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**Regulating Network-Based Industries:
The Case of Telecommunications**

Henning Klodt

September 1996



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Abstract

A mandatory open-network-provision (ONP) by dominant firms is the appropriate government regulation in the presence of network externalities. For basic telephone services and online services, a permanent ONP regulation seems indispensable, whereas telecommunication networks only require transitional ONP regulation as long as public or privatized PTTs dispose of a dominant market position.

Regulatory institutions tend to prefer either cost-plus or price-cap contracts for defining appropriate price-ceilings for network-access under ONP regulation. In order to avoid the specific disadvantages of both, governments should better apply incentive contract schemes which allow a sharing of efficiency gains among producers and customers.

JEL-Classification: D82, L51, L96

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Abstract

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I. Introduction*

Telecommunications has long been regarded as a typical "natural monopoly" where unrestricted private competition would result in severe monopolistic inefficiencies. Almost all over the world this industry was heavily regulated and dominated by public enterprises. Over the past decades, however, several countries have adopted a liberalization approach which started in the United States, swept over to Japan and the United Kingdom and finally reached continental Europe. This shift towards deregulation and privatization was basically effected by three major developments:

- First, the market position of public enterprises was eroded by the rapid development of new technologies which enabled the entrance of new competitors at the rim of the public monopolies.
- Second, governments became increasingly aware of the fact that excessive pricing and allocative inefficiencies may be even more severe with public monopolies as with private monopolies. The attempts to cope with market failure by establishing public monopolies had obviously generated substantial institutional failures.
- Third, new developments in the theory of industrial economics significantly altered the economists' view about the conditions for a stable natural monopoly. It was recognized that markets may be highly contestable even in the presence of large economies of scale and monopolistic market structures.

* Paper presented at the Egon-Sohmen-Symposium "Privatization at the Turn of the Century", Budapest, September 6-7, 1996. The results are mainly based upon a research project under the "Reports on Structural Adjustment" (Strukturberichterstattung), which are commissioned by the German Federal Ministry of Economics. I would like to thank Jens Oliver Lorz and Rainer Maurer for helpful suggestions and comments. I am also grateful to the participants of the Egon-Sohmen-Symposium, above all to Stephen C. Littlechild and Klaus M. Schmidt.

The liberalization of telecommunications is still in process, and many issues are still unsolved. The crucial question is the appropriate role of government after privatization. Will privatization and deregulation solve all problems, or will some government regulation still be required - and if so, which ones? The following parts of the paper are mainly concerned with these issues. The basic questions are: why to regulate (section II), where to regulate (section III) and how to regulate (section IV). Section V concludes.

The analysis is addressed to basic regulatory issues which may be relevant also for other network-based industries such as utilities and railways. It would go far beyond the scope of this paper, however, to present a detailed evaluation of regulatory issues for all these industries. Instead, the focus is on telecommunications where public debate and actual liberalization policy are most vivid and where the author can rest upon a recently published study about the regulatory requirements in German telecommunications after the complete dissolution of public monopolies in 1998 (Klodt, Lorz, Maurer, 1994).

II. Why to Regulate: Competitive Potentials of Telecommunications

At present, the German market for telecommunication is still dominated by the Deutsche Telecom AG, which was transformed into a stock-company in 1994 and will be partly privatized in autumn 1996 and later on. It still has the exclusive right of providing basic telephone services (voice telephone) and an almost exclusive right of providing cable and wireless telecommunication networks. In the early 1990s, the telephone market was somewhat opened by the establishment of two private cellular phone networks which started in 1992 (D2) and 1994 (e-plus). By the end of 1996, a third cellular phone license (E2) will be granted and corporate networks will be allowed to provide non-voice telecommunication services to the public. In 1998, finally, all remaining public telecommunication monopolies will be dissolved in Germany and most other EU countries. In order to create an adequate regulatory framework for the future, the German parliament has just past the Telekom-

munikationsgesetz (telecom law), which will take effect on 1 January 1998 and will completely replace existing German telecommunication laws.¹

Although the basic decisions about future regulation of telecommunication are made, there is still a lively debate about the implementation of the new law. It is still open, for instance, whether the new regulatory framework is intended as permanent or only as transitional guidance from public monopolies to fully private competition. In addition, the optimal design of price control mechanisms, universal service provision and the regulatory segmentation of telecommunication from broadcasting are heavily disputed. The economist's answers to such questions strongly depend upon the evaluation of basic technological features of telecommunication markets.

1. Natural Monopolies in the Light of the New Industrial Economics

Network-based industries have long been regarded as natural monopolies because ever-declining average costs would give the incumbent an invincible cost advantage against new entrants. Unregulated private monopolies, it was argued, would be able to set monopoly prices, would restrict output to an inefficient level and would earn excessive monopoly profits.

The perception of natural monopolies was dramatically changed by new developments in industrial economics - especially by the theory of contestable markets, which was developed in the context of breaking up the monopoly position of AT&T in the United States. In the pioneering work of Baumol, Panzar and Willing (1982) it was shown that a natural monopoly in networks does not necessarily imply the existence of a natural monopoly in network services. If there are no significant economies of scope between the provision of networks and the

¹ For a survey of international developments in deregulating telecommunications see, e.g., Tyler and Bednarczyk (1993) and Welfens and Graak (1994).

provision of services, there is no reason for a multi-product monopoly even if both segments display significant economies of scale. For the case of telecommunications, it was concluded that the extent of scope economies is rather low. Hence, networks and services may be separated without substantial losses of economic efficiency. The same basically applies to railroad transport and utilities, where a separation of network provision from the production of services is also technologically feasible.

Moreover, it was demonstrated that markets may be competitive even in the presence of high fixed costs, if these costs are not sunk, i.e., if the dominant market position of an incumbent can be attacked by hit-and-run competition of new entrants (contestability). In this case, the market performance of an unregulated private monopoly may be similar to the performance under perfect competition, where no government regulations are required. Finally, potential competition from neighboring markets must be taken into account if the products of those markets are close substitutes to the products of the market under consideration (intermodal competition). Hence, an evaluation of the intensity of competitive pressure on dominant firms requires an assessment of the contestability of the respective market and of the intensity of intermodal competition.

There are two major policy lessons from the new industrial economics:

- First, the scope for welfare-enhancing government regulation appears much narrower than previously expected. No supervision of private monopolies is required if the respective markets are contestable or are under the pressure of intermodal competition.
- Second, the design of regulatory policies changes from a comprehensive to a minimalistic approach. In previous decades governments had tended to completely regulate market performance in network-based industries, and sometimes regulation even spread to neighboring markets such as road transport and private wireless communication. According to the new theories, regulation should concentrate on

"monopolistic bottlenecks" without interfering into non-monopolistic market segments.

2. Scale Economies and Network Externalities

A significant impediment to competition in telecommunication may result from the existence of large *scale economies*. They can be traced back to three major reasons:

- The two-thirds-effects: "thick" cables are relatively cheaper than "thin" ones, because the installation costs of cable networks mainly result from construction work and not from material costs of cables. Equivalently, the costs of radio masts do not proportionally increase with capacity.²
- Density effects: the infrastructure costs per household are decreasing with population density, because a high density allows the installation of more series-connections.
- Stochastic demand effects: as the time profile of demand from different customers will probably exhibit different patterns of peaks and troughs, the maximum network capacity per customer is declining with the total number of customers.

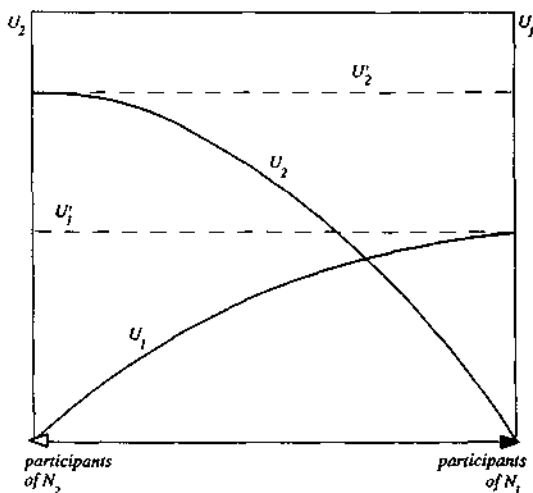
Hence, it can be expected that an infrastructure monopolist will have lower network costs than a number of independent network suppliers.

The second important technological feature of telecommunications is the existence of *network externalities*. For the customers of a telephone service, for instance, the utility highly depends upon the total number of participants. Hence, the entrance of an additional participant generates a positive utility for all other participants without financial compensation. Moreover (and more important), network externalities may create

² The term "two-thirds-effects" refers to the fact that the surface of cables approximately increases by a factor of two thirds with cable volume.

lock-in effects, which can be illustrated by a simple model as presented in Figure 1.

Figure 1 - Network Externalities and Open Network Provision



The right hand vertical axis displays the utility per customer (U_1) of an existing network (N_1), which increases with total number of participants. The utility of customer i is given by

$$U_{1,i} = U_{1,i}(n_1, p_1),$$

where n_1 is an index of the technological properties of Network N_1 and p_1 represents the total number of participants of N_1 . It can be assumed that U_1 will be convex with respect to p_1 . The utility per customer of a new, technologically superior network (N_2) is displayed at the left-hand vertical axis, where the horizontal axis is inverted. Technological superiority results from $n_2 > n_1$, i.e., for a given number

of participants (\bar{p}) customers would be better-off with the new network

$$U_{2,i}(n_2, \bar{p}) > U_{1,i}(n_1, \bar{p}).$$

No individual participant has an incentive, however, to change from N_1 to N_2 because the technological advantage of N_2 is more than offset by the higher number of total participants of N_1 . The provider of N_1 is able to monopolize the complete network market and the implementation of N_2 is blocked. Hence, the economy is locked-in to an inefficient technology (Arthur, 1989; David, 1985; Katz and Shapiro, 1985, 1994).³

This type of market failure can be avoided by the installation of network bridges, which enable the participants of N_2 to communicate with N_1 -participants.⁴ In this case the utility of N_2 -participants is given by

$$U'_{2,i} = U'_{2,i}(n_2, p_1 + p_2),$$

which is indicated by the dotted line U'_2 in Figure 1. U'_2 is a horizontal line because $(p_1 + p_2)$ is a constant. For each $p_1 > 0$ the utility of an interconnected network will exceed the utility of a non-connected network. A similar utility function (U'_1) can be constructed for an interconnected network N_1 .

³ Liebowitz and Margolis (1994) are citing a number of cases, however, where such lock-in effects were surmounted in reality. In the context of Figure 1, for instance, the provider of N_2 could offer favourable subscription prices until the number of N_2 participants exceeds the "critical mass" at the intersection of U_1 and U_2 .

⁴ In this paper, the term "network bridges" is used as a synonym for all types of bridges, routers, gateways and other appliances for network interconnection.

If there is no price differentiation between N_1 and N_2 , an N_2 -monopoly is the only stable equilibrium. However, the provider of N_1 will probably be able to prevent the collapse of his market share by lowering prices. If a significant part of network costs is sunk, price-cuts may even go below average costs, which may keep at least some customers into the old network. The final outcome of oligopolistic competition among network providers is hard to predict, because it depends on the specific properties of cost functions, on the extent of product differentiation between networks and differentiation of demand, and on the competitive behavior of network providers (Cournot vs. Bertrand). It may well result in a new monopoly of N_2 , but this outcome is still superior to the monopoly of N_1 which would result in the absence of network bridges. As technological progress continues, the new monopolist of N_2 can be expected to be delivered to competitive pressure from network N_3 , which will be able to attack the monopoly of N_2 if adequate network bridges between N_2 and N_3 are available.

Obviously, the provider of N_1 has no incentive to install network bridges on his own account, because they would undermine his initial monopoly position. Hence, there is scope for a welfare-enhancing government regulation which imposes the obligation of maintaining network bridges on network providers. Such a regulatory measure is able to increase the social value of both networks. In addition, it encourages the development and application of advanced network technologies and intensifies competition among network suppliers. In essence, this line of arguments is the theoretical base for a mandatory open network provision (ONP) in telecommunications.⁵ In the European Union, such a regulation was imposed upon all network providers by a decision of the Council of Ministers (1990) which was transferred into national German law by the Telekommunikationsverordnung in 1991.

⁵ In utilities, the principle of "third party access" (TPA) corresponds to the ONP principle.

Scale economies and network externalities can be regarded as necessary, but not as sufficient conditions for an economic vindication of government regulation. If there exist several competing networks, for instance, private providers will probably offer network bridges voluntarily, because customers will prefer open networks to closed ones.⁶ It might be argued that in such cases an obligatory open network provision would do no harm, because it would be redundant where network bridges automatically emerge from competitive pressure. However, such a view ignores the fact that an ONP regulation inevitably requires to define technical standards for network bridges, which may retard future technological development and may restrain competition from outsiders (Farrell, Saloner, 1985; Besen, Saloner, 1989; Besen, Farrell, 1994). The anti-competitive effect of inappropriate standards will be reinforced if regulatory institutions are under lobbying pressure from incumbents.

In addition, there may exist market niches for highly specialized small network providers which can only survive in the market if they are not forced to open up their networks to big network companies. In the course of time, small niche producers may grow and may exert significant competitive pressure on conventional networks. There may be good reason, therefore, to impose ONP regulation only upon network providers with a dominant market position. Hence, regulatory market interventions in telecommunications should be based not only upon the analysis of technological conditions for market failure, but also upon an analysis of the economic potential for competition.

⁶ Katz and Shapiro (1985) show that firms with low market power are more likely to prefer compatibility than dominant firms.

III. Where to Regulate: Contestability and Intermodal Competition on Telecommunication Markets

1. Services

According to the minimalistic approach as suggested by the new industrial economics, there is no reason for regulating *value-added services*, because there is strong monopolistic competition among service providers and barriers to entry are low. For the area of telephone services, by contrast, intermodal competition is low, because mail services and communication by e-mail or by the internet are much less comfortable, which makes them a quite imperfect substitute for telephone communication.

Table 1 - Cellular Phone Services in Germany

Network	Frequency (MHz)	Operation period	Participants	
			Capacity	Actual (mid 1996)
A	150	1958-77	10,000	
B	150	1972-96	26,000	<10,000
C	460	since 1985	850,000	600,000
D1	900	since 1992	4 mill.	1.8 mill.
D2	900	since 1992	4 mill.	2.0 mill. (a)
e-plus	1800	since 1994	8 mill.	400,000
E2	1800	since 1997	.	.

(a) The number of D2-participants increased to 2 million in August 1996.

Source: Klodt, Lorz, Maurer (1995, p. 18), updated by newspaper information.

As discussed above, the existence of network externalities also creates significant barriers to entry in the market for *telephone services* if no access to existing services is guaranteed. Only with an appropriate ONP regulation this market becomes contestable. In Germany, the

power of such a regulation was demonstrated by the highly successful and profitable introduction of the private D2 cellular phone service which went into operation in 1992 and has up to now acquired two million customers (Table 1).⁷ Without access of D2-participants to the existing telephone service of the Deutsche Telekom AG, such an impressive start-up performance of a private competitor would probably have never been feasible.

A similar conclusion can be drawn for *online services*, where intermodal competition from print media and other non-electronic services is low. And market entry by new online services is hampered by the fact that for large groups of customers the attractiveness of online services strongly depends on the availability of specific services. If these specific services can be monopolized, it may become feasible to monopolize also the market for online services. For instance, the acceptance of an integrated multimedia online service in Germany would be rather low if the offered services would not include TV transmission of major soccer games. In this context, many Germans are at present concerned by the exclusive right of broadcasting the next soccer world championship in 1998, which was granted by the FIFA to the Kirch trust and which will force consumers to subscribe to Kirch pay-TV.

In a longer-term perspective, however, there is some hope for soccer fans and other consumers, because the Kirch trust recently signed an agreement with the Bertelsmann trust which will enable consumers of digital pay-TV services to receive the broadcastings of both suppliers. This ONP accord was substantiated by an agreement upon the technical standards of the so-called d-box (a decoder required for receiving satellite TV programs). In the view of many observers, this voluntary ONP accord would not have been achieved if the Kirch trust would not have been under the threat of monopoly proceedings by the German Cartel Office (Wirtschaftswoche, 1 August 1996).

⁷ The A-, B-, C-, and D1-networks are run by the Deutsche Telekom AG. c-plus is the second (but much less successful) private cellular phone service in Germany.

In essence, the low contestability of online service markets is the effluence of oligopolistic market structures in the media markets. In order to prevent a spill-over of monopoly power to the market for online services, governments should impose an ONP regulation on large online service providers. An overview of competitive potentials in telecommunication services is presented in the upper part of Table 2.

Table 2 - Competitive Potentials in Telecommunications

	Contestability	Intermodal competition
Services		
Telephone	x*	-
Value-added	x	x
Online	x*	-
Networks		
Cable	-**	x
Cellular phone	-	x
Satellite	-**	x

*Contestable with ONP regulation. - **Hit-and-run competition by binding commitments.

2. Networks

The *contestability* of networks is low because large investments are required and the main bulk of installation costs is sunk. There are also significant scale economies which were described in the previous section. Nevertheless, new competitors may be able to enter the market if they can conclude legally binding contracts with potential customers (Baumol, Sidak, 1994). If the incumbent pursues excessive monopoly pricing, a potential competitor may offer more favorable prices to customers and may install a competing network.

This form of hit-and-run competition will only work, however, if the contracts between the customers and the new entrants are concluded in advance before the incumbent is able to lower prices in order to deter entry. For the customers, the decision to shift towards the new network is not time-consistent, because the post-entry prices of the incumbent may even be lower than the prices of the new competitor.⁸ Therefore, the legal power of the contracts between customers and the new entrant must be rather strong.

Moreover, it is essential for this strategy that the new entrant is able to identify his potential customers. This task may be quite difficult in the area of cellular phone services, because the regional mobility of users precludes the conclusion of regionally well-defined contracts. There may also appear significant transaction costs for the new entrant if the number of potential competitors is large and the economic value of each individual contract is small. Most observers agree, therefore, that the markets for telecommunication networks are hardly contestable.

Competitive pressure can rise, however, from *intermodal competition*. For more than hundred years this pressure was low because the cable was the predominant carrier of telecommunication services, whereas radio telephony was restricted to a few specialized applications. In recent decades, however, new radio-based technologies have entered the market which can serve as a more or less perfect substitute for solid networks. The most successful innovation was the cellular phone network, which had started already in the 1950s (see above Table 1), but which experiences a rapid take-off since the early 1990s.

Satellite networks are still in their infancy, but it can be expected that they will also play a dominant role in the telecommunication market after the turn of the century. At present, geo-stationary satellites are widely used for international connections of national solid networks,

⁸ If a large fraction of network costs is sunk, the incumbent will be ready to reduce prices to the level of marginal costs, which may destroy the profit opportunities of new entry.

but their potential for completely replacing cable networks is limited due to the large distance of their orbit from the surface of the earth (36,000 km). An independent satellite network requires the launching of low earth orbit satellites (LEOs), where the number of satellites required decreases with the altitude of the orbit. The most important world-wide satellite networks under construction are displayed in Table 3.

Table 3 - Major Projected Satellite Networks

Network	Number of satellites	Orbit altitude (km)	Installation costs (bill.\$)	Estimated start-up
Teledesic	840	700	9.0	2001
Iridium	66	780	3.5	1999
Globalstar	48	1,200	1.7(a)	1997
Odyssey	12	10,000	2.0	1998
Inmarsat	10	10,355	2.6	1999

(a) Low investment costs because the network can partly rest upon existing satellites.

Source: Klodt, Lorz, Maurer (1995, p. 60).

In addition, there is a variety of alternative networks, which already exist or can easily be installed, but which are not permitted for public telecommunication services under present legislation. Most important are the corporate networks of electric service companies, which have equipped large parts of their long-distance power transmission cables with optical fibers. Similar networks have been established by natural gas providers and - last not least - by the German railways company (Deutsche Bahn AG). The Telekom AG still disposes of the by far largest fiber network in Germany (Table 4), but the alternative networks could well be expanded at rather low costs. For instance, the Deutsche Bahn AG has completely equipped its long-distance railroad

network with copper cables for the cellular phone C net, which could easily be replaced by optical fibers.⁹

Table 4 - Optical Fiber Networks in Germany

Company	Industry	Network size (km)
Deutsche Telekom AG	telecommunications	87,000
Viag AG/Bayernwerk	electricity	4,000
Deutsche Bahn AG	railways	2,000
Rheinisch-Westfälische Elektrizitätswerke (RWE)	electricity	2,000
Veba AG	electricity/telecom.	1,300
Energieversorgung Schwaben	electricity	1,000
Wintershall AG	natural gas	1,000
Badenwerk	electricity	600
Vereinigte Elektrizitätswerke (VEW)	electricity	600
Hamburger Elektrizitätswerke (HEW)	electricity	270

Source: Klodt, Lorz, Maurer (1995, p. 20).

In 1998, all these corporate networks will be permitted to carry public telecommunication services of any kind (including voice telephone). One major obstacle of market entrance by corporate networks could be the limited technological expertise of the respective companies in the area of telecommunications. This problem is currently solved, however, by the forging of numerous strategic alliances between German

⁹ The fiber cables of the Deutsche Bahn AG displayed in Table 4 are installed along the high-speed railways (ICE).

corporate network owners and international telecommunications companies (Table 5).

Table 5 - Strategic Alliances of Major German Network Providers (a)

German network company	International partner
Deutsche Telekom AG Sales: 66.1 Empl.: 220	France Télécom (F) Sales: 50.8 Empl.: 150 Sprint (USA) Sales: 19.5 Empl.: 48
Mannesmann Sales: 34.9 Empl.: 123 DB Kom (b) Empl.: 6.5	AT&T (US) Sales: 114.2 Empl.: 302
Viag Sales: 41.9 Empl.: 84 RWE Sales: 63.6 Empl.: 137	British Telecom (UK) Sales: 32.4 Empl.: 135
Veba Sales: 72.4 Empl.: 125	Cable & Wireless (UK) Sales: 12.4 Empl.: 40
Thyssen Sales: 39.1 Empl.: 97	Bell South (US) Sales: 25.6 Empl.: 87

(a) Sales in billion DM, employment in 1000. - (b) Subsidiary of the Deutsche Bahn AG.

Source: Der Spiegel (1996, No. 29, p. 81).

The second obstacle to market entrance is the bridging of the so-called "missing mile", i.e., the geographical gap between the terminal point of

corporate telecommunication networks and private households. The high-tension cables of electricity companies only span over large distances and do not reach into agglomeration centers. The railway network goes into the heart of cities, but does not reach individual households. In essence, there appear to be three options for bridging the missing mile:

- First, corporate networks could be connected to the cable network of the Telekom AG at the local level.
- Second, corporate network providers could install local radio stations based upon the DECT technology (Digital European Cordless Telephone). In this case, private households would have to be equipped with cableless telecommunication appliances.
- Third, corporate network providers could cooperate with municipal utilities, which have access to each individual household by their gas, water and sewage pipes. There seem to be no major technical difficulties of furnishing these junctions with adequate telecommunication cables.

Actually, the first DECT frequencies will be assigned to private competitors of the Telekom AG by the German Ministry of Post and Telecommunications in the course of 1996. And several municipal utilities companies have established an organization for preparing their entrance into the telecommunication markets already in 1995 ("Arbeitsgemeinschaft Telekommunikation" within the "Verband kommunaler Unternehmen"). All in all, these developments are increasingly eroding the network monopoly of the Telekom AG. There seems to be no doubt, therefore, that all types of telecommunication networks will be under strong pressure from intermodal competition in the years to come (see above, lower part of Table 2).

3. Tentative Policy Conclusions

All in all, government regulation of telecommunication networks appears to be a temporary rather than a permanent task. In the long run

it can be expected that monopolistic behavior of network providers will be prevented by competing networks and that market failure from network externalities will be avoided by voluntarily installed network bridges. In the short run, however, network supply in most countries is strongly concentrated at dominant PTT firms (in Germany at the Deutsche Telekom AG), which deserves careful attention by regulatory authorities.

For Germany, it has been suggested to mitigate the short-term problem of network concentration by a separate privatization of the different Telekom AG networks, which include the ordinary telephone network, the cellular phone network of D1 and the cable-TV network (see, e.g., Klodt, 1996). The British experience has demonstrated that especially the cable-TV network can effect significant competitive pressure on the telephone network. The German government, however, seems not ready to adopt such an approach.

As long as the Telekom AG remains the predominant provider of networks, a mandatory ONP regulation should be imposed. A similar regulation can be recommended for basic telephone services, where actual market concentration is even higher than in networks and where new competitors will probably not be able to enter the market without unrestricted access to the telephone service of incumbents. A further area for ONP regulation is the market for online services, where open networks may prevent the spillover of concentration from the media market. If the regulatory agencies succeed in guaranteeing the ONP principle, no further sector-specific control of monopolistic behavior seems necessary. Moreover, independent institutions should examine the requirement of ONP regulation at regular time intervals in order to eliminate those regulations which have become redundant in the course of the competitive process.

These guidelines for telecom regulation are easily written down in working papers, but may be hard to implement in reality. The central problem of ONP regulation is the determination of adequate access prices. As the provision of network bridges is associated with costs, it

would not be appropriate to impose a regulation on network providers to offer network bridges without financial compensation. If access prices are not controlled, on the other hand, the network provider may charge prohibitive prices which completely invalidate ONP regulation. This issue is analyzed in the following section.

IV. How to Regulate: Concepts of Price Regulation

The traditional form of price regulation was cost-plus regulation, where the regulated firm declares its costs and the regulatory authority assigns a price ceiling which allows the regulated firm to cover its costs and to earn a "fair" rate of return on invested capital. There is a bulk of literature about the deficiencies of this type of regulation which basically points to insufficient incentives for cost reductions and to the "Averch-Johnson-effect", i.e., the incentives to increase capital intensity to inefficient levels (see, e.g., Liston, 1993).

Regulatory concepts were completely shuffled by the "price-cap revolution" which started from the regulation of utilities and telecommunications in the United Kingdom in the early 1980.¹⁰ The British government had lent an open ear especially to S.C. Littlechild (1983) who recommended a new type of price regulation which starts with a fix-price ceiling (p_{\max}) and develops over time as follows:

$$\dot{\Delta} p_{\max} = \Delta RPI - X$$

where RPI denotes the retail price index and X is "a number specified by the government" (Beesley, Littlechild, 1989, p. 455). In the German case of regulating the access prices of the Telekom network for the cellular phone provider D2, the historical difference between productivity growth rates in the economy as a whole and in the telecommunications industry was chosen for determining X . The idea was that this productivity differential can be expected to prevail in the future and that it delineates the development of access prices which would have

¹⁰ The term "price-cap revolution" was coined by Laffont (1994, p. 510).

emerged in a competitive environment. X may also serve for gradually withdrawing monopoly rents from the regulated firm or for gradually enforcing cost-reductions and productivity improvements.

The central purpose of price-cap regulation is to avoid the distortion of incentives for the regulated firm. If the price-cap rule is pre-announced and if the regulated firm cannot influence the level of X , there is no reason for choosing an excessive capital intensity and for retarding or postponing the introduction of cost-reducing technologies. Hence, allocative inefficiencies are likely to be reduced. This advantage over cost-plus regulation gave strong support to the price-cap concept in economic research and in economic policy as well (see, e.g., the contributions to the special issue of the *Rand Journal*, Autumn 1989, with an introduction by Acton and Vogelsang).

The appraisal of price-cap regulation was challenged, however, by new developments in principal-agent theory where it was argued that price-caps would solve some problems, but would generate others. In this view, the optimal contract between the regular and the regulated firm would be an "incentive contract" which includes elements of both price-cap and cost-plus regulation (Laffont, Tirole, 1986).¹¹

The common starting point of the price-cap and the incentive contract literature is the existence of an information asymmetry between the regulator and the regulated firm. The regulator is assumed to be able to observe market performance, but has only limited information about the parameters of the cost function of the regulated firm. In accordance with Laffont and Tirole (1986), it is assumed that the cost function of the regulated firm is described by

$$c = (\beta - e) q + (\alpha - ke)$$

where β and α denoted initial marginal costs and initial fixed costs (which together represent initial efficiency), q denotes output, k is a

¹¹ For a critical view upon price-caps see also Neu (1993).

constant, and e is a level of effort which decreases marginal and fixed costs. The utility level of the firm's manager is represented by

$$U = (pq - c) - \gamma(e)$$

where the first term represents profits and the second term represents the disutility of effort. Alternatively, $\gamma(e)$ could also be interpreted as innovation costs or other types of costs which arise from any strategy of improving efficiency.

Table 6 - Optimal Contracts in the Presence of Asymmetric Information

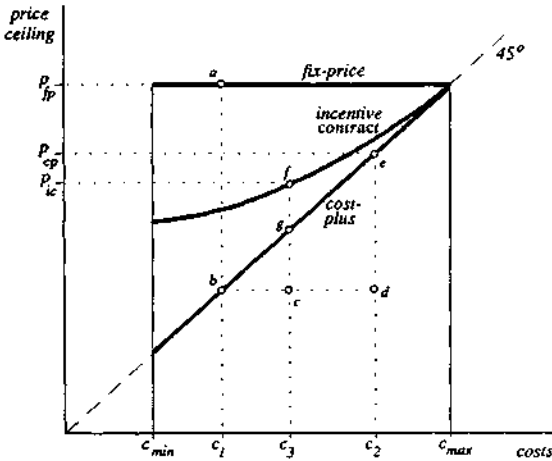
	Asymmetric information about				Cost observability		Optimal contract
	efficiency		effort				
	Yes	No	Yes	No	Yes	No	
(1)		x		x	x		(symmetric information)
(2)	x		x			x	Fix-price
(3a)		x	x		x		Fix-price
(3b)	x			x	x		Cost-plus
(3c)	x		x		x		Incentive

Every price regulation has to take into account that revenues of the regulated firm must at least cover its costs, because otherwise the firm would refuse to produce the desired product (participation constraint). For designing the optimal regulatory contract, several cases must be distinguished which refer to different types of asymmetric information (Table 6):

- (1) If ex-post control is feasible and the regulator can both observe the efficiency of the regulated firm (β and α) and its effort to control costs (e), the regulatory task becomes trivial because there is no relevant information asymmetry. In this case, the regulator can fully describe the socially optimal market performance and can impose corresponding regulations on prices and output.
- (2) If no ex-post cost observation is feasible, a fix-price contract is optimal, because the regulatory institution has no way of verifying the cost announcements of the regulated firm.¹² With perfect capital markets, it does not matter whether the fix-price is settled for the whole regulatory period or is gradually reduced by a price-cap rule.
- (3) If ex-post cost observation is feasible and
 - (a) the regulator can observe efficiency but not effort (moral hazard), a fix-price rule (or a price-cap rule) is the optimal contract, because the price can be fixed at average costs and the firm has no incentive for inefficient production.
 - (b) the regulator can observe effort but not efficiency (adverse selection), cost-plus regulation is optimal, because exaggerated cost-announcements of the regulated firm can be rectified by ex-post cost control. In this case, a fix price contract may lead to excessive pricing and suboptimal output which would result in allocative distortions at the demand side of the regulated market.
 - (c) the regulator can observe neither effort nor efficiency (moral hazard plus adverse selection), an incentive contract should be conferred which adopts a compromise between fix-price and cost-plus regulation.

¹² This result was already described by Baron and Myerson (1982).

Figure 2 - Price Ceilings Under Different Regulatory Concepts



The idea of the incentive contract is illustrated in Figure 2. It is assumed that the regulator estimates the costs of the regulated firm to be in a range between c_{\min} and c_{\max} without any further information about efficiency and effort. Actual costs can only be observed ex post by the regulator. Under a fix-price rule the regulator would have to set a price $p_{fp}(= c_{\max})$ in order to meet the participation constraint. Under a regime of cost-plus regulation, the approved price ceiling would be equal to actual costs (including a return on capital). Under an incentive contract regime, the regulator offers a menu of different contracts, and the firm is free to choose any point on the curve of Figure 2. The contracts offered are of the following type:

$$p_{\max} = F + ac; \quad \text{with } F = F(a) \text{ and } dF / da < 0.$$

F denotes a fix-price and c are the costs announced by the firm. For an announced cost level of c_{\max} , a reaches unity and F falls to zero. For an announced cost level of c_{\min} , a is zero and F reaches its maximum. For these extreme cases the incentive contract scheme resembles a

cost-plus rule and a fix-price rule respectively. For any other cost level it is a mixture of both. Each individual contract is linear in costs, but the set of price ceilings over the whole cost spectrum may be non-linear.

For illustrating the differences between the three regulatory concepts it is assumed that the firm would be able to reduce its actual costs to c_1 in a first-best world.¹³ If it is forced to pass all cost cuts to customers via lower prices, however, it restrains effort and actual costs are at a level of c_2 .

- Under a fix-price rule there is no moral hazard and the firm realizes a cost level of c_1 . Hence, there are no inefficiencies at the regulated firm. However, the charged price does not equal marginal costs but is set at p_{fp} , which leads to suboptimal demand and corresponding allocative distortions on downstream markets.
- Under cost-plus regulation prices are equal to average costs (p_{cp}), but the cost level reaches c_2 because effort is suboptimal.
- Under an incentive contract the firm will have some incentives to reduce costs, because it is not forced to pass all its productivity gains to the customers. Hence, the realized cost level will be between c_1 and c_2 (say c_3) and the price level (p_{ic}) will be lower than p_{fp} and perhaps also lower than p_{cp} .

The information rent which can be extracted by the regulated firm under a fix-price rule is given by the distance \overline{ab} in the diagram. Under a cost-plus rule there is no information rent to the firm, but an allocative inefficiency of size \overline{de} due to insufficient effort. Under an incentive contract rule, the firm earns an information rent of \overline{fg} and an allocative inefficiency of \overline{cg} arises. The concept of incentive contract

¹³ Note that c_{\min} does not denominate actual cost cutting potentials, but only represents the guess of the regulator.

regulation can thus be interpreted as an attempt to balance the trade-off between the supply-side distortions of a cost-plus rule and the demand-side distortions of a fix-price rule.

The concrete parameters of the incentive contract scheme should depend on the relative importance of information asymmetries about efficiency and effort. If efficiency considerations are judged as predominant, the incentive contract curve of Figure 2 should be rather close to the cost-plus curve, whereas a high weight upon effort considerations should be reflected in a close proximity of the incentive contract curve to the fix-price curve. For this reason, the incentive contract curve of Figure 2 is upward bending: if the regulated firm chooses an incentive contract close to c_{\min} , it reveals that it is relatively efficient and that it rather strongly reacts to incentives for increasing effort. Therefore, the incentive contract curve should be almost as flat as the fix-price curve for low levels of c .

A second aspect is the relative importance of allocative distortions on the supply side and on the demand side. If supply-side inefficiencies are considered as most important, the incentive contract curve should be rather flat and close to the fix-price curve. On the other hand, "it is generally optimal to make price more responsive to actual cost when consumers' surplus is the objective, even at the cost of reducing incentives for efficient production" (Schmalensee, 1989, p. 435).

In reality, such a fine tuning of the incentive contract scheme may be illusionary, because the relevant information is probably not available. There is some experience from U.S. states with less complex forms of incentive contracts for regulating the regional Bell Operating Companies. Nineteen states apply a linear sharing of incremental earnings between the regulated firm and its customers (Donald, Sappington, 1995).¹⁴ Similar forms of rather simple incentive contract schemes could also be designed for access pricing.

¹⁴ Among the remaining states seventeen are applying cost-plus regulation.

V. Concluding Remarks

The basic regulatory problem of network-based industries is to ensure unrestricted access of potential competitors to the networks of well-established firms. In this paper, it is argued that a permanent ONP regulation should be imposed upon dominant providers of basic telephone services and online services in order to promote competition and to foster technological progress. Without such a government intervention, incumbents may be able to blockade market entry and to restrain the diffusion of advanced technologies. For value-added services, no specific government intervention is required because competitive potentials are high. For the providers of telecommunication networks, a transitional ONP regulation seems appropriate as long as public or privatized PTTs dispose of a dominant market position. Presumably, a regulatory enforcement of unrestricted network access may also be desirable for electricity, water and gas distribution (third-party access) and for the railways network (see, e.g., Joskow, Schmalensee, 1983; Kumkar, 1996).

There is little doubt that regulatory authorities should better abandon the cost-plus approach when regulating the pricing of network access, because this type of regulation is associated with severe allocative inefficiencies at the regulated firms. If governments are unable to gather any reliable information about the cost structure of the regulated firm, they should choose fix-price contracts when approving price ceilings. These contracts should preferably be negotiated as a price-cap rule, where pre-announced reductions of the price ceiling can enforce gradual reductions of allocative inefficiencies.

If regulatory agencies are able, however, to observe ex-post cost performance, they should make use of this information and should prefer incentive contracts which allow a sharing of efficiency gains among producers and customers. Under such a regulatory regime, the regulator is enabled to balance the trade-off between minimizing the sum of allocative inefficiencies at the supply side and the demand side of the respective market. In a world of moral hazard and adverse selection, it

can be assumed that the regulated firm will be less efficient under an incentive contract regulation than under a price-cap regulation, but it can also be expected that the level of access prices will be lower, which benefits the customers of the regulated network provider. In principle, the concept of incentive contracts can also be applied to other network-based industries if ex-post cost observation is feasible.

Of course, this paper can only provide a brief sketch of optimal regulatory contracts which ignores many problems of the real world. For instance, the provision of network access is in general associated with significant fixed costs which make marginal cost pricing unfeasible. From a theoretical point of view, the charged prices for network access should follow a Ramsey rule, which would require a price discrimination by the different price elasticities of demand on downstream markets (Laffont, Tirole, 1993). Such an approach would impose a huge informational burden upon the regulatory agency which can probably never be solved. Most observers conclude, therefore, that the structure of access prices should be oriented at marginal costs with a proportional mark-up for covering fixed costs (see, e.g., Laffont, 1994). Nevertheless, future research may well lead to more sophisticated regulatory concepts also in this area.

Another complex issue is the technical definition of ONP. The regulator can never avoid to define at least some minimum norms and standards which have to be adopted by the regulated network provider. In telecommunications, standardization requirements are somewhat reduced by an international agreement on basic principles of network architecture according to the model of Open System Interconnection (OSI), but even this model (which by itself constitutes a technical standard) requires regulatory definitions of routers, gateways and bridges (for details see Heap, 1993). Regulatory agencies are always in danger of setting inappropriate standards which may be adapted to the technologies of yesterday or may privilege incumbents.

The paper has also ignored the rich literature about the optimal duration of regulatory contracts: For instance, a price-cap contract which is

renegotiated at rather short time-intervals, does not solve the moral hazard problem, because the regulated firm will take into account that efficiency gains of today will result in lower price ceilings of tomorrow. Among all the available contract types, only cost-plus contracts do not need periodic revisions (Schmalensee, 1989). The problem of time inconsistency constitutes a severe objection to price-caps and incentive contracts as well.

All in all, there is a number of unsolved theoretical and empirical issues and much to learn for economists and regulators as well in the area of network-based industries. Nevertheless, the recent attempts to liberalize these industries all over the world are undoubtedly a big leap towards improving efficiency, increasing competition, promoting technological progress and raising aggregate welfare.

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