Regulation of Telecommunications

Access and Interconnection Pricing Issues in Telecommunications*

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As a result of competition the telecommunications sector today consists of a multitude of networks. Also, many telecommunications service providers own partial networks. With the exception of private networks, all of these have access to each other or are interconnected to form a network of networks that is usable by all service providers. Without access and interconnection such networks and competition between them would hardly have spread so quickly. Here, *interconnection* shall mean that two networks are linked to provide call origination, transit and termination for each other and the networks operate at the same level of network hierarchy. In contrast, *access* refers to the case, where the networks operate at different hierarchical levels and only one network uses the other to originate or terminate calls.

Access and interconnection benefit consumers and the competitive process. They are necessary for carriers to provide ubiquitous service and enable end-users to call anybody and be called by anybody (the any-to-any principle) without having to sign up with a system-wide network monopolist. Being able to be called by or call more people increases a subscriber's utility and thereby provides a network externality that access and interconnection help secure. Access and interconnection also help reduce market power. They lower barriers to entry, because entrants need not establish full-coverage networks. Furthermore, in the absence of access and interconnection, owners of narrow monopolies could make use of network externalities (and economies of scope) to leverage their market power into other telecommunications markets. In contrast, interconnection could, among sufficiently symmetric competing networks, also provide incentives for collusion.

Access and interconnection are indispensable for the functioning of a competitive telecommunications market. However, to the extent that they create network externalities, the market is likely to provide too little of them. In addition, the originally dominating network providers have few incentives to give competitors access to their facilities, especially to those that are hard or impossible to duplicate.[1] Antitrust policy could deal with such bottleneck issues in principle, but actually implementing the so-called "essential facilities doctrine" involves ongoing supervision and pricing assessments that resemble regulation. In an already regulated telecommunications sector such additional regulation therefore comes naturally. Today, access and interconnection pricing are a paramount policy concern of telecommunications regulators.

The structure of this article emphasizes the difference between an access model and an interconnection model or, in more accepted language, between *one-way access* and *two-way access*. One way access (or the access model) concerns the provision of bottleneck inputs by an incumbent network provider to new entrants, while two-way access (or the interconnection model) concerns reciprocal access between two networks that have to rely upon each other to terminate calls. The distinction arose for two reasons. *First* the one-way access problem is the provision of a monopoly input by a vertically separated or a vertically integrated monopolist, while the two-way access problem is the coordination of an essential input between two firms in more or less symmetric situations. *Second*, as competition in the telecommunications industry matures, the two-way access problem becomes increasingly relevant as it has always been between geographically separated monopolies.

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[1] While incumbents with almost 100 percent market share have little to gain from the network externalities provided by entrants, entrants have everything to gain from the network externalities provided by the incumbent.

One-way Access

Issue: Treatment of bottleneck inputs

The one-way access problem concerns an upstream bottleneck input owned by a vertically integrated dominant incumbent operator ("incumbent") and essential for non-integrated entrants competing with the incumbent in a downstream market. One-way access is of continuing concern, as long as incumbents dominate the direct access to the subscriber (the "last mile"). Hopes have been that convergence of mobile and fixed network services would solve the issue but the emergence of fiber to the home may keep it alive for a long time to come. The one-way access problem is closely linked to the essential facilities doctrine in antitrust. It becomes an antitrust or regulatory problem if the nonintegrated firms cannot reasonably duplicate the bottleneck facility and if the integrated firm is not willing to let them use it at reasonable terms. The network externality makes bottlenecks particularly troublesome in telecommunications because localized bottlenecks could be used effectively to exclude competitors from large markets. This would be less so under vertical separation, which turns the bottleneck issue into one of fairly straightforward input monopoly and which has some empirical relevance, particularly in the U.S. after the 1984 AT&T divestiture. Regulation of long-distance access charges of the divested Bell Operating Companies nevertheless remained controversial because of cost allocation and cross-subsidization issues.

Pricing rules

From the perspective of policy makers, access charges could help achieve a number of tasks, such as encourage the right amount of downstream entry and upstream bypass, encourage efficient network investment and network utilization, while being manageable. The tasks are conveniently aggregated in social surplus under the Ramsey approach to access pricing taken by Laffont and Tirole (1993). Ramsey prices maximize welfare subject to a break-even constraint on the regulated firm(s). However, applying the Ramsey approach to access pricing by vertically integrated incumbents leads to potentially complex results, as they incorporate the incumbent's budget constraint, demand relationships, cost relationships and types of competition. This complexity reflects the complicated nature of the problem and is the price to be paid for general rather than partial optimization. While regulators could try and approximately implement such complex Ramsey pricing formulas, there have been no known attempts to do so. This may be as much attributable to interest group influences opposed to the resulting markups of prices on costs as to lack of information about elasticities, costs and competitive reactions and the inability to solve complex conceptual problems. Economists and practitioners have therefore proposed simpler ways to determine access charges (and final goods prices) with desirable properties, including:

- the efficient component-pricing rule (ECPR), also known as Baumol-Willig rule,
- cost-based access charges,
- price caps for access and/or end-users,
- deregulation of end-user prices.

Taking Ramsey prices as the efficient but impractical standard, each of its alternatives simplifies or neglects some of its properties. The ECPR takes final goods prices as given and deducts costs saved by the incumbent downstream. Cost-based access charges use proportional rather than differentiated markups. Price caps substitute imperfect incentives for control of markups but, in the case of global price caps with a single basket of access and end-user services, could approximate Ramsey prices. Last, end-user price deregulation would substitute for downstream Ramsey prices and would work well with access price caps.

All three principal access-pricing methods – Ramsey pricing, the ECPR and cost-based pricing – have their advantages and drawbacks. Ramsey prices and a theoretically clean ECPR require detailed information about demands and competitive interactions in addition to the cost information required for cost-based access charges. Global price caps or access price caps can reduce these information requirements but will only approximate the desired result at best. In principle, the ECPR will provide the best entry signals if downstream prices are optimal and if bottlenecks cannot be bypassed, while cost-based access charges will provide the correct bypass signals for the access facility and will work best if downstream competition is intense or if other policy instruments correct for downstream distortions. Increasing regulated access charges over time in a predetermined way could provide incentives for entrants to build bypass facilities and could well reflect increased downstream competition.

In practice cost-based access charges with small common cost markups have come to prevail worldwide. This holds, for example, for the EU and the US. The ECPR has widespread relevance for resale of services. It has also been tried, but was ultimately rejected by the Privy Council as highest court, in New Zealand. A major insight from the ECPR is that, in the absence of a second instrument (tax), access charges may have to mimic the incumbent's retail price structure if the regulator imposes a particular retail price structure (such as geographically uniform prices) on the incumbent. However, a second instrument would be preferable for achieving noncompetitive goals, such as universal service. Access price caps are used in the UK and, for long-distance access charges, in the US. Given the controversies and difficulties in finding acceptable methods of regulating access prices, new approaches are worth looking at, including those relevant for two-way access.

Two-way Access

Issues: Collusion versus exclusion

Two-way access has been around for a long time in the form of international calling arrangements between countries (settlements) and the arrangements between adjacent local exchange companies in the US. These involve carriers that do not compete with each other. In contrast, the two-way access problems we are concerned with here occur between competing carriers operating at the same level of integration and offering local and long-distance services. Thus, these firms use each other's bottleneck inputs and compete with each other. The issues arising in this context are collusion and exclusion. While collusion is more of an issue in symmetric interconnection relationships, exclusion is more likely by a large network provider interconnecting with a small network provider.

Interconnection pricing

In the context of international calls between countries with different monopoly providers, the interconnection pricing problem in the non-cooperative setting burns down to the pricing of two inputs (termination on each side) at their respective monopoly prices. Combined with their retail monopolies this leads to double marginalization and therefore (even in the symmetric case) fails to generate a joint profit maximum. Explicit cooperation in this case can lead to lower interconnection prices that reduce double marginalization, while independent behavior increases the problem (Carter and Wright 1994). When firms offer complementary services their collusion is socially desirable. In contrast, if the end-user services are close substitutes and the firms providing mutual interconnection therefore compete with each other we would expect cooperation between them to be potentially harmful. One of the main questions in the literature on two-way access has hence been whether interconnection prices can be used as instruments to facilitate such harmful collusion.

The answer has been that perfect collusion through reciprocal access charges is possible, if firms compete in linear end-user prices downstream. This result holds because an increase in reciprocal access prices increases marginal costs relevant for end-user pricing but also increases revenues from incoming calls (Armstrong, 1998a; Laffont, Rey and Tirole [L-R-T], 1998). The result loses its relevance under two-part pricing, though, and two-part pricing holds for many telecommunications services.

Bill-and-keep and the value of incoming calls

While a lot of the early work on two-way accesss concentrated on the collusion issue, the new problems, such as those raised by replacement of conventional telephone networks by IP-based networks (so-called Next Generation Networks or NGNs), shifted the focus of the discussion.

In the past, the interconnection arrangements between Internet Service Providers (ISPs) were of the bill-and-keep kind, meaning that reciprocal access services were provided free of charge. These so-called "peering arrangements" have induced some economists, such as Brock (1995), to call for similar arrangements among competing telecommunications network providers. More recently, the Internet arrangements have changed. Now, peering without charge only continues between core ISPs, while non-core ISPs have to pay. Using a non-cooperative bargaining framework to analyze the negotiations between a core ISP and other ISPs, Milgrom, Mitchell and Srinagesh (2000) hypothesize that in early stages of the Internet network size did not convey a major bargaining advantage so that bill-and-keep arrangements would be likely outcomes independent of relative

sizes. In contrast, in the later stage, with increasing market penetration the larger ISPs gain a bargaining advantage over smaller ones because their own customers value outside communications less highly than before. The resulting peering arrangements (and the lack thereof) are efficient, as long as there are sufficiently many core ISPs.

The justification for bill-and-keep interconnection pricing in telecommunications has traditionally included the savings of transaction and measurement cost and the failure of per-minute rates to reflect the truly relevant capacity costs of networks (which are zero most of the time and quite high during peak periods). In particular, if these reasons had some importance and if traffic were symmetric bill-and-keep would be a desirable approach for the pricing of telecommunications interconnection.[2] By now, however, the value of calls to the receiving party and the ability of the receiving network to charge its subscribers for the resulting utility increase has become a potentially much more powerful justification of bill-and-keep, even under asymmetric traffic.

This reason had been neglected in the literature, until recent practice in the US showed that entrants could turn the seeming disadvantage of high interconnection charges into an advantage by concentrating on subscribers with more incoming than outgoing calls. If both the caller and the receiver benefit from a call they should both contribute to its payment (DeGraba, 2000a; Hermalin and Katz, 2001). Hence, each network can cover the termination cost it incurs through a call from another network by charging its own subscriber, who has been the called party. This can take the form of usage charges, as for wireless calls in the US, or additional fixed monthly fees. While the ability of the receiving network to estimate receiver demand for incoming calls could be limited, competition for subscribers could lead to efficient prices for incoming calls. In contrast, networks usually have a monopoly position with respect to call termination, resulting in distorted pricing under caller pays principles.

Unfortunately, there do not seem to exist demand estimates for incoming calls.[3] But since we regularly answer the phone, the value is obviously positive on average. Nevertheless, values in both directions are unlikely to be equal (on average). Retail prices to caller and receiver should therefore depend on the two demands and on the sum of originating and terminating costs, but not on their cost share. However, the welfare-maximizing interconnection charges depend on each network's costs, because they influence retail prices (Hermalin and Katz, 2001). So, from a valuation perspective, bill-and-keep would not necessarily be efficient but neither would any of the other pricing approaches, such as those discussed above for one-way access. Compared to those, bill-and-keep may have an important disadvantage, known as the "hot potato" problem, meaning that a network provider will try to hand over a call to the other network as quickly as possible and thereby save on network expansion. In order to avoid this kind of free-riding on other networks and to induce optimal network investment, DeGraba's (2000b) COBAK (central office bill-and-keep) proposal restricts the bill-and-keep portion of a call to the termination of calls from the last central office to the called party, while the sending network would be responsible for transport and switching until that point. This suggestion also addresses the conjecture that incoming calls are, on average, valued less than outgoing calls (DeGraba, 2002).

A major issue with the value of incoming calls is that usually the calling party pays for the call, resulting in a call externality from being called, which is hard to internalize by the two parties. Switching to a receiver-pays regime would eliminate that externality but replace it with a call externality for the caller. Thus, a payment by both parties would be required for eliminating that externality. In this case the receiver payment would be associated with a discount on termination charges (Jeon, Laffont and Tirole, 2004, in the context of two-part tariffs downstream). By providing network providers with an incentive to institute such a reception payment bill-and-keep is likely to reduce call externalities (DeGraba, 2002).

Thus, bill-and-keep, as amended by the COBAK proposal, has a number of advantages over other pricing rules. This would, in particular, hold for NGNs. Something similar to COBAK is already applied to broadband access networks. Extending this to narrowband would help eliminate the currently existing and growing arbitrage problems and competitive distortions between conventional telephony and VoIP. It would help establish a compatible

[2] Generally, symmetric traffic will arise independently of the relative sizes of the networks if the characteristics of the subscribers are the same on each network.

[3] Given the importance of this subject, such estimates are dearly needed. They could either be derived from experience with the receiver pays principle or as a residual between the demand for outgoing calls and the demand for subscriptions.

interconnection system for all networks and all services. At the same time, it would get the regulator out of ongoing price regulation of interconnection charges, because the remaining transit networks not covered by bill-and-keep are already competitive or on their way towards competition. The main regulatory tasks would then concern decisions on the relevant "central offices", between which and final users bill-and-keep would hold. In particular, when it comes to conversion of circuit-switched by packet-switched networks, those offices could be quite far away from end-users and could be located at interconnection points with core networks.

Competitive bottlenecks and discriminatory pricing between on-net and off-net calls

Besides two-way interconnection in an NGN world the main current interconnection problem in many countries is that of mobile termination. It concerns the high termination prices mobile telecommunications carriers charge fixed network providers and each other. This problem has its roots partially in competitive bottlenecks, partially in discriminatory pricing.

Armstrong (1998b, 2002) terms the problem of monopoly over call termination one of competitive bottlenecks because it can happen under full competition between networks for subscribers. Because the receiving network (usually) has a monopoly for termination to the subscriber being called, it can charge a monopoly price for termination. If callers only have average information about termination charges and do not know which network the receiver subscribes to the termination charges in small networks may even exceed monopoly prices. Free entry can lead to biases in favor of small firms and a dissipation of the resulting monopoly rents in the form of low monthly fees or free phones or the like (Wright 2002). Small firms, however, are at a disadvantage, when it comes to price discrimination between on-net and off-net calls.

Originally introduced as "Friends and Family" by MCI in the 1980s, discrimination between calls that terminate within the call originating network (on-network calls) and those that terminate on the other network (off-network calls) has spread and is now common, for example, in the European mobile telephone industry. In a symmetric market equilibrium the on-net retail price decreases with substitutability and with the access price. If substitutability is sufficiently small, the off-net price increases in the access charge. The main insight of L-R-T (1998) in this context is to show the existence and working of price-induced network externalities. Belonging to a larger network allows a consumer to do more lower priced on-network calls. Thus, a high access charge that leads to a high off-network retail price hurts a network with a small market share. A full coverage incumbent can squeeze a small coverage entrant through a high access price. This is important for access charge regulation and for regulatory permission of price discrimination in the retail market.

In this discriminatory pricing environment, an increase in access charge may actually increase retail competition, because an access charge increase drives a wedge between the marginal cost of an off-net call as opposed to an on-net call. High access charges therefore are not necessarily a good collusion device. Rather they induce firms to increase their market shares in order to have more on-network calls (avoiding the access charge). In a second best sense, therefore, the price discrimination can improve welfare by reducing double markups (on access and retail) if networks are sufficiently differentiated. This will happen, because the high off-net price will not have many users. The problem is that, at the same time, the incumbent could foreclose a small entrant. This problem suggests that a regulator would want to forbid such price discrimination (by the incumbent), when competition is in its infancy, while such price discrimination would be advisable, once entrants are viable (having large coverage sunk networks).

Under two-part tariffs and price discrimination downstream, the networks may actually reduce each other's access charges below marginal costs. Bill-and-keep or even negative access charges could then act as collusion devices. This result by Gans and King (2001) turns the "Friends and Family" idea of discrimination between on-net and off-net calls on its head, because access charges below marginal costs would lead to on-net usage prices above off-net prices. In this case, subscribers will want to belong to the smaller network. This softens competition for subscribers. Thus, end-users are faced with low usage prices and high subscription fees. It is not clear that this specific behavior has any empirical relevance so far, since subsidized subscription fees have been common worldwide. However, it adds to the anti-competitive effects that discrimination between on-net and off-net calls can have.

Overall, the literature shows that discrimination between on-net and off-net calls seems to have few

desirable and many detrimental effects, largely because it increases the market power of the dominant firms. Disallowing it or restricting it to entrants may therefore be a better policy than a regulated interconnection charge tailored to it. In contrast, DeGraba (2000b) argues that bill-and-keep will by itself reduce the on-net/off-net discrimination issue.

Conclusions on the interconnection pricing models

A major difference between optimal pricing under one-way and two-way access is that one-way access charges will not ordinarily be below incremental costs, because the incumbent cannot make up the difference downstream. In contrast, this matters less under symmetric two-way access, because the low access charges are both paid and received. Thus, in the symmetric case, two-way access charges have allocative but no direct budgetary effects. While interconnection prices above marginal costs could be socially optimal, regulated prices discussed in practice have been based on longrun average incremental costs or bill-and-keep. Reciprocity is required in the US, but not so far in Germany.

In the US, competitive local exchange carriers (CLECs) were initially afraid that they would have much more outgoing than incoming traffic (due to multiple lines of business customers, who would use the CLECs for their outgoing traffic, but keep the incumbent's lines for incoming traffic). However, the actual calling patterns were often reversed. These experiences suggest that balanced calling patterns are unrealistic and that competitors can target selected customer groups. This can be due to subscriber heterogeneity and/or the value of incoming calls. Including the value of incoming calls has recently started to impact the interconnection pricing philosophy. The insight that each network can charge its subscribers through fixed or usage fees for the value of incoming calls has completely changed the assessment of low interconnection charges or even bill-and-keep, along with the accompanying retail pricing methods and price structures.

What recommendations can regulators take from the literature on two-way access pricing? The literature suggests differentiated approaches depending on symmetries between incumbent and entrant, customer heterogeneity, downstream pricing (and price regulation) and the valuation of incoming calls. Such differentiation in policy could itself have adverse selection and moral hazard effects known as *regulatory arbitrage* because most of these variables are endogenous. The question then is if there exist either robust specific policies or general policies with sufficiently good properties. In a fully regulated state, COBAK could be such a winning policy if there were only one to choose from.

General conclusions

While the focus of this article is on telecommunications, the principles it reviews could be relevant to other networks depending upon their particular characteristics. Electricity transmission grids, credit card networks and railroad tracks can be bottleneck facilities to which the one-way access model would apply. In fact, Baumol (1983) first formulated his version of the ECPR for a railroad example. Nevertheless, because many results in the literature are not rebust to fairly small changes in the underlying assumptions, a main lesson from our discussion is that the applicability of theoretical results to policy largely depends on the sector-specific properties incorporated in the models.

The normative results suggest that, for one-way access to bottleneck facilities, the two leading approaches to regulation appear to be global price caps or access price caps combined with deregulated retail tariffs. These approaches could include an imputation requirement related to the Baumol-Willig rule. The article emphasizes that two-way access is characterized by both potential exclusion and potential collusion, largely depending on asymmetries and on the type of downstream pricing. Since for the interesting case of economies of scale in the network, optimal interconnection charges could be above or below marginal costs, there is no simple optimal rule.

Taken together, this suggests that, in a system with both one-way and two-way access, there might be access price caps, possibly with two baskets, one for one-way access and one for two-way access charges. This could reduce some of the cost measurement problems encountered, when basing access and interconnection charges on costs and it reduces the danger of premature deregulation of access and interconnection. At the same time, retail could be deregulated (possibly helped by a universal service policy as a second policy instrument). However, the consequences of price caps for two-way access need to be analyzed first and compared to other regulato-

ry options, such as the COBAK approach. Such comparison should include the effects on intermodal competition, as bill-and-keep could improve the competitiveness of traditional phone services against Internet-based telephony. Further research is also badly needed about nonlinear access and interconnection charges, about asymmetries in interconnection and about the investment effects of different access and interconnection regimes.

As in any area of active research perceived gaps fairly quickly lead to new discoveries. The static approach of the models has given way to new dynamic approaches that emphasize entry and investment decisions. The old insight that incoming calls have value is finally bearing fruit in the two-way access models. It yet needs to be fully appreciated in the context of one-way access. For example, a local exchange carrier, providing call termination services to a long-distance carrier can benefit from the value of incoming calls by being able to increase subscription charges. It may thus have less of an interest in high access charges that reduce the volume of incoming calls. A similar incentive could hold for originating access charges, which are passed on into long-distance charges and therefore affect willingness to pay for subscription. These observations suggest that the FCC (2001) may be on the right track by looking for a unified approach to one-way and two-way access charges.

A final word on regulation and competition policy: Access and interconnection price regulation is very technical and requires an in-depth knowledge of the industry. This favors industry-specific regulation over antitrust agencies. However, as telecommunications competition matures, many of the technical problems will have been solved routinely, so that competition policy can take over.

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