEPR Discussion Paper No. 2133.

Taylor, C.R. (1999), "Supplier surfing: competition and consumer behavior in subscription markets," mimeo, Dept. of Economics, Texas A&M University.

Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press.

Van Damme, E.E.C. (1999), *Competition in the local loop: a study for VECAI*, Visions, VECAI, The Hague.

Wright, J. (2000a), "Competition and termination in cellular networks," mimeo, University of Auckland.

Wright, J. (2000b), "Non-dominant network competition," mimeo, University of Auckland.

Industry studies

Ballon, P., P. Verhoest, and M. Poel (2000), *De Nederlandse telecommunicatiesector in cijfers 1999*, TNO-rapport STB-00-04, TNO Strategie, Technologie en Beleid, Delft.

Bouwman, H., W. Hulsink, and J. van de Riet (1999), *Arrogante aanbieders of onwetende vragers in een zich ontwikkelende market: Telecommunicatiemanagement in Nederlandse ondernemingen*, Onderzoek onder auspiciën van stichting Telecomgebruikers Nederland, Delft/Rotterdam.

Glass, S. (1997), Telecommunications Systems: An Introductory Guide, Gilbert & Tobin,
http://www.gtlaw.com.au/pubs/telcosysintroguide.html.

IDC (1999), *De telecommunicatie diensten markt in Nederland*, Amsterdam.

Morgan Stanley Dean Witter (1999), *Global telecommunications primer: a guide to the information superhighway*, Equity Research/Global Telecommunications.

NERA (1999), *A price cap model of KPN*, Final report for Opta, London.

Ovum (1998a), *Unbundling the local loop: a regulatory and market assessment*, Core study report, London.

Ovum (1998b), *Unbundling the local loop: a regulatory and market assessment*, Country study: The Netherlands, London.

Policy reports

European Commission (1999a), *Towards a new framework for Electronic Communications infrastructure and associated services: The 1999 Communications Review*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, COM(1999) 539, Brussels.

European Commission (1999b), *Fifth Report on the Implementation of the Telecommunications Regulatory Package*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, COM(1999) 537 final, Brussels.

European Commission (2000a), DG Information Society Working Document, INFSO A/1, Brussels.

European Commission (2000b), *Unbundled Access to the Local Loop*, Communication from the Commission, COM(2000) 237, Brussels.

European Commission (2000c), *On Unbundled Access to the Local Loop*, Commission Recommendation, C(2000) 1059, Brussels.

DGTP (2000a), *Netwerken in cijfers: Trendrapportage over ICT-infrastructureen 2000*, Ministerie van Verkeer en Waterstaat.

DGTP (2000b), *Netwerken in de Delta: Eerste klas voorzieningen voor netwerkeconomie en informatiemaatschappij*, Ministerite van Verkeer en Waterstaat.

Oftel (2000), *Consumer awareness and use of competition in the residential fixed line market*, London, http://www.oftel.gov.uk/cmu/research/choice00.htm.

Opta (1998), Consultation document on special access services, 4 June, The Hague.

Opta (1999), *Collectie 1999*, Het belangrijkste uit Opta Connecties, The Hague.

Opta (2000), *Jaarverslag 1999*, The Hague.

Opta (2000b), *Consultation Document on* “Price squeeze,” 9 October.

Opta (2000c), *Consultation Document on* “Collocation and non-recurring costs with regard to access to the local loop,” 13 October.

Software and mathematics

Burden, R.L. and J.D. Faires (1988), *Numerical Analysis*, Fourth Edition, PWS-Kent.

Chiang, A.C. (1984), *Fundamental Methods of Mathematical Economics*, Third Edition, McGraw-Hill.

Froeb, L.M. and G.J. Werden (1996), “Simulating the Effects of Mergers Among Noncooperative Oligopolists,” in: H.R. Varian (ed.), *Computational Economics and Finance: Modeling and Analysis with Mathematica*, Springer/Telos, 175-195.

Huang, C.J. and P.S. Crooke (1997), *Mathematics and Mathematica for Economists*, Blackwell Publishers.

Shone, R. (2000), “Mathematica v4.0 for Windows 95/98/NT,” Software reviews, *Economic Journal*, February.

Varian, H.R. (1996), “Mathematica for Economists,” in: H.M. Amman, D.A. Kendrick and J. Rust (eds.), *Handbook of Computational Economics*, Volume I, Elsevier Science, 489-505.

Glossary[54]

For an overview of telecommunications technology, see also section 2.2.

Access markup
Difference between a terminating or originating access price and the marginal (traffic-dependent) cost of access.

ADSL (or more generally xDSL)
Asymmetric Digital Subscriber Line; a technology that increases the speed of access through the existing (copper line) local loop.

Carrier Preselect
Facility which allows customers to opt for calls to be carried by an operator selected in advance, without having to dial a routing prefix.

Carrier Select
Facility which allows customers to opt for calls to be carried by an operator selected by dialling a routing prefix (typically consisting of four digits).

Carrier Select-based competition (CSC)
Competition between operators such that entrants do not build customer access networks, but have originating access to end-users via Carrier Select services.

Collocation
Ability for other operators to install equipment in the incumbent's local switches in order to supply services over the incumbent's local loop.

Copper line
Main transmission medium to connect a telephone to a local switch. Copper lines are "slow," that is, have narrow bandwidth unless combined with an enabling technology such as ADSL.

Customer access network
Network connecting end-users' telephones and local switches (sometimes also referred to as local network, local access network, local loop).

[54] See also http://www.oftel.gov.uk/glossary.htm#O.

Facilities-based competition (FBC)
Competition between operators such that entrants build their own facilities, in particular customer access networks.

Fixed telephony
Telephony over a network with fixed connections to end-users, in the sense that the locations of endpoints are geographically fixed. Usually, the connections consist of wires (“wireless local loop” is an exception).

Incoming call
Call originating at another operator’s network, and terminating at one’s own network.

Interconnection
Linking of telecommunications networks in order to allow the subscribers of one operator to communicate with subscribers of another operator, or to access services provided by another firm (e.g. an operator or an internet service provider).

Internet
Worldwide “network of connected networks,” typically accessed by users with a computer, a modem, and a telephone connection via an internet service provider (ISP).

Internet service provider (ISP)
Firm who provides access to the internet.

ISDN
Integrated Services Digital Network. Network based on the PSTN, providing digital connections to customers.

Lease price of local loop
Wholesale lease price paid by an operator for taking over connections to end-users from the incumbent (also referred to as line rental).

Local access / local loop
Connection between the customer’s premises and the local PSTN switch. The physical link is usually a loop comprised by two copper wires.

Local loop unbundling (LLU)
Local loop unbundling allows other operators lease the incumbent’s access network connection between customers’ premises and the local switch. The customer can then choose another operator to provide telecommunications services and end its subscription with the incumbent.

Long-distance network
Network enabling calls to be routed between local switches (sometimes also referred to as backbone).

Marginal cost
Cost of producing an additional unit.

Mobile telephony
Telephony over a network with mobile connections to end-users, in the sense that the locations of endpoints are not fixed geographically. End-users use mobile handsets to connect to the network.

Off-net call
Call originating and terminating on different networks.

On-net call
Call originating and terminating on the same network.

Originating access
Provision of a connection between the calling party and a network which is not the originating network.

Originating access price
Wholesale price paid for originating access, usually paid per time unit.

Originating network
Network to which a calling party is directly connected .

Originating operator
Operator on whose network a call originates.

PSTN
Public Switched Telephone Network. It is circuit-switched: each call reserves an end-to-end physical circuit between the calling party and called party during the call.

Switch
Means by which temporary connections in a telecommunications network, between a calling and a called party, are established (also known as exchange).

Telecommunications
Conveyance of data (e.g., voice and other sounds, visual images) by wire, radio, optical or other electromagnetic means.

Telecommunications network
Transmission systems, switching equipment, and signaling systems, permiting the conveyance of signals by wire, radio, optical or other electromagnetic means.

Terminating access
Provision of a connection between the called party and a network which is not the terminating network.

Terminating access price
Wholesale price paid for terminating access, usually paid per time unit.

Terminating network
Network to which a called party is directly connected.

Terminating operator
Operator on whose network a call terminates.

Voice telephony
Provision of direct transport of two-way, real-time speech, usually over the PSTN.