International Handbook on Economic Regulation

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Edward Elgar
Cheltenham, UK • Northampton, MA, USA

Published by
Edward Elgar Publishing Limited
Glensanda House
Montpellier Parade
Cheltenham
Glos GL50 1UA
UK

Edward Elgar Publishing, Inc.
136 West Street
Suite 202
Northampton
Massachusetts 01060
USA

A catalogue record for this book
is available from the British Library

Library of Congress Cataloguing in Publication Data

ISBN-13: 978 184376 671 1 (cased)
ISBN-10: 4376 671 X (cased)

Typeset by Manton Typeseters, Louth, Lincolnshire, UKPrinted and bound in Great Britain by MPG Books Ltd, Bodmin, Cornwall

13 The economics of access and interconnection charges in telecommunications

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Introduction

In telecommunications and other industries, certain providers must rely on other firms when delivering products and services to their customers. While this situation is not new, the nature of such dependencies (or interdependencies), as well as the economic analysis that suggests how such arrangements should be priced, are becoming increasingly complex as technologies advance and formerly separate markets converge. The following examples of interconnection and access arrangements from the telecommunications industry – the empirical focus of this chapter – illustrate the myriad ways in which firms and regulators have addressed the need for firms to exchange certain critical inputs and set prices for such facilities, services and transactions: (1) two adjacent, non-competing, telephone networks establish facilities so that subscribers on one network can call the subscribers on the other; (2) long-distance carriers obtain access to the facilities of a local service provider and compete against that provider in providing long-distance services to a common customer base; (3) traditional wireline telephone and new wireless (mobile) carriers establish interconnection arrangements so that subscribers of a traditional phone service can call wireless subscribers, and vice versa; (4) new competitive local telephone carriers obtain certain network elements from the incumbent carrier and at the same time establish interconnection arrangements, so that they can both capture subscribers in the common service territory and allow their subscribers to call subscribers that remain on the incumbent's network; (5) customers of the incumbent telephone carrier make telephone calls to their dial-up Internet Service Provider, which in turn is a customer of a competing local carrier; and (6) firms offering a service in which part of the call is routed by Voice over Internet Protocal (VoIP) interconnect with traditional local service providers to complete the call.

The numerous and complex situations where interconnection and access arrangements occur are accompanied by (1) comparably complex real-world terms and prices, often established by regulation, (2) a large number of stated or proposed objectives for pricing access and interconnection, and (3) a growing economic literature with the common purpose of how to establish efficient ac-

cess and interconnection prices, albeit with differing conclusions that depend on the specific aspects of the overall problem that are addressed as well as the particular assumptions employed to describe how consumers and firms respond to such prices. In addition, real-world pricing takes place in a rapidly changing technological and competitive environment. As a consequence, as Armstrong (2002, p. 381) observed in concluding his comprehensive treatment of the economics of access pricing, it is difficult for economic theory to keep up with the problems it is designed to solve:

> An important next step in the theoretical research in this area is, I believe, to provide a proper analysis of the *dynamics* of access pricing, focusing on the need to provide long-run, stable incentives for the incumbent (and other firms) to invest efficiently in infrastructure and innovation.

Similarly, once access and interconnection prices have been established, outcomes may well differ considerably from what was expected, because existing and new competitors may respond in ways that were unanticipated by either contemporary theory or practice.

For example, in the early days of local telephone competition in the United States, a common belief was that new entrants would tend to serve customers such as large businesses that originated more calls than they received, suggesting, in turn, that incumbent carriers would terminate a disproportionate number of calls from competitors' networks. Accordingly, incumbents tended to favour relatively high interconnection charges, while entrants typically advocated low (or even zero – 'bill and keep') charges.[1] In fact, certain entrants attracted customers that received many more calls than they made (i.e. Internet Services Providers) and the resulting payments of interconnection charges to these competitors came to be viewed as a serious problem, particularly by the incumbents. Of course, industry participants and regulators do respond to such problems, but there is a real question of whether they can react early or rapidly enough in light of the pace of change in the industry.

The remainder of this chapter is organized as follows. The second section defines the two major categories of interconnection arrangements – one-way and two-way – and the economic and public policy objectives access and interconnection prices are intended to satisfy. The following two sections describe the findings from the economic literature and outline practical policy issues for one-way and two-way interconnection prices, respectively. The final two sections of the chapter describe the historical trends and future directions in US access and interconnection pricing and summarize the conclusions and implications for other industries.

Access and interconnection: definitions and objectives

Types of interconnection and access

Previous analyses of access and interconnection pricing have distinguished between cases in which providers must obtain inputs from another provider in order to offer service to their customers (*one-way interconnection*) and situations in which two or more carriers must connect their facilities (or networks) so that customers of one carrier can call customers served by other carriers and vice versa (*two-way interconnection*).[2] One-way interconnection situations include those in which the firm supplying the inputs does not compete with the purchasers of the inputs; for example, in the first several years after the divestiture of AT&T in the United States, long-distance carriers such as AT&T, MCI and Sprint obtained access from local exchange carriers that were legally prohibited from offering ubiquitous long-distance services. However, in most of the rest of the world, as well as in the United States in recent years, the providers of access also offer long-distance services in direct competition with the carriers that purchase access services. These arrangements are examples of vertical integration[3] and, as we discuss in detail below, the focus is often on whether the combination of access prices (the upstream input used by competitors) and the access provider's long-distance prices (the downstream service that is subject to competition) permits the most efficient downstream provider to compete successfully.

Similarly, two-way interconnection can involve situations in which there is (1) no competition between the carriers exchanging traffic (e.g. international long-distance, or calling between customers of two adjacent local exchange networks); (2) competition between carriers offering services that are close substitutes (e.g. competition among carriers serving the same territory); as well as (3) arrangements between carriers offering services that may not be close substitutes, such as the exchange of calls between traditional wireline and wireless networks.[4] The relationship between interconnecting firms is sometimes described as a vertical one in that a call between customers served by different carriers requires 'inputs' from both carriers. However, unlike the one-way interconnection case, the carriers do not fit neatly into an upstream input provider and a downstream competitor. Further, the fact that interconnection arrangements can involve payments between carriers in both directions creates interesting theoretical and practical problems not encountered in one-way interconnection.[5]

Finally, one-way and two-way arrangements can co-exist – in particular, when new entrants obtain parts of their networks from incumbent providers and then exchange traffic with the incumbent. In this case, the elements obtained from the incumbent, such as the telephone wires between customers and switching facilities, are upstream inputs in the standard vertical integration sense, while

there is no obvious upstream–downstream designation for the two-way intercarrier payments.

Access and interconnection pricing objectives[6]

Economic theory and regulatory practice have ascribed several, not necessarily compatible, objectives for access and interconnection prices. Such prices should promote *economic efficiency*. Efficiency consideration include: (1) *allocative efficiency*; consumers of final products should pay prices that reflect the economic cost of the resources consumed in providing the products or services (e.g. the calls to other customers) and at the same time, they should not be discouraged from consumption when the value exceeds the production cost; (2) *productive efficiency*; in competitive situations the most efficient provider should not be precluded from serving customers; and (3) *dynamic efficiency*; all firms, both entrants and incumbents, should have proper incentives to invest in technologies that lower cost and/or expand product offerings.

In addition to the economic efficiency objectives, public policy in certain countries has enunciated objectives of promoting competition and universal service.[7] While from an economic perspective there is no conflict between promoting competition and proper consideration of the various manifestations of economic efficiency, public policy at times has attempted to 'jump start' such competition and shape its form, through policies that resemble 'infant industry' protection in other contexts.[8] Similarly, there is a long regulatory history in which charges for basic services (e.g. the monthly charge for a basic residential telephone service) have been maintained at below-cost levels in some situations in order to encourage widespread subscribership. Also, recently, interconnection charges in the form of payments to wireless carriers for call terminations have been set at high levels in some countries, so that charges to wireless subscribers could be kept low in order to facilitate rapid expansion of wireless demand. In both the traditional wireline universal service policy and the newer wireless termination charge policies, expansion of subscribership is considered to capture an externality benefit that makes the service increasingly more valuable to all subscribers as the total number of subscribers increases.[9]

One-way access and interconnection

Much of the initial theoretical and practical work on access and interconnection has focused on the one-way situation (Laffont and Tirole, 2000, p. 179); that is, where an incumbent firm offers 'upstream' inputs to other firms that offer services in 'downstream' markets.[10] This literature has primarily addressed the issue of how access prices should be set and secondarily, what are the competitive consequences resulting from access charges that depart from the marginal cost of providing the service in question. For both issues, the efficient component pricing rule (ECPR),[11] explained below, has served as a prominent reference point.

Public policy objectives in establishing access prices

The analysis of the proper level for access prices has produced numerous objectives that these prices are intended to satisfy.[12] First, whether or not the incumbent provider of the upstream input participates in downstream markets, the access price should provide downstream firms the proper incentive to acquire that input from the incumbent when it is least costly to do so. For example, in the early period of long-distance competition in the United States, the per-minute usage charges for accessing local exchange carriers' customers were more than ten times higher (in nominal terms) than current charges. Consequently, there was considerable concern that long-distance carriers would find other ways to 'bypass' the local exchange carriers in reaching customers and, as a result, local exchange carriers would suffer substantial revenue losses. The systematic and steady reduction of access charges from the initial levels was explicitly designed to mitigate the bypass threat.

Second, when the incumbent access provider also competes against entrants in downstream markets, the access price should be set so that (1) the most efficient downstream provider has a legitimate opportunity to win the business and (2) downstream customers are provided the proper price signals to consume the services efficiently.

Finally, the theoretical literature routinely produces the result that access prices can be set to offset imperfections in retail price levels. For example, if public policy requires the price of a basic local service to be uniform, regardless of any cost differences in providing that service (and there is no other way to rectify distortions caused by the departure from cost-based prices), then the efficient access price would be correspondingly higher when retail prices are above cost and correspondingly lower for below-cost retail prices. Similarly, when competition is less than perfect in downstream markets, that is, when downstream prices would exceed marginal cost[13] if access were priced at its marginal cost, then 'second best' access prices would be set below cost in order to offset market-power in the downstream market.

Summary of previous findings

In this subsection, we review the findings on (1) the efficient level for access prices[14] and (2) the competitive consequences of setting access prices at particular levels. To set the stage, it is useful to describe the ECPR, which facilitates the discussion of both issues.

The ECPR establishes a relationship among (1) the price the incumbent charges for the downstream service, (2) the efficient price for access, and (3) the marginal costs the incumbent incurs to produce the access and downstream services. In particular,

$$p_a = mc_a + (p_r - mc_r).$$

In words, the ECPR establishes the access price (p_a) as the sum of the marginal cost (mc_a) and the profit (or contribution to the firm's shared and common costs) – price less marginal cost – contained in the incumbent's downstream service ($p_r - mc_r$).[15] For example, if the incumbent's price for its retail service were 5 cents and the marginal cost for supplying that service were 2 cents, then the retail margin between price and cost would be 3 cents (5 – 2). The ECPR specifies that this margin be added to the marginal cost of supplying access to competitors. Therefore, if the marginal cost of access were 1 cent, the ECPR would produce an access price of 4 cents (1 + 3).

The rationale for ECPR being an efficient price is that if the downstream market is competitive *and* only the incumbent produces the upstream input, that is, it is an essential facility, then (1) the incumbent firm should be indifferent between producing the downstream service and providing access to a competitor, which in turn supplies that service instead of the incumbent; and (2) the firm with the lowest combination of access and downstream costs will serve the market, thus achieving productive efficiency in that market.

As Laffont and Tirole (2000, p. 122) and Armstrong (2002, p. 336) explain, ECPR provides efficient (welfare maximizing) prices in special circumstances, in particular when (1) entrants have no market power in providing the downstream service, (2) the cost of providing access to the incumbent and its competitors is the same, (3) the incumbent and entrants have the same costs in the downstream market, and (4) the incumbent and competitors face symmetrical demand conditions in the downstream market. When these four conditions are not met, the determination of the efficient access price becomes more complex. In particular, the deviation of the access price from its marginal cost is determined by a Ramsey-like inverse elasticity rule, where the elasticities in question include the own and cross-price elasticities of the incumbent and entrants in the downstream market (Laffont and Tirole, 2000, pp. 102–104). It is also the case that certain specific demand curves bring cost differences into play. For example, when the incumbent and an entrant face symmetric linear demand curves, the efficient access price would exceed ECPR when the entrant has lower costs, and be lower than ECPR when the incumbent is more efficient.[16] For purposes of practical implementation of access prices, the importance of these generalizations of the ECPR is the amount of information necessary to determine such prices, which we will discuss in the next subsection.

Finally, the effects of access prices on downstream competition are noteworthy. Weisman (2003) summarizes the literature in this area and presents the major findings from that literature and his own research. Interestingly, the competitive consequences depend on whether firms compete on the basis of price (Bertrand competition) or quantity (Cournot competition). With regard to Bertrand competition, Weisman reports that when a regulator sets the access price according to the ECPR, the incumbent has no incentive either to discriminate

against its rivals (in particular anti-competitively increase their costs) or to engage in a price squeeze – that is, set a downstream price that includes a smaller mark-up than that which is contained in the access charge established by the regulator. However, when the access price is set higher than the ECPR, the unequal margin conditions reflective of a price squeeze are present. When the access price is set at a level less than the ECPR, the incentive to engage in non-price discrimination or sabotage (i.e. raising a rival's costs) is present.

The Cournot competition findings are somewhat different. In particular, when the incumbent is at least as efficient as the entrant in the downstream market, Weisman found that it has incentives to raise its rival's costs. However, if the entrant is sufficiently more efficient than the incumbent, the incentive to discriminate disappears. Evidently, in this case, the incumbent's profit-maximizing choice is to 'buy' the downstream functionality from its rival, rather than 'make' it by deploying its own network.

Weisman's Cournot competition findings are similar to those reported by Weisman and Kang (2001). Based on a model in which the incumbent's profits can be affected by discriminating against rivals (by raising their costs) and by the extent of the regulator's ability to detect such discrimination, the authors also find that incentives to discriminate are lower when the rivals are more efficient than the incumbent. Other factors that reduce incentives to discriminate include a high market elasticity for the downstream product and/or more competing firms (both of which tend to lower the downstream price and thus make discrimination less profitable), greater ability of the regulator to detect discrimination, and higher access charges (because successful discrimination results in lower profits from supplying access to rivals).

Practical implementation of one-way access prices

The discussion in the previous section illustrates that when access prices are the only policy instrument to facilitate efficient competition, meet other objectives such as universal service (Baumol, 1999), and provide for recovery of the incumbent's fixed shared and common costs,[17] not only are they carrying a heavy policy load, but the information required to determine efficient price levels can also be quite demanding. For this reason, to the extent that there are other politically acceptable means to meet some of these objectives, the determination of efficient access charges would become easier. For example, the need for above-cost access charges would decrease to the extent that universal service is ensured through a combination of rebalanced rates and targeted subsidies and/or through mechanisms such as broad-based revenue taxes (or surcharges).[18]

In the most general case, establishing efficient access rates involves the following information. First, to the extent that competition for downstream services is at issue, it is necessary to define the markets for those services and determine the prices and price structures that prevail. While the theoretical literature often

posits fairly simple services, such as a single toll service with a uniform per-minute price, in the real-world downstream offerings are becoming considerably more complex, for example packages of services that combine local, long-distance, advanced features, and even wireless. In these circumstances, determining prices, costs, and forgone profit (as defined by ECPR) becomes increasingly difficult.

Second, except in the case of perfect competition (or contestability), determination of the efficient access price requires information on the demand elasticities of incumbent and competing carriers. Further, such information is likely to become increasingly difficult to obtain, as well as subject to change, as carriers enter, exit, and expand their product offerings through the introduction of increasingly complex packages of services.

Third, determining the efficient interconnection price, at a minimum, requires information about the incumbent's cost for access and possibly a downstream service. While regulators rely on estimates of these costs in many situations, such estimation nonetheless can be highly controversial. Telecommunications networks tend to deploy capital-intensive equipment, which at the same time has long (but uncertain) economic lives, is subject to relatively rapid technological progress, and where the demand for the wholesale and retail services provided by the network is highly uncertain.[19] When cost information on one or more competitors is required, the information requirements are even more demanding. These competitors may well have different network configurations, deploy different technologies, and otherwise create costing information requirements well beyond what regulators typically have access to in currently available cost analyses.

Fourth, the definition of market power in the downstream market (and the use of lower, perhaps even below-cost access prices to offset it) is quite narrow: any price that exceeds its marginal cost indicates some degree of market power.[20] However, being network-based firms in their own right, downstream competitors will very likely have their own fixed shared and common costs, which are often reflected in the prices that unregulated firms charge. In these circumstances, tasking access prices with offsetting a 'problem' that is pervasive in unregulated markets may be ill-advised.

Finally, the fundamental premise that access services (or particular unbundled elements) are essential facilities is becoming increasingly less descriptive of the industry.[21] For example, even with respect to the quintessential example of long-distance services, the advent of VoIP has allowed certain carriers to compete without using traditional carrier access services. Such developments not only provide additional impetus to access charge and intercarrier compensation reform proposals (which we discuss later in this chapter), but ultimately call into question the premise that one-way access should be set by regulators, rather than in the market.[22]

Two-way interconnection

Two-way interconnection is becoming increasingly prominent in both the economic literature and in practice. The growing number of examples where it has or may occur is accompanied by increasing complexity in models used to analyse efficient prices and supplier behaviour. Not surprisingly, conclusions drawn from these models can differ, depending on the particular aspects of the complex interconnection problem that are emphasized and the specific assumptions about the interconnecting firms that are maintained. As DeGraba (2002a, p. 62) cogently observed:

> More generally, determining appropriate interconnection rates is an empirical matter. The interconnection charge regime will affect a vast number of decisions, including usage levels by customers, subscription levels of customers, regulatory arbitrage, and decisions made by regulators. An appropriate policy must balance the costs and benefits among all of these decisions.

Two-way interconnection framework

At the most general level, two-way interconnection deals with the situation in which two customers jointly consume a service (e.g. a telephone call), which may be provided by more than one firm. In addressing questions such as (1) how to establish an optimal interconnection charge (in the economic literature, this charge is usually represented as a usage-based, e.g. per minute charge, paid by the provider whose customer originates a call to the provider of the receiving party), (2) how firms will establish retail prices for their services (and possibly compete for customers) once the interconnection charges have been set, and (3) whether acceptable interconnection charges can result from market forces and/or negotiation among interconnecting firms, numerous factors come into play. Further, these factors can vary in ways that suggest different optimal interconnection rates (e.g. equal to cost, above cost, or zero 'bill and keep'), and/or different reactions by firms (e.g. acceptable versus anticompetitive negotiated interconnection rates) in different interconnection situations. In addition, while certain optimal outcomes are sometimes easy to state, for example that the sum of the prices charged to the originator and receiver of a call should equal the total cost of producing the call, the way in which interconnection charges facilitate (or hinder) this outcome again can depend on the particulars of the relationships among firms and their customers, as well as the particular modelling assumptions used to represent them.[23]

Turning first to the customers, important considerations include (1) the quantity of calls *made* and how that calling level responds to a retail price, (2) the quantity of calls *received* and how that calling level responds to a retail price, (3) whether customers make more calls than they receive, receive more than they make, or experience an approximate balance, (4) how customers choose among competing networks in response to the retail prices offered by available

providers, (5) how customer choose among different retail calling plans that may be offered by networks that attract heterogeneous customers, and (6) whether or not certain customers subscribe to any service at all, given the retail pricing options offered by competing carriers.

With regard to firms, issues that might be considered include (1) whether and to what extent the firms compete; for example, are the calls offered by the interconnecting firms close substitutes, (2) how do these firms price their services to their customers, (3) whether there are explicit interconnection payments between firms,[24] and (4) what the firm's cost structure is and whether it differs from the cost structure of other interconnecting firms.

On the customer (or demand) side, some of the differences in actual conditions, which may or may not be reflected in a particular model, include whether the party that originates a call receives the same benefit as the recipient, which in principle can differ with the nature of the call. Similarly, while in some situations the number of originating and terminating calls could be fairly balanced (e.g. between networks that attracted similar mixes of customers), in other situations it clearly will not be (e.g. calls from an incumbent's network to an entrant that has attracted Internet Service Providers (ISPs) as customers and/or from a wireline to wireless network will be disproportionately in one direction). So while subscription to a particular network (or type of network) may be nearly ubiquitous (e.g. traditional telephone service in North America) for newer technologies, such as wireless in its early years, new customers can be attracted by favourable retail prices.

Perhaps the greatest complexity in describing interconnecting firms, as well as the largest discrepancy between typical models and reality, is in the price and cost structures. While the models typically represent calls as having a simple price structure based on a usage charge, real firms are offering increasingly complex packages of services with pricing plans that may be far removed from particular calls within or across networks. For example, in recent years, US residential customers have been offered a growing variety of plans, some of which offer unlimited local and long-distance calling for a fixed monthly rate. On the cost side, not only might the cost structures of interconnecting carriers differ, but it is also far from clear that each increment of usage has an equal marginal cost. For example, certain components of the switching equipment used in providing calls within and between networks do not vary with calling volumes and the other components are usually sensitive to usage only in peak periods, yet typical models (as well as traditional usage tariffs) assume there is a cost for each minute.[25] These developments raise the question of how properly to define the units of output that are the source of the consumer benefits and the concomitant marginal costs.

Finally, while the differences in the particulars of an interconnection arrangement may imply different interconnection charges in theory, such as cost-based

charges in the case of one pair of firms but above cost in another, some regulators (e.g. in the US) have stated a clear preference for uniform charges. At least with respect to incumbent networks, because interconnection arrangements typically do not differ with the nature of the other interconnecting networks (e.g. similar facilities are used to interconnect both competing local carriers and traditional long-distance carriers to an incumbent's network), any variations in interconnection charges produced by theoretical models would reflect factors such as cost differences between the incumbent and interconnecting networks, differences in the vigour with which they competed with the incumbent, and differences in the type of customers they served. Not only would detecting such differences pose challenging information requirements, maintaining interconnection charge differentials could be a significant enforcement problem.

Implications and findings from the economic literature

As was the case for one-way interconnection, the theoretical literature suggests that interconnection charges may be called on to serve multiple objectives. First, because each interconnecting network enjoys some degree of market power – it is typically the only connection, hence a bottleneck, between a firm's customers and customers of other networks – there is some concern that carriers could exploit this market power if they set their own interconnection charges.[26] Second, as in the case of one-way interconnection charges, the literature suggests that two-way charges be lowered to offset less than perfect competition in retail markets. Third, in models that explicitly consider a call as jointly consumed between sender and receiver, the interconnection charge has been viewed as a mechanism to induce retail prices that reflect the relative benefits that each party receives. Similarly, in the case in which (1) callers to one network benefit from calling subscribers of the other, and (2) attractive prices would encourage more subscribers to join the latter's network, above-cost access prices have been suggested as a means for subsidizing the subscribership growth. Finally, to the extent that interconnection charges are designed to contribute to the recovery of the fixed, shared and common cost of a network, departures from purely cost-based pricing would ensue. Clearly, when the proposition that prices tend towards costs in competitive market is used as a reference point, these various considerations would cause deviations from costs in either direction, with the precise magnitude dependent on the particular facts and/or assumptions at issue. Although there are potentially many factors that affect the efficient level of access charges, it is useful to classify the literature into two broad categories: (1) models and analyses that implicitly assume that the calling party receives all of the benefits of the exchange, and (2) models that start from the premise that both parties might benefit.

Calling party is the benefit recipient The first broad category is in many ways an extension of the one-way interconnection literature. That is, models start with a characterization of the amount of competition that prevails in retail markets (the analogue to downstream competition with one-way interconnection), then essentially view interconnection as similar to an essential facility, and finally determine the retail prices that would result from the competitive structure in question, as well as the interconnection charges that would arise from that competition and/or would be set by a regulator to maximize welfare.

For example, Laffont and Tirole (2000, pp. 190–96) model the case of duopoly competition, employing the symmetric Hotelling model to depict the competition for the common subscriber base in the service territory. The implications of the model are (1) in the absence of the need to recover fixed shared and common cost, a regulator would set the interconnection charge at less than cost (to offset the effect of less than perfect retail competition),[27] (2) depending on the magnitude of the fixed costs, the socially efficient access charge could be above or below cost, and (3) *if* the competitors were allowed to collude to set an interconnection price that generated monopoly prices, the interconnection charge would exceed cost.

The possibility that unregulated termination charges could exceed the socially optimal levels has been one motivation for introducing complications into the representation of two-way interconnection representations. For example, Poletti and Wright (2004) consider whether the following influence the extent to which voluntary interconnection prices depart from optimal levels: (1) the existence of heterogeneous customers (high versus low volume customers, with perhaps different splits of placing and receiving calls), (2) whether low volume customers subscribe at all, given the available prices (participation constraint), and/or (3) whether carriers are able to price discriminate between high and low volume customers, based on alternative price plans (incentive-compatibility constraint). Although the authors find that firms would negotiate cost-based prices when customers are homogeneous, the negotiated interconnection prices could depart substantially from optimal levels when customers are heterogeneous and the incentive and participation constraints bind.

Calling and called parties share the benefit Approximately coincidental with the FCC's ongoing investigation of intercarrier compensation (which encompasses both one-way and two-way interconnection charges), a number of articles based on a call as a jointly consumed product emerged. As part of that investigation, DeGraba (2000 and 2002b) listed three premises in support of his 'bill and keep' proposal – eliminating interconnection charges in certain situations:[28] (1) that both calling and called parties benefit from a call, (2) competition works more effectively when networks charge their own customers, because interconnection payments are made to other carriers that possess a bottleneck to gaining

access to their customers, and (3) bill and keep would eliminate the arbitrage opportunities arising from similar access arrangements being priced differently for different types of carriers. DeGraba also noted that the per-minute charges that are pervasive in interconnection tariffs (and extremely prominent in the theoretical literature) are difficult to determine and, as noted earlier, may not align with the way costs are incurred.

In response to the FCC's request for comments on DeGraba's and other proposals, Hermalin and Katz (2001) presented a formal framework for evaluating the bill and keep concept. Focusing on the premise that both the calling and the called party may benefit from the call, they present a model in which two networks exchange traffic and charge customers for both originating and receiving calls.[29] The fundamental question is then what level of interconnection charge would induce the networks to set efficient retail prices (for making and receiving calls).

When sender and receiver have the same demand conditions; that is, enjoy the same benefit from calling, then the efficient calling and receiving prices are the same, and under perfect competition their sum would equal the sum of the marginal costs of the two networks. Consequently, the interconnection charge would be the amount necessary for the each carrier to just break even:

$$a = (c_2 - c_1)/2$$

where c_1 is the marginal cost of the first network and c_2 is the second network's cost.[30] Note that (1) if the networks have the same cost characteristics, the interconnection charge is zero (bill and keep),[31] and (2) the charge would be negative if the calling party's network had higher costs.[32]

Accounting for demand considerations would reduce the interconnection charge paid to the receiving party's network if the called party valued the call less than the calling party and vice versa if the called party received the greater benefit.[33] For example, in a commentary on DeGraba's bill and keep proposal, Wright (2002) suggested that the benefits to wireline customers might be greater if there were more wireless customers that could be called. This, in turn, suggests the wireline customers pay a higher price for calling, which in turn would be reflected in higher (i.e. most likely greater than zero) interconnection payments to wireless carriers.

Finally, although some derivations of bill and keep as potentially efficient are based on the presence of retail charges for receiving calls, there are other derivations that suggest that bill and keep is an approximately efficient outcome. For example, when analysing efficient interconnection charges for dial-up calls to ISPs, Wright (2004) first observed that the efficient charge for interconnection when the ISP is served by another network would be (the difference between the price of a local call (in this case to the ISP) and the cost of an end-to-end

call reduced by the cost the caller's wireline network avoids because it does not have to terminate the call to a customer on the same network.[34] He then makes the practical observation that termination charges may be so small that the cost of measurement outweighs any benefits from nonzero interconnection charges.[35] In fact, when there is no retail charge for each local call (which is typically the case for residential customers in the US), Wright's equal markup approach would imply a negative interconnection payment; that is, the carrier serving the ISP would pay the calling party's network, which would offset the losses incurred from pricing local usage below its marginal cost.

Further, even though bill and keep is possibly an efficient outcome for a two-way interconnection arrangement, proposals for unified intercarrier compensation mechanisms, such as the US FCC's ongoing investigation, may be applied in typical one-way arrangements as well, hence if there were a bill and keep arrangement for a particular form of interconnection, long-distance carriers would pay nothing for call origination or termination.[36] In this context, Gilo and Spiegel (2004) derive the interesting result that if there were competing local networks (which themselves had a two-way interconnection arrangement) to which a long-distance network could originate and terminate its calls, bill and keep for the long-distance carrier is an outcome that could result from unregulated negotiations among the local and long-distance networks.

Two-way interconnection: summary and implications for interconnection pricing policy

The alternative frameworks for analysing two-way interconnection produce somewhat different fundamental outcomes. When the calling party is viewed as the only source of demand, the interconnection charge becomes a mechanism for ensuring that the customer faces the full cost associated with a call. However, because of factors such as demand conditions for local calling, the nature of retail competition for local calling, and the possibility that the interconnection charge may need to recover fixed shared and common costs and/or subsidies such as those supporting universal service, there can be Ramsey-like departures of optimal interconnection prices from cost. Thus not only are the information requirements challenging, but also determining whether optimal charges would be above or below cost depends on the empirical data and the analytical approach used in particular instances.

When both the calling and called parties are assumed to benefit from a call, an interconnection charge would reflect the relative benefits, as well as possible cost differences, between interconnecting networks. When parties enjoy the same benefits from calling and their networks have the same costs, then the optimal interconnection charge would be zero-bill and keep. Of course, departures from this outcome would be the result of comparably complex considerations that arose in the alternative framework.

The practical implication of these results (to the extent that recovery of fixed shared and common costs and/or subsidies can be accomplished through other means, i.e. there is no need to include 'taxes' in interconnection charges) is first that the complexity of the task of establishing these charges is reduced. However, both demand conditions and cost differences between networks would still pose formidable information requirements and the outcomes from such analyses can be both unexpected (e.g. payments from the network of the called party to the calling party's network) and controversial (depending on which networks have substantial interconnection payments or receipts).

Accordingly, the favourable reception bill and keep proposals have received in some circles is quite understandable. Eliminating explicit payments between carriers not only considerably reduces if not eliminates much of the information that would otherwise be required (and hence the cost of regulation), but it would also have the prospect of shifting the competitive energies from figuring out ways to extract payments from competitors to investing in order to provide innovative services that attract customers.

Access and interconnection pricing in the US: historical trends and future direction

The existing system of interconnection and access prices that prevails in the US and how that system has evolved illustrate many of the theoretical and policy issues discussed in the preceding sections. Before the divestiture of AT&T in 1984, there was little competition for either local or long-distance services (legal or otherwise) and long-distance prices were well above cost, in order to provide a subsidy for the basic telephone service. The AT&T divestiture created perhaps the prototypical one-way interconnection arrangement, with the newly divested local exchange carriers providing the upstream service and AT&T and its long-distance competitors providing the downstream service. From that time until the early part of the 2000s, the former affiliates of AT&T were for the most part precluded from competing in the downstream market. This arrangement eliminated the potential for anticompetitive problems to arise when a vertically integrated provider competes with dependent firms in the downstream market.

But the fact that the initial access charges inherited the subsidy burden previously carried by long-distance prices created an ongoing concern that long-distance carriers would have incentives to inefficiently 'bypass' the local exchange access services and in the process severely undermine the generation of subsidies for universal service.

Consequently, there has been a long-running trend of per-minute access charge reductions, offset by increasing monthly charges assessed directly on customers and in surcharges (essentially taxes) applied to the revenues of certain classes of carriers. In particular, the initially high per-minute access charges

were reduced by almost a half (in nominal terms) between 1984 and 1989, while a charge assessed to end-users increased from US$0.00 to US$3.50 per month. Shortly after the passage of the 1996 Telecommunications Act, the FCC (1) established rules for establishing two-way interconnection charges at rates that were well below the prevailing access charges for long-distance services,[37] and (2) shifted certain costs that were not deemed to be usage-sensitive to monthly end user charges. In 2000, the FCC (2000) approved a plan developed by a consortium of local exchange and long-distance carriers that continued the shift from per-minute usage charges to end-user charge.[38] Table 13.1 illustrates these developments.[39]

Table 13.1 History of US interstate long-distance access and residential subscriber line charges (US$)

Year	Monthly customer charge (residential primary line), US$	Per Minute Access Charge, US$
1984	0.00	0.1726
1989	3.50	0.0911
1997	3.50	0.0604
2000	3.50	0.0285
2004	5.96	0.0144

The trends depicted in Table 13.1 reflect some harmony in the positions of regulators and competing carriers: to the extent that possible costs not associated with usage should be removed from per-minute charges and replaced, if necessary, with flat rate charges assessed on end users. Thus, while at any particular time incumbent carriers may oppose unilateral reductions in per-minute charges, and the carriers that purchase these services may advocate cost-based rates,[40] the disagreements arise more because of factual disputes (such as the magnitude of costs) and how the transition from current rates to more reasonable and sustainable ones can be implemented rather than because of conflict over the generally desirability (for both theoretical and practical reasons) to have regulatorily imposed per-minute access and interconnection charges as low as possible.

The per-minute charges presented in Table 13.1 are the averages paid by long-distance carriers for originating and terminating calls subject to the jurisdiction of the FCC (i.e. between states) in the territories of the large (non-rural) local exchange carriers. Numerous other rates apply for other interconnection arrangements, including access for intrastate long-distance calls for large carriers, interstate and intrastate access rates for smaller rural carriers, interconnection

between wireline and wireless carriers, and interconnection of incumbent and entrant local exchange carriers. Even more significantly, these rates vary considerably. For example, ICF (2004, Appendix C) – the Intercarrier Compensation Forum – reports interstate rates for one end of a call well under US$0.01 per minute, which is consistent with the level shown in the table. These large carriers charge over four times as much for intrastate long-distance access. Small incumbent (rural) carriers charge two to three times as much as large carriers for interstate and intrastate access and the corresponding rates for local exchange entrants are somewhere in between. However, for the exchange of local traffic, which under the Telecommunications Act must equal the additional cost a carrier incurs to terminate the traffic, average costs are approximately US$0.002 for non-ISP traffic and US$0.001 for ISP traffic, or several times lower than the interstate access charges for large incumbents. Indeed, there is a 50-fold difference between the lowest average per-minute rate (US$0.001) and the highest (US$0.05) charge by small incumbent local exchange carriers for intrastate long-distance access.

In large part motivated by these big discrepancies, the FCC (2001b) initiated a review of intercarrier compensation, with the objective of unifying the disparate charges. According to the FCC, such reform was necessary to overcome the following inefficiencies and problems in current rules and prices: (1) the arbitrage incentives from widely varying rates for similar interconnection services, (2) the possible exercise of market power by terminating networks, (3) possible inefficiencies arising from cost difference between interconnecting networks, (4) the possibility that inefficient interconnection rates could be reflected in inefficient retail prices, and (5) the possibility that inefficient interconnection rates could result in inefficient customer choices among competing carriers. A major focus of the FCC's investigation has been DeGraba's bill and keep proposal, which was discussed in an earlier section.

Because, in part, of the large amount of revenue raised by current charges[41] and the otherwise sweeping nature of a unified compensation regime, the FCC has yet to order a plan, although there have been specific proposals from various parties. For example, following a process somewhat similar to that which resulted in the FCC's 2000 approval of a consortium's access charge reform proposal, the ICF[42] has offered a proposal that includes four major elements. First, for the facilities that interconnect networks, the plan designates which carrier is responsible for arranging the facilities and, in the case of interconnecting with an incumbent local exchange carrier, regulates the monthly charges for these facilities.[43] Second, the plan calls for unified default per-minute charges within three years of the plan's beginning at a rate of US$0.000175, which is only a fraction of the lowest per-minute charge that currently prevails. Subsequently, over a three-year period, that unified charge would be lowered to zero-full bill and keep for all formerly usage-based charges.[44] Third, end-user

charges added to basic service prices would gradually increase from an initial level of US$6.50 per month (somewhat higher than the current average charge) to US$10. Fourth, the universal service funding source would shift from a percentage surcharge on the revenues of certain types of carriers to a per month assessment, based on working telephone numbers and other non-switched connections to end use customers. At the time this chapter was written, the FCC (2005) had just begun a proceeding that requested comments on this and other comprehensive proposals. There will undoubtedly be disagreement with the form and particulars of the competing proposals that will emerge from the proceeding.[45] Nevertheless, the general changes proposed by ICF – more uniform and lower per minute charges, higher charges for basic services, the need for clear and consistent responisbilities between carriers seeking interconnection, and the establishment of sustainable universal service funding for high-cost areas – will probably characterize the next interconnection and access charge regime, if and when it emerges.

Conclusions

Establishing efficient, yet at the same time practical, interconnection charges in telecommunications is challenging because of the breadth and complexity of interconnection arrangements. In particular, factors such as (1) the historical use of above-cost prices to subsidize universal service, (2) the growing need for interconnection arrangements among carriers offering customers different services with different technologies (e.g. wireline and wireless), and (3) the difficulty in aligning increasingly complicated prices for consumer products with the underlying cost structure of interconnection and access facilities, make the establishment of access and interconnection charges that have the welfare-enhancing properties predicted by particular theoretical models a difficult task. Also, while such charges have traditionally had a volume-sensitive component (e.g. a per-minute charge), there has been an inexorable trend towards much lower usage charges in the US – a trend that almost certainly will continue, perhaps culminating in no ('bill and keep') interconnection and access charges. That trend is the result of the combination of (1) the fact that the associated marginal (or incremental) costs for interconnection are relatively low, and (2) the theoretical and practical difficulties of establishing and maintaining above-cost charges.

The application of the findings from the telecommunications literature to other industries, such as electricity, most likely lies in one-way interconnection applications because, unlike a telephone call, most products are consumed exclusively by the buyer.

Consequently relationships among interconnecting firms are likely to be the classical vertical arrangements that underlie the analysis of one-way interconnection. Accordingly, the key issues are establishing interconnection charges

that facilitate efficient, non-discriminatory competition in downstream markets. To the extent that prices and access charges are usage-sensitive, the theoretical findings from the telecommunications literature would apply. Accordingly, as in telecommunications, the challenge in designing access charges in practice is aligning downstream prices and access charges with the cost structure of access.

Notes

1. Laffont and Tirole (2000, p. 139) describe how in 1996 two incumbents in California claimed that 'bill and keep' for interconnection with competing carriers was tantamount to a taking of their property. As I discuss in more detail below, some incumbents, including the corporate parent of one of the two California incumbents, have endorsed 'bill and keep' interconnection charges. Under a 'bill and keep' interconnection arrangement, interconnecting carriers exchange traffic with a volume-sensitive charge equal to zero. There may be flat charges (e.g. fixed monthly rates) for the interconnection facilities themselves.
2. See, for example, Armstrong (2002) and Laffont and Tirole (2000, Chapters 3–5).
3. See, for example, Weisman (2003).
4. Wireless (primarily mobile) and traditional wireline services have not been very close substitutes when the former is a relatively new service, wireless prices are high and/or subscribership is low. However, when wireless and wireline prices become much closer and (as in some countries) wireless subscribership approaches or even overtakes that of the traditional telephone service, the two technologies become closer substitutes. As we discuss later, access and interconnection prices must account for this development.
5. The amount of these intercarrier payments can be significant, even when they are purportedly close to the cost of providing interconnection. And to the extent that the interconnection rates are above cost (e.g. for fixed to mobile call completion in countries such as Brazil), intercarrier payments can constitute a large proportion of the revenues of certain carriers.
6. These issues are also discussed in Noam (2002).
7. For example, the 1996 Telecommunications Act in the United States clearly stated an objective of promoting competition. At the same time it contained detailed prescriptions for funding universal access to traditional wireline telephone service; see, Kahn et al. (1999) and Tardiff (2002).
8. For example, in upholding the FCC's rules for setting the prices of unbundled network elements pursuant to the Telecommunications Act of 1996, the US Supreme Court noted: 'The Act thus appears to be an explicit disavowal of the familiar public-utility model of rate regulation ... presumably still being applied by many states for retail sales, ... in favor of novel ratesetting designed to give aspiring competitors every possible incentive to enter local retail telephone markets, short of confiscating the incumbents' property' (Supreme Court of the United States, 2002, Majority: 16–17). See also Weisman (2002b).
9. For example, the number of possible connections is given by $P(n) = n(n-1)/2$, where n is the number of subscribers.
10. As described earlier, there are different one-way access arrangements, such as per-minute call origination and termination charges assessed by local exchange carriers on long-distance carriers, and monthly rental changes for unbundled subscriber loops provided by incumbent local exchange carriers to new competitive carriers in a common service territory, etc. The discussion in this section generally applies to all such one-way arrangements.
11. See, for example, Baumol and Sidak (1994).
12. Indeed, as we discuss below, because such prices can become a multitask workhorse, the question of whether other policy instruments should be used for some of the tasks arises.
13. The downstream marginal cost would be the sum of the marginal cost of the access service obtained from the incumbent plus the additional costs incurred by the downstream firm.
14. A corollary of the efficient access price problem is establishing the minimum pro-competitive price (price floor) for the incumbent's downstream service. The findings discussed in this

section apply equally to determining such minimum prices; see, for example, Hausman and Tardiff (1995) and Weisman (2002a).

15. Armstrong (2002, p. 311) provides a more general statement of the ECPR: 'access charge = cost of providing access + incumbent's lost profit in retail markets caused by providing access'. The statement generalizes the version of the ECPR stated in the text, because demand and/or cost conditions may be such that the lost retail profits differ from those contained in the incumbent's downstream price.
16. This outcome would appear to have perverse dynamic efficiency consequences: efforts by the incumbent to lower costs in the downstream market would in turn decrease the access charge their competitors would pay.
17. Laffont and Tirole (2000, p. 102) explain how universal service obligations can be treated as a component of the incumbent's fixed costs.
18. See, for example, Tardiff (2002) and Armstrong (2002, pp. 334–5).
19. See, for example, Laffont and Tirole (2000, pp. 149–57) and Hausman (2003).
20. When market power is defined as the ability to charge prices that result in supranormal profits, a price that is above marginal cost does not necessarily imply market power. Firms with fixed shared and common costs must charge above marginal cost in at least some markets to earn normal profits.
21. Indeed, in the US, at the directive of the DC Circuit Court, the FCC (2004c) recently removed end-office switching from the list of network elements incumbent local exchange carriers are required to provide to competitors at regulated prices.
22. Armstrong (2002, pp. 319–21) presents a version of the ECPR that accounts for the possibility of substitution away from the access input provided by the incumbent. The erosion of the essential nature of access also has implications for establishing minimum prices for the incumbent's downstream services. For example, Weisman (2002a) proposes that the amount of forgone contribution called for by ECPR be multiplied by the proportion of a competitor's downstream output that requires the incumbent's access input. Consequently, as the access input becomes ubiquitously competitively supplied, the incumbent's minimum pro-competitive price would be its marginal (or incremental) cost, without any mark-up for forgone contribution (Hausman and Tardiff, 1995).
23. Models that address various aspects of interconnection pricing include the following examples: Armstrong (2002, 2004), Berger (2005), Cambini, et al. (2004), DeGraba (2000, 2002a, 2002b, 2003, 2004), Dessein (2004), Hermalin and Katz (2001), Gilo and Spiegel (2004), Jeon et al. (2004), Laffont and Tirole (2000), Poletti and Wright (2004) and Wright (2002, 2004).
24. While these payments are typically usage-based charges from the firm serving the calling party to the firm serving the called party in practice, theoretical models can produce negative charges in some cases.
25. In some recent regulatory proceedings in the US, there has been movement away from per-minute cost and price structures for switch usage. For example, the FCC's Wireline Competition Bureau (2003) and the California Public Utilities Commission (2004) establish a flat monthly rate in lieu of a per-minute rate for wholesale switching provided by incumbent firms to competing local carriers.
26. In fact, in the US because of concerns that entrant competitive local carriers were charging long-distance companies too much to terminate calls on their networks, the FCC (2001a) limited the size of such charges, based on comparisons with comparable rates of incumbent local carriers.
27. The intuition behind setting interconnection prices at cost if retail competition were perfect is that (1) the calling party should face the full marginal cost of the call and (2) the cost of terminating the call on the called party's network is part of that full cost.
28. As we describe in more detail below, the FCC's investigation and DeGraba's proposal encompass both one-way and two-way interconnection payments.
29. The authors employ a similar approach in Hermalin and Katz (2004).
30. The calling party's network incurs a cost of c_1 and pays the other network an interconnection charge of $(c_2 - c_1)/2$, resulting in total costs of $(c_1 + c_2)/2$, or half of the total costs of the call.

31. Armstrong (2004, p. 389) also observes that if there is a retail charge for receiving calls, the optimal interconnection arrangement could be bill and keep.
32. It is interesting to contrast this property of efficient interconnection charges with how carriers that terminate calls to ISPs are typically compensated. For ISP-bound calls, (1) both the calling party (the ISP's customer) and the called party (the ISP) benefit from the transaction and (2) the costs to terminate the Internet call (at least when assessed on a per-minute basis) are likely to be lower than the costs incurred on the calling party's network. Thus, Hermalin and Katz's analysis suggests that the ISP's network should pay the calling party's network, and not vice versa as happens in the real world. However, Hermalin and Katz note that if the more expensive network received the interconnection payment (regardless of the direction of the call) there would be perverse incentive properties, i.e. investments that reduced network costs would result in higher interconnection payments. DeGraba (2003, p. 213) also observes that efficient interconnection charges can be negative when the costs of the terminating party's network are lower.
33. See, for example, Jeon et al. (2004, p. 88).
34. This observation is equivalent to Armstrong's (2004, p. 380) 'equal markup' rule.
35. Similarly, Berger (2005) concluded that when the called party benefits from a call but only the calling party pays, efficient interconnection charges are less than cost (in order to capture the network externality) and in certain circumstances, the efficient charge would be zero.
36. Future recovery of costs that were covered by such charges would be shifted to local carriers' customers under unified mechanisms.
37. For example, while the average access charge under the FCC's jurisdiction was approximately US$0.03 per minute in 1996, the FCC's local competition rules (FCC, 1996) established a default rate of US$0.0015 per minute.
38. The consortium included three of the four large incumbent local exchange carriers (Verizon, SBC, and BellSouth) and two of the three largest long-distance carriers (AT&T and Sprint).
39. FCC (2004a, pp. 1–5, 1–6). The access charges are the sum of originating and terminating charges on both ends of the call – the charge at a single end is approximately half of the list value. These charges apply to services under the FCC's jurisdiction. Each state has separate rates for calls it regulates.
40. For example Armstrong (2002, p. 336) observes that entrants generally favour cost-based pricing, while incumbents favour the ECPR.
41. For example, usage-based interstate access charges accounted for about US$4.4 billion in 2002, which because of the rebalancing that began in 2000 was over 50 per cent lower than the US$9.7 billion from 1999 (FCC, 2004b, p. 164). In the case of rural carriers, Glass (2004) reports that fully half of their revenues are payments for other carriers intended to keep customer rates lower than what cost-based rates would require in these typically high-cost areas.
42. The ICF includes the three major long-distance carriers, one of the four large incumbent local exchange carriers (SBC), a rural telephone company, and local exchange entrants. Although the other three large local exchange carriers (Verizon, BellSouth, and Qwest) have not at this time signed up to the specific provisions of the ICF proposal, all had previously endorsed some form of bill and keep arrangement for usage charges, at least in the case of two-way interconnection of local exchange networks.
43. DeGraba's proposal contained a similar provision, which would require the calling party's network to arrange facilities that connect with the switching locations (central offices) of the called party's network.
44. The ICF proposal would allow interconnecting parties to negotiate rates that differ from the default usage charges specified in the plan, e.g. when the 'bill and keep' provisions take effect, parties could agree to establish a positive charge for exchanging traffic.
45. For example, the Alliance for Rational Interconnection Compensation (2004), a group of rural, high-cost carriers, disagrees with the rationale DeGraba offered for a bill and keep regime.

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