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ACCESS PRICING AND COMPETITION IN TELECOMMUNI-CATIONS

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Abstract: This study reviews the key economic features of the telecommunications industry and outlines two benchmark models that have been developed in previous literature for introducing competition into local telecommunications. One possibility is services based competition, where entrant telephone operators have no network of their own, and another is facilities based competition, where competitors build their own networks. Determining the price for access, that is, the price at which one operator can use the infrastructure of another, plays a central role in ensuring the effectiveness of competition in each case and access price regulation can in many cases increase welfare. In addition to the theoretical discussion, we apply the theories to form an analysis of Finnish policies towards competition and access pricing in the local telecommunications market.

Key words: telecommunications, competition, access pricing, regulation

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Tiivistelmä: Tässä tutkimuksessa tarkastellaan verkkomaksujen roolia telealan kilpailun edistämisessä. Televiestintämarkkinoiden erityispiirteiden tarkastelun jälkeen esitellään kaksi perusmallia kilpailun aikaansaamiseksi paikallispuhelumarkkinoilla. Yksi vaihtoehto on avata alueellisen monopolin viestintäverkko uusien kilpailijoiden käyttöön, jolloin kilpailu perustuu telepalveluiden myyntiin. Toisaalta kilpailijat voivat käyttää omaa verkkoaan, jolloin kilpailu tapahtuu verkkoyritysten välillä. Kummassakin tapauksessa operaattoreiden toisiltaan perimät verkkomaksut ovat kilpailun toimivuuden kannalta keskeisessä asemassa ja sääntelyllä voidaan usein parantaa markkinoiden tehokkuutta. Teoreettisen tarkastelun lisäksi tarkastellaan Suomen paikallispuhelumarkkinoita ja analysoidaan kilpailun edistämiseen tähtäävää politiikkaa.

Asiasanat: telekommunikaatio, kilpailu, verkkomaksut, sääntely

Contents

1 Introduction

Introducing effective competition into local telecommunications has been an important goal of industrial policy in many European countries since the 1980s and the 1990s. When telecommunications markets have been liberalised, it has been realised that the duplication of all facilities of the incumbent telecommunications operator will not always be necessary or even reasonable. Therefore determining the correct price at which one telecommunications operator can use the infrastructure of another, that is the access price, has become a central issue in the attempt to make the liberalised telecommunications markets truly competitive. The question of how the pricing of access to another firm's facilities affects competition in telecommunications markets has therefore been at the forefront of discussion both in academic literature and in public policy debate in recent years.

The market share of the incumbent telecommunications operator in the local telecommunications market in all European countries was above 80 % and in most of them well above 90 % at the end of the 1990s. It is also rather remarkable that those countries where telecommunications liberalisation had already taken place did not fare much better than the rest in this respect. Because of such difficulties with introducing competition into local telecommunications, a thorough analysis of the access pricing issue is indeed mandated. Further, the problems with introducing competition suggest that regulator intervention in the setting of access charges will often be necessary, and therefore an analysis of optimal access prices will give invaluable guidance to regulators.

In this paper the access pricing problem will be discussed in the light of the following questions:

1) What are the special characteristics of telecommunications markets, and how do these characteristics make access pricing a central issue in the industry?
2) How should access by other operators to an incumbent's network be priced so that the structure of charges leads to a social optimum?
3) If the traditional assumption about the desirability of monopoly in local network operation is relaxed, how does this affect the nature of the access pricing problem?

The approach of this study will for the most part be theoretical, introducing and reflecting on the main results from recent academic literature on the topic. Recent and comprehensive surveys of the theoretical principles of access pricing in telecommunications are given in Armstrong (2001) and Laffont and Tirole (2000). This study will bring out some of the points contained in those surveys and in a large number of other, more specific theoretical studies.

Two approaches have been developed to address the question of optimal one-way access pricing, that is, access pricing in a situation in which the entrants have no network of their own. These are the efficient component pricing rule (ECPR) approach introduced by Willig (1979) and advanced also for example by Baumol and Sidak (1994), and the Ramsey approach developed by Laffont and Tirole (1994; 1996). A synthesis of the two approaches is provided in Armstrong, Doyle and Vickers (1996). We will discuss the two approaches, provide an explicit comparison and also comment on the differences that still remain between them. An important extension to traditional treatments of one-way access pricing considers a situation in which the retail market is deregulated. This has been discussed in Laffont and Tirole (1994), Armstrong and Vickers (1998) and Armstrong (2001). We will take this discussion one step further by providing an explicit formula for the Ramsey optimal access charge in this situation.

The concept of two-way access relates to the case in which competitors have their own networks. This is in contrast to the way in which production in the industry has traditionally been organised, that is, at least the local network has traditionally been operated by a monopolist. A model to study the case of two-way access has been developed by Armstrong (1998) and Laffont, Rey and Tirole (1998a). A number of authors have built on the benchmark model introduced in those papers to analyse several extensions to the basic framework. We will provide a recapitulation of a number of the cases analysed in previous literature, in order to build a comprehensive view of the role of access pricing in this setting. In particular, we will consider the question of whether regulatory intervention will be necessary also when there are a number of local networks.

In addition to the theoretical discussion, an important aim of the study is to apply the theories discussed to form an analysis of Finnish policies towards competition in the local telecommunications market. This topic has not been extensively studied previously. This study will therefore provide some important new information in this respect, and a good starting point for further research on regulation in Finnish telecommunications markets.

In line with previous literature, the emphasis in this study will be on discussing access charges that aim at achieving static economic efficiency. Other possible objectives for access pricing, such as dynamic incentives for investment in infrastructure development and new services, will not be examined explicitly, even though the firms' need to cover fixed costs of infrastructure will be taken into account.

The issue of optimal (vertical) market structure, that is, the question of whether vertical separation or integration should be promoted, is not considered here. It is assumed that the market is characterised by vertical integration, that is, the provider of network services operates also in other market segments. Such a policy of preserving the vertically integrated dominant firm has been the policy more commonly adopted by regulators after the privatisation of national monopolies in utilities industries.

The main emphasis in this study will be on access pricing in local fixed networks and therefore the study addresses both the EU and Finnish regulators' concern about promoting competition particularly in the fixed network. Despite the development of mobile communications, the fixed telecommunications network still plays a central role in the policy agenda of European authorities due to the desire to promote the use of services that require high transmission capacity, such as high-speed internet services. However, some of the theories discussed can also be applied to the analysis of mobile networks. These models will be pointed out in the discussion.

The outline of the study is as follows. Chapter 2 discusses the vertical structure and the main economic characteristics of the telecommunications industry. Chapter 3 explores some possible ways in which competition can be introduced into local telecommunications, and explains why access pricing plays a central role in the industry regardless of which form of competition emerges. Chapter 4 discusses the principles of access pricing in the context of one-way access and Chapter 5 considers optimal policies in the case of two-way access. In particular, the question of whether the need to regulate access charges still remains in the context of two-way access will be examined. Chapter 6 introduces some aspects of Finnish telecommunications policy related to competition and interconnection, and assesses these policies in the light of the theory. Chapter 7 concludes.

2 Central features of the telecommunications industry

2.1 Vertical structure

In order to understand the functioning of the telecommunications industry, it is important to distinguish between different sectors of the industry, because economic characteristics differ between them. The main sectors of the telecommunications industry are (i) the local network; (ii) the long-distance and international network and (iii) service provision over the network. Network operation (sectors (i) and (ii)) can further be broken down into infrastructure or capacity provision on the one hand, and the apparatus that is used for the routing of calls through the network, that is, network switches and control facilities, on the other. However, in this paper these different elements of the network are treated as one service, network operation. Services that can be provided over the network (sector (iii)) include traditional voice telephony and a large number of other services, such as internet services[1]. The main emphasis in this paper is on local telecommunications, that is, on local network operation and on service provision over that network.

The vertical structure of local telecommunications is illustrated in Figure 2.1. The point of the illustration is to emphasise the simple notion that network operation and service provision over the network should be thought of as separate services. This line of reasoning implies that the local telecommunications sector consists of two separate markets: network owners sell the intermediate good of network capacity to service providers in the access market, who then sell telecommunications services to final customers. This conceptual separation should not be obscured by the fact that same firms often operate in both of these markets. With the above market definition, it should be clear that if a firm has market power in one segment this does not necessarily imply that it has market power in the other. Further, it is important to note that one segment can be potentially competitive even if the other segment remains monopolised. These issues will be returned to a number of times later in the discussion.

[1] Equipment manufacturers and content providers for value added services can also be considered as a part of the telecommunications industry. These segments will not be examined in this study.

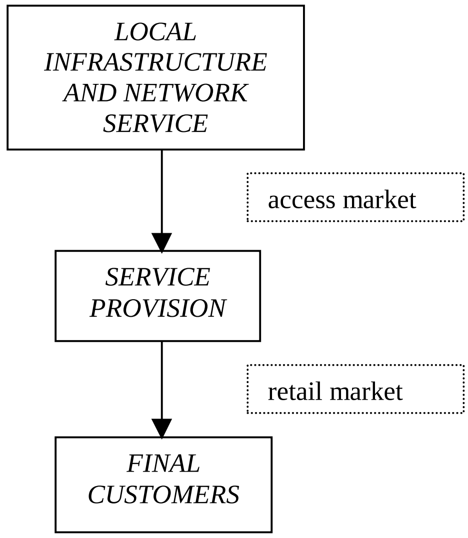

Figure 2.1 Vertical structure of local telecommunications.

The structure of the telecommunications network can be briefly described as follows. Each customer is connected to the network at the local exchange and the part of the network between the customer's home and the local exchange is called the local loop. Local exchanges are then connected to trunk exchanges by higher capacity transmission lines. Trunk lines are mutually connected by a system of high capacity trunk links, some of which are then finally connected to the international network. (Armstrong 1997a, 65.)

2.2 Economic characteristics

The telecommunications industry is a prime example of a network industry. The industry is characterised by network externalities and there are high fixed and sunk costs that result in, as has traditionally been believed, natural monopoly conditions.

Positive network externalities (or simply network effects) are said to exist when the utility of a user of a network increases with the number of other users of the network. That is, adding one more user to the network makes the service more valuable to other users. The interpretation of this idea is obvious in the case of a monopoly, to which it was indeed first applied by Rohlfs (1974). In the case of an oligopoly, the presence of network externalities imply that consumer utility increases with the number of users of compatible products: that is, the utility of consumers is not only dependent on the number of users of their own network, but also on the number of users of other, compatible networks or products. Network externalities in the case of oligopoly were first studied by Katz and Shapiro (1985). The existence of positive network externalities implies that the technology exhibits what can be called demand side economies of scale, but in the case of oligopoly one should again take care to note that these economies of scale are not firm specific, but rather, they are associated with the network of compatible products.

The following example provided by Economides (1996) serves to illustrate how positive network externalities arise in telecommunications. Consider a telephone network with n users. This implies that there are $n \cdot (n-1)$ potential goods associated with the network, as each of the n users can call the other $n-1$ customers of the network. When an additional user joins the network this produces an externality on the other users: the number of potential goods rises by $2n$ as the new customer can call the existing customers *and* the existing customers can now also reach him.[2]

The above paragraph discussed the so called direct network externality, where the externality is generated through a direct effect of the number of purchasers on the quality of the product (Katz and Shapiro 1985, 424). This effect is clearly very strong in telecommunications, as the network has no value to a user unless there are other people connected to it. However, from the point of view of this study it is important to recognise that network effects in telecommunications can also arise due to other forces besides the direct network externality discussed above. As noted by Armstrong (1997a, 67) there can also be additional network externalities in the form of wider social benefits associated with an extensive telecommunications network, arising for example from better availability of emergency services in remote areas. Another source of network externalities in telecommunications, which is of significance from the point of view of study, arises if operators can price discriminate according to the destination network of a call. This generates so called tariff-mediated network effects that can have a significant effect on the functioning of the market (see Section 5.3.2 below). For example, if telephone networks price discriminate in favour of calls that terminate on their own network, a firm-specific network effect reappears as customers will prefer the largest firm. (Laffont, Rey and Tirole 1998b, 39-40.) [3]

Let us now turn to the role of natural monopoly cost conditions in the telecommunications industry. An industry is said to be a natural monopoly, if the industry cost function $C(\mathbf{q})$ is (strictly) subadditive, that is, if the following inequality holds for any set of output vectors $\mathbf{q}_1,\ldots,\mathbf{q}_m$:

$$C\left(\sum_{i=1}^{m}\mathbf{q}_i\right) < \sum_{i=1}^{m} C(\mathbf{q}_i)\,. \tag{2.1}$$

[2] It should be noted that there can also be negative network externalities in telecommunications, if increasing the number of users causes congestion in the network. However, this occurs very rarely in the fixed telecommunications network, and it seems clear that positive network effects dominate.

[3] In addition to the direct and tariff-mediated network effect that are crucial from the point of view of this study, there are a number of other sources of network effects. See for example Katz and Shapiro (1985) or Tirole (1988, 404-409) and the references therein for more details.

Informally, the above formula implies that in a naturally monopolistic industry, producing a given vector of outputs **q** in a single firm is cheaper than spreading production into a number of firms[4]. Caveats to this purely technical, cost-based definition of natural monopoly will be noted in Section 3.1, when the issue of desirability of competition is discussed.

Natural monopoly cost conditions arise for instance when there are non-negligible fixed costs that result in economies of scale in production. In such cases the spreading of production over a number of firms would entail unnecessary duplication of fixed costs. Another source of natural monopoly cost conditions in the case of multiproduct firms is economies of scope. Equation (2.1) directly yields one formulation of economies of scope. For example, consider two different goods q_1 and q_2. For a strictly subadditive cost function, the following inequality always holds:

$$C(q_1, q_2) < C(q_1, 0) + C(0, q_2). \tag{2.2}$$

That is, again, it is cheaper to produce the two goods together in one firm rather than produce them separately. (Tirole 1988, 20.) Finally, a third source of natural monopoly cost conditions is economies of density, which refers to economies of scale related to production in a specific geographical area.

It has recently become a rather commonly accepted view that the only sector in the telecommunications industry that is possibly characterised by natural monopoly cost conditions is local network operation, and in particular the local loop. In long distance and international telecommunications, natural monopoly cost conditions have ceased to exist due to technological progress, for example the use of fibre optics. In general, cost conditions in service provision in telecommunications are such that this segment of the industry is potentially competitive. (Armstrong 1997a, 66-67.)

The question of whether natural monopoly cost conditions prevail in the local network is a somewhat more complicated matter. Armstrong (1997a, 66) emphasises the role of economies of density and substantial fixed connection costs to telecommunications networks as sources of natural monopoly cost conditions in local telecommunications. Cave and Williamson (1996) analyse cost conditions in UK telecommunications and they show that economies of density in local telecommunications are indeed significant, with costs per customer decreasing as penetration increases. Further, those authors find significant economies of scope between telecommunications and cable television services: the cost of providing telecommunications and entertainment services over two separate networks substantially exceed those of having a single supplier (Cave and Williamson 1996, 104-5.) Therefore economies of scope in telecommunications networks extend to a wider range of services than traditional voice telephony. This is an example of convergence between different sectors of the communications industry,

[4] This is the subadditivity condition for a multiproduct industry. The subadditivity condition for a single product industry is a special case of (2.1), where the output ‘vector’ consists of a single good.

which has received plenty of attention in recent years both from policy makers and academics.

Panzar (1989) shows that even though economies of scale and scope are usually associated with subadditivity, neither of them is in fact a sufficient condition for subadditivity to hold.[5] Therefore, even though the above observations suggest that local telecommunications probably is characterised by natural monopoly cost conditions, in order to obtain conclusive evidence on this it would often be necessary to test for subadditivity per se. There have been a large number of empirical studies on the structure of costs in local telecommunications. In a recent study, also an attempt to address some econometric problems present in previous studies[6], Wilson and Zhou (2001) examine the costs of 71 local exchange carriers in the United States during the period 1988-1995. They show that the costs of these local exchange carriers are strongly subadditive, and conclude that in the light of their study local telephone monopolies are indeed natural.

Despite findings such as those reported above, there has recently been some debate on whether even the local loop can be regarded as a natural monopoly. However, in our view it seems clear that due to the high fixed costs of building the local loop, natural monopoly conditions do still indeed apply at least to *call termination* in local fixed networks: due to the high fixed costs of connecting to a network, each user is likely to be connected to one network only, and therefore a caller cannot choose which operator terminates the call. This point, that a network operator is a monopolist on calls received by its customers, is emphasised, among others, by Laffont and Tirole (2000, 186).[7]

Laffont and Tirole (2000, 215) do however acknowledge the possibility of multiple terminating lines in the future, for example, in a situation where a household is connected to both the local telephone network and a cable network that is updated to carry voice telephony. Shy (2001, 159) makes a similar point, envisioning a possibility for the removal of all bottlenecks in telecommunications in the future. For example in Britain, cable television companies have already been permitted to offer telecommunications services since 1991[8]. A further possibility for removing the local loop bottleneck is the provision of local telecommunications services via other existing networks, such as the electricity network.

However, it should be noted that the technological feasibility of the above mentioned alternatives to the local loop does not imply the removal of natural monopoly cost conditions in that segment. Even if the alternative network is in place for historical

[5] Non-negligible fixed costs do imply subadditivity. However, economies of scale (declining average costs) in general do not. Further, subadditivity implies economies of scope but not vice versa. See Panzar (1989) for more details.
[6] For example Shin and Ying (1992) come to the conclusion that the cost function of the local exchange carriers in their study is not subbadditive. Unlike Shin and Ying, Wilson and Zhou (2001) control for unobserved firm heterogeneity and conclude that with such controls the cost function turns out to be strongly subadditive.
[7] When mobile networks are considered as a complement to fixed networks, this issues seems to become more complicated.
[8] See for example Armstrong (1997b) and Armstrong, Cowan and Vickers (1994, Ch. 7).

reasons and the fixed cost of building a new network is therefore avoided, the presence of economies of scope or density can still provide a compelling reason for the provision of communications services over a single network. Subadditivity in general, be it associated with high fixed costs or not, implies that the costs of being served by two firms would exceed those of being served by a single firm. In such a case, then, customers will find it beneficial to connect to one network only, and despite the existence of alternative networks, each network remains a monopolist on the calls received by its own customers. In the light of the above discussion we find the assumption of cost subadditivity in local fixed network operation reasonable, and therefore we will make this assumption in the remainder of this study.

3 Introducing competition into local telecommunications

3.1 Desirability of competition in local network provision

The question of whether competition is desirable in a given industry has most commonly been discussed with reference to the notion of natural monopoly. Competition is then judged to be desirable in those industries not characterised by natural monopoly cost conditions, while monopoly should prevail in those that are. The present Section notes some caveats to the traditional definition of natural monopoly, and discusses the issue of the desirability of competition in more detail.

The previous Chapter introduced a standard definition of natural monopoly, that relies on the static cost characteristics of the industry. However, if competition is successfully introduced into an industry with cost characteristics resembling a natural monopoly, this can itself bring efficiency benefits that make the introduction of competition desirable. Introducing competition can worsen productive efficiency on the industry level, if fixed costs are duplicated. However, competition can on the other hand improve productive efficiency by giving better incentives for cost minimisation. As explained by Armstrong, Cowan and Vickers (1994, 50), the definition of subadditivity given in (2.1) assumes that the industry cost function is exogenous. However, when the regulator has imperfect information about the incumbent's cost function, it is likely that the introduction of competition would bring better incentives for cost minimisation for the incumbent firm. The subadditivity condition will still hold as competition will not eliminate the fixed costs of network provision. However, if the efficiency gains from cost reduction outweigh the efficiency loss from the duplication of fixed costs, entry would then be beneficial.

Even if we take into account the previous caveat to the definition of natural monopoly, we still do not have a satisfactory measure of whether competition will be desirable. Even if we have a realistic view of the costs of competition compared to the costs of monopoly, we naturally need to consider the additional benefits that would be brought about by competition. One of the main benefits of introducing competition is that competition, if it is effective, will bring prices closer to marginal cost and therefore allocative efficiency is improved. Therefore, as explained by Armstrong, Cowan and Vickers (1994, 106-111), when there are significant fixed costs, the introduction of competition entails a trade-off between allocative and productive efficiency. This trade-off is illustrated also for example in the findings of Economides and White (1995), who argue that if competition reduces the incumbent's market power, then entry may be desirable even if the entrant produces at higher cost than the incumbent.

Gasmi, Laffont and Sharkey (2002) take into account some of the above issues in a novel attempt to determine whether a duopolistic market structure would be superior to a monopoly in local network provision. Firstly, they allow for the possible endogeneity of the industry cost function with respect to market structure. Secondly, they take into account the effect of competition on equilibrium prices. The authors then compare monopoly and duopoly on the basis of aggregate social welfare achieved under these alternative market structures. Their conclusion illustrates the significance of the points discussed above: even though the industry cost function is subadditive, the efficiency loss associated with higher costs is more than offset by the benefits of higher output and stronger incentives for efficiency in duopoly.

A further possible justification for network competition in telecommunications is the increase in variety brought about by competition. If consumers value variety, and if the services of different networks are differentiated, then competition brings additional benefits that are not captured by the productive / allocative efficiency trade-off.

Therefore, even though we have admitted that cost conditions in local network provision are likely to resemble those of a natural monopoly, this does not necessarily imply that network competition will be undesirable. However, when we discuss the desirability of competition in local network provision, one further point needs to be strongly emphasised. Multiple networks will be desirable only if the benefits that accrue from *network* competition outweigh the costs of network duplication. On the other hand, the benefits of competition in the provision of telecommunications *services* can, at least potentially, be achieved without building duplicate networks. Here, the notion discussed in Section 2.1, that different sectors of the local telecommunications market should to a certain extent be treated separately, becomes crucial. As we have mentioned above, cost conditions in service provision are such that competition in this sector is unambiguously desirable. Whether there will be additional benefits to competition in network provision that mandate the building of duplicate networks is a question that we will be better placed to discuss later on in the study. The essential features of two different ways of organising competition in local telecommunications services, depending on whether the local network is duplicated or not, are discussed in the next Section.

3.2 Models of competition in local telecommunications

Depending on whether the regulator regards competition in network provision desirable, there are two different models of competition in the provision of local telecommunications services that could be adopted at liberalisation. Firstly, if it is accepted that network provision in local telecommunications should be monopolised, then the following recommendation for the mode of competition in local telecommunications is appropriate: the monopolies in local network provision should be retained, but competition can be introduced in service provision by allowing new operators to enter. This scenario results in so called *services based competition*, where entrant operators do not build their own network, but buy access to the incumbent's network. Secondly, if one takes the view that competition is desirable also in local network provision, then one should promote so called *facilities based* or *network competition* in local telecommunications, where entrants build their own networks. The networks then compete for directly connected customers.[9]

Regardless of which form of competition the regulator chooses to promote, access pricing will play a crucial role in the functioning of the industry. In the case of services based entry, competition in service provision will remain only *potential*, unless fair terms of access to the local network are guaranteed to the entrant. That is, if the local network remains monopolised, there is a danger that liberalisation in service provision will only lead to ineffective competition unless regulators pay proper attention to the network access problem. Because the entrant requires essential inputs from the incumbent but not *vice versa*, services based competition requires the application of one-way access pricing. Optimal policies in the case of one-way access are discussed in Chapter 4.

The central role of access pricing in the case of facilities based entry is perhaps less obvious. However, the economic characteristics of the telecommunications industry imply that the question of access will be crucial also in this case. Firstly, as was explained in Section 2.2, due to the high fixed costs of connecting to a network each user is likely to be connected to one telephone network only. Therefore, even though the networks compete for directly connected customers, each network is an *ex post* monopolist on the calls received by its customers. Clearly, this feature together with the prominence of network externalities in telecommunications implies that there are substantial benefits to be had from interconnecting separate networks, thus increasing the aggregate number of people that any given user of each network can reach. Therefore, as noted by Armstrong (1997a, 67), these two features of the telecommunications sector together explain why the issue of network interconnection is of such importance in telecommunications and why the problem of finding an appropriate price for access arises even when there are a number of networks. Further, network interconnection will be crucial also from the point of view of ensuring the effectiveness of competition when the incumbent network is faced with entry by a smaller rival: in the presence of network externalities, interconnection is necessary to give entrants with only limited network coverage a chance of competing with the incumbent. If networks are interconnected, then the incumbent's advantage from network externalities is removed: as was argued in Section 2.2, network externalities in a duopoly relate to the entire network of compatible products. Because each network needs to buy access to the customers of the other network, the case of facilities based competition is characterised by the need for two-way access. The principles of two-way access pricing will be discussed in Chapter 5.

There are also other possible ways of introducing competition into local telecommunications besides the two benchmark options outlined above. A mixture of the above two strategies, where the entrant uses partly its own facilities and partly those

[9] These two forms of competition in telecommunications have been examined for example in Armstrong (1997a), who calls them *competition in service provision* and *competition for directly connected customers*, respectively.

of the incumbent, is also a relevant possibility. For example, it is possible to separate the actual network infrastructure from the technology needed for routing calls within the network, that is, network switches and other control facilities. The entrant could, for example, provide its own switches, and only hire the local loop infrastructure from the incumbent. This form of entry is called *unbundling based entry*, as it involves providing different parts of the network separately. As unbundling based entry does not involve the duplication of network infrastructure, it can in this sense be classified as a form of services based competition and is therefore another possibility available to the regulator if network duplication is judged to be undesirable. Further, potential problems with achieving effective competition in the case of unbundling based entry are often similar to those related to services based entry, as the incumbent can seriously disadvantage entrants by excessive pricing of the local loop. However, the task of determining optimal access charges becomes slightly more complicated than in the two benchmark cases, as it is necessary to determine optimal prices for the different components of the network. Therefore, despite the similarities with services based entry, it is important to note that the simple one-way access pricing benchmark cannot be used in the case of unbundling based entry[10]. In this study, however, we will not consider these more complicated situations, but concentrate on optimal access pricing in the two polar cases of one-way and two-way access.

The essential features of one-way and two-way access are summarised in Figures 3.1 and 3.2. In the case of one-way access, the incumbent (M) is a monopolist in local network provision, and the competitor (C) buys network services from M in order to supply telecommunications services to final customers. In the case of two-way access both firms (M_1 and M_2) have their own networks. The networks are interconnected and each network buys access to the other firm's network to be able to deliver calls to that firm's customers[11].

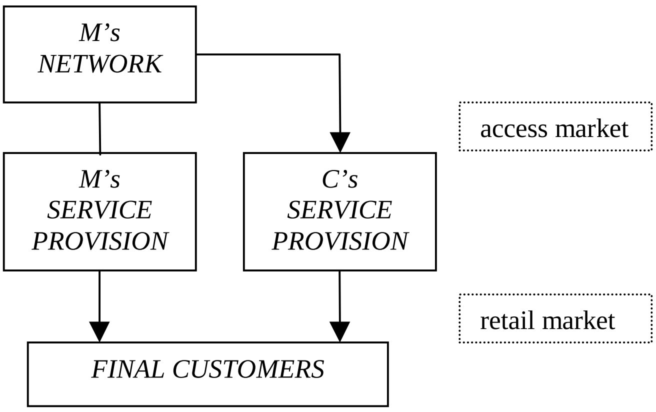

Figure 3.1. One-way access.

[10] In fact, unbundling based entry in most cases requires the application of a modified version of two-way access pricing: when the incumbent's customers call those of the entrant, the incumbent will have to pay an access charge for using those parts of the network that are provided by the entrant. For a model of unbundling based entry, see Laffont, Rey and Tirole (1998a, 15-16).

[11] Note that the terms *access* and *interconnection* are used interchangeably throughout this study.

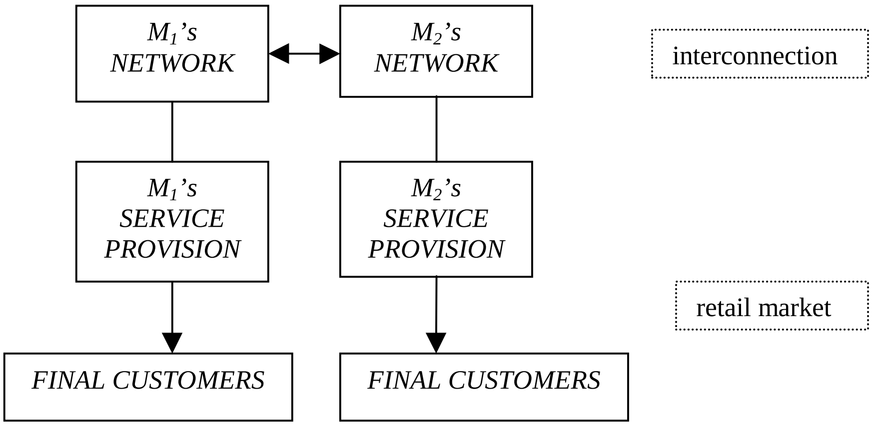

Figure 3.2. Two-way access.

At this stage in the discussion the policy of promoting services based competition might appear clearly superior to facilities based competition, as it avoids the cost of network duplication whilst achieving the benefits of competition in services. However, achieving effective competition on the retail level depends on how the problem of access is solved, and if regulatory intervention is found necessary, on the regulator's ability to control the access charge optimally. Which form of competition to promote should therefore also depend on the regulator's ability to deal with potential problems associated with guaranteeing the effectiveness of each type of competition. The regulator's role in ensuring effective competition in the cases of one-way and two-way access is discussed in Chapters 4 and 5.

4 Optimal policies for one-way access

4.1 The nature of the one-way access pricing problem

The models of one-way access apply in a situation in which there is a vertically integrated incumbent monopolist who owns the telephone network and also operates in the retail market. Other firms that wish to provide telecommunications services in the retail market do not have a network of their own and will therefore require access to the incumbent's network, which is an essential input to providing telecommunications services. There has been some controversy over whether the incumbent monopolist has an incentive to distort downstream competition, that is, to add a monopoly mark-up to the access charge, thus distorting the entrant's choice of whether and how much of the retail service to provide. Armstrong (2001, 10-14) shows that even though in some simple models the incumbent has no incentive to distort downstream competition, this result is not robust in more realistic settings[12]. There is indeed a consensus in the literature on one one-way access that regulation can potentially improve efficiency and social welfare in this setting.

The broad objective of "promoting competition" is too vague a starting point for designing optimal regulation. It is important to specify the objectives of and the instruments available to the regulator, as the optimal policy will depend crucially on both. These two issues are also closely connected, as the number of instruments used will affect the number of objectives that can be optimally achieved. Whenever there are fewer instruments than there are objectives, some trade-offs between the objectives will have to be tolerated.

Firstly, regarding the objectives of regulation, this study will concentrate on optimal access pricing in a static context. Therefore dynamic issues such as providing optimal incentives for investment in infrastructure or new services will not be discussed[13]. Another feature of our static approach is the following: we make the simplifying assumption that providing incentives for cost minimisation is not an issue, either because the regulator has full information on costs, or because incentives are best ensured through other means besides price regulation[14]. Further, we will not consider the possible redistributive effects of regulation. Even though regulators are often

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[12] Armstrong (2001) uses a unit demand model to demonstrate a case in which the incumbent has no incentive for foreclosure, but shows that this result does not hold for example in a model in which the incumbent competes against a competitive fringe. See also Rey and Tirole (1997) for a more extensive discussion on foreclosure.

[13] In general, dynamic issues have received very limited attention so far in the access pricing literature. See Armstrong (2001, 32-33) for a short introduction to dynamic issues related to the pricing of one-way access.

[14] Laffont and Tirole (1990, 15-25) show that the incentive effects of pricing depend on the very fine details of the cost function and derive conditions under which the issues of pricing and incentives can be separated. Laffont and Tirole (1994, 1679-1684) extend this analysis to access pricing. Based on these articles, Laffont and Tirole (2000, 129-130) argue that the decoupling of access pricing and incentives is a reasonable rule of thumb in the absence of detailed information about the cost function.

influenced by redistributive concerns, particularly in the context of public utilities industries such as telecommunications, such concerns have not been a central issue in the access pricing literature.

Leaving aside dynamic issues and redistributive concerns, there are then *four* possible goals for regulation to be considered: in cases where optimal outcomes are not achieved through market forces, regulation should be used to promote allocative and productive efficiency[15], both at the level of the network and in the retail segment. When we introduce each of the models discussed in this study, we will attempt to make clear the objectives considered in that particular model.

Let us turn next to the question concerning the instruments available to the regulator. Due to the importance of the terms of access for achieving effective competition in telecommunications, the main focus of this study is access pricing and access price regulation. However, as a consequence of the multitude of possible aims, access pricing has often been discussed in connection with other instruments, such as retail price regulation and various forms of taxation. The basic models of one-way access pricing that will be discussed below are indeed concerned with a situation in which *both* the access charge and the retail price of the incumbent are regulated. However, as the tendency today is towards less regulation rather than more, we will assume that the regulator does not have powers of taxation. In a similar vein, we will also consider an extension of the basic models of one-way access pricing to a situation in which the retail price is deregulated. The focus on such a limited set of instruments entails that whenever there are a number of distortions present, any single objective will rarely be addressed perfectly. Second best policies that involve trade-offs between the different objectives will then have to be considered.

Two main approaches to one-way access pricing have been developed in previous literature. The efficient component pricing rule (ECPR) for pricing access in network industries was first introduced by Willig (1979)[16]. The ECPR has been discussed further for example in Baumol and Sidak (1994). Laffont and Tirole (1994; 1996), on the other hand, have promoted the application of Ramsey pricing as a solution to the access pricing problem. These two approaches will be analysed in turn below: Sections 4.2 and 4.3 introduce the ECPR and Ramsey approaches, and the two approaches are then compared in Section 4.4. Section 4.5 considers the effect of retail price deregulation on the optimal access charge.

[15] As our static approach implies that the cost functions of individual firms are assumed to be exogenous, productive efficiency implies simply ensuring that the market is served by the most efficient firm.

[16] It is useful to note that Willig (1979) uses slightly different terminology to that used by most authors today: he uses the term *access price* to refer to the fee paid by customers to connect to the network and the term *technical network access price* to refer to the price paid by an entrant operator for using the incumbent's network.

4.2 The efficient component pricing rule

The key assumption of the efficient component pricing rule approach is that the retail price of the incumbent is fixed by regulation at some level $\overline{p}_i$ prior to setting the access charge. The optimal access charge is then chosen, given the retail price. The criterion for optimality in the original ECPR framework is productive efficiency in the retail segment: the access charge should be set at such a level that an entrant with lower marginal costs in the retail segment than the incumbent will find it profitable to enter, whereas inefficient entry should be deterred.[17] In the simplest situation the following assumptions are made: (i) the retail products of the entrant and the incumbent are perfect substitutes; and (ii) for each unit of the retail product, the entrant needs exactly one unit of network access from the incumbent[18].

Let c_i be the incumbent's marginal cost in the retail segment, a the access charge and c_a the incumbent's marginal cost of providing access, that is, the marginal cost of providing the network service both to itself and to its rivals. The condition that only efficient entry should be profitable is satisfied by an access charge set according to the following simple rule:

$$a = \overline{p}_i - c_i\,. \qquad (4.1)$$

The rule in (4.1) states that the access charge should be equal to the difference between the incumbent's price and marginal cost in the retail segment. Perhaps a more intuitive way of explaining the formula is the following: the margin between the incumbent's two prices, that is, the margin between the retail price and the access charge ($\overline{p}_i - a$), should be equal to the incumbent's incremental cost in the retail segment (c_i). (Vickers 1997, 22.)

The fact that access charges set by the previous formula will induce only those potential entrants to enter whose marginal costs are lower than those of the incumbent, can be seen as follows. Let the entrant's marginal cost in the retail sector be c_e. The entrant is assumed to be a price taker and will therefore make a profit only if its marginal cost is lower than the price in the retail segment: $\overline{p}_i > a + c_e$. Substituting the expression for a from the ECPR formula above into this inequality, we can see that the entrant will be able to make a profit if and only if $c_i > c_e$, that is, if the entrant is more efficient than the incumbent.

Another formulation of the ECPR is the following:

$$a = c_a + \left[\overline{p}_i - (c_a + c_i)\right]. \qquad (4.2)$$

[17] For Willig's original formulation of this aim, see Willig (1979, 139).
[18] Assumption (ii) incorporates two assumptions often stated separately (see for example Vickers 1997): there is fixed coefficients technology (one unit of output requires one unit of input) and there is no possibility of bypass (only the incumbent supplies that input).

This formulation is equivalent to Willig's (1979) original formulation of the ECPR[19] and shows that the optimal access charge equals the marginal cost of providing access plus the amount of retail profit lost by the incumbent in providing one unit of access. This formulation stresses the notion that the proper measure of marginal cost is the *opportunity cost* of providing a service: the access charge should not equal the incumbent's physical marginal cost, but instead the opportunity cost of providing access.

If one or both of the two assumptions (i) and (ii) stated above does not hold, which is likely to be the case in reality, then the ECPR formula should be revised accordingly. If the incumbent's and the entrant's products are not perfect substitutes, or if the entrant does not require exactly one unit of access for each unit of output it produces, the opportunity cost of providing access has to be revised from that given in Equation (4.2). To derive the optimal access charge in this more complicated setting we follow the discussion in Armstrong (2001). In order to abstract from problems caused by entrant market power, we assume that the entrants behave competitively despite product differentiation. Such a situation can be modelled for example using a competitive fringe model such as the one in Armstrong (2001, 13), where firms in the fringe produce an identical product that is differentiated from that of the incumbent. The assumption of a competitive retail sector is reasonable, as the retail segment is assumed to have negligible fixed costs and it is therefore potentially competitive. It was argued in Chapter 2 above, that this assumption corresponds to the actual cost conditions in the industry.

With the access charge *a* the fringe has a minimum constant marginal cost $c_e(a)$ and firms in the fringe set a price $p_e = c_e(a)$, so that they make zero profit. The profits of the incumbent $\pi(\bar{p}_i, a)$ are given by the sum of profits from selling access and profits from selling the final service, and are therefore given by

$$\pi(\bar{p}_i, a) = (a - c_a)q_a + (\bar{p}_i - c_i - c_a)q_i, \qquad (4.3)$$

where q_a is the total demand for access by the fringe and q_i is the incumbent's output of the final good.

The optimal access charge is the access charge that maximises social welfare, when the incumbent's retail price is taken as given. In accordance with our assumption that there is no need to pay attention to redistributive issues, social welfare is throughout this paper taken to be the unweighted sum of consumer surplus and profits. Social welfare in the current case is therefore given by

$$W = S(\bar{p}_i, c_e(a)) + \pi(\bar{p}_i, a), \qquad (4.4)$$

[19] See Equation (72) in Willig (1979, 142).

where $S(\bar{p}_i, c_e(a))$ is consumer surplus. From the envelope theorem, net consumer surplus has the property that $\frac{\partial S}{\partial p_i} = -q_i$ and similarly for the entrant's price. By Shephard's Lemma we also know that $c'_e(a)$ is the demand for access per unit of output produced by the entrant and therefore the total demand for access can be written as $q_a = c'_e(a)q_e$, where q_e is the entrant's output of the final product. The optimal access charge is now given by

$$a = c_a + \sigma[\bar{p}_i - (c_a + c_i)], \qquad (4.5)$$

where $\sigma = \left|\frac{\partial q_i / \partial a}{\partial q_a / \partial a}\right|$ is the so called *displacement ratio*. This terminology was introduced by Armstrong, Doyle and Vickers (1996), who were the first to derive the generalised ECPR access charge in Equation (4.5).

The displacement ratio determines how much sales the incumbent loses as a result of supplying one unit of access to its rivals. If the assumptions (i) and (ii) above hold, then $\sigma = 1$ and Equation (4.5) reduces to Equation (4.2). However, if the entrant's product is not a perfect substitute to that of the incumbent, or if the entrant can substitute away from the access service provided by the incumbent, then $\sigma < 1$ and the ECPR access charge is lowered relative to that implied by the original ECPR. (Armstrong, Doyle and Vickers 1996.)

One of the main implications of the ECPR approach is that appropriate access charges can deviate significantly from marginal costs, which is in contrast to the approach traditionally taken by many regulators. This is in particular the case if the services provided by the incumbent and the entrant are close substitutes, that is, when $\sigma \approx 1$. However, product differentiation, variable proportions technology and the possibility of bypass will reduce the opportunity cost of the incumbent in providing access: in these situations and the appropriate access charge will be closer to physical marginal cost[20]. (Vickers 1997, 24.)

It is interesting to note that when the entrant has possibilities for substituting away from the incumbent's access service, the ECPR no more ensures productive efficiency even though this was the sole objective of the original ECPR. When network bypass is a possibility, productive efficiency at the network level becomes an issue[21]. When there are a number of alternative ways of access available, the only way to achieve productive efficiency at the network level would be to price access at marginal cost. However, as was noted above, the ECPR access charge involves a mark-up over marginal cost. This is naturally an instance of the inadequate instruments problem mentioned in the

[20] Armstrong, Doyle and Vickers (1996) also provide a decomposition of the displacement ratio into the effects caused by product differentiation, variable proportions in production, and bypass.

[21] However, as the retail products of the incumbent and the entrant are now assumed to be differentiated, we can no more state the conditions for productive efficiency at the retail level in any straightforward manner.

previous Section: as explained by Armstrong (2001, 23), the access charge here is required to perform two tasks and the regulator must therefore compromise between allocative and productive efficiency.

The ECPR approach to access pricing has been criticised on a number of accounts. One rather natural reaction is the claim that setting access charges according to the ECPR rule will allow the incumbent to maintain monopoly profits, as the incumbent is compensated for any loss of profits caused by entry. However, this criticism of the ECPR can easily be overcome: as noted by the rule's proponents, the validity of the rule depends on the retail price also being regulated optimally. "Partial enforcement", where the ECPR is applied on its own while allowing the incumbent to earn supernormal profits in the retail segment, will not produce the desired result. (Baumol and Sidak 1994, 108.)

The discussion in the previous paragraph, however, leads to another criticism of the ECPR approach. As explained above, the ECPR approach takes the retail price as given when the access charge is chosen, and the question of how the retail price is regulated is left unanswered. This raises the question of would it not be possible to achieve an improvement if one could vary all of the incumbent's prices (that is, both the retail and the access prices) together: in such a situation also the interactions between the different pricing decisions could be taken into account. The Ramsey approach to access pricing, described below, will consider the problem of regulating the incumbent's entire price vector simultaneously.

4.3 Ramsey pricing

The Ramsey pricing problem in the context of the telecommunications industry involves choosing all prices of the incumbent telecommunications firm, including the access charge, so as to maximise social welfare. Further, the regulator has to also make sure that the incumbent does not make a loss. In this situation the fact that the access pricing problem is crucially affected by the instruments available to the regulator becomes obvious. One implicit but very important assumption in the Ramsey approach is that the regulator cannot use lump-sum transfers. If it could, then the regulator's problem would be rather trivial, as it would be clear that the optimal solution would be reached by setting all prices at marginal cost and covering the incumbent's fixed costs by a lump-sum payment. In this case allocative efficiency in both the retail and the access markets would be ensured[22]. However, it is widely accepted that using non-distortionary lump-sum transfers, which would require both lump-sum taxation and lump-sum subsidies, is not a feasible policy option. Therefore the presence of fixed costs implies that second best optimal prices that cover the incumbent's deficit with the least possible welfare cost need to be derived.

[22] The question of productive efficiency does not arise in the Ramsey approach as the entrant's presence in the retail segment is taken as given and the original model assumes no possibility for bypass.

Such an exercise involves applying the principles first derived by Ramsey (1927) in the context of optimal taxation. Ramsey examined the problem of collecting a given amount of tax revenue with the least possible welfare cost, that is, with the smallest possible distortion to consumer choice. It is clear that the problem analysed here is analogous to the problem considered by Ramsey; therefore also the results derived for access charges and the prices of other telecommunications services are analogous to the Ramsey formulae for optimal taxation.

Prior to its application to the access pricing problem, Ramsey pricing has been applied in general to the question of optimal regulation of a multiproduct firm with a fixed cost recovery constraint. As noted by Vickers (1997, 22), the access pricing problem could in principle be handled in terms of this more general framework, simply treating the provision of access as one product among others. However, it seems worthwhile to derive an explicit expression for the access price implied by the Ramsey approach, as this will make application of the formulae easier and also enables comparisons with the ECPR formula.

The following derivation of Ramsey prices follows Armstrong (2001, 23-25) and Laffont and Tirole (2000, 102-103), with some additional remarks and some differences in notation. As in Section 4.2, we consider a simplified case where the incumbent supplies two products, access to competitors and retail telephony to final customers. The other firms in the industry only operate in the retail segment and buy access from the incumbent. These other firms are again assumed to behave competitively.

Let p_i be the final price charged by the incumbent in the retail market, q_i the quantity of the final product supplied by the incumbent, and c_i the marginal cost of the incumbent in the retail market. Let a be the access charge and c_a the incumbent's marginal cost of providing access, that is, the marginal cost of providing the network service both to itself and to its rivals. The fixed cost of network operation is k. The other firms in the industry provide a quantity q_e of a uniform telephone service with marginal cost c_e+a. For the sake of simplicity we again adopt assumption (ii) above, that the entrant requires exactly one unit of network access from the incumbent for each unit of the retail service[23]. With this assumption q_e is also the total amount of access provided by the incumbent to its competitors and therefore the profits of the incumbent firm are given by

$$\pi(p_i, a) = (a - c_a)q_e - k + (p_i - c_i - c_a)q_i\,. \qquad (4.6)$$

As the other firms in the industry are assumed to behave competitively, they charge a price $p_e = c_e + a$ and make zero profit.

Finally, let $S(p_i, c_e + a)$ be the net consumer surplus from all the telephone services provided to final customers. Total social welfare in this model is given by

[23] See footnote 18.

$$W = S(p_i, c_e + a) + \pi(p_i, a) \tag{4.7}$$

and the Ramsey problem in the context of access pricing can now be expressed formally as

$$\max_{a, p_i} W \quad \text{subject to} \quad \pi(p_i, a) \geq 0. \tag{4.8}$$

It should be noted that the Lagrange multiplier (λ) associated with the constraint in (4.8) can be interpreted as *the shadow cost of public funds*[24]. Due to the presence of fixed costs, λ is strictly positive in the present case. Solving the maximisation problem in the simplified case where demands for the incumbent's products are independent yields the following formulae:

$$\frac{p_i - c_i - c_a}{p_i} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_i} \tag{4.9}$$

$$\frac{a - c_a}{a} = \frac{\lambda}{1+\lambda}\frac{1}{\eta_a} \tag{4.10}$$

where $\eta_i = \left|\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i}\right|$ and $\eta_a = \left|\frac{\partial q_a}{\partial a}\frac{a}{q_a}\right|$ are the (own) price elasticities of demand for the final product and for access. In the more realistic case where demands for these two services are not independent, the elasticity terms are replaced by the so called superelasticities that take into account demand interactions between the services.[25]

Formulae (4.9) and (4.10) give one of the most common formulations of Ramsey prices. These equations show that the Ramsey optimal price of each product exceeds its marginal cost by an amount that is inversely proportional to the price elasticity of that product. Setting the highest price for the product with the lowest elasticity of demand minimises the distortion to consumer choice as the pattern of consumption changes relatively little from the efficient pattern associated with marginal cost pricing. These results can easily be extended to a case where the incumbent offers a large number of products instead of only two as in this simplified example.

Note that the above results also imply that the access charge should be lower, the more elastic the demand for the entrant's product in the final market. The optimal access charge in Equation (4.10) can be stated in another way that makes this point more

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[24] As was noted above, we assume that the regulator cannot use lump-sum transfers. The regulator still has the alternative of covering the firm's deficit from public funds. This would however involve a distortion associated with distortionary taxation / subsidies, and therefore a cost to society. This cost is reflected in the parameter λ.

[25] See for example Laffont and Tirole (2000, 103) or Braeutigam (1989, 1324-1325) for details. Braeutigam's article also contains a general introduction to Ramsey pricing. A rewriting of the Ramsey access charge that takes into account demand interactions as well as the possibility of bypass is given in Equation (4.14) below.

obvious. The optimal access charge in the case of independent demands is also given by[26]

$$a = c_a + \frac{\lambda}{1+\lambda} \frac{p_e}{\eta_e} \qquad (4.11)$$

where $\eta_e = \left| \frac{\partial q_e}{\partial p_e} \frac{p_e}{q_e} \right|$ is the elasticity of demand for the entrant's final product. If there are for example different groups of entrants that offer services to different market segments, then access charges should differ according to the elasticity of demand for each final product. The relationship between end market demand elasticity and the access charge is as straightforward as in Equation (4.11) only in the case where the entrant has no possibilities for substituting away from the incumbent's access service. In this case the elasticity of demand in the final market has a direct effect on the incumbent's ability to collect revenue through the access charge. However, this point has significance in more general settings as well, as long as demand in the end market and demand for access are positively related, which is a reasonable assumption.

Further, the Ramsey formulae can be applied in a straightforward manner to a case in which the incumbent charges a two-part tariff in the retail market. As is explained by Laffont and Tirole (2000, 69), a two-part tariff should be analysed as the provision of two separate services by the incumbent: the fixed part of the two-part tariff entitles a consumer to connect to the service, whereas the variable charge is the price for making calls. These two services should then be priced according to their respective demand elasticities[27]. The case of a two-part tariff can also be used to illustrate the effect of demand interactions on optimal Ramsey prices. The two services, interconnection and telephone calls, are complements and this complementarity should be taken into account in pricing decisions: it is worth losing some revenue on interconnection in order to keep customers connected, as a larger number of connected customers also entails more revenue from calls.

The main results of the Ramsey pricing approach are therefore the following: (i) all prices should contribute to the fixed cost recovery problem; and (ii) the optimal contribution depends on the demand elasticity of each product: the higher the elasticity, the lower the contribution.[28] Further, as noted above, optimal Ramsey prices also take into account cross-price effects between products. These results will be discussed further in section 4.4 below.

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[26] Because $p_e = c_e + a$ and because c_e is assumed to be constant, it follows that $\partial q_e / \partial a = \partial q_e / \partial p_e$ and the access charge can be written as in (4.11).

[27] Note that the simple Coasian two-part tariff, where the fixed fee is set high enough to cover the entire deficit of the incumbent is optimal only if the demand for connections is assumed to be completely inelastic. See Brown and Sibley (1986, 94-95) for a related discussion and explicit formulae for the optimal two-part tariff in the case of a single retail product.

[28] This result is analogous to the Ramsey rules for optimal taxation, which state that the good with the least elastic demand should be taxed most heavily in order to minimise the distortion caused by taxation.

4.4 Comparison of the two approaches to one-way access pricing

In this Section we draw together a number of points from the previous Sections in order to provide an explicit comparison of the ECPR and the Ramsey approaches. Firstly, an important difference between the approaches is the role of the fixed cost recovery constraint of the incumbent. The Ramsey pricing approach explicitly takes this constraint into account, whereas in the ECPR approach it is not considered. Secondly, in the Ramsey approach all prices are set simultaneously by the regulator, whereas in the ECPR approach the retail price of the incumbent firm is assumed to be fixed when the access charge is chosen. These two differences are clearly interlinked. The reason that the fixed cost recovery constraint is not considered in the ECPR approach is that the incumbent's fixed costs can be assumed to be already covered by its optimally regulated retail price. Therefore the fixed cost recovery problem is irrelevant when the access price is set.

Thirdly, and related to the previous two points, the objectives of the two approaches are somewhat different. Whereas the original ECPR approach concentrates solely on ensuring productive efficiency, the Ramsey pricing problem is concerned with minimising the distortion to allocative efficiency and involves the maximisation of a more general social welfare function. However, the dissimilarity of the objectives of the two approaches relates mainly to the original formulation of the ECPR approach. As was explained in Section 4.2 above, the ECPR approach has been extended to take into account the possibility of bypass, product differentiation and variable proportions technology. In this refined ECPR approach, productive efficiency has ceased to be the only objective, and the ECPR and Ramsey pricing approaches have converged.

The similarity between the generalised ECPR access charge in Equation (4.5) and the Ramsey access charge can be seen by deriving a Ramsey access charge that is optimal when the simplifying assumptions of no bypass and fixed proportions technology are relaxed also in the Ramsey approach. The incumbent's profit is then given by

$$\pi(p_i, a) = (a - c_a)q_a - k + (p_i - c_i - c_a)q_i, \qquad (4.12)$$

as q_a can now differ from q_e. Further, social welfare in this case is

$$W = S(p_i, p_e(a)) + \pi(p_i, a) \qquad (4.13)$$

The Ramsey optimal access charge in the case of interdependent demands can now be written as follows:

$$a = c_a + \sigma[p_i - (c_a + c_i)] + \frac{\lambda}{1+\lambda}\frac{a}{\eta_a} \qquad (4.14)$$

where σ is as in Equation (4.5). This rewriting of the Ramsey access charge was first derived by Armstrong, Doyle and Vickers (1996, 136-139) and it has the benefit that the effect of the incumbent's budget constraint on the optimal access charge can now be seen more clearly. When Equation (4.14) is compared with the modified ECPR access charge in (4.5), we see that the two expressions are exactly the same except for the last term in (4.14). This additional Ramsey markup demonstrates the differences that still remain between the ECPR and Ramsey approaches: as the Ramsey access charge takes into account the fixed cost recovery constraint of the incumbent firm, it gives a greater weight to the incumbent's profits in the social welfare function. This greater weight is embodied in the parameter λ. The Ramsey access charge is therefore above the ECPR level, as the access charge has to contribute to the covering of the incumbent's deficit.

Armstrong (2001, 36) takes the above argument as far as stating that "the difference between the two approaches simply has to do with the social cost of public funds". While this statement is strictly speaking true, we feel that it understates the differences that remain between the approaches. The first and second differences mentioned at the beginning of this Section have not disappeared with the rewriting of the ECPR. Due to these differences, the Ramsey pricing approach can still be considered as an improvement on the ECPR. Whereas the ECPR approach simply assumes that the fixed costs of the incumbent are covered by its retail price, it was shown above (see Equations (4.9) and (4.10)) that ideally, all prices of the incumbent should contribute to covering the incumbent's deficit. Therefore the Ramsey approach provides some guidelines as to how the incumbent's deficit should best be financed, whereas in the ECPR approach this problem is simply assumed away.

Whatever their differences, the two approaches both come to the conclusion that, in the situation considered, optimal access charges do in general deviate from marginal costs. Further, both approaches imply that the optimal markup over the marginal cost of access is not constant but depends on the nature of the service that the incumbent's network is used as an input for. Firstly, this markup should differ according to differences in substitutability between the entrant's and the incumbent's retail products. Secondly, the Ramsey approach implies that the optimal access price depends on the elasticity of demand for the entrant's retail product. These features imply that optimal access charges do not only depend on costs, but they are usage based, which is in contrast to the tendency of regulators to favour simple cost based access charges.

4.5 Extension: deregulated retail market

The framework that was used above to derive optimal access and retail prices in the one-way case is highly simplified. Let us now consider one important modification to the basic framework, that is, the case where the retail price is unregulated and the access charge is then the only instrument available to the regulator.

Access pricing with a deregulated retail market is analysed in Laffont and Tirole (1994, 1689-90), Armstrong and Vickers (1998) and Armstrong (2001, 26-30). The derivation of the optimal access charge in this situation is slightly complicated by the fact that we can no longer be certain of whether the incumbent firm's budget constraint is binding. The larger the incumbent's fixed costs and the more competitive the deregulated retail market, the more likely it is that the budget constraint will be binding, as competition will prohibit large deviations from marginal cost when the incumbent sets its retail price. Armstrong and Vickers (1998) and Armstrong (2001) consider the case where the incumbent's budget constraint is not binding, whereas Laffont and Tirole (1994) assume that it is. We will combine these approaches by deriving a formula that takes into account the incumbent's budget constraint, but is decomposed in a manner analogous to Equation (4.14), so that the exact effect of the budget constraint can be isolated (and therefore ignored, if the constraint is not binding).[29]

We consider a game where the regulator first sets the access charge and the incumbent then chooses its retail price. As before, we assume that the incumbent competes against a competitive fringe, so that the entrants' price p_e is equal to $c_e(a)$. We assume, however, that the incumbent still has market power also in the retail segment. The sources of the incumbent's market power are again not explicitly modelled here, but market power could remain for example due to customer loyalty or due to product differentiation. We use the same method as Laffont and Tirole (1994) to derive the optimal access charge, but in contrast to those authors, we assume that bypass of the local loop is a possibility[30]. The regulator maximises social welfare subject to the incumbent's breakeven constraint as in the standard Ramsey pricing problem. However, the regulator now has another constraint as well, namely that the incumbent's marginal profit has to equal zero. If the problem is formulated in this way, it can be solved as if the regulator chose both the incumbent's price and the access charge. That is, the regulator's problem can be expressed formally as

$$\underset{p_i, a}{\text{Max}}\ W \quad \text{subject to} \quad \pi(p_i, a) \geq 0 \quad \text{and} \quad \frac{\partial \pi}{\partial p_i}(p_i, a) = 0, \tag{4.15}$$

where W is as in Equation (4.13) and $\pi(p_i, a)$ is as in (4.12). It is shown in the Appendix that the optimal access charge is now given by

$$a = c_a + \sigma\left(p_i^* - c_i - c_a\right) + \frac{\lambda}{1+\lambda}\frac{a}{\eta_a} + \frac{1}{1+\lambda}\frac{\partial p_i^*}{\partial a}\frac{q_i}{\partial q_a / \partial a}, \tag{4.16}$$

where p_i^* is the incumbent's profit-maximising price. The access charge in (4.16) can be compared with the access charge under complete regulation given in (4.14). There is

[29] Armstrong, Doyle and Vickers (1996) do not examine the case where the retail market is deregulated. In their extension to that paper, Armstrong and Vickers (1998) consider the effect of a deregulated retail market, but do not incorporate a budget constraint.

[30] Further, we take the derivation slightly further than those authors, by providing an explicit formula for the optimal access charge.

a completely new term $\frac{1}{1+\lambda}\frac{\partial p_i^*}{\partial a}\frac{q_i}{\partial q_a/\partial a}$ in Equation (4.16), that reflects the effect of retail market deregulation. This effect depends on the relationship between the access charge and the incumbent's retail price, that is, on the sign of the derivative $\frac{\partial p_i^*}{\partial a}$. The intuition behind this is that because the incumbent still has market power in the retail segment, the regulator now has to attempt to achieve one more objective with the use of the access charge, namely controlling the incumbent's retail price. This then creates a further distortion in the access charge. Armstrong (2001, 29) argues that $\frac{\partial p_i^*}{\partial a}$ is likely to be positive: the more profitable selling access to its rivals is, the less aggressively the incumbent will compete with rivals. If we make the assumption that $\frac{\partial p_i^*}{\partial a} > 0$, Equation (4.16) implies that the access charge should be *lowered* relative to the full regulation case in order to reduce the distortion in the incumbent's retail price.

One interesting feature about Equation (4.16) is that the effect of retail market deregulation on the access charge is different depending on whether the incumbent's budget constraint is binding or not: if the budget constraint is not binding $(\lambda = 0)$, the new term is larger than if the constraint is binding $(\lambda > 0)$. That is, if the budget constraint is binding, optimal regulation has to allow the access charge to be higher relative to the case where the budget constraint is not binding. If we set $\lambda = 0$ in Equation (4.16), it becomes identical to Equation (8) in Armstrong and Vickers (1998) and Equation (35) in Armstrong (2001).

However, as noted by Laffont and Tirole (1994, 1690), retail market deregulation has also a second effect on the optimal access charge: the fact that deregulation allows the incumbent to raise p_i implies that also p_e should be raised, in order to rebalance consumers' choice between the incumbent's and the entrants' retail products. This consideration calls for a *higher* access charge relative to the full regulation case. Therefore the overall effect of retail market deregulation on the access charge is ambiguous: we cannot be sure whether the access charge in this case is higher or lower than the access charge associated with full regulation, or even whether the access charge is above or below marginal cost. Laffont and Tirole (1994) show that conclusive results can be obtained if the demand functions for both the incumbent and the entrant's final products are linear: in this case the two effects on the optimal access charge mentioned above cancel each other out, and the optimal access charge is the same as the Ramsey access charge under full regulation.

The above discussion relates to a case in which the incumbent still has some market power in the retail segment. However, the removal of retail price regulation is usually motivated by the assumption that competition in the retail market has driven prices down to marginal cost in that sector. Armstrong (2001, 26-28) argues that in this case also access should be priced at marginal cost. We would however like to treat this question slightly differently to the discussion in that paper[31]. Assuming that the incumbent and the entrant have equal marginal costs c in the retail segment, the incumbent's price will be driven down to $p_i = c + c_a$ and the entrant will charge $p_e = c + a$. In order for both the incumbent and the entrant to survive in the market, the regulator indeed has to set $a = c_a$. If, on the other hand, the entrant has higher marginal costs in the retail segment than the incumbent, then productive efficiency would call for monopolisation of the retail segment as well. However, taking into account the benefits of competition discussed in Section 3.1, there might be a case for compromising productive efficiency in order to make competition viable: there would then be a case for subsidising access, that is setting $a < c_a$. On the other hand, if the incumbent has higher costs in the retail segment than do prospective entrants, then either access should be priced above marginal cost, or the incumbent would exit the retail market and only provide the network service.

However, no matter which of the above scenarios will be the one that prevails in reality, in the case of perfect competition in the retail market the viability of the incumbent network provider becomes an issue. As all prices would be set at or close to marginal cost, the incumbent's fixed costs would have to be covered from public funds. A conclusion that has not previously been emphasised in the literature then emerges here: it seems that if the incumbent firm is vertically integrated, then the functioning of the retail and the access markets cannot be separated as effectively as has been proclaimed in the literature. Perfect competition in the retail market calls for access to be priced at marginal cost, but this in turn causes problems for the viability of the incumbent. One way of solving this would be for the incumbent to only operate as a network provider, in which case the access charge could again be set according to Ramsey principles: this would enable the incumbent's deficit to be covered efficiently, and would preserve a level playing field between entrants in any given market segment. However, examining such alternative market structures in detail is beyond the scope of this study.

Both the ECPR and the Ramsey approaches to one-way access pricing come to the conclusion that optimal access charges do in general deviate from marginal costs and further, the optimal access charge can differ between services even when the marginal cost of access is the same for these services. The effect of retail market deregulation on the access charge is ambiguous in the case in which the incumbent still has some market power in the retail segment. If competition in the retail market is perfect, the setting changes considerably. On the one hand, the need to cover the incumbent's deficit seems to call for a higher access charge as the retail price will be close to marginal cost and therefore cannot contribute to the task of covering the incumbent's fixed costs. On the other hand, however, a high access charge would make competition impossible as it would seriously disadvantage the position of price taking competitors. The issue of

[31] It seems that Armstrong's (2001) argument requires an assumption that the retail market is contestable, as perfect competition is assumed to prevail even though it is assumed that the retail market is served only by the most efficient operator.

optimal regulation of access in the case of perfect retail competition remains an interesting issue for further research.

5 Optimal policies for two-way access

5.1 The nature of the two-way access pricing problem

If the regulator rejects the traditional view that the local network should be monopolised, then it should promote facilities based entry into the local telecommunications market. Nevertheless, access pricing remains a relevant issue for the optimal functioning of the market. As was explained in Chapter 3, separate networks need to be interconnected in order to exploit positive network externalities. Further, in the presence of network externalities, interconnection is necessary to give entrants with only limited network coverage a chance of competing with the incumbent. This is an important consideration, as the desire to introduce competition into telecommunications is the main reason for discussing the problem of access in the first place.

In the two-way access models considered in this study, retail prices are assumed to be unregulated and the access charge is therefore the only instrument available to the regulator. As was mentioned in the introduction, the interesting question regarding two-way access pricing is, whether network competition removes the need for all regulation. This question plays a key role also in the decision of whether to promote services or facilities based competition. It was explained in the previous Chapter, that regulation will be necessary in order to achieve optimal outcomes in the case of one-way access. If network competition is found to obviate the need for regulation, then the case for promoting this form of competition becomes stronger.

The main issue in this Chapter is therefore whether network competition is sufficient to produce a socially optimal outcome in the local telecommunications market, either non-cooperatively or through negotiations between firms. The main concerns that have been raised in this respect are that if no cooperation is allowed, access charges will be set inefficiently high and, on the other hand, if cooperation is allowed, this might allow firms to collude also in the retail market.

There are two rather distinct situations that require two-way access in telecommunications. Firstly, as in the case of international telecommunications, the networks that need to be interconnected can operate in different markets: the services provided by the two networks are then complementary. Secondly, the networks can operate in the same market, competing for the same, directly connected, customers. This second situation arises with facilities based competition in local telecommunications. It has also already arisen in many countries in the market for mobile telecommunications, and the two-way access models presented below can be used to examine the issue of interconnection between mobile operators as well. The case of fixed-mobile interconnection is an interesting one: many authors have viewed this situation as belonging to the first category, as fixed and mobile telephony have been viewed as complements rather than substitutes. However, it seems that in many situations fixed and mobile operators can indeed be competing for market share, in which case the second paradigm would apply. It should be noted, however, that the models introduced in this study cannot be applied to fixed-mobile interconnection without paying due attention to the special features of that case.

As the focus of this study is competition in local telecommunications, we will concentrate on the second type of situation mentioned above, where networks compete for market share. However, the case of interconnection between monopoly networks is also relevant: it will be used below in Section 5.2 as a benchmark case to demonstrate how the problem of inefficiently high access charges arises, when no cooperation between firms is allowed. The second problem, the possibility of collusion in the retail market, can on the other hand only arise in the case where firms compete for market share. This issue will be discussed in Section 5.3.

Compared to research on one-way access pricing, the literature on two-way access has developed only very recently. The case of networks that do not compete for customers has been examined mainly in the context of international telephony, which has been discussed for example by Hakim and Lu (1993), Carter and Wright (1994), Cave and Donnelly (1996), Laffont, Rey and Tirole (1998a), Laffont and Tirole (2000) and Armstrong (2001). Research on the case of interconnection with competition for customers has developed during the last five years: it has been analysed for example by Armstrong (1998), Laffont, Rey and Tirole (1998a,b), Carter and Wright (1999), Laffont and Tirole (2000) and Armstrong (2001).

5.2 Non-cooperative setting of access charges

The problem with non-cooperative setting of access charges is an instance of the basic externality that occurs in vertically related market segments when these segments are imperfectly competitive.[32] Let us first examine the case of monopoly networks, where the problem occurs in its most severe form. The following model is a slightly modified version of the model in Armstrong (2001, 47-50) and Laffont and Tirole (2000,185-6)[33].

Consider two networks A and B that operate in two different countries. Let the marginal cost of call origination be c_o and the marginal cost of call termination c_t in both countries. Further, let the access (termination) charge of network *i* be a_i, $i = A, B$. We assume that the fixed costs of international calls are negligible, so that the total cost of a call is $c = c_o + c_t$ and the perceived marginal cost of an international call for firm *i* is $c_o + a_j$, where a_j is the access charge set by the other firm. The price of a call from

[32] For a general treatment of the nature of the basic vertical externality, see Tirole (1988, 174-176).
[33] Armstrong considers two countries that maximise social welfare non-cooperatively, whereas here we examine the behaviour of profit-maximising firms. Laffont and Tirole use a specific demand curve and a slightly different cost function than the one used here (see footnote 38). These differences do not affect the results.

network *i* to network *j* is p_i and the demand for calls from *i* to *j* is $q(p_i)$[34]. The profits of network *i* from the international market are therefore given by

$$\pi_i = (p_i - c_o - a_j)q(p_i) + (a_i - c_t)q(p_j). \tag{5.1}$$

The first part of Equation (5.1) are profits from call origination and the second part are profits from call termination.

The firms play a two-stage game where they first choose access charges and then retail prices. We start solving the model from the second stage, where firm *i* chooses p_i to maximise (5.1), taking a_i , a_j and p_j as given[35]. This maximisation problem gives the familiar inverse elasticity rule for $p_i^*(a_j)$:

$$\frac{p_i^*(a_j) - c_o - a_j}{p_i^*(a_j)} = \frac{1}{\eta}, \tag{5.2}$$

where $\eta = \left|\frac{dq}{dp_i}\frac{p_i}{q}\right|$ is (the absolute value of) the elasticity of demand for international calls.

It is clear from (5.2), that when firm *j* chooses its access charge in the first stage, it in effect also determines firm *i*'s retail price. Firm *j* chooses its access charge to maximise profits from call termination, that is, to maximise

$$(a_j - c_t)q(p_i^*(a_j)) = (a_j - c_t)q\left(\frac{c_o + a_j}{1 - 1/\eta}\right). \tag{5.3}$$

Therefore the firm will choose an access charge equal to

$$a_j = \frac{\eta c_t + c_o}{\eta - 1} \tag{5.4}$$

and the equilibrium retail price for international calls is

$$p^* = p_A = p_B = \frac{c}{(1 - 1/\eta)^2}. \tag{5.5}$$

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[34] As our only purpose here is to demonstrate how the problem of double marginalisation occurs, we will only consider the simplest case where firms have identical costs, and demands for international calls are identical in the two countries.

[35] We assume that there are no cross-price effects between the demand for international calls in different countries.

Due to our assumption of identical costs and demands, this price will be the same in both countries.

It can be seen from (5.5) that the price distortion created by a chain of complementary monopolies is even greater than the distortion caused by a single monopoly. This additional distortion is caused by the so called double marginalisation problem: firstly, network *j* uses its market power and sets $a_j > c_t$. Secondly, network *i* sets its retail price according to Equation (5.2), that is, network *i* adds its own monopoly mark-up to its perceived marginal cost $c_o + a_j$ which is greater than the true marginal cost of a call (c). These successive mark-ups exacerbate the familiar problem associated with market power. If the firms were to act as a joint monopolist[36], they would charge the joint profit maximising retail price $p^m < p*$ associated with the true marginal cost c, that is,

$$p^m = \frac{c}{1 - 1/\eta}. \tag{5.6}$$

As is explained by Laffont and Tirole (2000, 186), the problem is further aggravated if there are a large number of networks. In the case of *n* networks that act non-cooperatively, the final retail price of a call that passes through all of these networks will be

$$p^* = \frac{c}{(1 - 1/\eta)^n}. \tag{5.7}$$

Equation (5.7) shows that in the hypothetical case where $n \to \infty$ the market price grows infinitely large and the market ceases to exist.

The above model deals with monopoly networks, whereas our main interest is in networks that compete for market share. The double marginalisation problem occurs in its most severe form when the market segments are monopolies and complements, as in the model described above. However, the source of the problem is the market power of individual firms. Therefore one would expect the problem to persist as long as the firms have at least some market power, that is, some discretion over their pricing decisions. In the following Section we model a differentiated duopoly, where horizontal product differentiation gives the firms some market power even though they act as price setters: that is, in contrast to the benchmark Bertrand model of homogeneous firms, the equilibrium of the model involves pricing over marginal cost. Indeed, using such a setting, Laffont, Rey and Tirole (1998a, 14-15) show that the double marginalisation problem does not disappear when there is a degree of substitutability between the networks. The problem persists at least for low substitutability even though the distortion is then alleviated to some extent, and high degrees of substitutability may lead to non-existence of equilibrium in their model.

[36] For ways in which this can be achieved, see Tirole 1988, 176-177.

As non-cooperative setting of access charges leads to severe inefficiencies, the question of whether cooperation between the networks will bring about an efficient outcome should be considered. This issue will be discussed in the next Section.

5.3 Cooperative setting of access charges

5.3.1 The basic model

Cooperative setting of access charges in the case of competing networks has received plenty of attention in the literature. It is in this case that the concern about the possibility of collusion in the retail market is relevant[37]. Let us first look at the benchmark model developed by Armstrong (1998) and Laffont, Rey and Tirole (1998a) to see how the concern that negotiations over access prices may result in collusion in the retail market arises. The basic model involves two firms A and B selling telecommunications services and both firms have their own networks with full coverage. The following simplifying assumptions are made in the basic version of the model:

- **A1.** The networks charge linear prices.
- **A2.** All customers have the same demand for and receive the same number of calls.
- **A3.** There is no network based price discrimination: the price charged for calls that terminate on the subscriber's own network is the same as the price for calls that terminate on the competing network.
- **A4.** There is full subscriber participation, so that all potential subscribers are served by either one of the firms.
- **A5.** The firms have identical cost structures.

Note that assumption A2 implies that the proportion of the calls made by the subscribers of network i ($i = A, B$), that terminate on the other network *j*, is given by the market share of network *j*. Assumption A2 also implies that for equal marginal prices, flows of traffic in and out of a network are always balanced, even if market shares are not (Laffont, Rey and Tirole 1998a, 3). Further, assumptions A3 and A4 together imply that in the basic model there are no network effects present that would affect customers' choices of which network to use: all potential subscribers are connected to either one of the networks and the price of a call is assumed to be independent of the terminating network. Each consumer makes the choice of which network to subscribe to on the basis of individual preferences and the firm's retail prices only.

[37] In the case of regional monopolies the problem of collusion cannot possibly arise, as the firms operate in separate markets. Cooperation is then unambiguously desirable. The double marginalisation problem occurs also in other network industries. Brueckner (2000) has demonstrated the benefits of cooperation in the case of the airline industry. In his study fees were shown to decline significantly (by 13-21 per cent) when carriers operating in complementary routes were allowed to negotiate over fees.

We also assume throughout the discussion that access charges are set reciprocally so that the access charge is the same for both firms. In this simple model the firms are assumed to be symmetrical and the assumption of reciprocal access pricing therefore seems natural. This symmetrical model better describes situations where competition is already mature (Armstrong 2001, 62). In cases in which one of the firms has just entered the market the analysis will be more complicated as the entrant is likely to have only partial coverage and perhaps also higher costs than the incumbent.

(i) Costs

In the basic model the cost structures of the firms are identical: both have a fixed cost k for connecting a customer, a cost c_o for originating a call and a cost c_t for terminating a call[38]. The total marginal cost to a firm of a call that both originates and terminates on its own network is thus $c_o + c_t$. However, the perceived marginal cost of a call that terminates on the rival network depends on the reciprocal access charge and is $c_o + a$. Let n_1 and n_2 denote the market shares of the two firms. According to assumption A2 above, a fraction n_j of calls that originate on network i terminate on network j. Therefore, network i's average marginal cost of a call made by its own customers is given by

$$c_o + c_t + n_j(a - c_t)\,. \tag{5.8}$$

Equation (5.8) shows that with the reciprocal setting of access charges the marginal cost of a call is endogenous, that is, it is contingent on the firm's own choice of the access charge. This endogeneity of marginal costs is a crucial feature of the model.

(ii) Demand

In the model of Armstrong (1998) and Laffont, Rey and Tirole (1998a), the structure of demand and the determination of market shares has been modelled with a Hotelling model of consumer choice, that is, with a model of horizontal differentiation[39]: the firms' services are differentiated, but not in a way that would make the products of one firm unambiguously superior to those of the other (vertical differentiation). Rather, some consumers prefer to buy from one firm and some consumers from the other due to differences in tastes, convenience and so on. As was noted in Section 3.1, introducing variety is one reason why competition may be desirable even in the presence of natural monopoly cost conditions. Some problems with this approach towards modelling differentiation in the telecommunications industry will be pointed out at the end of this Section.

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[38] We use the same cost structure as in Section 5.2. This is the cost structure used in Armstrong (1998), whereas in Laffont and Tirole (1998a) it is assumed that $c_o = c_t$. This is a minor difference and does not affect the results.

[39] The model is originally due to Hotelling (1929). See Tirole (1988, 97-99, 279-282) for a simple general version of the model.

Horizontal differentiation is modelled by assuming that the two firms are "located" at each end of a unit interval. A consumer's type, or preference for the provider of telephone services, is denoted by $x \in [0,1]$ and it is assumed that consumers are distributed uniformly on this interval. A consumer of type x is assumed to incur an additional cost τx if he uses network A (located at $x_A = 0$) and $\tau(1-x)$ if he uses network B (located at $x_B = 1$). The parameter τ denotes the cost of not being able to choose a product that exactly corresponds to one's preferences[40], and is also a measure of the degree of differentiation between the two networks: the lower the value of the parameter τ, the more substitutable are the two services. Let u_0 denote the fixed gross surplus gained by a customer from being connected to a network and $u(q)$ the variable gross surplus from making q units of calls. A consumer located at x and selecting firm i $(i = A, B)$ therefore obtains a total gross surplus given by

$$u_0 + u(q) - \tau|x - x_i|. \tag{5.9}$$

Let $v(p_i)$ denote the maximum variable net surplus achieved by a consumer from using network i, that is,

$$v(p_i) = \max_q [u(q) - p_i q]. \tag{5.10}$$

Net consumer surplus again has the property that $v'(p_i) = -q(p_i)$. We assume that the price difference between the two firms is such that the market share of each firm is positive, and that prices are not too high so that the entire market is covered[41]. Then the market share of firm i can be solved by finding the location of the customer that is indifferent between the two networks, and is given by

$$n_i = 1 - n_j = \frac{1}{2} + \frac{1}{2\tau}[v(p_i) - v(p_j)]. \tag{5.11}$$

Given assumption A2 and the market shares in (5.11), the net number of calls from network i to network j is given by

$$d_i = n_i n_j [q(p_j) - q(p_i)]. \tag{5.12}$$

(iii) Retail price competition

Let us now examine profit maximising behaviour of the two firms, assuming that the firms behave as price setters. We assume that the firms first agree on a reciprocal access

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[40] This cost arises because firms are "located" at each end of the interval, whereas consumers are distributed uniformly over the interval.

[41] See Tirole (1988, 98) for more details of the derivation of market shares in the Hotelling model.

charge, and then choose retail prices to maximise profit. Given the average marginal cost of network *i* in (5.8), network *i*'s profit is given by

$$\Pi_i = n_i\{[p_i - c_o - c_t - n_j(a - c_t)]q(p_i) - k\} + n_i n_j (a - c_t)q(p_j), \qquad (5.13)$$

where the expression within the curly brackets is the profit from calls made by the network's own subscribers and the remaining part of the Equation, $n_i n_j (a - c_t)q(p_j)$, is the profit from selling access to network *j*. Using (5.12), Equation (5.13) can be rearranged to give

$$\Pi_i = n_i \pi(p_i) + d_i(a - c_t), \qquad (5.14)$$

where $\pi(p_i) = q(p_i)(p_i - c_o - c_t) - k$ is the firm's profit from on-net calls and $d_i(a - c_t)$ is the (net) profit from access.

As usual, we will first consider the second stage of the game, where each firm chooses its retail price to maximise (5.14), given the reciprocal access charge. The first order condition for a symmetric equilibrium where $p^* = p_A = p_B$ is

$$\frac{\partial \Pi_i}{\partial p_i} = -\frac{q(p^*)}{2\tau}\pi(p^*) + \frac{1}{2}\pi'(p^*) - \frac{1}{4}q'(p^*)(a - c_t) = 0. \qquad (5.15)$$

Now, using (5.15) and the implicit function theorem we can derive $\partial p^*/\partial a$ and verify that the equilibrium retail price is an increasing function of the access charge[42]:

$$\frac{\partial p^*}{\partial a} = \frac{q'(p^*)}{4\partial^2 \Pi/\partial p^{*2}} > 0. \qquad (5.16)$$

Therefore, by setting a high reciprocal access charge in the first stage of the game the networks can in effect agree on a high retail price[43]. The mechanism behind this result is the following: by choosing a high access charge, the firms can raise each other's marginal costs. Higher costs then imply a higher equilibrium price in the retail market[44]. This is what Laffont and Tirole (2000, 190, 195) call the *raise-each-other's-cost effect* and it is made possible by the endogeneity of marginal costs, noted above.

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[42] The numerator of (5.16) is negative under the standard assumption that the demand for phone calls decreases with price. The second order condition for a maximum implies that also the denominator in (5.16) is negative, and therefore the entire expression is positive. See Laffont, Rey and Tirole (1998a, 9, 32) for another formulation of (5.16).

[43] It is interesting to note, however, that in fact, $\partial p^*/\partial a > 0$ is in general not a necessary condition for the access charge to be an instrument of collusion. It is sufficient to show that the optimal price is uniquely determined by the access charge (see for example Section II of Carter and Wright (1999)). This idea has played an important role in the further development of the theories on two-way access pricing – see the discussion on the effects of network based price discrimination below.

[44] Note that because the inflow and outflow of calls is balanced in equilibrium, access charges do not have any direct effect on profits; the incentive to raise access charges in order to achieve a higher retail price is therefore the crucial issue here.

Now, consider what exactly happens in the first stage of the game. From (5.14), joint profits in a symmetric equilibrium are given simply by $\pi(p)$ and joint profit maximisation therefore requires that $\pi'(p)=0$. Therefore, using Equation (5.15) we see that the collusive access charge $a*$ is given by

$$a* = c_t + \frac{2}{\tau}\frac{p*}{\eta}\pi(p*) > c_t . \tag{5.17}$$

The collusive access charge is indeed above marginal cost, and will be higher if (i) substitutability between the networks is high (τ is low); (ii) elasticity of demand for phone calls (η) is low; or when (iii) the maximum profit per subscriber ($\pi(p*)$) is high (Armstrong 2001, 55.)

The conclusion that the access charge can be used as an instrument of collusion holds if the above joint-profit maximising equilibrium exists. Equilibrium in this model fails to exist if (i) the networks are highly substitutable and/or (ii) the margin between the access charge and the cost of call termination is high. Intuitively, if the networks are close substitutes, one network can capture the entire market by lowering its price slightly from $p*$. Further, the incentive to undercut is stronger if access charges and therefore final prices are high. In such circumstances then, the collusive outcome is not an equilibrium[45]. (Laffont, Rey and Tirole 1998a, 10-11.)

An interesting implication of the result that firms can inflate their perceived marginal costs and therefore retail prices by setting a high reciprocal access charge is the following: when the firms are identical and have identical market shares, two networks regulated to set their retail price at marginal cost will choose access charges that support monopoly prices and therefore the firms can achieve monopoly profits despite regulation in the retail market. (Carter and Wright, 1999, 8.) Therefore, in this situation the regulator would achieve nothing if it used the retail price as the only instrument of regulation. However, because the equilibrium retail price is unambiguously determined by the access charge, the access charge is a much more powerful tool for the regulator: the regulator can in fact implement the socially optimal retail price, the Ramsey price, through regulation of the access charge only[46].

The considerations involved in the determination of the optimal access charge in this situation are in part analogous to those explored in Section 4.5 in the context of one-way access pricing with a deregulated retail market. Because retail prices are assumed to be unregulated in the two-way access model, optimal access charges should involve a subsidy to offset the retail price distortion caused by market power: this calls for access charges below marginal cost. On the other hand, if there are fixed and sunk costs of

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[45] To show that *no* equilibrium exists one still needs to show that the cornered market solution is not an equilibrium either – see Laffont, Rey and Tirole (1998a, 10).

[46] For some implications of and problems with applying the original form of the ECPR in the context of two-way access, see Laffont, Rey and Tirole (1998a, 22-28).

network provision[47], this calls for a Ramsey mark-up over marginal cost also in the access charge. Which one of these effects dominates is ambiguous, and therefore the socially optimal access charge in the two-way interconnection case can be either above or below the marginal cost of call termination. (Laffont and Tirole, 2000, 194-196.) The optimal access charge is likely to be above marginal cost if the networks are close substitutes and/or the fixed costs of network provision are high, but the potential problem of non-existence of equilibrium should be kept in mind.

5.3.2 Extensions to the basic model

As the above benchmark model with the assumptions A1-A5 is very restrictive, it is important to examine the effect of relaxing some of these assumptions in order to determine whether access charges can facilitate collusion in more realistic settings. Firstly, we will consider the effect of the simple change of allowing firms to charge two-part tariffs. Secondly, we will take into account consumer heterogeneity regarding their demand for phone calls, and the ability of firms to price discriminate between different classes of customers. Thirdly, we will consider a situation in which firms are allowed to practice another form of price discrimination, namely discrimination according to the destination network of a call.

These same cases have been considered for example by Armstrong (2001) and the aim here is to provide a recapitulation of the different cases. Considering these cases will allow us to achieve a reasonably realistic view of how symmetric firms will behave in the two-way interconnection case. Non-linear prices are widely used in the telecommunications industry, and even though rather rare in the fixed sector, network based price discrimination is in practice widely used in mobile telecommunications. Assumption A4, that is, full participation in the market, is currently not very restrictive in the fixed sector and is becoming less so also in the mobile sector. However, if the increased substitutability between fixed and mobile networks is taken into account, the assumption of full participation is likely to become problematic especially in the future[48]. Considering the case of limited participation in detail is beyond the scope of this paper. However, as it has some interesting similarities with the case of network based price discrimination, we will make some comments on it in the course of the discussion. Further, we will not extend the analysis to the very important case where firms are asymmetric with respect to costs and/or network size[49].

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[47] Laffont, Rey and Tirole (1998a) call these costs *joint and common costs* as opposed to the fixed costs of connecting a customer; the latter type of costs are consistent with constant returns to scale at the network level.

[48] For example in the Finnish case, fixed line penetration which was 98% in 1998 is indeed now decreasing (see the web site of Statistics Finland at www.stat.fi and Ministry of Transport and Communications 2001, 49, 51).

[49] The situation of extreme asymmetry where the other firm has no network was dealt with in Chapter 4. See Laffont, Rey and Tirole (1998a, Section 7), Laffont, Rey and Tirole (1998b, Section 6), Armstrong (2001, Section 4.2.3) and Carter and Wright (1999, Section V.2) for some discussion of situations where firms are asymmetric.

(i) Relaxing assumption A1

Consider the situation in which each firm sets a two-part tariff in the retail market, that is, the firms now engage in second degree price discrimination. The model used in this subsection was introduced by Laffont, Rey and Tirole (1998a) and has also been discussed for example by Armstrong (2001).

When firm i sets a two-part tariff $T_i = p_i q_i + f_i$ (where f_i is a fixed fee), the profit function in (5.14) is modified to

$$\Pi_i = n_i[\pi(p_i) + f_i] + d_i(a - c_t), \qquad (5.18)$$

Determination of market shares involves a simple modification of the benchmark Hotelling model. With the above tariff structure, the variable net surplus achieved by a customer of network i (see Equation (5.10)) is now given by

$$w_i = v(p_i) - f_i \qquad (5.19)$$

and the market share of network i is

$$n_i = \frac{1}{2} + \frac{1}{2\tau}(w_i - w_j). \qquad (5.20)$$

We use the proof in Armstrong (2001, 56) to show that equilibrium profits are now independent of the access charge[50]. Consider a symmetric equilibrium where $T_A = T_B = T$ and therefore $n_A = n_B = \frac{1}{2}$. If one of the firms were to deviate from this equilibrium by lowering the fixed component of its tariff by an amount ε, the market share of the deviating firm would increase by $\frac{\varepsilon}{2\tau}$ (from (5.20)). Because call charges p remain unchanged, the net outflow of calls d_i in Equation (5.12) remains zero despite the change in market shares. The deviating firm's total profit from (5.18) is therefore given by

$$\left(\frac{1}{2} + \frac{\varepsilon}{2\tau}\right)(\pi(p) + f - \varepsilon). \qquad (5.21)$$

For the original fixed charge to be an equilibrium, that is, for $\varepsilon = 0$ to maximise (5.21), we obtain the condition $\pi(p) + f = \tau$. The left hand side of this condition is the total industry profit, and therefore equilibrium profits per firm are equal to $\frac{\tau}{2}$. This is the profit per firm in the standard Hotelling model[51] and it is clearly independent of the

[50] We use slightly different notation than Armstrong at this point so that the similarity between this proof and the one in the next subsection becomes immediately obvious.
[51] See Tirole 1988, 279-280.

access charge: profits are determined entirely by the degree of differentiation between the firms.

It is remarkable that even this small change in the assumptions of the model is sufficient to remove the collusive impact of access charges. The intuition for this result can be seen through a comparison with the case in which firms use linear prices. In the benchmark model, high prices can be maintained due to the fact that lowering the retail price unilaterally would upset the balance between the inflow and outflow of calls and would therefore cause higher access payments for the deviating firm. This mechanism reduces the incentive to lower prices in the retail market. However, we showed above that in the case of two-part tariffs, a network can increase its market share through a low fixed fee, without changing its net demand for access which is always zero if firms have equal marginal prices (see Equation (5.12)). Therefore even though high access charges still do feed through to high marginal prices[52], profits are partly competed away in trying to build market share through a lower fixed fee. (Laffont and Tirole 2000, 198-201.)

In the following analysis we continue to assume that firms are not constrained to use linear pricing. By doing this we ensure that our results from relaxing the other assumptions are not affected by the restrictive nature of the assumption of linear pricing.

(ii) Relaxing assumptions A1 and A2

Let us consider how the analysis changes if the assumption of customer homogeneity with respect to call demand does not hold and the firms can use non-linear tariffs (in this case also third degree price discrimination becomes relevant, as customers are now assumed to be heterogeneous). Armstrong (2001) examines this case based on the work of Dessein (2001) and Hahn (2000). The following exposition follows Dessein (2001). Dessein assumes that there are two types of consumers of telephone services: a fraction α of consumers are light users (denoted by subscript L) and a fraction $1-\alpha$ are heavy users (H). The total gross surplus of a consumer of type s $(s = L,H)$ located at x, and selecting a firm located at x_i ($i = A,B$) is now modified from (5.9) to take into account consumer type and is given by

$$u_0 + \gamma_s^{\frac{1}{\eta}} u(q_s) - \tau\left|x - x_i\right|, \qquad (5.22)$$

where $\gamma_L < \gamma_H$. The parameter γ_s then captures the difference in the intensity of demand between the two types of consumers. Further, Dessein drops the assumption that all customers receive the same number of calls (the second part of Assumption A2) and adopts the more general calling pattern characterised by the pair (l_H, l_L), where l_s is the fraction of calls that customers of type s make to light users.

[52] We have not considered the determination of prices in detail, as we are mainly interested in how access charges affect profits. See Laffont, Rey and Tirole (1998a, 21) for details on prices.

Both firms offer a pair of contracts that specify a quantity of calls q_S in return for a total charge t_S so that the contract offered to light users will be (q_L, t_L) and the contract for heavy users is (q_H, t_H).[53] The variable net surplus for a user of type *s* is then given by

$$w_S = \gamma_S^{\frac{1}{\eta}} u(q_S) - t_S. \tag{5.23}$$

Let n_S denote the market share of network A in the market segment of type *s* subscribers. This market share is given by

$$n_S = \frac{1}{2} + \frac{1}{2\tau}\left(w_S - w_S'\right), \tag{5.24}$$

where w_S' is the surplus offered to type *s* customers by the other network.

As noted by Dessein (2001, 11) the following analysis and therefore the results of this subsection apply regardless of whether the firms can discriminate explicitly between heavy and light users, or whether only implicit discrimination is possible. However, in the latter case where the firms cannot identify customer type, they will need to ensure that each customer chooses the contract that corresponds to his type. The contracts will therefore have to satisfy the following incentive-compatibility constraints:

$$\begin{aligned} w_H &= \gamma_H^{\frac{1}{\eta}} u(q_H) - t_H \geq \gamma_H^{\frac{1}{\eta}} u(q_L) - t_L \\ w_L &= \gamma_L^{\frac{1}{\eta}} u(q_L) - t_L \geq \gamma_L^{\frac{1}{\eta}} u(q_H) - t_H. \end{aligned} \tag{5.25}$$

Dessein (2001, 11-12) shows that in a symmetric equilibrium where both firms offer the same pair of quantities and the market share of network A is the same in both segments $(n_H = n_L)$, traffic is balanced between the networks, that is, the net demand for access is again zero. Using this result, it can be shown that in any symmetric equilibrium, profits are independent of the access charge. The proof used here is identical to the proof in the previous subsection, except that we now have to ensure also that the incentive constraints in (5.25) are not violated. Let $\{q_L, t_L, q_H, t_H\}$ be the symmetric equilibrium, with profits per type *s* subscriber denoted by π_S. Average profits per subscriber are then given by $\pi = \alpha\pi_L + (1-\alpha)\pi_H$. Consider what happens if one firm reduces both its tariffs t_L and t_H by the same amount ε. The incentive constraints in (5.25) are not affected by this change and from Equation (5.24), the market shares of the deviating

[53] We know from the revelation principle that assuming this type of tariff structure involves no loss of generality – see for example Gravelle and Rees (1992, 694-700).

firm increase by the same amount $\frac{\varepsilon}{2\tau}$ for both types of subscriber. As the condition $n_H = n_L$ still holds, the firm still incurs no access deficit and its total profits are

$$\left(\frac{1}{2}+\frac{\varepsilon}{2\tau}\right)(\pi-\varepsilon). \tag{5.26}$$

For the original contract to be an equilibrium, that is, for $\varepsilon = 0$ to maximise (5.26), we obtain the condition $\pi = \tau$ and profits per firm are therefore again equal to $\frac{\tau}{2}$. (Dessein 2001, 12.) Therefore, the result that access charges have no effect on profits holds also when customer heterogeneity is taken into account.

Hahn (2000) has obtained similar results to those in Dessein's model, albeit in a more general framework. Hahn assumes a continuum of types of consumers with respect to their demand for calls. Further, also Hahn allows consumers to differ in how many calls they receive, but in his model this is not necessarily correlated with a consumer's type with respect to demand (in Dessein's model, these two dimensions of consumer heterogeneity are perfectly correlated). Hahn shows that also in this more general setting, profits are independent of the access charge.

As profits are independent of the access charge, the present case has the interesting feature that firms will have no objection to a requirement to set the access charge at the level that maximises social welfare. Dessein (2001) shows that if the firms are required to set $a = c_t$, they find it optimal to set a *single* cost-based two-part tariff in the retail market despite customer heterogeneity. Therefore the socially optimal access charge in this setting is equal to the marginal cost of call termination. However, the following qualification to the above result should be noted: Armstrong and Vickers (2001, 599-600) show that a single cost-based two-part tariff is an equilibrium only if all consumers choose to participate in the market with this equilibrium tariff. It therefore seems that the conclusion that $a = c_t$ maximises social welfare holds only *if* all customers are willing to pay a fixed fee that is large enough to cover the network's fixed costs[54].

Further, the profit neutrality result in this model is not robust to certain changes in the assumptions. In particular, it can be seen from the proof of the profit neutrality result above that the result requires (i) cost and demand symmetry across networks, (ii) distribution of consumer types *(H,L)* to be independent of their location and (iii) the substitutability parameter τ to be independent of the variable consumption or consumer type. (Dessein 2001, 13.) The assumption of symmetric networks is in our view the most restrictive of the three. This assumption has been made throughout the discussion

[54] In other cases, the elasticity of demand for subscriptions should be taken into account and a Ramsey access charge would be optimal. To put this another way, $a = c_t$ is Ramsey optimal if the demand for subscriptions is completely inelastic, in which case the entire burden of covering fixed costs should be placed on the fixed part of the two-part tariff. See footnote 27 and the comments at the end of the next subsection on the case of limited participation.

and therefore it is worth stressing again that the models discussed here are best applicable to a mature industry where network symmetry is not an unreasonable assumption.

(iii) Relaxing assumptions A1 and A3

In this subsection we again assume that firms can use non-linear pricing. Further, we assume that they can charge different prices according to the destination network of a call, that is, they are allowed to use network based price discrimination. In this subsection customers are again assumed to be homogeneous, so that the non-linearity of prices implies the use of simple two-part tariffs. The discussion here follows Armstrong (2001).

Let us assume that firms charge two-part tariffs $T_i = p_i q_i + \hat{p}_i \hat{q}_i + f_i$, where p_i is the marginal price for on-net calls and $\hat{p}_i$ the marginal price for off-net calls of network *i* ($i = A, B$). The variable net surplus achieved by a customer of network *i* is now given by

$$w_i = n_i v(p_i) + (1 - n_i) v(\hat{p}_i) - f_i \quad (5.27)$$

and the market share of network *i* is as in (5.20). The analysis is simplified by the observation that each network will set marginal prices equal to marginal costs, as is usually the case with two-part tariffs. Therefore we know that firms will set $p_A = p_B = p = c_o + c_t$ and $\hat{p}_A = \hat{p}_B = \hat{p} = c_o + a$. These prices are the same for both firms, as we continue to assume that firms have identical costs and charge reciprocal access prices. The market share of network *i* as a function of the fixed charges now becomes

$$n_i = \frac{1}{2} + \frac{(f_j - f_i)}{2\tau - 2[v(c_o + c_t) - v(c_o + a)]} \quad (5.28)$$

and its profit is

$$\Pi_i = n_i (f_i - k) + n_i n_j (a - c_t) q(c_o + a). \quad (5.29)$$

Using a similar argument as in the previous subsections, we find that the profit of a firm that deviates from the symmetric equilibrium fixed charge $f^* = f_A = f_B$ by an amount ε is given by

$$\left(\frac{1}{2} + \frac{\varepsilon}{2\tau - 2[v(c_o + c_t) - v(c_o + a)]} \right) (f^* - k - \varepsilon) \quad (5.30)$$

and therefore the equilibrium fixed charge is

$$f^* = \tau + k + v(c_o + a) - v(c_o + c_t). \qquad (5.31)$$

The total industry profits with this fixed charge are then given by

$$\Pi = \tau + v(c_o + a) - v(c_o + c_t) + \frac{1}{2}(a - c_t)q(c_o + a). \qquad (5.32)$$

This result is in contrast to the one in previous subsections: this profit function now depends on the access charge. If firms were to set $a = c_t$, total profits would be equal to τ as above: $a = c_t$ implies $p = \hat{p}$ and profits would therefore be the same as in the case where network based price discrimination is not allowed. However, the firms can do better than this. The access charge that maximises (5.32) is

$$a^* = c_t - \frac{p^*}{\eta} < c_t. \qquad (5.33)$$

Therefore profits are at maximum when the access charge is below the marginal cost of call termination. Intuitively, when call termination is subsidised, off-net calls are cheaper than on-net calls, and customers prefer to belong to the smaller network. The market then exhibits negative network externalities and networks have less incentive to compete for market share by lowering f. Therefore, networks can soften competition by agreeing on an access charge below the marginal cost of call termination. (Armstrong 2001, 60-61.) Network based price discrimination therefore restores the collusive impact of access charges, albeit high profits are now associated with low, rather than high, access charges[55].

The previous result has interesting implications for regulation. As social welfare would in this setting be maximised if $a = c_t$, there is scope for regulator intervention[56]. One alternative would be to regulate the access charge. However, as it is the presence of network based price discrimination that restores the firms' ability to collude, another solution would be to prohibit network based price discrimination altogether. (Armstrong 2001, 61.) This solution is not stressed by Armstrong, but in our view it seems to be a straightforward way to solve the problem. Further, as different forces can cause the collusive access charge to be either above or below cost, the regulatory task of designing optimal intervention is difficult. Gans and King (2001) suggest that in the presence of network based price discrimination even a "bill and keep" agreement between the networks, that is no access charge, might be collusive. It therefore seems that prohibiting network based price discrimination would be a rather simple welfare enhancing mechanism in an otherwise complicated setting[57].

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[55] See footnote 43.

[56] However, the result that $a = c_t$ is optimal again depends on the assumption that the demand for telephone connections is completely inelastic.

[57] However, Laffont, Rey and Tirole (1998a, 44-51) show that under *linear* pricing, network based price discrimination can sometimes increase welfare (for a given access charge).

The above discussion entails a prediction that with network based price discrimination, off-net calls will be *cheaper* than on-net calls. However, this is not what we observe in practice. For example in the Finnish mobile telecommunications market where network based price discrimination is widely used, off-net calls are invariably more expensive than on-net calls. A part of this result might be explained by the assumption of symmetry. Laffont, Rey and Tirole (1998b, 53-55) show that when the firms are asymmetric in the sense that one of the firms has only partial coverage, the larger network will have an incentive to charge a high $\hat{p}$ in order to disadvantage the smaller firm. This then forces also the rival to set a high $\hat{p}$ in order not to incur a large access deficit. This example shows the restrictive nature of the assumption of symmetry. However, it does not change the conclusion of the discussion. Rather, the observation that a dominant firm can use network based price discrimination to disadvantage its smaller rivals further strengthens the conclusion that network based price discrimination should not be allowed.

The above model with network based price discrimination exhibits what Laffont, Rey and Tirole call tariff-mediated network externalities: in principle, network externalities are eliminated by network interconnection, but some externalities reappear whenever on-net and off-net calls are priced differently (Laffont, Rey and Tirole 1998a, 39-40). It is interesting to compare this case with another situation in which network externalities are present despite network interconnection. This happens when the model has limited participation, so that a part of potential customers do not subscribe to any network and the existing users of the network would benefit if they did. This case has been examined by Dessein (2001). Dessein uses a model with limited participation, non-linear pricing and homogeneous customers (with respect to call volume demand) and finds that also in this case networks can achieve the collusive outcome by agreeing on an access charge below the marginal cost of call termination[58]. Further, Dessein argues that the welfare maximising access charge in the case of limited participation exceeds the marginal cost of call termination. Therefore two interesting conclusions emerge from Dessein's analysis. Firstly, we can make the more general conclusion that when network externalities are present, either due to network based price discrimination or due to limited participation in the market, access charges can be used as an instrument of collusion. Secondly, the analysis provides support for the idea that we have brought up a number of times in the course of the discussion: if the demand for subscriptions is elastic, the optimal access charge can be above marginal cost despite the use of two-part tariffs in the retail market.

(iv) Discussion

Finally, let us make a comment on the way differentiation between networks has been modelled here and point to some problems with that approach. In line with previous research, we have assumed Hotelling type horizontal differentiation between the networks. Carter and Wright (1999) acknowledge that since telephone services are

[58] The mechanism in this case is rather different from the case with tariff-mediated network externalities. See Dessein (2001, Section 5) for details.

apparently homogeneous, the assumption of product differentiation requires some justification. Those authors provide two interpretations of this assumption. One interpretation is that the networks are differentiated by the complementary services they provide: for example, if cable TV networks enter the local telephone market, they will provide a very different bundle of services to that of the traditional telephone company. Alternatively, this kind of model of product differentiation could be justified by the presence of switching costs that make customers loyal to a given network. (Carter and Wright 1999, 9.) Switching costs can be significant for example as a result of a lack of number portability and should include for example the cost of evaluating which network is cheaper.

However, in our view both of these interpretations can be problematic. Let us turn to the second interpretation first. Switching costs provide an explanation why customers prefer their network once they have already joined it: after joining, the cost of switching to the other network reduces customers' willingness to change suppliers. Therefore switching costs make networks differentiated *ex post*, that is, after each customer has chosen which network to join. However, switching costs cannot be used to explain the kind of *ex ante* differentiation assumed in the Hotelling model[59].

The other justification of modelling horizontal differentiation between telecommunications networks, built on the differences in complementary services of the networks, can also in some cases be problematic. Whether it provides a justification for a model of horizontal differentiation, depends on the details of any particular case. It clearly does fit the example of facilities based competition between cable TV and traditional telecommunications networks, mentioned above, but for example in the case of interconnection between mobile networks the source of differentiation is more difficult to pin down. The case of fixed-mobile interconnection is also interesting in this respect. It indeed provides one possible example of horizontally differentiated networks, as the complementary services provided over fixed and mobile networks are rather distinct: perhaps the main distinguishing feature of a fixed connection is currently that it can be used for high-speed access to the internet, whereas the main distinctive feature of a mobile connection is its mobility. However, this setting is likely to change with the development of mobile internet services. In that new situation, fixed-mobile competition might be better described by a model of vertical, rather than horizontal differentiation. This discussion reveals a further dimension of the assumption of symmetry that we have made in the discussion: we have assumed that competition between telecommunications networks is competition among equals in the sense that networks are horizontally and not vertically differentiated. This assumption might not be innocuous in reality[60].

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[59] This is especially problematic in the case of symmetric networks discussed here. If one examines entry into a previously monopolised market, switching costs can of course be used to explain customer loyalty to the incumbent, as is done by Carter and Wright (1999) in their paper. In this case switching costs, however, are a source of vertical differentiation as *all* consumers prefer the incumbent to the entrant (other things equal).

[60] Nattermann and Murphy (1998) emphasise another source of differentiation between telephone networks in the Finnish case, namely their cooperative structure of ownership, which has increased customer loyalty to their own telephone company. The significance of this point has recently decreased

Our main results on the effects of cooperative setting of access charges are summarised in Table 5.1. It was shown that in the benchmark model of network competition with linear pricing, negotiated access charges can be used as an instrument of collusion also in the retail market. This conclusion was shown not to be robust to simple changes in the assumptions: it was shown that relaxing the assumption of linear pricing in the retail market removes the collusive impact of access charges, whether or not customer heterogeneity is taken into account. However, as a final point it was shown that the collusive impact of access charges is again restored if the possibility of network based price discrimination is taken into account. It was suggested that if firms use non-linear pricing, the regulatory task could be made easier by prohibiting network based price discrimination. It should be noted that several simplifying assumptions remain in the analysis. In particular, the restrictive nature of the assumption of symmetry between networks was pointed to a number of times in the analysis and should be taken into account when interpreting the results.

Table 5.1. The effect of cooperation in access pricing on retail competition.

A1. Linear prices	A2. Homogenous calling pattern	A3. No network based price discrimination	COLLUSION
X	X	X	YES
	X	X	NO
		X	NO
	X		YES

It can be concluded that network competition is not necessarily sufficient to produce optimal outcomes in the local telecommunications market and therefore there will be a role for regulation also in this case. However, the problem from the point of view of the regulator in the case of mature facilities based competition relates to prohibiting collusion between networks. This is in contrast to the case of services based entry where problems arise due to the network operator's ability to abuse its dominant position in the market for access. If the retail market is assumed to be unregulated regardless of the type of competition, then the considerations involved in determining the level of the optimal access charge have some similarities in the two cases. The level of the optimal access charge in the case of network competition depends on the magnitude of the fixed and sunk costs of network operation and on the intensity of competition between the networks.

(see the next Chapter). Further, customer loyalty to cooperatives lead to vertical rather than horizontal differentiation in the local telecommunications markets: each area had only one local cooperative and outside rivals were therefore in a disadvantaged position.

6 Telecommunications competition and access pricing policy in Finland

6.1 Liberalisation: the Finnish model of competition in telecommunications

The main policy questions regarding liberalised telecommunications markets from the point of view of this study are the following:

(i) Which form of competition is promoted?
(ii) How are interconnection charges determined?

We will examine how these issues have been addressed by the Finnish authorities. The process of telecommunications liberalisation in Finland and the structure of competition that has emerged will be discussed in the current Section, providing an answer to question (i). The main features of Finnish policy towards the determination of interconnection charges will be analysed in Section 6.2, providing an answer to question (ii). The aim is to highlight the broad policy choices made by Finnish authorities, and the details of individual cases regarding for example the settlement of interconnection disputes will not play a central role in the discussion.

The approach taken here, that is, treating Finnish telecommunications policy separately from its European counterpart, might require some explanation as many of the issues discussed here belong to the jurisdiction of the European Union. Our approach is motivated by two factors. Firstly, Finnish authorities have in many cases acted ahead of the European Commission in advancing telecommunications liberalisation, and therefore many developments in the Finnish telecommunications market have taken place independently of developments in European legislation. Secondly, in many cases European legislation does leave some leeway for national authorities on how the policy guidelines are to be implemented. In such cases decisions made on the national level become significant. In some cases, however, Finnish policy does coincide with European policy, and in such cases we refer directly to the appropriate Directives or other official documents of the European Union.

The local and long distance telecommunications market in Finland was fully liberalised on 1 January 1994[61]. Prior to liberalisation, the market for local telecommunications had been divided between the Finnet Association, which was a group of locally based telecommunications companies run as cooperatives, and Telecom Finland Ltd[62]. These companies were regional monopolies: Finnet operated mainly in urban areas of

[61] See HE 163/1996 for an account of partial steps taken toward liberalisation in 1988-93.
[62] Since 30.9.1999 Sonera Corporation.

Southern Finland and had 73 % market share[63] in the country as a whole, and Telecom Finland operated in the less densely populated areas of Northern Finland, with 27 % market share. (Nattermann and Murphy 1998, 760.)

Two different possibilities for the introduction of competition into local telecommunications, services or facilities based competition, were discussed in Chapter 3. In Finland, the authorities initially wished to promote facilities based competition in local telecommunications: the market was liberalised through granting each telecommunications operator a licence to build their own network. This was rather exceptional from a European perspective, as by the mid-1990s Sweden and Britain were the only other countries in Europe that had granted licences for building competing networks in local telecommunications. The emphasis on facilities based competition was further strengthened by the fact that the Telecommunications Act of 1987 did not contain any requirement for the incumbent local network provider to lease access lines to entrants[64]. (HE 180/1995.) Therefore, in order to compete in the local market, the only possibility for an entrant was initially to extend its network all the way to the local loop level.

The justification given for this policy was a concern that, on the one hand, the right to demand access to the incumbent's network would distort an entrant's incentive to build its own facilities and, on the other hand, the requirement to offer excess capacity to competitors would have reduced the network operator's incentives to invest in the network beyond its own immediate needs (HE 180/1995). This justification conveys a lack of confidence in the regulator's ability to control the conditions of access so as to achieve optimal outcomes in the market. However, as we have not explored theories in this paper that deal with dynamic issues such as incentives for investment, we cannot give a detailed assessment of statements concerning such issues. Nevertheless, it is clear that the above argument does not provide a convincing justification for the policy of denying access altogether: it is very unlikely that the correct incentives will be provided by setting the access charge infinitely high, that is, when no access to the incumbent's network is allowed. In this case, in order to be able to compete at all, the entrant is forced to invest in a new network, regardless of whether this is the most efficient alternative. Further, from the point of view of theories examined in this study, it is interesting to note that firstly, the problem with ensuring fair terms of access for services based competitors was not mentioned as a justification for the initial policy of favouring facilities based competition. Secondly, the cost structure of local telecommunications was not mentioned as a potential problem from the point of view of achieving facilities based competition.

However, the policy of promoting facilities based competition proved to be a failure at least initially, as by the end of 1996 practically no competition had emerged in the local sector. Telecom Finland, which attempted entry into the areas formerly served solely by

[63] Market share is here measured by the number of customers.

[64] To be precise, Finnish legislation did contain a requirement to lease excess capacity to those operators that did not have a licence to build a network. However, as all operators in the Finnish market had such a licence, this requirement had limited significance.

Finnet, had only gained a market share of 2.8 % in those areas and another entrant, Telivo[65], had only gained a negligible market share of 0.09 %. (Nattermann and Murphy 1998, 760-761.) By the end of 1999 Telecom Finland's (then called Sonera) market share in these regions had risen slightly but was still only 4.9% (Ministry of Transport and Communications 2000, 62).

These early developments in the Finnish local telecommunications market do indeed seem to support the view that cost conditions in the local loop are such that at least this part of the telecommunications network still remains a natural monopoly[66]: in practice no new entrant decided to enter the market through constructing its own fixed network even though legal barriers to entry had been removed. However, the Finnish authorities have stressed the influence of another barrier to entry that is largely peculiar to the Finnish local telecommunications market: this is associated with the cooperative structure of ownership of the majority of Finnish telephone companies, and the practice used by these companies of giving discounts on fees to their owners, which put entrants in a disadvantaged position (HE 180/1995). Customer loyalty caused by the cooperative structure of ownership is also found by Nattermann and Murphy (1998) to be the main reason for the lack of competition in the Finnish local telecommunications market in the years directly following liberalisation. However, the significance of this feature has much decreased since the mid-1990s: at the beginning of 2002 only 11 out of the 47 operators that offer fixed connections used arrangements that resemble a cooperative structure[67], and a further 5 operators had ceased to give discounts on telecommunications fees to owners (Liikenne- ja viestintäministeriö 2002, 24). However, despite liberalisation and the drastic decrease in the number of cooperatives, the firms that operate in the local loop still, to a large extent, remain local monopolies. This in our view gives support to the natural monopoly argument in the Finnish case.

Due to the initial difficulties in the liberalisation process, Finnish legislation was changed[68] and since August 1996 network owners have been required to lease excess capacity to other operators, regardless of whether the competitor possesses a licence to build its own network. This new legislation created better preconditions for the second form of local competition described in Chapter 3, namely services based competition, to develop in the Finnish local telecommunications market[69]. The explanation for the change in policy was clear: the authorities had concluded that building a new local telecommunications network would be prohibitively expensive for competition to emerge in this way. Further, the environmental costs of constructing multiple networks were also acknowledged. (HE 180/1995.)

When Finnish legislation was changed so as to create the preconditions for services based entry into local telecommunications, the authorities indeed had high hopes

[65] Telivo was bought by the Swedish operator Telia in 1996-1997; the name was changed to Telia in 1997.
[66] In the narrow, cost-based sense of the term; see Section 2.2.
[67] Compared with 42 out of 47 operators in 1994.
[68] Amendment (343/1996) of the Telecommunications Act.
[69] In this Section we classify also unbundling based entry as services based, because both of these forms of entry imply no duplication of network infrastructure (see Section 3.2).

associated with the change in policy. It was expected that the new legislation would bring a large number of new services based operators into the market, and that the new competitors would capture a market share of over 10 % by 2000. It was also expected that competition would bring about a 10-15 % reduction in final prices during the same time period. (HE 163/1996.) Against this background it is interesting to note that despite the change in policy towards encouraging services based entry, strong competition in the market for local calls has still failed to develop in Finland. Contrary to the optimism of the authorities, entrant operators have mainly offered services to business customers only and local call prices have increased by 29% in real terms between 1995 and 2001[70] (Liikenne- ja viestintäministeriö 2002, 16).

The access pricing policies of the network operators with ownership of the local loop indeed seem to be an important reason for why only limited services based competition has emerged so far: for example, the Competition Council ruled in May 2001 that three companies (Elisa Communications Ltd, Turun Puhelin Oy and Salon Seudun Puhelin Oy) had hindered competition in the local loop by charging excessive access prices to competing operators and substantial sanctions were imposed on the three companies.[71] A study carried out by the Ministry of Transport, conducted through interviews of representatives of Finnish telecommunications operators, also identifies high access charges as the main obstacle to competition in the local telecommunications market (Liikenneministeriö 1998b).

Despite the wish to create better preconditions for services based entry, the Finnish authorities have not abandoned hopes that facilities based competition would play an important role in local telecommunications in the future. The authorities have stressed the importance of alternative technologies that can be used instead of the traditional fixed local loop. Indeed, promoting services based competition was originally seen as a way to speed up the emergence of competition while the new technologies were still being developed. (HE 163/1996.) Further, an Amendment to the Telecommunications Market Act (489/2002) was passed on 14.6.2002 with the aim of ensuring that all methods of transmitting communications services are treated equally and that any legal barriers that might distort competition between different transmission methods are removed (HE 241/2001.)

Two alternatives for achieving facilities based competition in local telecommunications were pointed to in Section 2.2, namely the provision of telecommunications services over the cable TV and electricity networks. Firstly, the potential benefits of encouraging the provision of telecommunications services over the cable TV network are clearly

[70] A part of this increase is due to the requirement that operators have to offer access to competitors at the same terms as to their own customers: this has increased the monthly subscription fees that were previously offered at a discount to owner-customers, but have now been increased to reflect costs. Monthly fees have increased by 45 % in real terms from 1995 to 2001. However, local call charges have also increased by 5% rather than decreased, as one would have expected if effective competition had emerged. (Liikenne- ja viestintäministeriö 2002, 25, 31.)

[71] See Ministry of Trade and Industry press release (28.05.2001) "Kilpailuneuvosto määräsi seuraamusmaksut kolmelle puhelinyhtiölle määräävän markkina-aseman värinkäytöstä" at http://www.pressi.com/pressi-html/26800.html (in Finnish; cited May 2002).

demonstrated by the situation in Britain, where cable TV companies have become effective competitors in the local telecommunications market (see for example Cave and Williamson 1996). In Finland, however, only Internet services but no voice telephony are offered via the cable network and by spring 2001, cable internet was available in only nine Finnish towns (Ministry of Transport and Communications 2001, 62-63). Finnish authorities have been active in examining the possibilities for a wider use of cable TV networks: the Ministry of Transport and Communications has carried out investigations on the possibility of using cable TV networks for the supply of telecommunications services in 1996, 1998 and 2002. However, the possibilities for competition from cable TV networks in Finland are severely limited by the fact that most of these networks are owned by local telecommunications network operators[72], who naturally have no incentive for introducing new products to be supplied via the cable network, that would compete with their existing services. Therefore, even though the provision of telecommunications services over cable networks is now technologically feasible and even though the coverage of cable networks is rather high in Finland[73], it is clear that in the present situation, a policy of encouraging facilities based competition from cable TV networks could not possibly be effective.

The second alternative mentioned above will soon be tried in Finland, as the energy company Turku Energia Oy has announced that it will start to provide broadband internet services and at a later date also voice telephony over its electricity network in the Turku area. In the light of the problems associated with using the cable TV network as an alternative to telecommunications networks, this new form of competition should be especially warmly welcomed as it comes from outside the communications sector. This second alternative to the fixed local loop has, however, been developed mainly on a commercial basis and has not been actively promoted by Finnish authorities. Turku Energia's decision was preceded by a period of trial and development of the service among seven Finnish electricity companies and therefore this alternative for obtaining communications services might become more widely available in the future.[74] Further, if economies of scope apply also to the provision of electricity and telecommunications services over one network, this has positive effect on the electricity companies' ability to compete in local telecommunications. Electricity companies, transmitting both electricity and telecommunications services over their network, would then have an advantage over telecommunications network operators that only offer the latter service.

To summarise, it seems that the ultimate goal of Finnish authorities is to achieve facilities based competition in local telecommunications. As was noted above, building

[72] 14 out of the 17 cable TV companies covered by one of the above mentioned studies carried out by the Ministry of Transport and Communications were owned by a local telecommunications operator or a subsidiary of such a company (Liikenneministeriö 1998a), with 70% of the cable networks being owned by Sonera alone (HE 241/2001).

[73] In 2000 the number of cable TV subscriptions in Finland was 950 000, that is, 40 % of households had a cable TV subscription (Ministry of Transport and Communications 2001, 63).

[74] See the press release of Turku Energy (28.5.2002) at http://www.turkuenergia.fi/Ajankohtaista/ (in Finnish only; cited May 2002). It is also interesting to note that Telivo's (now part of Telia) fixed telecommunications network was built on the electricity network of Imatran Voima Oy. However, neither the former Telivo or Telia has become a strong competitor in the Finnish local telecommunications market.

a completely new local fixed network is no more encouraged. This policy seems reasonable in the light of the evidence cited above on the natural monopoly argument in the Finnish case. Nevertheless, even though it has been concluded that building a completely new fixed network would be prohibitively expensive, the prospect of facilities based competition from alternative networks has been welcomed. This illustrates the point made in Section 3.1, that even though the industry might be characterised by natural monopoly cost conditions, network competition might still be desirable: this is the case if the costs from losing economies of scale and scope when alternative networks are used are outweighed by the benefits of increased competition.

However, even though facilities based competition is aimed at in the long run, creating better preconditions for services based competition will be important especially in the near future while alternative technologies to the fixed local loop are still being developed. On the other hand, to obtain the benefits of facilities based competition in the future, the regulator will have to address the potential problems associated with making this type of competition effective. As has been mentioned a number of times in this study, there will be a need for some kind of access pricing policy regardless of which kind of the two broad forms of competition emerges.

However, as was shown in Chapters 4 and 5, the two forms of competition pose different sources of concern for the regulator: services based competition leads to a possibility for abuse of dominant position by the network owner in setting access charges, whereas in its mature phase, facilities based competition leads to a possible cartelisation problem. The first type of problem is the one that has been more widely acknowledged by regulators. For example, the British telecommunications regulator, Office of Telecommunications (Oftel), has come to the conclusion that the *only* way to achieve effective competition in local telecommunications is through facilities based entry, and have adopted some very active measures that benefit the facilities based competitors of the incumbent network operator (Oftel 1996; Armstrong 1997a, 81). The British policy of emphasising facilities based entry as the only way of achieving effective competition conveys a belief that the regulator's ability to guarantee fair terms of access to the local loop is limited. It is interesting that the British authorities, with far stronger traditions of regulation than their Finnish counterparts, have come to this conclusion. Some initial problems that have been experienced with guaranteeing fair terms of access to the local network in the Finnish case have already been pointed to above.

The second type of problem has not received attention from regulators either in Finland or at the European level, and therefore it is natural that network competition has been regarded ultimately as a better way of achieving competition in local telecommunications. In the light of the above discussion on the problems associated with achieving facilities based competition in the Finnish local telecommunications market, the potential problems with network competition in its mature phase might indeed seem a very distant prospect. However, also this problem will have to be dealt with in the future, if the aim of effective facilities based competition is to be achieved. The next Section discusses current Finnish policy towards interconnection and access pricing, and whether these policies are likely to achieve optimal solutions to the challenges that the regulator faces.

6.2 Interconnection policy

6.2.1 The procedure for setting access charges

On the whole, the aim of both the EU and Finnish authorities has been to adopt a relatively passive stance with respect to the regulation of the terms of access and interconnection between telecommunications operators. With the Interconnection Directive (97/33/EC) the European authorities started to favour a model where access charges are set in commercial agreements between firms, and the regulator intervenes only if firms fail to agree. The provisions of the Interconnection Directive have been enforced in Finland through the Telecommunications Market Act (396/1997) and the Decision of the Ministry of Transport and Communications on the Interconnection of Telecommunications Networks and Services of Telecommunications Operators (1393/1997)[75]. Another decision of the Ministry of Transport and Communications, namely the decision on the Leasing of Subscriber Lines in Fixed Telecommunications Networks to a Telecommunications Operator (468/1997), is also relevant here. This decision states that the regulator can be called upon to settle a dispute only if negotiations on the pricing of the local loop have lasted for two months without a result and also otherwise, when it is apparent that matter cannot be settled. European legislation does not contain any such requirements on the minimum length of negotiations before intervention can take place. Therefore the emphasis on commercial negotiations seems to be stronger in Finnish policy than what is required by European legislation.

The benefits and disadvantages of the principle of relying on commercial negotiations are an interesting issue. From the point of view of the regulator, the main rationale behind a policy of regulator restraint is that after liberalisation, markets should be left to function according to market rules, intervention should be kept to a minimum and industry specific regulation should give way to general competition policy. This line of thinking is very strongly emphasised in Finnish telecommunications policy (see for example HE 180/1995; HE 163/1996)[76]. However, this approach presumes that effective competition has already emerged in the market in question, as the approach relies upon competition to do the work that has traditionally been the responsibility of regulators. It is clear, however, that some monopoly problems do still remain in telecommunications and therefore the current policy raises several concerns.

[75] Most of this legislation can be found at the web site of the Ministry of Transport and Communications at http://www.mintc.fi/www/sivut/english/tele/statutes/index.html.

[76] Similar arguments have been used to justify the complete abandonment of retail price regulation in telecommunications. See also the web site of the Ministry of Transport and Communications on http://www.mintc.fi/www/sivut/suomi/tele/saantely/index.html (in Finnish; cited July 2002).

In particular, the policy of favouring commercial agreements seems ill suited for the case of services based competition, where the incumbent is in a much stronger negotiating position than competing operators. These situations are likely to require regulator intervention, as in the case of Elisa Communications, Turun Puhelin and Salon Seudun Puhelin, mentioned above. Such a lengthy process of first negotiations and then regulatory review and possibly even court cases can be a significant barrier to entry for small competitors[77]. Further, as was noted above, competition in Finnish local telecommunications still to a large extent depends on services based competition and despite the development of alternative technologies, the fixed local loop is still in many cases the only way for a customer to receive telecommunications services. This is the case in particular regarding services such as the Internet that requires relatively high transmission capacities. Fostering the development of the information society features high on the agenda of Finnish policy makers and therefore promoting cheap access to such services plays a central role in Finnish policy towards the communications sector (HE 163/1996; HE 241/2001). If these considerations are kept in mind, the policy of relying on commercial negotiations to produce optimal outcomes seems difficult to justify.

European authorities have acknowledged the problems associated with relying on commercial negotiations a number of times since the adoption of the Interconnection Directive, in particular in cases where one of the parties is in a much stronger negotiating position than the other[78]. Such a concern is restated also in the new Access Directive (2002/19/EC) that came into force on 24.4.2002. Even though also this new legislation emphasises commercial negotiations as the basis for access agreements, it can be interpreted as extending the national authorities' powers of intervention to ensure the effectiveness of services based competition[79]. It remains to be seen whether this point of view will be adopted by the Finnish authorities in the future.

Secondly, as was explained in Section 5.2, the theory of two-way access pricing clearly indicates that allowing cooperation between networks on access charges is better than prohibiting such cooperation. Evaluating the role of the regulator in this process, however, is less clear cut: it is not clear whether complete regulator restraint once an agreement has been signed is the optimal policy. As was argued in Chapters 3 and 5, even network competition is not sufficient to remove all monopoly problems in telecommunications and it is not therefore clear whether commercial agreements between firms will result in optimal access charges in this case either.

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[77] Currently, EU legislation requires the national authority to issue a binding decision on an interconnection dispute "in the shortest possible time frame and in any case within four months except in exceptional circumstances" (Directive 2002/21/EC). However, solving such disputes has previously taken much longer than this in Finland: for example, Telia submitted its complaint on Elisa's (then called Helsinki Telephone Company) local loop prices in November 1997. The final decision on the appropriate level of access charges was issued by FICORA in November 2001, after a series of appeals on previous decisions.

[78] See for example recital (10) in the introduction to Regulation No. 2887/2000 and Article 5 in Commission Recommendation (2000/417/EC) on unbundled access to the local loop.

[79] See recitals (5) and (6) in the introduction to the Access Directive.

Even though no examples of mature facilities based competition are yet available in the fixed sector in Finland, the Finnish mobile[80] telecommunications market involves two fairly strong facilities based competitors, Sonera and Radiolinja. It might therefore be valuable to draw some examples of two-way access situations from the mobile sector. It seems that the concern about collusion is relevant here, even though it is beyond the scope of this study to determine whether collusion actually has occurred. It was explained in Section 5.3.2 that when network based price discrimination is allowed, the result that access charge agreements can facilitate collusion is not merely a theoretical peculiarity, but it can occur even in more realistic situations, for example when networks use non-linear tariffs in the retail segment. In Finland, network based price discrimination is indeed widely used in calls between mobiles, which suggests that operators might be able to use access charges in a collusive manner. The major mobile operators have indeed now reached commercial agreements on access charges with competitors; an example of this is Sonera's agreements on mobile termination charges with both Telia and Radiolinja[81]. To our knowledge the authorities have paid no attention to the possible collusive impact of such agreements.

One sector of the Finnish telecommunications industry where commercial agreements on access charges are likely to function well is the market for long-distance telecommunications: the Finnish telecommunications market is on the whole very segmented in the sense that there are a large number of operators that do business in geographically separate markets. A policy of allowing negotiations on access charges between such firms is likely to be especially beneficial: this situation is comparable to the case of international telecommunications studied in Section 5.2, where it was argued that interconnection agreements between complementary networks can bring substantial efficiency gains compared to a situation where interconnection charges are set unilaterally.

However, it can be concluded that even though the current policy of favouring commercial negotiations on access charges will most likely bring efficiency gains in the Finnish long-distance telecommunications market, it is not very well suited for promoting competition in the local telecommunications market, even though this is where the emphasis of current policy lies. The policy of favouring commercial negotiations does not suit the case of services based competition. This is crucial, as competition in the Finnish local telecommunications market still to a large extent depends on successful services based entry. Further, the current policy raises concerns about the possibility of collusion between symmetric firms in the two-way interconnection case if network based price discrimination is also allowed. Even though the prospect of this occurring in the Finnish local telecommunications market is still a rather distant one, this is an issue that will have to be recognised by policy makers in the future.

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[80] It was explained in Chapter 5 that the two-way access model can also be applied to mobile-mobile interconnection.

[81] For some information on these agreements, see for example Sonera's press releases at http://www.sonera.com/. Sonera and Telia have later (on 26.3.2002) announced a planned merger.

6.2.2 The level of access charges

In cases where operators fail to agree on access charges and regulator intervention is called for, the regulator will need to decide on the appropriate level of these charges. More generally, the EU and therefore also the Finnish regulators have shown some sensitivity to the remaining monopoly problems in telecommunication by paying special attention to access pricing by dominant operators. Both the Interconnection Directive and the Finnish Telecommunications Market Act contain clauses that constrain operators with significant market power (SMP) to charge interconnection prices that are closely related to cost. Another restriction is that the interconnection charges of SMP operators should be non-discriminatory. These same obligations on SMP operators are maintained in the new Access Directive. However, the Directives only contain rather unspecific clauses on what the cost orientation and non-discrimination of access charges should mean in practice. More detailed interpretations of these provisions can be found in the Commission Recommendation (98/195/EC) of 8 January 1998 on interconnection in a liberalised telecommunications market (Part 1 - Interconnection pricing) and in the Explanatory Memorandum associated with the Recommendation[82].

According to the Commission Recommendation, access charges should be based on forward-looking long-run average incremental cost (LRAIC). This is a particular measure of marginal cost that would be incurred by the most efficient firm in a fully competitive market[83]. This recommendation immediately raises the following objection: intuitively, setting the regulated access charge at the level that would prevail in a competitive market seems to involve an inherent contradiction, as regulation is at present needed precisely because the market is not fully competitive. Therefore it seems obvious that the special features of the market, such as high fixed costs, that still make it deviate from a fully competitive environment should be taken into account when designing regulation. A similar objection to regulators' tendency to use marginal costs as the basis of access charges is also raised by Laffont and Tirole (2000, 7). It was argued in Chapter 4 that in an optimal regulatory scheme, the prices of all of the incumbent's services should contribute to covering its fixed costs, and there is no reason why the access charge should be exempt from this rule. Indeed, the theories of optimal access pricing analysed in Chapter 4 show that optimal access charges can in general deviate even significantly from the underlying costs.

However, even though LRAIC pricing is stated in the Interconnection Directive as the general rule for setting access charges, it should be noted that the Interconnection Directive does allow for justified mark-ups over the LRAIC benchmark, to allow network operators to cover the joint and common costs of the network. Together with the non-discrimination clause the allowance for mark-ups entails that in some circumstances average cost pricing of access will be allowed: the non-discrimination clause implies that access charges should be independent of the network where the calls originate and also that the mark-up should be independent of the type of service that the

[82] The Explanatory Memorandum can be found at
http://europa.eu.int/ISPO/infosoc/telecompolicy/en/intconen.doc (cited July 2002).
[83] See the Explanatory Memorandum for a more detailed explanation on how the LRAIC is calculated.

network is used as an input for. The Explanatory Memorandum to the Commission Recommendation (98/195/EC) gives fixed-mobile interconnection as an example of how the non-discrimination principle should be interpreted: the document states that because the cost of terminating a call is the same regardless of whether the call has originated on a mobile network or on another fixed network, there is no justification for charging different prices for call termination in the two situations.

Due to the non-discrimination clause even these modified charges that involve an allowance for fixed costs are not in line with economic theory. It is true that average cost pricing would be the second best solution to the pricing problem of a *single* product firm with a break-even constraint, but this conclusion is not valid in the case which is relevant here: in the case of a multi-product firm optimal deviations from marginal cost pricing are given by the Ramsey approach. An important conclusion of the discussion in Chapter 4 was that optimal access charges do differ according to the service that the network is used as an input for, and are not necessarily the same even if the cost of access is identical. Rather, optimal access charges will differ according to the demand elasticity in the final market and also according to the degree of substitution between the firms' final products. There is therefore no theoretical justification for the current policy of automatically imposing a cost based and uniform access charge in all situations. Further, Ramsey considerations are likely to become more significant in the future, when the diversity of services offered over the network increases and therefore the need for price differentiation increases. The policy of requiring equal conditions of access regardless of the nature of the service that is provided over the network then becomes even more problematic.

Further, it is interesting to note the Commission's view on which fixed costs can be included as the basis for calculating the access charge: the Commission Recommendation (98/195/EC) states that the fixed costs of the local loop should never be included in this calculation. This seems rather peculiar, as it was argued in Section 2.2 that the local loop constitutes the main fixed cost element of the local network. Further, it is precisely the local loop that constitutes a bottleneck in both one-way and two-way access, and therefore it would seem natural to include the costs of the local loop in the access charge. Commission Recommendations are not binding on national authorities, but Finnish authorities have nevertheless chosen to follow the Commission's recommended policies in determining interconnection charges[84].

According to the Commission's Recommendation, fixed costs of the local loop should be covered through fixed subscriber charges only. The results of Section 4.3 imply that this policy would be approximately appropriate, if the demand for subscriptions is very inelastic, at least much more so than the demand for other telecommunications services. This has probably been a reasonable assumption in the past. However, as noted by Laffont and Tirole (2000, 15) in their criticism of policies that promote the recovery of fixed costs solely through the fixed subscriber charge, the demand for subscriptions has

[84] See the decisions of the Finnish Communications Regulatory Authority (FICORA) on cases 342/532/00 and 267/532/2000 at http://www.ficora.fi/suomi/tele/toimenpidepyynnot.htm (in Finnish; cited July 2002).

recently become more elastic due to possibilities for bypassing the network with mobile phones. This is a consideration that is especially relevant in Finland, where 20 % of households have opted to only have a mobile phone and no fixed connection and fixed line penetration is now indeed decreasing (Ministry of Transport and Communications 2000, 53; Ministry of Transport and Communications 2001, 49, 51). The elasticity of demand for subscriptions will increase even further if effective competition between fixed networks becomes a reality, for example if electricity or cable TV networks become successful competitors to the traditional fixed telephone network.

It should be noted that the above analysis relates to applying Ramsey rules to the regulation of Finnish telecommunications. As was explained in Section 4.5, these rules should be modified if the retail market is deregulated, which is indeed the case in the Finnish telecommunications market. It was shown, however, that even with a deregulated retail market, there is no clear justification for pricing access at marginal cost, but usage based Ramsey access charges will still be optimal as long as the incumbent has some market power in the retail segment.

However, the authorities' desire to deregulate the retail market has been motivated by the thought that as this sector has already been opened to competition, prices in that sector should have been driven down to marginal cost (HE 180/1995). It was explained in Section 4.5 that for competition to be viable in such a situation, the access charge of a vertically integrated network operator should indeed be set equal to marginal cost of access or even below it, if entrants are less efficient than the incumbent in the retail segment. As this is the scenario that the regulators have in mind, then some of the above criticisms seem to be misplaced.

The current policy nevertheless raises two concerns. Firstly, if the retail market indeed were perfectly competitive, then as all prices would be forced down to marginal cost either by competition or by regulation, the policy would threaten the viability of the network operator. Further, as was noted above, the European policy makers' recommended solution of covering the fixed cost of the local loop through fixed subscriber charges has become problematic due to the increased elasticity of demand for fixed telephone connections. Secondly, as was noted above, adopting a regulatory policy suited for a fully competitive industry involves an inherent contradiction. As it is clear that full competition has not yet emerged in the local telecommunications market, the policies that are adopted in the meantime should be the ones suitable for the current situation: that is, policies such as those introduced in this study, that take into account both incumbent market power and the need to cover the network's fixed costs. Current policy on access charges has failed to address either of these issues optimally.

As the above criticism on the level of regulated access charges relate to policies on access and interconnection in the two benchmark cases of one-way and two-way access, we cannot provide a complete assessment of either European or Finnish policy towards entry in telecommunications. Unbundling based entry has become increasingly significant in the last few years in the Finnish telecommunications market, and it has also been actively promoted by European authorities. Therefore a number of recent access disputes in the Finnish telecommunications market relate to unbundling based entry[85], but the decisions reached on the level of access charges in these cases cannot be analysed using the simple models of one-way or two-way access pricing discussed in this study. In these cases the Finnish authorities have referred to EC Regulation No. 2887/2000 on unbundled access to the local loop, which states that "pricing rules should ensure that the local loop provider is able to cover its appropriate costs". The Regulation does not contain an explanation of what the term "appropriate costs" implies, but Finnish authorities have interpreted this rather vague rule as implying that also fixed costs of the local loop can be covered through a fixed monthly charge paid by the entrant. Whereas this policy seems reasonable, we are not in a position to analyse it more fully in this study.

Therefore, the discussion in the present Chapter has also revealed two important ways in which the theories explored in this study are insufficient for providing a full analysis of Finnish policies on access pricing. Firstly, an analysis of optimal charges in the case of unbundling based entry in its different forms, and a comparison of these optimal charges to the ones that have been applied by Finnish regulators, would be necessary. Secondly, a dynamic approach would be needed in order to gain a full understanding of policies that give optimal incentives for investment. As was noted in Section 4.1, the access pricing problem has not yet been modelled in such a dynamic context. This remains an interesting area for future research, as promoting investment in new technology has high priority on the agenda of today's regulators.

Further, a criticism of current policies should ideally involve a specific recommendation of how the suggested policies can be implemented in practice. Laffont and Tirole (1996, 658-663) have developed a suggestion of how to implement Ramsey prices through a so called global price cap. The problem with this suggestion from the point of view of the Finnish case, and also from a wider European perspective, is that it would involve extending regulation back to the retail segment. This is something that the regulators are most likely unwilling to do. Therefore the discussion in this Section indicates that further research is also needed on optimal access pricing in the case of deregulated retail markets, and in particular on how these charges can be implemented in practice.

[85] See FICORA case 57/532/2000 at http://www.ficora.fi/suomi/tele/toimenpidepyynnot.htm (in Finnish; cited July 2002) and 29/531/98 at http://www.ficora.fi/englanti/document/Elisa.pdf (cited July 2002). The latter document gives FICORA's final decision on Elisa's local loop prices in the case mentioned above.

7 Conclusion

The purpose of this study has been to highlight the relationships between access pricing and competition in telecommunications: on the one hand, the access pricing problem has been shown to be a central issue in achieving effective competition in telecommunications, and on the other, the form of competition that emerges influences the role that access pricing plays in the market. We have reviewed the key economic features of the telecommunications market and outlined two benchmark models that have been developed in previous research for introducing competition into local telecommunications. One possibility is services based competition, where entrant telephone operators have no network of their own, and another is facilities based competition, where competitors build their own networks. It was argued that access pricing is a central issue in both forms of competition, but ensuring the effectiveness of competition in the two cases poses different problems to the regulator.

In the case of services based entry, the regulator should be concerned about guaranteeing fair terms of access to the incumbent's infrastructure. It was explained that the optimal solution to the access pricing problem depends on the instruments available to the regulator. Optimal access charges in two different cases were considered. Firstly, it was assumed that both the incumbent's retail price and the access charge are regulated. Two different approaches to optimal access pricing developed in previous literature, namely the efficient component pricing rule and the Ramsey approach, were introduced and a comprehensive comparison between the two approaches was provided. It was shown that the optimal access charge in both models is above marginal cost. Secondly, the analysis of optimal access pricing was extended to a case where the access charge is the only instrument available to the regulator. Unlike in previous literature, an explicit formula for the Ramsey optimal access charge in the case of a deregulated retail market was derived. It was shown that the effect of retail price deregulation on the access charge is ambiguous, and that the access charge in this case can sometimes be even below marginal cost.

Literature on facilities based competition was then reviewed and it was explained that competition between networks is not sufficient to remove all monopoly problems in telecommunications. In a simple model with linear prices, competition between networks raises the possibility that operators can use the access charge as an instrument of collusion over retail prices. Using models developed in previous literature it was shown that this conclusion is not robust to simple changes in the assumptions: relaxing the assumption of linear pricing in the retail market removes the collusive impact of access charges, whether or not customer heterogeneity is taken into account. However, as a final point it was shown that the collusive impact of access charges is again restored if the possibility of network based price discrimination in the retail market is taken into account. It was suggested that if firms use non-linear pricing, the regulatory task in the case of mature facilities based competition could be made easier by prohibiting network based price discrimination.

The regulator's decision on which of the alternative forms of competition to promote should therefore depend on two factors: firstly, on the regulator's view of the economic characteristics of the industry, which determines the costs of network duplication. Secondly, the decision of which form of competition to promote should depend on the regulator's ability to deal with the problems associated with making each type of competition effective, which determines the possible additional benefits of network competition compared to competition in services only.

The theories examined in Chapters 2-5 were then applied to form an analysis of Finnish policies towards competition and access pricing in the local telecommunications market. It was noted that even though the Finnish regulators hope that facilities based competition will emerge in local telecommunications in the long run, services based competition has been promoted while alternative technologies to the fixed local loop are still being developed. It is probably because of the difficulties with achieving facilities based competition in the short run that Finnish authorities have so far only paid attention to the potential problems associated with services based entry. However, it was argued that the policies that have been adopted are not very well suited to deal with these problems. Firstly, the policy of reliance on commercial negotiations of access charges fails to appreciate the implications of market power of the network owner and can be a barrier to entry. Secondly, current policy on the level of access charges set by large operators requires these charges to be set at an inefficient level. In particular, the fixed costs of the network operator are either ignored or financed in a suboptimal manner. However, it was noted that an analysis of the local loop prices associated with unbundling based entry would be necessary in order to achieve a fuller assessment of Finnish policy towards the local telecommunications market. Nevertheless, this study should provide a useful starting point for discussing the policies adopted by Finnish authorities and also for further research on regulation in the Finnish telecommunications market.

This study has pointed to a number of interesting issues for further research also from a theoretical perspective. Firstly, the analysis so far of access pricing with retail market deregulation has been rather limited. As the retail sector of the telecommunications markets for example in most European countries have indeed already been deregulated, more research on this topic is clearly needed. In particular, guidance on the practical implementation of optimal access charges in this case should be welcomed by regulators.

Secondly, there is a need to incorporate a dynamic aspect to access pricing models, that would clarify the effect of access charges on incentives for investment in both new technology and in the quality of existing infrastructure. This is in particular the case as promoting investment in new technology has high priority on the agenda of today's regulators. Further, incumbent operators often use the need for financing investments as a justification for relatively high access charges. As long as policy makers do not have a clear understanding of how such dynamic considerations affect optimal access charges, it will be difficult to determine whether such demands on the part of the operators are justified.

Thirdly, our discussion of the two-way interconnection case indicated that there is a need for further research on competition between asymmetric networks, that is, between a dominant firm and a smaller rival. Further, it was suggested that differentiation between telecommunications networks could sometimes be better described by a model of vertical rather than horizontal differentiation. Such a way of modelling differentiation could also provide a new framework for analysing competition between fixed and mobile operators.

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Appendix: Proof of Equation (4.16)

When bypass is possible, the incumbent's profit is given by

$$\pi(p_i, a) = (a - c_a)q_a - k + (p_i - c_i - c_a)q_i ,$$

as q_a can now differ from q_e. Let

$$W = S(p_i, p_e(a)) + \pi(p_i, a)$$

denote social welfare and

$$\frac{\partial \pi}{\partial p_i}(p_i, a) = q_i + \frac{\partial q_i}{\partial p_i}(p_i - c_i - c_a) + \frac{\partial q_a}{\partial p_i}(a - c_a)$$

is the incumbent's marginal profit. The regulator solves the following constrained maximisation problem:

$$\operatorname*{Max}_{p_i, a} W \qquad \text{subject to} \qquad \pi(p_i, a) \geq 0 \quad \text{and} \quad \frac{\partial \pi}{\partial p_i}(p_i, a) = 0 .$$

Let λ and μ be the shadow prices associated with the two constraints. The derivative of the Lagrangian with respect to p_i is

$$\frac{\partial S}{\partial p_i} + (1 + \lambda)\frac{\partial \pi}{\partial p_i} + \mu \frac{\partial^2 \pi}{\partial p_i^2} = 0 ,$$

which yields

$$\mu = -\frac{\partial S}{\partial p_i} \frac{1}{\partial^2 \pi / \partial p_i^2} = \frac{q_i}{\partial^2 \pi / \partial p_i^2} . \qquad \text{(A1)}$$

Noting that $\frac{\partial S}{\partial a} = -q_a$, the first order condition with respect to a is

$$\begin{aligned} &\frac{\partial S}{\partial a} + (1 + \lambda)\frac{\partial \pi}{\partial a} + \mu \frac{\partial \pi}{\partial p_i \partial a} = \\ &-q_a + (1 + \lambda)\left[\frac{\partial q_i}{\partial a}(p_i - c_i - c_a) + q_a + \frac{\partial q_a}{\partial a}(a - c_a) + \mu \frac{\partial \pi}{\partial p_i \partial a}\right] = 0 \end{aligned} . \qquad \text{(A2)}$$

Using the implicit function theorem for $\frac{\partial \pi}{\partial p_i}\left(p_i, a\right)=0$ and Equation (A1), the last term in Equation (A2) can be written as

$$\mu \frac{\partial \pi}{\partial p_i \partial a}=-q_i \frac{\partial p_i^*}{\partial a}. \tag{A3}$$

Rearranging (A2) and using (A3) gives the optimal access charge

$$a=c_a+\sigma\left(p_i^*-c_i-c_a\right)+\frac{\lambda}{1+\lambda} \frac{a}{\eta_a}+\frac{1}{1+\lambda} \frac{\partial p_i^*}{\partial a} \frac{q_i}{\partial q_a / \partial a}.$$

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