The Three Stages of Network Evolution

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1

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Because several of the changes in international telecommunications policy originated in the United States, they are often viewed as the product of particularly U.S. business interests, wrapped in a Chicago economic ideology. Beginning in the mid-1980s, however, several other industrialized countries began adopting similar policies, or at least discussed previously unthinkable changes.

The question then arose whether the changes reflected something more fundamental, beyond the governments in power. I posit that these policy changes are indeed part of a broad transition, one in which a multiplicity of centrifugal forces transforms the traditional network into a loosely interconnected federation of subnetworks, a network of networks.[1]

Three stages of evolution in networks can be distinguished and will be discussed further:

1. *The cost-sharing network.* Expansion is based on the logic of spreading fixed costs across many participants, and increasing the value of telephone interconnectivity.
2. *The redistributory network.* The network grows through politically mandated transfers among users.
3. *The pluralistic network.* The uniformity of the network breaks apart because the interests of its numerous participants cannot be reconciled, and a federation of subnetworks emerges.
4. *The global network.* Various domestic subnetworks stratify internationally and form networks that transcend territorial constraints.

There is a logical progression to these trends. The network first expands because of economic and technical considerations; later, it expands due to political imperatives. As the network provider succeeds in offering full service to every household, however, it also undermines the foundation of its exclusivity.

Most countries are still engaged in the cost-sharing and redistributory network. A few have reached substantial penetration and have begun moving toward the pluralistic stage. Economic growth and telephone penetration are strongly correlated—historically, roughly an additional telephone per $50,000 of GNP.

Thus a progression through the various stages is reaching the high-growth nations of the Pacific Basin and Europe.

This chapter is primarily concerned with the forces leading to the emergence of the pluralistic network. The first section looks at the nature of networks. Their dynamics and evolutionary stages are taken up. The second section looks at the trends and fares leading to network centrifugalism. In the final sections the new network coalitions and their international implications are discussed.

1.1 A Theory of Network Evolution

Almost all analysis of telecommunications concentrates on the *suppliers* of services. Issues are inevitably posed in terms of AT&T versus MCI, NTT versus the NCCs (new common carriers), Intelsat versus Cable & Wireless, VANs versus basic carriers, and so on.

It is more useful, however, to examine a "*demand*-side" telecommunications analysis. Telecommunications should not be considered primarily as a service produced by carriers, but as an interaction of societal groups, with the interaction facilitated by service vendors called *carriers*. Left to its own devices, supply structure reflects the underlying interactions of users, whether in an all-encompassing "user coalition" or in smaller groupings. A universal public network interconnecting everybody with anybody under a single organizational roof is technically and financially merely one arrangement out of several.

Thus, deregulation should be seen as far more than a policy liberalizing the *entry* of suppliers. It is also the liberalization of *exit* of users from a sharing coalition that has become confining.

Integration and centrifugalism are two basic types of forces common to many social processes. In telecommunications, their current purest expressions are the moves toward the integrated services digital network (ISDN) as the "superpipe," and the establishment of modularized interconnection arrangements such as open network architecture (ONA) that introduces segmentation into the very core of the network.

Telecommunications is but one instance of the widespread ascendancy of centrifugalism within previously shared arrangements. Wherever one looks, people are breaking up social networks of interaction to form new ones. Examples abound in the United States, including public education, mass transit, public safety, dispute resolution, pension systems, health provision, electrical power and gas distribution, stock exchanges, and so on.

One way to look at a network is as a cost-sharing arrangement between several users. Fixed costs are high, marginal costs low, and a new participant helps existing ones lower their cost. In that way it is similar to a swimming pool or national defense (i.e., to a "public good"). While there is only one national defense system, however, there are many types of arrangements for swimming pools. We may want to share the pool with a few dozen families,

but not with thousands. A pure public good admits everyone, but a pure private good, only one. There is a wide spectrum between (Buchanan 1965).

A telecommunications network is one intermediate example. It is not a private good, nor does it meet the two main conditions for a public good, namely nonrival consumptions and nonexcludability. In fact, nonexcludability had to be established as a legal requirement, and we call it the *universal service obligation*.

We will now develop, in a stepwise fashion, a model for network evolution and diversification.

1.1.1 The Basic Model[2]

Let the total cost of a network serving n subscribers be given by a function of fixed costs and variable costs. We assume that users are homogenous. (Of course, some network participants are much larger than others, but that poses no problem if we define a large organization to consist of multiple members of type n, such as telephone lines or terminals rather than accounts.) We assume positive network externalities to exist though at a declining rate (i.e. a subscriber is better off the more other members there are on the network, *ceteris paribus*) (including network performance and price).

We assume that the network membership is priced at average cost (i.e., that users share costs equally). (This assumption will be dropped later.) This can be shown schematically in Figure 1.1, where utility $u(n)$ is steadily increasing, though at a declining rate, and price = average cost is declining, at least at first. At this stage, the network is in its cost-sharing phase.

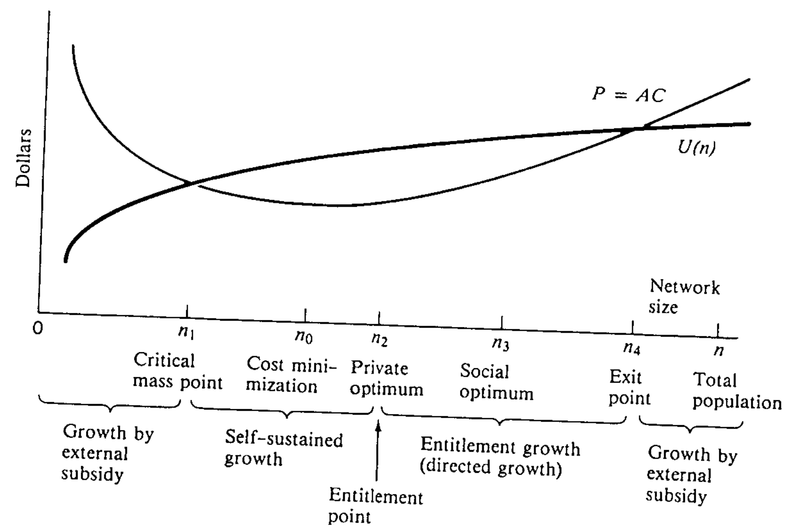

Figure 1.1

1.1.2 Critical Mass

Subscribers will find it attractive to join a well-sized network because total costs are shared by many, making average costs low, while the number of subscribers n adds to utility. This can be seen in Figure 1.1, where the utility of joining a network rises at first. Conversely, where the network is small, average cost is high and externalities small. In that range, below a "critical mass" point n_1, a network will not be feasible, unless supported by external sources.

To reach n_1 requires a subsidy of sorts, either by government or by the network operator's willingness to accept losses in the early growth phases of operations. The strategic problem is to identify in advance a situation in which such a break-even point n_1 can be reached. It is possible that such a point does not exist, and subsidies would have to be permanent in order to keep the network from imploding. We will return to the critical mass issue later.

1.1.3 Private Optimum

Through the cost-sharing phases of network growth, the earlier network users can lower their cost by adding members. However, at some point average cost AC increases.

Some further expansion would be accepted by the network members since newcomers beyond the low cost point would still add to utility. This will be up to the point n_2. Left to themselves, the existing subscribers of the network would not accept members beyond n_2, the private optimum.

1.1.4 Social Optimum

From a societal point of view, however, the optimal network size in an equal price system may diverge from the private optimum. Net social welfare increases at n_2, and becomes zero at a point of intersection n_4. Hence, social optimum n_3 is somewhere in between those two points.

What is the implication? Left to itself, the network association will cease growth beyond n_2, at least as long as costs are equally shared. Existing network subscribers would not want to admit newcomers beyond n_2. Latecomers beyond that point add cost, because they raise AC, and add fewer externality benefits. The socially optimal size n_3 will not be reached by itself, but by some external governmental direction through required expansion, and/or a differentiated pricing scheme, or through some internal politics of expansion.

Politically directed growth beyond private optimum n_2 can be termed an "entitlement growth" because it is based on political arguments of *rights* to participate in the network where average net benefits are positive (encouraging attempts of entry) while marginal net average benefits are negative, leading to attempts at exclusion. When the marginal net benefits are positive, there is no need to resort to the language of entitlements, since growth is self-sustaining and sought by network insiders. It is only beyond that point that entitlements, rights, and universal service rights (i.e., obligations by the network) become an issue.

1.1.5 Exit from the Network

If $n_2 < N$, with N being the total population, some people would be left out of the network. As discussed previously, a government would require the network to be open to other users. Yet there may well be a point where the network is expanded to an extent that, given its increasing price, a user is better off by not participating. We define n_4 as the "exit point" (i.e., the largest n such that the indifference exists between dropping off the network and sharing in the cost of supporting the expanded network).

It is possible that this exit point lies beyond the total population, $n_4 > N$. But this seems not likely under an average-pricing scheme, because the last subscribers may impose a heavy burden on the rest of subscribers, and the subsequent departure of some subscribers would lead to further reduction in the utility of the remaining members and may induce a secondary exodus. Thus, assuming $n_4 < N$, a government's aim to establish a truly universal service, without resorting to a subsidy mechanism or price discrimination, is likely to be infeasible. In other words, a universal service policy is dependent on a redistributive policy. This is the second stage of evolution, that of the redistributory network.

1.1.6 Political Price Setting and Redistribution

We have so far assumed that universal service is something imposed externally by government. In this section, however, it will be shown that the *internal* dynamics of network members can take the network toward universal service, and towards its own disintegration.

As has been shown, a network will cease to grow on its own after private optimum n_2. This conclusion, however, was based on a pricing scheme of equal cost shares. Yet there is no reason why such equality of cost shares would persist if they are allocated through a decision mechanism that permits the majority of network users to impose higher cost shares on the minority. (This assumes that no arbitrage is possible.)

Suppose for purposes of the model that decisions are made through voting by all network members.[3] Let us assume at this stage that all users are of equal size (or that voting takes place according to the number of lines a subscriber uses) and that early network users have lower demand elasticity for network use. The determinative vote is provided by the median voter located at $n/2$. A majority would not wish to have its benefits diluted by a number of beneficiaries larger than necessary. This is the principle of the "minimal winning coalition." Its size would be $n/2+1$.

A majority will establish itself such that it will benefit maximally from the minority. The minority that can be maximally burdened are the users with less elastic demand for telephone service, which are the early subscribers. But there is a limit to the burden, given by utility curve $u(n)$. If price gets pushed above $u(n)$, subscribers will drop off. Hence, the majority $n_2/2+1$) will burden the minority ($n_2/2-1$) with a price up to positive utility, and they will bear the rest of the cost.

This then is the redistributory outcome, assuming no discrimination within majority and minority.

1.1.7 Monopoly and Expansion

Such redistribution, however, is not a stable equilibrium. Before, network size n_2 was reached (once the critical mass threshold was crossed) by voluntary association. Further members were not admitted because they lowered utility to the incumbents. With internal redistribution, however, several things happen. There are now incentives for the minority network members to exit the network and form a new one in which they would not bear the redistributory burden. This would be possible if the minority were of a size larger than critical mass, $n_2/2>n_1$. Even where that were not the case, the minority could band together with those beyond network size n_2 who desire telephone service but were previously excluded.

This exit would deprive the majority of the source of its subsidy and is therefore held undesirable. The only way for the majority to prevent this "cream-skimming" or "cherry-picking" is to prohibit the establishment of another network, both by those wanting to leave the original network and similarly by those not admitted to it by being beyond n_2.

Thus, a monopoly system and the prevention of arbitrage become essential to the stability of the system.

At the same time the model predicts that the network must expand beyond n_2. For the majority, there is added utility from added network members, while most of its cost is borne by the minority. They will therefore seek expansion. The cost to the majority is only that the subsidy by the minority must be shared with more network participants. Therefore, the majority would admit new members up to the point n_5 where marginal utility to its members is equal to the marginal price due to the diluted subsidy.

This is not the end of the story, however. With expansion to n_5, the majority is now $n_5/2$ rather than $n_2/2$ (i.e. larger than before), and it can also tax a larger minority ($n_5/2$) than before. Hence, the expansion process would take place again. This process would continue, until an equilibrium, $n_5{}^*$ would be reached at the point where $du/dn=0$ for a minority member.

$n_5{}^*$ is the point up to which the network will grow under the internal dynamics described earlier. It will be larger, the greater the marginal utility from added network members is, the smaller marginal cost, and the greater fixed cost are.

1.1.8 Network Tipping

As this process of expansion takes place, the minority is growing, too. The likelihood that its size increases beyond the point of critical mass n_1 is increased, and the utility of its members, given the burden of subsidy, may well be below that of membership in a smaller but nonsubsidizing alternative network. We have so far assumed that there is only one network, and that a user's choice is whether to join or not. Suppose there are no legal barriers to the formation of a new network. In that case, a user's choice menu is to stay, to drop off altogether, or to join a new network association. Assume that the new network would have the same cost characteristics as the does traditional network. (In fact, it may well have a lower cost function for each given size if there has been accumulated monopolistic inefficiency in the existing network and rent-seeking behavior by various associated groups.)

Then, minority coalition members would find themselves to be better off in a new network B, and they would consider such a network, abandoning the old one. The only problem is that of transition discontinuity. A new network, in its early phases, would be a money-losing proposition up to its critical mass point n'_1. The minority will strive to exit the redistributory network once the latter's size is more than twice the size of critical mass. The network has entered its pluralistic stage.

1.1.9 Subsidies for Reaching Critical Mass

We have mentioned before that waiting for demand to materialize prior to the introduction of a network or network service may not be the optimal private or public network policy. Demand is a function of price and benefits, both of which are in turn functions of the size of the network. Hence, early development of a network may require internal or external support in order to reach critical mass.

This suggests the need, in some circumstances, to subsidize the early stages of the network—up to the critical mass point n_1—when the user externalities are still low but cost shares high. These subsidies could come either from the network provider or its membership as a start-up investment, or from an external source such as a government as an investment in "infrastructure," a concept centered around positive externalities. The question is how the internal support is affected by the emergence of a system of multiple networks.

The private start-up investment in a new form of network is predicated on an expectation of eventual break-even and subsequent positive net benefits to members. If one can expect the establishment of additional networks, however, which would keep network size close to n_1, there would be only small (or no) net benefits realized by the initial entrants to offset their earlier investment. This would be further aggravated by interconnection rights because a new network could make immediate use of the positive network externalities of the membership of the existing network that were achieved by the latter's investment. Hence, it is less likely that the initial risk would be undertaken if a loss were entirely borne by the initial network participants while the benefits would be shared with other entrants who would be able to interconnect and thus immediately gain the externality benefits of the existing network users, but without contributing to their cost-sharing. The implication is that in an environment of multiple networks that can interconnect, less start-up investment would be undertaken. It pays to be the second entrant rather than the first. A situation of market failure exists.

In such a situation, there may be a role for direct outside support, such as by a government subsidy. At first this may seem paradoxical. Should a competitive system of multiple networks not be *less* in need of government involvement than a monopoly? On second thought, however, there is some economic logic to this. Just as the subsidies to individual network users that were previously *internally* generated by other network users will have to be raised *externally* (through the normal mechanism of taxation and allocation) if at least some users are still to be supported, so might subsidies to the start-up of a network as a whole have to be provided externally. This will also be done through taxation and allocation, where network externalities as well as start-up costs are high enough to make the establishment of a network desirable.

1.1.10 Social Welfare and Multiple Networks

If network associations can control their memberships, stratification is inevitable. They will seek those members who will provide them with the greatest externality benefits—those that have many actual or potential contacts with. Furthermore, they will want to admit low-cost, high-volume, good-risk customers as members. Thus, different affinity-group networks and different average costs will emerge.

What, then, about social welfare in such a differentiated system? The traditional fear is that the loss of some cost-sharing and externalities brought by a second network would reduce social welfare. However, where the network was at n_3 or substantially larger than the socially optimal size n_4, the fracture of the network could increase social welfare, depending on the cost and utility functions, if cost closer to n_0 is reached. Where mutual interconnection is assured, one can keep the externalities benefits (and even increase them) while moving down the cost curve toward a lower AC. Furthermore, the cost curves themselves are likely to come down with the ensuing competition.

The welfare implications of the formation of collective consumption and production arrangements is something analyzed by theorists of clubs, among whom are Schelling, Buchanan, Tullock, Rothenberg, Tiebout, and McGuire. The club analysis, applied to networks, can show:

1. Given mobility of choice, different user groups will cluster together in associations according to quality, size, price, interactive density, and ease of internal decision making. When "voting with one's telecommunications node," the economically optimal association size need not encompass the entire population.
2. Service quality and optimal group size are interdependent. Thus, the optimizing size of a network's membership will vary according to quality levels sought by different user classes.
3. Optimal group size depends on the ratio of marginal utilities for different services, set equal to the ratio of transformation in production. Thus, if different network services operate on different layers of the physical network, they will have different optimal sizes.
4. Most importantly, it is rarely Pareto-efficient to attempt income transfer by integrating diverse groups and imposing varying cost shares according to some equity criteria. Allowing homogenous groups to form their own associations and then redistributing income by imposing charges on some groups can be more efficient. Politically, however, the former may be easier to accomplish because the subsidy is not transparent (i.e., is not explicit).

The theoretically based analysis of the model described earlier means that a network coalition, left to itself under majority-rule principles, would expand beyond the size that would hold under rules of equal treatment of each subscriber. Such an arrangement can be stable only as long as arbitrage is prevented, as long as the minority cannot exercise political power in other ways, and, most importantly, as long as it has no choice but to stay within the burdensome network arrangement.

Beyond that point, however, the proexpansion policy creates incentives to form alternative networks. The more successful the network policy is in terms of achieving universal service and "affordable rates," the greater the pressures for fracture of the network. Hence, the very success of network expansion bears the seed of its own demise. This is what I call the "tragedy of the common network," in the Greek drama sense of unavoidable doom, and borrowing from the title of J. Hardin's classic article "The Tragedy of the Commons"[4] on the depletion of environmental resources. In the case of telecommunications the tragedy is that the breakdown of the common network grew from its very success—the spread of service across society and the transformation of a convenience into a necessity.

1.2 Forces of Change

Let us now become more concrete. Several broad trends contribute to new network coalitions becoming an increasingly realistic proposition. These are discussed in the following.

1.2.1 Saturation of Basic Service

For decades a primary policy goal has been to establish a network reaching every household, achievement of universal penetration in advanced industrial economies is a fairly recent phenomenon. In the United States household penetration rates peaked (at 41 percent) with the stock market in 1929 and then fell ten percentage points to a 1933 low. In 1946 household penetration passed 51 percent, reached 75 percent in 1957, 80 percent in 1962, and 90 percent by 1970 (Census 1975, p. 783). West German penetration was only 12 percent in

1960, and 75 percent by 1980. In France, it was 6 percent in 1967 and 54 percent in 1983. Universal Service was achieved by substantial redistribution.

1.2.2 Increasing Cost of Incremental Subscribers

Network characteristics typically include high costs for first users, and declining costs of subsequent users. Eventually, as in most economic processes, the marginal costs of additional users increase again, causing increased average costs. This trend is also evident in the entire Bell System, where average capital investment cost per new telephone steadily increased (in 1982–1983 dollars, *Telecom Factbook* 1986.)

1945	1955	1965	1975	1985
$1928	2050	2580	3960	4624[5]

1.2.3 An Activist Role by the Equipment Industry

Once universal penetration is reached, the supplying industry must reorient itself or face a dramatic drop in its level of activity. Having spread telephony, the supplying industry becomes a victim of its own success in saturating the market. This leaves several strategies.

Upgrade. The equipment industry advocates upgrading the network. This means an accelerated supply push rather than demand pull, and may include videotex, ISDN, broadband networks, and cable television projects.

Export. Increased attention to international activities can substitute for a shrinking domestic market. However, many markets in industrial and industrializing countries are protected by governments that use the network as a way to promote a domestic electronic industry. This results in trade frictions, but in most cases eventually leads to partial opening to achieve reciprocity.

Targeting Users as Equipment Buyers. Manufacturers turn to large users as a stable long-term market. In the United States virtually all capital investment in equipment in 1975 was by the carriers, but in 1986 the figure fell to only two-thirds. Noncarriers bought PBXs, multiplexers, concentrators, network management systems, satellite, and microwave facilities.

Users have increasingly assumed control over the network segments closest to them—first over equipment on their premises, then over the wiring segments in their buildings. Another type of user control has been through local area networks (LANs), which are privately established high-volume links serving the data flows within an organization, and among its equipment. In some organizations LAN traffic reaches 60 percent of the total communication flow. Here, too, expansion is inevitable; LANs often grow geographically into wide area networks (WANs), which may cover several continents.

The equipment industry, once a protector of the old order, has increasingly aided the creation of creating alternatives to the traditional shared network.

1.2.4 Reductions in Equipment Costs and Increases in Productivity

Another factor leading to greater subnetworking is the considerable downward shift in the economics underlying transport and switching. Network costs drop further as equipment becomes cheaper, more powerful, and lower in operating costs. Switch prices in North America fell from $230 per line in 1983 to less than $100 in 1992, while manpower requirements declined considerably and productivity increased.

Similarly, the price of fiber and of LEDs has radically dropped while their transmission capacity increased enormously. By the mid-1990s, fiber may be cheaper to install than copper.

For local distribution—in the past the segment with the greatest characteristics of "natural" monopoly—several types of new carriers have been emerging, based on radio, fiberoptic, and coaxial transmission. As the economic incentives to share in one large "network club" decline, alternative arrangements become more viable.

1.2.5 Increases in User Size

As the traffic volume of large users rises, it takes fewer users to travel down the cost curve and benefit from economies of scale. Average use per line increases annually, on average, by about 4–7 percent, as society and economy exhibit more information-intensive activities. This transition to a white-collar service sector as an area of major activity is observable around the world in economically advanced societies.

The purchase of communications capability at advantageous prices has become more important, and this has led to the emergence of a new breed—private telecommunications managers—whose function is to reduce costs for their firms and establish expertise outside the postal–industrial coalition. These managers aggressively seek low-cost transmission and customized equipment systems in the form of private networks of power and scope far beyond previous efforts.

The growth of large users means it takes a smaller number of them to reach any given volume. This reduces transaction costs of organizing and coordinating a new network, and makes it possible for a smaller number of users to enjoy economies of scale.

1.2.6 Upward Drift of the Old Network's Cost Curve

Costs and efficiencies of networks are a function of market structure as well as engineering. The traditional network operating as an exclusive arrangement tends to drift upward in cost terms. This can be exacerbated by regulatory arrangements that lead to wrong incentives, such as rate-of-return regulation with its overcapitalization. The cost reductions achieved when U.S. and Japanese companies experience competitive pressures are good indicators of such trends. This implies a new network, unencumbered by the accumulated high-cost attributes of the old one, could operate on a lower cost curve even in the presence of economies of scale.

1.3 The New Network Coalitions

The success of communalism engenders forces for particularism because the level of use and technical requirements of the some users are increasingly differentiated from those of average users. Consequently, where legally permitted, new coalitions of users are emerging. Examples are private intraorganizational networks, shared tenant services, LANs, WANs, and other specialized services.

Such private networks have begun to carve out slices from the public network. It does not take a large number of private networks to have an impact, as the operation and administration of some of them may require hundreds of skilled technicians and managers. The largest 3 percent of users typically account for 50 percent of all telephone revenues. While these activities are spearheaded by private firms, they are not exclusive to them; nonprofit institutions such as hospitals and universities, and public organizations such as state and local governments, have actively pursued similar strategies.

While most entities might participate in several networks, the pluralist networks would not require separate transmission links. Transporting the traffic of several low-volume users in "virtual" private networks over the general networks will make sense, and provide functions for traditional carriers and new forms of systems integrators. The economies of sharing are not abolished, but they must prove superior rather than being imposed by a legal requirement.

Many advocates of the traditional shared network system believe the demands of pluralism could be met by software options limited to the exclusive physical network of the traditional monopolist. This is wishful thinking. Granted, permitting software networks on a transmission monopoly is a correct first response to the emerging pressures. However, it is unlikely to be adequate in the long run. At some point users will also want to supplement transmission offerings in ways that satisfy their preferences in terms of technology, control, and economics. An exclusive network cannot be the superior solution in each instance, particularly if it has to follow political mandates or cannot bargain individually on prices.

Is it possible for the public network provider to supply each user grouping with whatever it needs, without requiring new network arrangements? Theoretically, the answer is *yes*. Indeed, some of the change is taking place on private networks supplied by the monopolists. However, it is unlikely to be institutionally adequate, if only because it requires heroic willingness by the traditional network to collaborate with schemes designed to reduce its revenue. In addition, it needs a substantial lowering of a cost-structure that has crept up over

time, as suppliers and employees have shared in monopoly profits. Finally, an enormous upgrading of innovativeness and responsiveness would be required, and traditional large firms often cannot match upstart organizations.

1.4 Global Networking and the Interaction of Liberalization

The pluralist network groupings need not be territorial. The idea of telecommunications as consisting of interconnected national systems is likely to be transcended in many instances as specialized and general transnational networks emerge, spurred by the drop in cost of international circuits, and consolidating various national subnetworks.

For satellite transmission the marginal cost with respect to distance is close to zero. Fiberoptic links also have lower distance-sensitive costs. This implies communication flows can be routed in ways to exit previously shared arrangements, or to join new and more congenial ones. Opportunities for arbitrage arise, creating incentives for a country to liberalize its regulatory regime, becoming a communications "haven." This undermines administrative attempts to set rules for prices and service conditions.

Eventually, specialized global networks will emerge for a variety of groups requiring intensive communication with each other. Their relationships are functional rather than territorial, and communication links will relate participants, making traditional physical clustering of related activities less necessary.

There are unique domestic elements that affect telecommunications in each country. There are also pressures such as technological change common to all, and interactions among countries. The more interrelated countries and their economic activities become, the less likely stable solutions to domestic policy issues exist, and instability in one country affects everyone else in the system at least to some extent.

Hence, politically optimal regulation in an interrelated world may be different than for single activities in isolated jurisdictions. In most instances one would encounter a positive cross-elasticity of regulation, where liberalization in A leads to greater liberalization in B, and vice versa. In some instances, however, the cross-elasticity would be negative. One example is transborder data flow protection laws, which may lead to unstable equilibriums. The less protected data is in one country, the tighter another may become in response.

Consider the response of regulators to each other's level of regulatory strictness. One possibility is a gradual convergence that does not require coordination—an equilibrium can be reached by unilateral actions and reactions. It is also possible, however, that regulatory strictness in each country either moves successively higher or lower in response to the other countries, causing excessive deregulation or regulation (corner solutions) or cyclical change.

The alternative is coordinated "supraregulation," but it may not be stable either. One jurisdiction's adherence to an agreement provides the other with an opportunity for gain by seeking a noncooperative policy. In each jurisdiction there are pressures to seek one's own ideal regulatory level, which is likely to be different from the agreed-on level or from the interactive equilibrium. Going-it-alone can be due to short-sightedness or lack of understanding of the interaction involved, or it could be based on the rational desire to gain advantages over others by breaking joint policy, at least in the short run.

Domestic instability in the regulation of telecommunications is therefore linked to international instability in such regulation; if a country's domestic system unravels, then the resulting repercussions of adjustment in turn affect other countries with stable domestic situations.

These changes lead to unstable situations affecting the entire system, where a single inconsistency with multiple secondary effects can lead to further inconsistencies. At the same time, collaborative regulatory adjustments become more difficult, because they cannot be confined to subsectors.

In telecommunications one might therefore expect the trend toward liberalization to be spreading, though accompanied by efforts of stabilization. This process, however, is not entirely one-sided. For example, due in part to the resistance of other countries, the United States has liberalized domestic services far more than such international ones as satellite carriers. Hence, a greater internationalization of communications will make it more difficult for any one country to go its own way.

Oscillations may occur as the matrix of interrelations steadily becomes more cross-elastic, but the long-term tendency should lead to reduced international protection of the traditional network system. In this manner, network pluralism is an expansionary process. It is less an ideological choice than a response to an internal inability to structure a stable equilibrium serving multiple domestic interests and goals. One may predict that similar inconsistencies will spread throughout the system.

In the past, international interactions have often been used to stabilize domestic arrangements. Now, however, a symmetrical scenario is being played out in the opposite direction, as an international trend toward liberalization undermines domestic stability.

Notes

1. Attempts at a broad interpretation of the transformation of networks are rare. One is the Huber Report, a study of the post-divestiture American network by the U.S. Justice Department (1987) based on the relative cost of transmission and switching. Another approach is that of NTT's Hayashi (1988), who discusses the economics of networks.

2. I will follow the network analysis as developed in Noam, Eli, "The Next Stage in Telecommunications Evolution: The Pluralistic Network," paper presented at the Pacific Telecommunications Conference, Japan, October 1988; section 1.2 contains parts of the methodology of my Columbia colleague Geoffrey Heal, "The Economics of Networks," Columbia University, unpublished paper, 1989.

3. This analysis should not suggest that a voting mechanism is governing in reality (although it exists for telephone cooperatives in Finland and the United States) but rather to understand the pressures and dynamics that are transmitted to the governmental institutions that embody the different user interests.

4. Hardin, Garrett, "The Tragedy of the Commons," *Science*, vol. 162, Dec. 13, 1968. *Tragedy* is used in the sense of Alfred North Whitehead: "The essence of traumatic tragedy is not unhappiness. It resides in the solemnity of the remorseless working of things."

5. Encompasses all U.S. carriers; translated for new telephones from data on access lines using 1975 ratio. *Sources:* Telecom Factbook, 1986; FCC Statistics of Communications Common Carriers, 1945, 1955, 1965, 1975, and 1985.

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