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Governing the Networks of the Information Society

Prospects and limits of policy
in a complex technical system

Johannes M. Bauer

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Governing the Networks of the Information Society

Prospects and limits of policy in a complex technical system

Johannes M. Bauer

Professor, Department of Telecommunication, Information Studies and Media
Executive Director, Quello Center for Telecommunication Management and Law
409 College of Communication Arts and Sciences
Michigan State University, East Lansing, Michigan 48824, USA
E-mail: bauerj@msu.edu, Internet: <http://www.msu.edu/~bauerj>

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Information and communication technology, governance, complexity, incomplete information, institutions, feasible policy

Abstract

This paper examines the prospects and limits of policies towards information and communications technologies (ICTs). The co-evolution of technological, economic, and political factors that has affected the information network infrastructure during the past three decades has transformed it from a relatively closed to more open system. As a consequence, the degree of complexity of the ICT infrastructure has increased with far-reaching implications for its governance. Paradoxically, policy was better able to control important performance characteristics, such as prices or investment levels, during the past monopoly era. However, the ability to control came at the high price of the inefficiencies associated with monopoly organization. In the present more competitive framework, many feasible policy instruments only work indirectly. Sector performance is an emergent property resulting from decentralized decisions in markets. It is influenced but not fully determined by policy choices. These changes need to be recognized more explicitly in the theoretical foundations, the formation and the implementation of policy. Applying concepts from the theory of complex evolving systems, the paper develops lessons for the design of effective information and communications policy.

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Earlier versions of this paper were presented at the Institute of Technology Assessment of the Austrian Academy of Sciences, Vienna, Austria (January 22, 2003) and at the Conference of the European Association for Evolutionary Political Economy in Maastricht, the Netherlands (November 8, 2003). Participants at both events provided stimulating and insightful comments. The author would like to thank Johann Cas for the invitation to present at ITA, which was the catalyst to bring hitherto scattered thoughts into more coherent shape, and Georg Aichholzer for detailed feedback on an earlier version of the paper.

I Introduction

This paper examines the prospects and limits of policies intended to govern the networks and technologies that enable knowledge-based societies. The past decades of restructuring have increased the performance of the information and communication infrastructure and contributed to the proliferation and nearly ubiquitous availability of networks. However, open access conditions have also increased the volatility of the sector. Disruptive technologies, such as WiFi or IP telephony, while promising significant innovations create additional challenges. The main thesis of the paper is that the co-evolution of technological, economic, and political factors, which unfolded during the past two to three decades, has transformed the network infrastructure from a closed to an open system. This has far-reaching implications for the control and governance of the sector. In the closed system, policy had tools available that could – at least in principle – achieve certain desired outcomes. In the present open system, policy instruments are typically confined to more limited aspects of the sector. Thus policy, while not irrelevant, may not be able to steer the performance or the evolution of the sector effectively.

Recent developments such as the glacial emergence of local competition or the meltdown of telecommunication stocks in 2000 can serve as examples of limitations of governance.¹ This observation has led some authors and policy-makers to the conclusion that any attempt to govern is in vein and would only deteriorate performance. As expressed by John Barry Parlow (1996), cyberlibertarians had for some time claimed that advanced networks could and should not be subject to any form of government oversight. With a like strong dose of ideological conviction, pundits such as George Gilder (2000) or Peter Huber (1997) argued that *laissez faire* and an application of case law would be sufficient to govern the “telecosm”. In contrast, William Melody (2003) identified four areas in which Internet governance could yield benefits although he is somewhat skeptic as to whether the appropriate institutions and instruments can be developed. Along similar lines, the recent World Summit on the Information Society expressed the hope that effective governance structures could help harnessing the benefits of the Internet (WSIS 2003). Patricia Longstaff (2003) analyzed the features of information and communication technology (ICT) and highlighted the fundamental challenges of regulating such a complex system. The question of whether advanced communications networks can be governed effectively – and, if so, with what means – is of utmost importance and is at the heart of this paper.

ICT regulation is based on a set of practical skills that are rooted in a much broader epistemic knowledge base (for a general discussion see Mokyr 2002). One of the findings of this paper is that the new environment of information industries may require a revision of part of the practical skills that form the basis of the present regulatory and policy model. Using the existing framework, there is a risk that unrealistic expectations as to the ability of policy to steer the information and communications system are created. Unexpected effects of public policy and private action are conveniently treated as aberrations rather than the results of more fundamental structural change and the limitations of controlling large-scale systems. At the same time, opportunities for sustainable forms of governance may not be recognized. Exploring these themes, the next section of the paper provides a short overview of the co-evolution of technology, policy, and the economic characteristics of the information and communication industries. Section three discusses at a general level the prospects and limits of governing complex adaptive systems such as next generation networks. Section four revisits the prospects and limits of regulation using several recent cases. The final section reviews lessons for research and public policy.

¹ “Governance” can be broadly defined as “the making of decisions that affect others in important ways” (Samuels 2002). This includes government, the corporate systems, non-governmental organizations, and international organizations. The present paper focuses on government action although the arguments can be extended to other modes of governance, such as co-regulation and self-regulation. These modes can help mitigate some of the information and political feasibility issues discussed below but not necessarily the problems related to complexity.

2 The co-evolution of policy, technology and sector economics

Telecommunication regulation is commonly conceptualized as a response to the technological and economic characteristics of communications technology. According to this view, public policy is seen as a correction of market failure or – and this is much more contested – as a correction of undesirable market outcomes. Thus, given the cost structure and demand conditions of the industry, public policy should protect consumers and competitors against an abuse of market power and support additional goals such as universal service. This perspective overlooks that regulation in turn influences the investment and innovation decisions of the regulated as well as unregulated firms and hence market structure, technology deployment and the economics of the industry. If several technological options are available, firms will choose solutions that are compatible with the prevailing or expected legal and regulatory environment. Firms operating under monopoly conditions will deploy technologies with high economies of scale and scope, in thereby reinforcing “natural” monopoly characteristics of the sector. Firms operating under competitive conditions will choose solutions with less significant sunk cost, resulting in a different technological path. While regulation initially may have been a response to the prevailing industry structure, at later points industry structure is also an outcome of the prevailing regulatory model. The relation between industry structure and regulation is therefore recursive: regulation and industry structure co-evolve, each shaping and being shaped by the other.

The recent transformation of information and communication infrastructure is well documented and does not need to be recapitulated in detail. The World Telecommunications Development Reports by the International Telecommunication Union (most recent ITU 2003), the biannual Communications Outlooks by the OECD (most recent OECD 2003) and reports by the World Bank provide rich institutional and empirical detail. More analytically focused treatments are Brock (1994, 2003) and Trebing (1994) for the United States, Mansell and Steinmueller (2000) or Natalicchi (2001) for the European Union, and Fransman (2002) or Madden (2003) at an international level. Within a period of several decades, beginning as early as the 1960s in the United States, the previous monopoly framework was replaced by an approach with a much stronger emphasis on competition. It is often overlooked that in most countries the traditional monopoly framework had also emerged over an extended period of time in a struggle between political and economic forces in favor of private ownership and competition and those in favor of government control (Bauer 2004, Schneider 2001). From this struggle a pragmatic guiding vision emerged that was built around three cornerstones. Telecommunications became viewed as a natural monopoly; it was accepted that the sector had strong public interest implications; and there was agreement that the state could and should improve the functioning of the sector compared to unregulated market outcomes.

The new sector model is likewise based on a pragmatic consensus. Recognizing technological and economic forces that had seemingly reduced the economies of scale in the sector, the vision was accepted that it could and should be organized in a competitive way. Where market power and even naturally monopolistic market segments prevail, they could be neutralized through innovative policies such as price caps, mandatory interconnection, unbundling, and antitrust enforcement. Goals that would not be realized in competitive markets (sometime lumped together under the nondescript term “non-market” goals), should be achieved with market-compatible and competitively neutral instruments. Whereas in the old vision state intervention was ideally seen as a substitute for competition, in the new vision it was modeled as a precondition and complement to competition. It is difficult to disentangle the effect of the policy transformation from other changes in the sector, such as the effects of “Moore’s Law” and “Metcalf’s Law.” As a result there is a temptation to at-

tribute any change in sector performance to policy reform, an approach that likely overestimates its contribution (Henten and Schneider 2003, Crandall and Waverman 1995).² Nevertheless, the more open market organization has gone hand in hand with a new sector dynamic, improvements in sector performance, and a wave of innovations in terms of services and pricing.

Most analyses of these transitions identify technological change and new user needs as the main drivers of policy responses and pay relatively little attention to other factors, such as the fundamental reorientation of public policy or global interest policies. Fewer studies recognize the inter-related nature of these changes and recognize that policy, technology and economics co-evolve (e.g., Trebing 1994, Dutton 1999, Mansell and Steinmueller 2000, and Fransman 2002). A comparison between the United States and the European Union (as well as between individual states in the United States and member states within the European Union) reveals patterns that illustrate the multiple contingencies between policy, technology, and economics. The new sector organization has similar general features in both regions, such as a separation of regulation and operational functions, a strong trust in competition, or interconnection and unbundling rules (Schneider 2001). Nevertheless, the mutual interdependence between political-institutional, economic, and technological factors shaped the path of the overall transformation and the details of the new approaches. Thus, within the new framework dissimilarities in the details of the legal and regulatory arrangements continue to exist. For example, the more porous legal and regulatory system in the U.S. allowed more gradual responses to changes in the overall system. Federal and state regulation responded to new information technologies and needs earlier than in any other nation but proceeded at a more moderate pace. In countries with a more centralized political system such as the EU and its member states, change emerged much later but often evolved faster, reflecting the higher ability of policymakers to effectively transform industry structure. For example, Cherry and Bauer (2002) demonstrate this phenomenon in the case of rate rebalancing. Moreover, the process exhibits a strong degree of path dependence. For example, while the break-up of AT&T in the U.S. facilitated the creation of competition in the long distance market, it greatly complicated the re-integration of the industry after it had become evident that the traditional geographic delineation into long distance and local markets made increasingly less sense. European countries had not split local and long distance services in a comparable way and thus did not have to confront this specific problem and the associated complicated regulatory issues.

One of the secrets of success of the new, more open legal and regulatory framework is its facilitation of entrepreneurship. It has allowed technological innovations to be deployed in the network, which have gradually transformed – and will continue to transform – its traditional architecture. The most important developments are the near-ubiquitous diffusion of digital technology, tremendous increases in the transmission capacity of networks (including, albeit slower, broadband local access networks), and the continued rapid increases in processor power that have transformed wireline and wireless communications alike. The Internet, best characterized as a logical platform residing on a patchwork of physical networks (*inter alia*, narrowband voice, cable television, and wireless networks), epitomizes the architecture of next generation networks (NGNs) (Elixmann and Schimmel 2003). More than the present networks, NGNs will constitute general-purpose technologies, platforms upon which applications and services can be configured. Depending on the overall network configuration, in this emerging environment, the physical network layer may become fully independent of the upper application and services layers. As a result, the historical ability of platform service providers to earn rents by tying services to their physical network platforms will be severely weakened (Clark 2001). Furthermore, a general-purpose network platform will also facili-

² Noam (2001) points out that substantial improvements were also achieved in countries that did not implement the new blueprint.

tate the adoption of disruptive technologies such as WiFi or VoIP.³ Should such an open network emerge, the ability of content providers to earn profits may also be weakened, especially in the presence of disruptive (if illegal) peer-to-peer file-sharing technologies.

These developments toward commodity markets for platform services and at least some forms of content conflict with the fundamental economic characteristics of the information and communication industries (Shy 2001, Gottinger 2003, Noam 2004). Most importantly, these industries are characterized by high fixed and low incremental cost. In a competitive environment, prices will converge to incremental costs and likely be below average costs, undermining sustainable business models. Many segments of the information and communications industries also exhibit network effects, that is, the benefits for a participant in the network are dependent on the overall size of the network (Liebowitz and Margolis 2002). Network effects can facilitate the growth of service providers but they may also work the other way and accelerate the shrinking of a supplier or a sector. In the new environment, the interdependence between industry segments is higher and developments in one market segment may have spillover effects on others. Overall, these features contribute to an increased structural volatility in the information services industries. Noam (2004) points out that this precariousness may destabilize not only the information sector but, due to multiplier effects, the entire information-based economy. To avoid the perils of operation in a commodity market, firms may attempt to merge and/or to strategically abuse remaining bottlenecks, especially in access networks. Moreover, they may have strong incentives to erect new “logical” bottlenecks, for example, by using proprietary protocols on their networks or by blocking access to certain Internet addresses and the related content, as is already the case in the United States’ broadband cable access market.

The remarkable transition from a monopolistic framework to the present and emerging open environment has fundamentally altered industry dynamics and the prospects for regulation. The old framework allowed sector planning in pursuit of important infrastructure goals.⁴ By reducing uncertainty and stabilizing expectations, it provided a market environment that facilitated long-term infrastructure investment at lower profit rates. In contrast, the new environment is more risky and – other things equal – requires higher profitability to elicit similar long-term infrastructure investment. This is not necessarily a disadvantage as the economic and technological life span of the components of the new networks is much shorter than previously and the network has a much higher degree of modularity and scalability. Both the old and the new information and communications industries can be described as large technical systems (Mayntz and Hughes 1988). Such systems may show varying degrees of complexity (see below section 3 for a more detailed discussion). A closed monopolistic system like traditional infrastructure industries typically has a low degree of complexity but a more open system will have a higher degree of complexity. Even though monopolistic large technical systems raise challenging control issues, in the historical monopoly environment it was easier to identify policy instruments that could achieve desired outcomes. In the new environment, the degree of complexity of information and communications industries has increased, rendering it more complicated to identify policy instruments.

Some common features characterize complex adaptive systems, all of which are present in the present information and communication sectors. Many agents involved in decentralized decision-making populate them. These agents have dispersed, differing, and localized knowledge (and hence incomplete knowledge of the entire system). Their actions in response to the perceived environment are often based on routines shaped by past experience. Furthermore, they differ with regard to their ability to learn and adapt to changing circumstances (Holland 1995). Decisions by these agents are interrelated, contributing to a degree of coupling between the components of the system. Such cou-

³ “Disruptive” is meant in an economic, Schumpeterian sense, implying that the new technology poses severe challenges to established organizations and institutions.

⁴ This does not necessarily imply that the chosen instruments were efficient.

pling can be on a continuum between loose or tight, in which case actions in one subsystem strongly affect another (Longstaff 2003). Coupling can exist in vertical (upstream-downstream) or in horizontal relations. For example, digitization has multiplied the substitutability relations between network service providers. Thus a decision mandating the unbundling of DSL broadband access platforms will have repercussions for broadband access providers in the cable market, for potential new market entrants and for content providers that may not be fully anticipated. However, under certain conditions, complex adaptive systems are self-organizing and the new policy model is principally designed to take advantage of this feature, mostly by promoting competition. Complex adaptive systems can be represented as layered systems, with individual decision-makers forming the lowest tier, organizations, markets, and sectors forming intermediate tiers, and the economy as a whole forming the highest layer. One of the fundamental insights into the operation of complex adaptive systems is that performance at higher tiers is an emergent property that cannot be traced back to decisions at a lower level analytically, greatly complicating the identification of effective policy instruments. Thus, the question arises, as to how this transition toward a system of higher adaptive complexity has affected the prospects and limits of regulating and governing the information infrastructure. This question is addressed in the next section.

3 Prospects and limits of governance of complex adaptive systems

Some economic schools, such as the American institutional tradition, which was very influential in shaping regulation until the 1970s, or some members of the German *Gemeinwirtschaftslehre*, which was similarly influential in shaping the public enterprise system in several European countries, saw the task of government in the transformation of capitalism. However, the dominant view of regulation saw it as a means to overcome weaknesses of the market. At least in market-based economies regulatory policy was therefore conceptualized as a means of correcting forms of market failure and of undesirable outcomes of unregulated markets. Classical scenarios for intervention were seen in the prevalence of natural monopolies (wired telecommunications), the absence of property rights (radio communications), as well as public and merit good characteristics (universal service, content regulation). A division of labor was accepted between policy-makers (who were to decide policy goals) and researchers (who were to identify the most efficient means of achieving the goals). Simplified models allowing the identification and calibration of policy instruments were developed for this purpose. Once the most effective means and their dosage were known, policy was an exercise in social engineering. Although this view prevailed in practice, its fundamental assumptions of a benevolent, omniscient, and omnipotent policy-maker were soon subject to increasing criticism (Dixit 1996). This lively discussion has revealed that policy is subject to multiple, interrelated conditions, which can be categorized into information, institutional, and systemic constraints. Before these issues are reviewed, it is necessary to briefly discuss the conditions of successful policy.

3.1 Conditions of successful policy

A policy instrument is effective if it is sufficient to cause a desired or prevent an undesired effect. Sufficiency implies that whenever the instrument is present a certain effect is also observable. This notion is expressed well in the frameworks for government policy as formalized by Tinbergen (1952) and Theil (1964) and summarized by Johansen (1977). Following the notation of Eggertsson (1998), a policy-decision has four aspects. Societal preferences are expressed in an objective function

$$W = W(x) \quad (1)$$

A policy model specifies empirical relations between policy variables a , which are part of a larger set of policy variables A ($a \in A$), outcomes x and external variables z .

$$x = f(a, z) \quad (2)$$

Moreover, analytical or computational methods are needed to determine policy instruments that maximize the objective function $W(x)$. If X_z is the set of possible outcomes given the external factors z , the goal of public policy is to find policy variables a^* , generating outcomes x^*

$$a^* = g(x^*, z) \quad (3)$$

that maximize the objective function $W^* = W(x^*)$. This is most evident in the case of macroeconomic policy but applies in analogy to regulatory policies designed at the level of individual firms or sectors. Policy instruments a^* need to be sufficient to achieve x^* . The underlying models are essentially mechanic and deterministic (Morçöl 2002). Moreover, the traditional view holds that W is determined by policy makers, whereas experts reveal the relevant theoretical and empirical relations $f(a, z)$ and assist in the choice of the optimal policy instrument.

In practice, many available policy instruments are not sufficient but only necessary conditions for a desired outcome. Necessity means that a factor can be observed whenever an effect is present but that it can also have other effects. Policy will be effective if an instrument is both necessary and sufficient for an outcome. The design of effective policy is complicated if multiple necessary conditions need to be fulfilled simultaneously. Policy faces the risk of failure if not all of the necessary conditions or not all components of a constellation of sufficient factors can be influenced. Furthermore, theoretical and empirical research have demonstrated that causation in social systems is often complex (Ragin 2000). This means that it is relatively rare to find one sufficient instrument for a desired outcome. However, a specific outcome may be the result of one or even multiple constellations of factors that, taken alone, may be neither sufficient nor necessary.

3.2 Information constraints

Beginning as early as the 1920s, the exploration of information constraints of economic activity has contributed to a broad re-thinking of public policy. Work in this area led to an abandonment of the assumption of an omniscient policy-maker and brought several important issues to the fore. The discussion, mainly conducted by economists and later cognitive scientists, addressed issues of decision-making under uncertainty, problems of asymmetric information, and the feasibility of planning and public policy in general. Given space constraints, this paper will not discuss the first line of argument in detail. Starting with Knight (1921) economists started to pay more explicit attention to the effects of uncertainty on decision-making and to develop criteria appropriate for these conditions. Both policy

analysis and management science have adopted the emerging principles (see Morgan and Henrion 1990 for an overview) but, so far, they are rarely used in information and communications policy-making.⁵

A second line of inquiry studied the problems raised by asymmetrically distributed information, the fact that knowledge is local and not fully shared among the participants in the economy and in the regulatory process in particular. Policy-makers (“principals”) are at a loss compared to “agents” who may have more pertinent information. Public policy-making typically can be described as multiple principal agent relations, for example, between voters and legislators, legislators and regulators, regulators and managers, and managers and employees, each level afflicted with problems of asymmetric information. Under the headings of information economics and contract theory researchers have studied how individual and collective decisions are made under such conditions (Stiglitz 1986, Laffont and Tirole 1993, Macho-Stadler and Pérez-Castrillo 2001, Laffont and Martimort 2002). This literature contributed to the development of “incentive compatible” regulatory mechanisms that mitigate or overcome the information deficits of the regulatory agency compared to the regulated firm (Sappington and Weisman 1996). It does not question whether policy can succeed but rather points out that under real-world conditions efficient policy often will require the use of complicated instruments (Laffont and Tirole 2000). For practical regulatory purposes less demanding, simplified forms of incentive regulation, such as price caps, were “derived” from this conceptual literature.

A third debate focused on the more fundamental question as to whether a centralized planner could succeed in steering the economy. The early discussion explored whether a centrally planned economy could solve the economic problem efficiently. Later the emphasis shifted to the question of whether planning could improve the working of a market economy. In the context of these disputes, Ludwig von Mises and Friedrich A. v. Hayek argued that a centralized economy would not be able to collect and process the enormous amount of information necessary to develop an efficient plan. In his view, it was the great advantage of a decentralized market organization to process localized knowledge in superior ways. Competition could be seen as a “discovery procedure” assisting individual agents to adjust their plans to the actions of others. The resulting “spontaneous order” would be superior to any planning attempts (Hayek 1944, Caldwell 2004). Hayek must not be read as endorsing total laissez-faire, but he is not specific as to where the boundary between free market activity and policy should be drawn (see the review of his *Road to Serfdom* by John Maynard Keynes cited in Skidelsky (2000), p. 285; see also Samuels 2002). As a consequence, the proponents of an extreme libertarian agenda often take his writings to support their own political agenda. Nevertheless, he highlights the importance of decentralized information processing and the difficulty of a central planner to overcome the inherent ignorance.

Whereas Hayek concluded that public policy could not reach superior outcomes due to structural information deficits of the planner, Lucas (1987), in a celebrated model, claimed that government actions were ineffective because they were anticipated and thus neutralized by individual decision-makers. As will become transparent in the remainder of the paper, Lucas does not distinguish between process policy and policies aiming at the legal and institutional framework (the “order”) in which decentralized decisions unfold. If individuals indeed have rational expectations, process policy will lose effectiveness, unless it is random. However, the overall regulatory framework of a sector or the economy as a whole becomes effective exactly by being incorporated into individual decision-making.

⁵ The U.S. Federal Communications Commission (FCC) has recently renamed its Office of Plans and Policy (OPP) to Office of Strategic Planning and Policy Analysis (OSP) with the mission to engage in such broader research efforts.

Lastly, cognitive psychology demonstrated that large parts of our knowledge of the world are constructed in the interaction of the human mind with the signals received from its environment (Rizzello 1999). Knowledge generation is a self-referential process as the accumulated stock shapes the creation of incremental knowledge. Whereas the knowledge base can be expanded at a cost, it nevertheless remains incomplete. Cognitive psychologists have also found that humans face processing constraints. Due to the opportunity costs of information processing, not all possible options are reviewed. Rather, as Herbert A. Simon (1982) explained, individuals search until an internal threshold is satisfied. This threshold is not fixed but is modified in response to the experience of individuals. As a result, human action is based on simplified models of a problem. Many decisions, including policy-decisions, are made based on routines rather than fully rational searches for the best alternative. For this reason, decisions based on a wrong model can persist for a long time (Denzau and North 1994). An example from the recent ICT policy debate may be the assumption that local competition is feasible, upon which regulatory policy is predicated. This may be a misleading premise although it might be very difficult to find out (see Cas 2003 for a recent critique). Recognizing this impossibility of knowing the “truth” Karl Popper proposed a process of piecemeal engineering as the most successful approach to public policy. Likewise, Williamson (2000) has proposed a “remediability” criterion, according to which a state can only be deemed inefficient if a more efficient alternative can be identified and if a path to this state exists.

A common theme emerging from these diverse strands of work is that, despite elaborate general equilibrium models of optimal policy design, regulatory policy is necessarily a dynamic trial and error process. Not all countries have the resources to go through a similar trial and error process as the pioneer nations (United States, United Kingdom, Japan, and so forth). Thus, the regulatory model adopted by these first movers has become a strong blueprint for others and is imitated and emulated by many others (Schneider 2001, Henisz, Zelner and Guillén 2004). The next section discusses institutional and other feasibility constraints that need to be met by information and communication policy.

3.3 Institutional constraints

Whereas information issues have questioned the omniscience of policy-makers, the burgeoning literature on institutional and political dimensions of policy-making has cast a more differentiated light on the view of government as a benevolent and omnipotent actor. Public policies are enabled and constrained by the specific legal, institutional, socio-cultural and historical framework of a society. The pertinent literature uses the term “institution” in three different ways, referring to (a) the rules of the game (North 1990); (b) organizations (Nelson 1994); or equilibrium expectations resulting from repeated interaction among the players of a game (Aoki 2001). North’s approach is intuitively compelling whereas Aoki’s formulation is theoretically more versatile. “Rule-of-the-game” theorists typically subscribe to the view that institutions are designed (although they do not offer detailed explanations as to how binding institutions emerge). Equilibrium theorists view institutions as emerging phenomena. In practice, institutions are both emergent (“spontaneous” in Hayek’s language) and designed (Samuels 2002). Each society can be described by a unique “stock” of formal and informal institutions.⁶ Formal institutions include the legal system (e.g., constitutional, statutory and case law) and the political set-up of a polity (e.g., the division of powers). Informal institutions include values, beliefs, customs and norms shared by the members of a society.

⁶ Levy and Spiller (1996) have termed this stock “institutional endowment”.

Except in periods of rapid transition or revolution, institutions evolve gradually and can be changed by expending time and effort (Brock 1994). To this end, institutional frameworks specify meta-rules that govern the process of formal institutional change (e.g., rules for amending the constitution). Therefore, at every given point in time the institutional endowment of a society reflects earlier periods, creating some form of path dependence. Regulation is embedded into this broader framework and needs to obey the constraints imposed by institutions, such as due process, the division of labor between federal and state jurisdiction or the role of courts exercising their power of judicial review. As a result, not all theoretically possible policy options are also feasible. For example, in the United States federal policy proposals are often challenged by the states and overturned in court, clearly limiting the set of feasible policies.

The political system of a nation is a particular component of its institutional setup. This is a rich topic in itself and cannot receive detailed treatment in the present paper although a few important points deserve mentioning. Legislative or regulatory change happens in a political process. The political setup, as expressed in formal constitutions and statutes as well as in informal power structures shapes policy outcomes. Legal measures can only be adopted if the required simple or qualified majorities are assembled. To reach such majorities, players often need to accept compromises, contributing to legislation far apart from an unconstrained “optimal” policy. Tsebelis (2002) has tried to capture the political diversity of national regimes in his veto-player model. According to this approach, the number of veto players crucially determines the path of legal transformation. The model allows capturing the most pertinent dimensions of the political process although its explanatory power collapses for information and communications reform once other political variables are introduced (Bauer, Häge and Schneider 2004). Other models as to the working of the political process were proposed by Lindblom (1968), March and Olson (1989) and Kingdon (1995). All these models emphasize the multiple contingencies of practical policy making.

For example, Lindblom argued that policy decisions are made by “proximate policymakers” (legislators, political executives, appointed bureaucrats, perhaps party officials). As they are highly specialized, there typically are only small groups that are able to focus their attention on specific policy areas. They operate within institutional structures and rules of the game, including the provisions of relevant constitutions, legislative acts, administrative rulings, executive orders, and judicial decisions. March and Olson analyzed processes of learning in political settings, emphasizing the role of networks of experts and peers, and the conditions for policy change to be incremental or non-incremental. Kingdon pointed out that in order to succeed with a specific reform proposal, three “streams” of events, a problem stream, a policy stream and a political stream need to be synchronized. As the number of political actors grows, it may become more difficult to adopt policies other than marginal changes from the status quo. Thus, in the current environment of information and communication industries, successful policy change may become less likely.

The institutional framework of a nation often contains provisions preventing policy change that affects the economic rights of stakeholders. For example, the Fifth Amendment to the U.S. Constitution bars the government from taking private property without just compensation. The U.S. Supreme Court has found that private profits are a derivative of private property, placing boundaries on the government’s power to regulate. Abrupt legal or regulatory change runs the risk of violating these provisions (Sidak and Spulber 1997). To survive constitutional challenge, policies thus need to be compatible with established legal provisions, for example, the rights and obligations of common carriers (Cherry 2003). This places an important economic sustainability constraint on possible reforms.

Lastly, there is also a long tradition of economists and political scientists studying the behavior of the government – and regulatory agencies in particular – under conditions of asymmetric information. One school of thought is tied to the University of Chicago and includes the work of Stigler (1971), Peltzman (1976), and Becker (1983). Models in this tradition show that self-interested regulators will more likely adopt measures that benefit articulate small groups at the expense of the

general public. In contrast to this “capture” theory of regulation, the Virginia school of scholars around James Buchanan and Gordon Tullock argues that the presence of government will inevitably lead to inefficient and wasteful rent-seeking behavior. Buchanan, Tollison and Tullock (1980) and their followers therefore emphasize the importance of constitutional rules to limit such undesirable behavior.

Like problems of incomplete information, institutional conditions therefore create deviations from unconstrained optimization, often rendering second and third-best options as the only feasible choices. Moreover, they may contribute to considerable inefficiencies and waste of resources.

3.4 System complexity

In a predecessor to more recent developments, Lipsey and Lancaster (1956), in their theory of the second-best, pointed out that in an interdependent system market failure could not be corrected with targeted interventions, as was, for example, the rationale for price regulation for telephone service. Rather adjustments were required in all related markets, rendering efficient policy very complicated to achieve. During the past three decades, researchers in multiple disciplines have directed their attention toward the study of technological artefacts and their controllability. These approaches have in common an emphasis on the crucial fact that economic, legal, political and socio-cultural conditions interact in a systemic fashion. Systemic constraints on regulation arise from three sources: (a) the necessity to find solutions that are simultaneously compatible with the economic, political, legal and other forces; (b) the complexity of the regulated industry and society at large; and (c) factors that are not controllable by policy.

Since the 1960s, sociologists, political scientists and (a few) economists have studied the conditions under which large technical systems evolve and can be governed (Hughes 1983, Mayntz and Hughes 1988). The systems theoretic school in sociology (Luhmann 1994) introduced tools that can be used to analyze such more complex forms of interaction. A systems view was also adopted by research on complex adaptive systems (Waldrop 1992), which will be discussed in more detail below. The most applied research in this vein emerged from work on the governance and control of large technical systems (Hughes 1983, Mayntz and Hughes 1988, Schneider 2001). According to Luhmann (1994) modern societies are characterized by the functional differentiation of activities. The economy, law, science, politics, religion, education, media, and social movements are important functional systems of society.⁷ These functional systems develop their own logic and dynamics. For example, the function of the political system is to develop collectively binding rules; the function of the economy is to ensure material reproduction; and the function of the legal system is to establish order and solve conflicts. The systems are structurally coupled to form overall society and constitute contingencies for change in any of the systems. As a result of this complex interaction, the ability of actors in any of the functional systems to control the overall system is limited.

More recently, the theory of complex adaptive systems emerged from attempts to understand dynamic processes that could not be explained with the prevailing equilibrium oriented models (Rosser 1999, Longstaff 2003). Systems vary in their complexity. Although the language is not fully consistent, scholars typically differentiate three states: order, edge-of-chaos, and chaotic (Kauffman 1993, 1995). Orderly regimes can be stable or they can oscillate between two or more positions. Whereas orderly regimes are predictable, edge-of-chaos and chaotic regimes cannot be predicted

⁷ Other functional areas are morality, ethics, arts, medicine, love, and the (individual) psychical system (Reese-Schäfer 1999).

with reasonable accuracy, although the general position of the system may be known (Morçöl 2002, p. 156). Complex systems may undergo phase transitions: orderly systems may become chaotic, a process studied by chaos theory. Conversely, chaotic systems can become orderly, a transition examined by self-organization theory. Complex systems often exhibit non-linear dynamic behavior. They show a high degree of diversity and agents in the system are connected via multiple flows over networks of nodes and connectors (Holland 1995, 1998, Colander 2000, Axelrod 1997).

Due to the multiplicity of links in complex systems, the limited ability of actors to influence the overall conditions of the system, and the adaptation of actors to changing system conditions, effective policies are difficult or impossible to determine. As policies are rarely based on a full understanding of all the relevant interactions and dynamic effects, policies often have unexpected effects. Only in rare circumstances (“leverage points”) will it be possible to define and implement effective policies. One of these leverage points is the redesign of the legal and regulatory framework of a sector. In most other conditions, public policy, especially discretionary measures, will only nudge the overall system in a direction (Brock and Colander 2000), with the overall effect determined by positive and negative feedbacks. Thus, process policy dynamically interacts with other actors in the system. In a slightly different perspective, policies defining the legal and regulatory framework can also be seen as defining the “fitness landscape” of players (Kauffman 1995). Thus, rather than coercing efficient solutions they are better viewed as the selection environment in which competitors struggle for survival. Thus, rules and regulations affect which firms are more likely to succeed.

Complexity theory does not necessarily provide radically new and different answers to the problem of governance. It sensitizes analysis to recognize non-linear phenomena and the possibility or even likelihood of unpredictable outcomes, which make it nearly impossible to determine appropriate policy-instruments. Moreover, it highlights the importance of the overall rules within which a sector evolves. In an industry in a static equilibrium or in a steady state expansion path, the insights from complexity theory more or less correspond with the results of network economics or advanced industrial organization. However, if these conditions do not hold – and the information and communication sector is unlikely in such an equilibrium state – it points our attention to aspects that are overlooked by traditional theory. In sum, both the literature on the governance of large technical system and the theory of complex adaptive systems result in relatively cautious views as to the possibility of effective control. The next section explores the consequences for ICT policy in more detail.

4 Implications for selected areas of communications policy

Communications policy faces a vast array of issues and it would be presumptuous to claim that all could be addressed and solved in a short paper. This section reviews a few selected issues using the framework laid out in the previous sections. From these arguments follows that, due to information and institutional constraints as well as complexity, policy and regulation need to be understood as endogenous to the overall system in which they take place. This implies, in sharp contrast to the dominant view of policy as an exogenous controlling force, that policy may have fewer degrees of freedom than previously assumed. On the other hand, as history and experience illustrate, the extreme position that policy has no degrees of freedom and no effect on the overall system cannot be sustained.

4.1 Complexity and regulatory restraint

The present regulatory framework for communications infrastructure is itself the outcome of the co-evolution described in section two of this paper. Thus, the elimination of monopoly structures and comprehensive government control is the response to the increasing complexity of the information and communications sector. Recent regulatory reform is predicated on the superiority of competition over centralized control. It has led to a reduction in the activities subject to regulation and has changed the mix between process-oriented policy intervention and measures affecting the overall framework of rights and obligations in which market forces can unfold. However, it has not necessarily simplified regulation. It is a paradox of the regulatory transformation, at least in the United States, that under the banner of liberalization certain aspects of regulation, especially unbundling, have become more detailed and intrusive. The European Union has attempted to simplify its regulatory framework following the 1999 Communications Review although it may again become more complicated in the course of implementation and possible court challenges.

Table 1 illustrates selected goals at three different levels and – under the strong assumption of ideal policy implementation and enforcement – identifies policy instruments to achieve them. In the present open market environment, sufficient regulatory instruments exist predominantly at the micro (firm, individual) level. Even at this level, however, the scope of regulation has been reduced to firms with market power. For example, less than half of the revenues of service providers are subject to some form of regulatory supervision. Although similar instruments exist in principle for the sector level, the deregulatory philosophy of the past decades has largely abandoned them instead trusting in competition as an organizing principle. As a consequence, the present toolkit of regulators only contains means that are neither necessary nor sufficient to achieve specific sector outcomes (unless they are forthcoming by unregulated market forces). The only exception is universal service policy, where a modicum of instruments has been preserved. Attempts to govern outcomes are supplanted by “weak invisible hand theorems” stating that outcomes are efficient as long as workably competitive conditions are maintained.

Table 1: Policy objectives and instruments in an open market environment

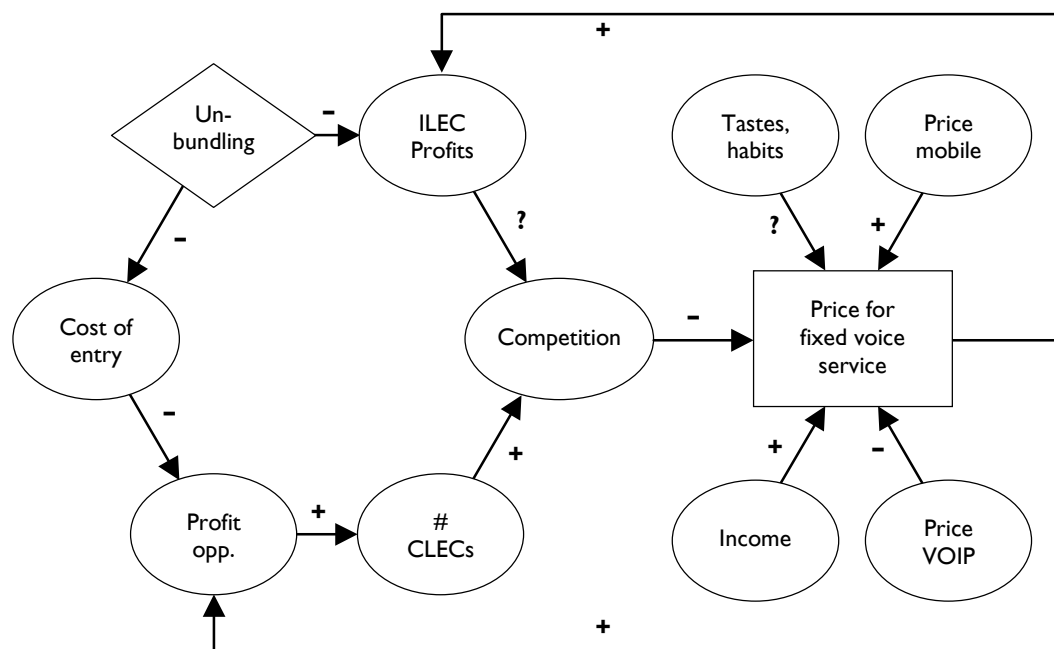
Policy goals	Sufficient	Necessary	Neither necessary nor sufficient
Information economy level			
Economic growth	[Expansive fiscal policy] ¹	Monetary policy	Competition in ICT
Innovation rate		Innovation policy	Competition in ICT
Employment growth		Workforce training	Competition in ICT
ICT use		Skill and knowledge development	Competition in ICT
ICT sector level			
Retail price level	[All prices set by regulator]		Competition in ICT
Universality of service	Targeted subsidies		Competition in ICT
Broadband access	[Targeted subsidies]		Competition in ICT
ICT investment level	[Direct public investment, targeted subsidies]		Tax incentives, competition in ICT
ICT employment	[Subsidies]	ICT workforce training	Competition in ICT
Quality of service	[Mandated service quality]		Competition in ICT
Protocols, standards	[Mandated standards]		Voluntary agreements, international agencies
Consumer protection	[Condition regulation]	Consumer protection laws	
Micro level			
Competitive behavior		Open market entry	Antitrust oversight
Access to incumbent network	Open access, inter-connection, unbundling obligations		
Wholesale prices	Wholesale price regulation		
Quality of service	[Quality of service standards]		
Investment level	[Targeted subsidies]		Tax incentives
R&D, innovation	[Targeted subsidies]		R&D incentives

Notes: ¹ Grey font indicates that this instrument is available in principle but not used as it is considered incompatible with the open market environment.

4.2 Instruments and objectives: unbundling, competition, and investment

Many of the aforementioned points can be illustrated in more detail using the example of unbundling policy and its links with the policy goals of competition and low prices for telecommunication services. Although interconnection policies have had an unbundling component since the early twentieth century (Noam 2002), in its recent form it is a product of the 1990s. Unbundling was introduced by the Telecommunications Act of 1996 to reduce barriers to entry into local markets. The original vision was that it would be a transitory phenomenon and facilitate market entry by facilities-based carriers who could build part of their networks and lease others from the incumbent. In practice most market entry has occurred via unbundled network elements. Contrary to expectations, according to recent FCC data, of the 11.1 % of total access lines that are provided by new competitors, 21.6 % are based on unbundled loops (“UNE-L”) whereas 66.9 % relied on customized

packages of loops and switching services (“UNE-P”)⁸ (FCC 2003). In the European Union local loop unbundling was mandated as of December 31, 2000 and is widely seen as facilitating new entry. Figure 1 presents a simplified diagram of the direct and indirect effects of local loop unbundling on competition and prices.



Note: A positive sign indicates that two variables move in the same direction (eg, if income goes up, ceteris paribus, the price for voice goes up). A negative sign indicates that the two variables move in opposite directions (eg, if the intensity of competition increases, ceteris paribus the price for voice goes down). A question mark indicates that the effect could be either positive or negative.

Acronyms: ILEC: incumbent local exchange carrier;
CLECs: competing local exchange carriers;
VOIP: voice over Internet protocol.

Figure 1: Direct and indirect effects of unbundling

Local loop unbundling allows new market entrants to buy network components or even full network platforms from an incumbent service provider. In this sense unbundling reduces the cost of market entry and *ceteris paribus* increases the opportunities for profitable market entry. At the same time it may also have negative incentive effects on network upgrades by the incumbent. The net effect of unbundling on sector outcomes can therefore only be assessed after these indirect effects are taken into consideration. Moreover, the effects of unbundling need to be isolated from other factors that influence market entry and investment decisions. Some may be preconditions for unbundling to have the desired effects: for example, without open market entry or the presence of potential entrants, unbundling will be ineffective. Other factors may influence the strengths of the relation between unbundling and new entry. For example, the prevailing retail price for voice service, the existing interconnection regime, and the availability of resale may all play a role. Depending on the constellation of these other variables, unbundling may have the desired effect, minimal effect, or be futile. In other words, unbundling might be a necessary and sufficient condition for new market

⁸ The remaining 11.5 % were resold lines. The share of UNE-P has been increasing steadily from 19.2 % in June 2000 (FCC 2003, Table 4).

entry under certain conditions, a necessary but not sufficient condition in other circumstances, or neither. Even if unbundling is sufficient or necessary for new market entry, it may have only very indirect impact on policy goals at the sector level, such as the level of investment in advanced infrastructure or the prices in the market for voice services. For example, the existing competitive structure of the voice market, the demand for voice service, and the availability and price of substitutes and complements will also shape the price charged for voice service.

Due to these counteracting forces, empirical assessments of the net effect of unbundling are critical. More evidence is desirable but some patterns seem to emerge. Controlling for other exogenous variables, Gabel and Huang (2003) as well as Prieger (2004) found for the United States that low prices for unbundled network elements coincide with lower investment into advanced network infrastructure. On the other hand, in a large cross-national sample, Garcia-Murillo and Gabel (2003) detected a significant positive impact of unbundling policies on broadband diffusion. In this latter study, the mixing of nations at very different income levels may have influenced the findings. In any case, the link between unbundling and these higher level objectives is indirect. A crucial question for policy makers is whether a lower level policy instrument consistently creates the right incentive with regard to higher level goals. Often, this cannot be determined based on past data. As analytical methods may not be able to overcome the problem of emergence in complex systems, computational or simulation methods may be the only practical alternative.

Unbundling also illustrates another aspect of interaction in complex adaptive systems, especially the political constraints. In the United States, the FCC's UNE rules as well as its TELRIC method for pricing were challenged in the courts (see FCC 2003 for an overview of the legal battles) and in the emerging void state regulatory agencies de facto set UNE prices. The unbundling policies were thoroughly overhauled in the FCC's Triennial Review Order in February 2003. Following an earlier court mandate, this Order adopted a more granular approach to unbundling and gave the states the task to review the competitive conditions in geographic markets, service markets, and customer classes to delineate those for which unbundling obligations should remain in force. On March 2, 2004 the Court of Appeals for the D.C. Circuit overturned this approach. This decision will again be subject to a court challenge. Some (e.g., Barbara Cherry of the FCC) have raised concern that the policy system itself has become chaotic, complicating investment and other business decisions. Although it will be necessary to develop a metric to assess whether the experience with unbundling is chaotic in the sense that it is fully unpredictable, this example highlights another use of the complexity view.

4.3 Disruptive technologies: VoIP, unlicensed wireless and the Internet

The open market environment has enabled a tremendous wave of innovations. Some of the new technologies pose significant challenges for the established legal and policy framework as well as incumbent players. For this reason, they can be termed "disruptive" technologies (in a Schumpeterian sense). The history of communications is full of technological advances with similar effects and the Internet is but a recent example of a disruptive technology with broad repercussions for the sector and the economy at large. In combination with the increasing availability of broadband access networks, the Internet has created a workable platform for another potentially disruptive technology: VoIP. In the current framework, VoIP is treated in many countries as information service and thus not subject to the policy compact governing traditional voice service. In international voice traffic, this has accelerated the decay of the (anyhow outmoded) system of accounting rates and termination charges. In domestic voice traffic, VoIP could have far-reaching effects on the existing voice service providers. In the United States, four areas of potential frictions exist between established policy goals and VoIP: access charges, universal service funding, emergency services, and law enforcement and national security.

As information service, VoIP is not subject to the system of access charges governing payments by long distance service providers (IXCs) to local exchange carriers (LECs). VoIP providers pay charges for the termination of traffic but they are by an order of magnitude smaller than current access charges. Although VoIP challenges the present system of intercarrier compensation, it will likely facilitate finding a more rational and coherent solution.⁹ Likewise, VoIP services do not contribute to the universal service fund and threaten to undermine the present system. This system has its known weaknesses and a more rational, competitively neutral restructuring would be desirable. However, unlike in the case of intercarrier compensation, it is less clear that this system can be fixed, given the many opportunities for VoIP providers to evade these contributions. Alternative means of funding universal service are available and VoIP may just force a rethinking of such options, which include general tax funding (unlikely, given the strained public budgets), funding from spectrum fees, or from levies on telephones.

Wireline (and more recently wireless) voice are furthermore subject to public interest obligations to facilitate emergency services as well as law enforcement. Service providers need to offer enhanced emergency calling (E911), which allows the linking of a caller with location and other information relevant for rescue teams. For example, firefighters are to be provided access to information on the materials used in a building, medical workers access to pertinent patient information, and so forth. Wireless service providers fought for several years against these obligations and only reluctantly and slowly complied. Some VoIP technologies are not easily capable of providing these services. Some experts argue that the decision to subscribe to emergency services and pay for any additional cost should rest with the subscriber and not the service provider.¹⁰ However this question is solved, it will have repercussions on the industry. At present voice service providers also have certain obligations to facilitate law enforcement, for example under the Communications Assistance and Law Enforcement Act of 1994 (CALEA). Whereas there is widespread agreement that these obligations should be extended to VoIP, it is not clear how they may eventually be implemented. VoIP raises other interesting issues. For example, in the United States interconnection obligations exist only between telecommunications service providers. Some potential VoIP service providers demand that interconnection privileges be extended to information service providers (NCTA 2004). This may indeed be an improvement over the status quo ante.

Another example of potentially disruptive technologies are “unlicensed”¹¹ wireless applications, which include, among others, WiFi, ultrawideband (UWB), cognitive radio applications, or meshed wireless technologies (Carter, Lahjouli and McNeil 2003). The main challenge posed by these applications is to incumbent service providers who have paid large sums to gain exclusive access to electromagnetic spectrum. The prospects, for example, of WiFi as a substitute for these services are not well understood. Recent developments such as handsets that are WiFi enabled, new antenna designs that extend the reach of WiFi signals up to 50 miles, and a fast growing infrastructure of access points, seem to amplify its likely impact. Other solutions, such as ad hoc networks, are not yet ready to be deployed on a mass scale. It is not clear what kind of applications they may support, although it seems more likely that they will be local. Governance issues in this realm are somewhat simplified by the fact that, with few exceptions like Guatemala or New Zealand, spectrum is presently considered a public resource. Thus, government agencies can control the amount of spectrum allocated to unlicensed services and they can establish rules for the use of these bands. In principle,

⁹ The FCC is currently conducting a proceeding on intercarrier compensation, with a final Order expected by July 2004. See Federal Communications Commission, *In the Matter of Developing a Unified Intercarrier Compensation Regime*, CC Docket No. 01-92, April 19, 2001.

¹⁰ See remarks by former FCC Chief Economist Michael Katz at the Fifth Quello Communications and Law Symposium, Washington, D.C., February 25, 2004, *Communications Daily*, vol. 24, no.38, February 26, 2004, p. 3.

¹¹ The term “unlicensed” is somewhat misleading. Although these services do not require individual licenses, equipment needs to comply with certain standards.

this control over the monopolized resource is sufficient to govern the effects of unlicensed services on the established wireless services (although not to govern services and applications configured in unlicensed bands). This is not to say this would be a desirable course of action but it illustrates that controllability increases in the presence of a monopoly resource. Furthermore, given the current belief in more open and flexible spectrum policy it is unlikely that the government will use this power.

A third example of a disruptive technology is the Internet itself. Its repercussions have led to a fundamental reorientation of information and communication law and regulation in many countries. It continues to challenge many traditional forms of regulation of communications that enjoy broad public support, such as the regulation of hate speech or porn. In addition, it raises new issues of governance in at least five areas (see also Melody 2003). These are engineering and coordination issues related to the Internet itself; issues related to the infrastructures upon which the Internet rests; issues related to the services provided via the Internet; issues related to Internet-based applications, such as electronic signatures; and security issues. One obstacle to finding an acceptable solution is the sheer number of players and their divergent interests and values. The present Internet governance regime, predominantly organized around ICANN, is to a large degree vested in its monopoly control over the root directory of the web (Mueller 2003). Thus, like in the case of wireless services, control over a crucial resource can, at least in principle, be leveraged in the design of policies. Of course, this does not necessarily imply that the present policies are efficient or accepted as legitimate. From the theory of complex adaptive systems one can conclude that a grand overall solution for Internet governance may not be feasible or desirable. Although the “end-to-end” philosophy is very widely accepted, it is *a priori* not evident why a certain degree of fragmentation would harm the Internet overall (Blumenthal and Clark 2001). This is especially the case if gateway technologies are available that can assure interoperability between different realms of the Internet.¹²

These examples indicate how the many decentralized decisions in a complex adaptive system can create significant innovations. They also illustrate the potential challenges to the incumbent service providers and prevailing policy rules. VoIP, unlicensed wireless and the Internet, while disrupting the established policy compact, offer an opportunity to rethink important solutions and adjust them to the world of advanced networks. If anything, these examples illustrate that flexibility with regard to governance is an absolute necessity in an open system. No grand design can anticipate new and unexpected developments. An institutional environment that can support piecemeal change and institutional competition is more likely to successfully cope with these challenges.

4.4 The new policy blueprint: superiority on average

During the past decades, the “old orthodoxy” of monopoly organization has been replaced by a “new orthodoxy” (Noam 2003) embracing, *inter alia*, open markets, competition, interconnection, unbundling, technological neutrality, and competitive neutrality as guiding lights. Overall, the evidence documenting the superiority of the new framework over the old model is decisive. However, like the old framework, the new consensus also has contributed to a selective perception and thus a simplistic interpretation of the data. Most of the reports by intergovernmental agencies rely on bivariate relations to establish the “success” of competition, independent regulation, or private ownership. Yet less is known about these links than is commonly perceived. What can be established is a correspondence (but not necessarily a simple causal relation) between these policy variables and

¹² In practice, as the research of Barabási (2002) demonstrates, the Internet presently does have a strong spatial structure and is far from the open web it is commonly perceived.

the performance of the information and communication industries. The availability of empirical data and more powerful statistical methods, especially to analyze panel data, have contributed to a wave of empirical cross-national studies. This research has to a large degree corroborated the patterns identified by less detailed studies but it has also revealed that the relations are often less clear-cut than commonly assumed.

For example, in a panel study of the effects of privatization and competition on network expansion and efficiency, Ros (1999) found that in high-income nations private ownership was correlated with significantly wider diffusion of telephone service, faster growth in the number of access lines per capita, and higher labor productivity. However, Ros did not find any influence of private ownership in countries with a gross domestic product per capita below US\$ 10,000. Boylaud and Nicoletti (2001) combined cluster analysis and panel data to examine telecommunications markets in the OECD. They found that privatization had weakly enhanced efficiency, but that competition had a more decisive influence. In a study of 31 privatized telecommunications firms in 25 countries, Bortolotti, D'Souza, Fantini and Megginson (2002) observed significant increases in post-privatization performance, and that a significant part of the gains was attributable to regulatory change and the introduction of competition. Wallsten (2001) found for a group of 30 African and South American nations that competition was the main source of efficiency improvements. Privatization alone yielded only limited benefits; however, privatization combined with regulation was positively correlated with better performance. Li and Xu (2002) detected that efficiency improvements were highest when privatization and competition were combined. Gutierrez and Berg (2000), Levy and Spiller (1996) and Henisz (2002) emphasize the importance of regulatory commitment and a stable institutional framework for investment as preconditions for good performance. The general tenor emerging from these studies is that the configuration of property rights, competition and regulation is crucial but that multiple arrangements may yield satisfactory outcomes.

Moreover, the data shows that the new policy blueprint works “on average”, which may be of help but not fully solve the decision-making problem of a policy-maker in a specific location, time, and context. Our discussion of complex adaptive systems demonstrated at a conceptual level that policy objectives at a sector and economy-wide level may, in fact, be achievable by different sets of policy instruments. Thus, there may not be just one “best” solution to governing the information and communication industries and different mixes of governing institutions and instruments may yield comparable outcomes.¹³ This outcome is compatible with a large body of comparative research (Ragin 1987, 2000). These studies indicate that it is often impossible to identify a single sufficient condition for an outcome but that several groups (“constellations”) of policy instruments may be able to realize them. Thus, fast broadband diffusion can be the outcome of concerted government efforts, the product of competition policy, related to user habits, or a combination of these factors.¹⁴ This does, of course, not throw overboard the need for sound policy frameworks. For example, policy and regulation are instrumental in creating an environment conducive to private sector investment. However, it does broaden the perspective to the fact that in complex adaptive systems like the present information and communications sector more policy options may exist than are currently utilized.

¹³ This raises a much broader issue, which cannot be discussed here in detail: markets do not exist in the abstract. As Samuels (2002, p. 89) points out “markets are a function of the institutions which help form them and work through them.” Therefore “differently structured markets organize knowledge and determine which/whose interests count in different ways” (*ibid.*). Therefore, there is no unique Pareto optimal solution (see also the contributions by Sen, 2002). Whereas this is a fundamental debate, it is currently not conducted in an explicit way in ICT policy-making.

¹⁴ Noam (2002) makes a similar point with regard to wireless services, which achieved significant growth even in countries with poor policy frameworks.

Such alternatives to the status quo will need to be explored and tested in practice. Just as competition is a discovery procedure, different legal and institutional arrangements are discovery procedures at a higher level of social organization. In the light of this argument and contrary to prevailing wisdom, agreements aiming at the simplification of policies across nations should not strive for full homogenization but preserve a degree of experimentation and diversity that can facilitate institutional learning. Where possible, policy-makers may in fact be well advised to allow competition between different policy regimes. Examples of competing legal, regulatory and technological regimes exist in today's information and communications industries and advance knowledge about governance. The coexistence of the Internet as an open end-to-end platform with other networks facilitated understanding of the relative advantages and disadvantages of these approaches. Likewise, in the wireless sector, the coexistence of exclusive and shared (unlicensed) bands allows overcoming the problems of incomplete information by allowing the accumulation of experience. Whereas such institutional diversity may, at any point in time, not be the most efficient solution, it nevertheless creates dynamic benefits.¹⁵ One important task for policy will therefore be to protect rather than reduce institutional diversity.

A last insight deserves brief mentioning. Levy and Spiller (1996) have pointed out that the optimal degree of complexity of rules depends on the institutional endowment of a nation or region. This is compatible with the view that dynamic adaptive systems work best in a zone between too much order and stability on the one hand and chaos on the other. The optimal mix may be dependent on the problem at hand although it may not be fully under the control of policy-makers. As a result, nations or regions may periodically "luck-out" although the "luck" may shift over time. At a high level, this is illustrated in a comparison between the U.S. and EU in their respective transitions since the 1990s. It seems that the EU's more centralized policy framework, which gave the Council and the Commission great leverage at a time when national regulatory agencies (NRAs) were not yet fully established, facilitated the creation of a more integrated policy space. Moreover, once the initial resistance to transformation was overcome, as owners of the incumbent service provider, the ability of governments to design and implement policy was much greater than the ability of the U.S. policy-makers, which are embedded in a much more complicated and multi-layered policy framework. Aggregate performance data reveal dramatically that, on average, the EU was trailing the U.S. in the early 1990s but that by the beginning of the next decade it had reversed that picture in key indicators, such as the prices paid for services, penetration of mobile services, and in many countries broadband access. As the number of stakeholders multiplies in the EU and NRAs become more entrenched, the EU's regulatory framework may begin to resemble that of the U.S., unless measures are undertaken to reestablish some more centralized form of control.¹⁶ This brief example illustrates that regulatory institutions are both emerging and created but not fully controlled by policy.

¹⁵ Competition, like its biological sibling evolution, is a wasteful process, as so vividly expressed by Joseph A. Schumpeter in his metaphor of the "gales of creative destruction."

¹⁶ A case in point may be the UMTS spectrum licensing approach, as mentioned above.

5 Preliminary lessons and conclusions

This paper raised the question of whether in the present more diverse and technologically dynamic environment, information and communication policy could successfully control and manage the performance of this crucial infrastructure. Contrary to the growing view that advanced information infrastructures cannot be successfully governed (and therefore should not be governed), the paper finds that governance is possible and makes a difference. However, in the emerging environment, problems of incomplete information, institutional feasibility conditions, and the increasing complexity of the sector alter the conditions of governance. In a complex adaptive system, it is more difficult to find sufficient instruments for policy objectives, especially at the sector and economy level. This has been aggravated by voluntary restraint to not utilize certain policy instruments. Some of these instruments, such as control via public ownership rights, are known to have serious limitations. Nevertheless, there may be scenarios under which they work reasonably well.¹⁷ While this paper certainly does not advocate a return to the past, it suggests a renewed pragmatic look at a broader range of policy instruments. Having said this, and with the caveat that substantial additional research will be necessary, some general insights emerge (see also the overview of Brock and Colander 2000 on policy implications of complexity theory in general):

- Given information constraints, political feasibility constraints, and complexity, grand policy designs aimed at controlling the overall evolution of this infrastructure carry significant risks (as exemplified by the European UMTS experience) as opposed to more gradual policies. In this sense, seen from a complexity perspective policy needs to become more humble, seeking for local improvements.
- It is easier to specify sufficient policy instruments at the micro level. However, these instruments are only indirectly linked with important policy objectives at the sector and economy level. Absent renewed interest in sector and macroeconomic governance, performance at these levels will be an emergent property, not fully controlled by policy instruments at the micro level.
- Where feasible, policy can support mechanisms of self-organization, most importantly competition. The stability of the information and communication sector will to a certain degree depend on policies that keep forms of destructive competition at an acceptable level. To this end, in addition to antitrust oversight, some regulatory inertia and friction may be desirable.
- From a systems perspective, it becomes apparent that information and communication technologies do not move toward a preordained equilibrium state (as assumed in most of modern regulatory economics). This implies that traditional regulatory theory may only be a good guide for static or dynamic steady state situations, but not for other problems. However, the normative foundations of more dynamic models are not developed yet.
- Using tools from the analysis of complex systems, more attention would be paid to nonlinear developments and events that might shift a predictable system into a chaotic region. Thus, rather than looking for efficiency-enhancing means the focus of attention would shift to stability-enhancing measures. Some inertia and friction in the governance framework of the sector may be desirable.
- Seen from the view of complex adaptive systems, policy recommendations are less certain as multiple indirect effects and time lags may complicate the calibration of measures. In many situations no policies may exist that can actually improve things. Attempts at fine-tuning governance are replaced by adherence to transparent rule-based regimes that facilitate stability and private contracts (Longstaff 2003).

¹⁷ Public and cooperative ownership is experiencing renewed interest in the United States in the context of broadband networks although no systematic assessment has been conducted.

- Complexity analysis sharpens the view of effects that may not show up immediately but involved slow feedback processes as well as indirect effects. Particular attention may be paid to abrupt changes in the stability of a system.
- It is recognized that in social systems regularities and patterns may change. Therefore, the effects of policies may change as well. Broader use of comparative methods and scenario thinking may help explore these issues.
- Complexity theory also would require an application of different methods to explore policy options. For example, it would continuously review policy outcomes based on empirical data and would more widely rely on computational and experimental methods.
- Overall, these insights would be more applicable to aggregate levels, that is, policies at the sectoral and economy-wide level. Nevertheless, micro-level policies would be reviewed using a richer set of questions and tools.

In practice, ICT regulators have adopted some of these proposals already. For example, in the United States computational analysis is slowly introduced into policy analysis at the FCC. Policy-makers in Europe and the United States have made an effort to monitor the experience with regulatory change, although the methods are in an early stage of development. Overall, the insights reviewed in this paper complement present tools and analytical methods. Governance matters but in ways that are more complicated than previously assumed. While this view to a certain degree weakens the trust in the established set of practical policy knowledge, it also may open a road to a deeper understanding of the prospects and limits of policy in this vital industry.

6 References

- Aoki, M. (2001), *Toward a comparative institutional analysis*, Cambridge, MA: MIT Press.
- Axelrod, R. M. (1997), *The complexity of cooperation: agent-based models of competition and collaboration*, Princeton, N.J.: Princeton University Press.
- Barabási, A.-L. (2002), *Linked: the new science of networks*, New York: Perseus.
- Bauer, J. M. (2004), „Privatisierung von Infrastrukturektoren aus wirtschaftswissenschaftlicher Sicht,“ in V. Schneider and M. Tenbücken (eds.), *Der Staat auf dem Rückzug: Die Privatisierung öffentlicher Infrastrukturen*, Frankfurt am Main: Campus Verlag.
- Bauer, J. M., Häge, F. and Schneider, V. (2004), „Vetospiele oder Institutionen: Zum Politikwandel in der Telekommunikation,“ in M. Tenbücken and V. Schneider (eds.), *Der Staat auf dem Rückzug: Die Privatisierung öffentlicher Infrastrukturen*, Frankfurt am Main: Campus Verlag.
- Becker, G. S. (1983), “A theory of competition among pressure groups for political influence,” *Quarterly Journal of Economics*, 98(3): 371-400.
- Blumenthal, M. S. and Clark, D. D. (2001), “Rethinking the design of the Internet: the end-to-end arguments vs. the brave new world,” in B. M. Compaine and S. Greenstein (eds.) *Communications policy in transition: the Internet and beyond*, pp. 91-139, Cambridge, MA: MIT Press.
- Bortolotti, B., D’Souza, J., Fantini, M. and Megginson, W. M. (2002), “Privatization and the sources of performance improvement in the global telecommunications industry,” *Telecommunications Policy* 26 (5-6): 243-268.

- Boylaud, O. and Nicoletti, G. (2001), "Regulation, market structure and performance in telecommunications," *OECD Economic Studies* n.32: 99-142.
- Brock, Gerald W. (1994), *Telecommunications policy for the information age: from monopoly to competition*, Cambridge, US: Harvard Business School Press.
- Brock, G. W. (2003), *The second information revolution*, Cambridge, MA: Harvard University Press.
- Brock, W. A. and Colander, D. (2000), "Complexity and policy," in D. Colander (ed.) *The complexity vision and the teaching of economics*, pp. 73-96, Cheltenham: Edward Elgar.
- Buchanan, J. M., Tollison, R. D., and Tullock, G. (eds.) (1980), *Toward a theory of the rent-seeking society*, College Station, TX: Texan A&M University.
- Caldwell, B. (2004), *Hayek's challenge: an intellectual biography of F. A. Hayek*, Chicago: Chicago University Press.
- Carter, K. R., Lahjouli, A. and McNeil, N. (2003), "Unlicensed and unshackled: a joint OSP-OET white paper on unlicensed devices and their regulatory issues," OPP Working Paper no. 39, Washington, DC: Federal Communications Commission.
- Cas, J. (2003), "Fallacies and inefficiencies of telecom regulation in Europe," *Communications and Strategies*, 51, 3rd quarter: 97-120.
- Cherry, B. A. (2003), "The political realities of telecommunications policies in the U.S.: how the legacy of public utility regulation constrains adoption of new regulatory models," *Michigan State DCL Law Review*, Fall, Issue 3: 757-790.
- Cherry, B. A., and Bauer, J. M. (2002), "Institutional arrangements and price rebalancing: evidence from the U.S. and the European Union", *Information Economics and Policy* 14: 495-517.
- Clark, D. (2001) "A taxonomy of Internet telephony applications," in L. W. McKnight, W. Lehr and D. Clark (eds.), *Internet telephony*, Cambridge, MA: MIT Press.
- Colander, D. (ed.) (2000), *The complexity vision and the teaching of economics*, Cheltenham: Edward Elgar.
- Crandall, R. W. and Waverman, L. (1995), *Talk is cheap*, Washington, DC: Brookings Institution.
- Denzau, A. T. and North, D. C. (1994), "Shared mental models: Ideologies and institutions," *Kyklos*, 47(1): 3-31.
- Dixit, A. K. (1996), *The making of economic policy: a transaction cost politics perspective*, Cambridge, US and London, UK: MIT Press.
- Dutton, W. H. (1999), *Society on the line*, Oxford: Oxford University Press.
- Eggertsson, T. (1998), "Limits to institutional reform," *Scandinavian Journal of Economics*, 100(1): 335-357.
- Elixmann, D. and Schimmel, U. (2003), "'Next Generation Networks' and challenges for future competition policy and regulation," *Communications and Strategies*, no. 50, 2nd quarter: 239-268.
- FCC (2003), *Local telephone competition: status as of June 30, 2003*, Industry Analysis Division, Federal Communications Commission, Washington, D.C.
- Fransman, M. (2002), *Telecoms in the Internet age*, Oxford: Oxford University Press.
- Gabel, D. and Huang, G.-L. (2003), "Promoting innovation: impact of local competition and regulation on deployment of advanced telecommunications services for business," presented at the AFEE conference, Washington D.C. January, available at http://itc.mit.edu/itel/docs/2003/promo_innov.pdf.

- Garcia-Murillo, M. and Gabel, D. (2003), "International Broadband Deployment: The Impact of Unbundling", paper presented at the 31st TPRC conference, Alexandria, September, available at <http://intel.si.umich.edu/tprc/papers/2003/234/IntrntBrdbndDeploy.pdf>.
- Gilder, G. (2000), *Telecosm: how infinite bandwidth will revolutionize our world*, New York: Free Press.
- Gottinger, H. W. (2003), *Economies of networks*, London: Routledge.
- Gutierrez, L. H. and Berg, S. V. (2000), "Telecommunications liberalization and regulatory governance: lessons from Latin America," *Telecommunications Policy* 24: 865-884.
- Hayek, F. A. (1944), *The road to serfdom*, Chicago: University of Chicago Press.
- Henisz, Witold J. (2002), "The institutional environment for infrastructure investment," *Industrial and Corporate Change*, 11: 355-389.
- Henisz, W. J., Zelner, B. A. and Guillén, M. F. (2004), "International coercion, emulation and policy diffusion: market-oriented infrastructure reforms, 1977-1999," paper presented at the AEA conference, San Diego, CA, January 3-6.
- Henten, A. and Schneider, M. (2003), "Has liberalisation of telecommunications failed in Europe?" *Communications and Strategies*, 50, 2nd quarter: 19-48.
- Holland J. (1995), *Hidden order: how adaptation builds complexity*, Reading, MA: Addison-Wesley.
- Holland, J. H. (1998), *Emergence: from chaos to order*, New York: Perseus.
- Huber, P. W. (1997), *Law and disorder in cyberspace: abolish the FCC and let common law rule the telecosm*, New York: Oxford University Press.
- Hughes, Thomas P. (1983), *Networks of power: electrification in Western society, 1880-1930*, Baltimore: Johns Hopkins University Press.
- ITU (2003), *World telecommunications development report*, Geneva: International Telecommunications Union.
- Johansen, L. (1977), *Lectures on macroeconomic planning I: general aspects*, Amsterdam: North-Holland.
- Kauffman, S. A. (1993), *The origins of order: self organization and selection in evolution*, New York: Oxford University Press.
- Kauffman, S. A. (1995), *At home in the universe: the search for laws of self-organization and complexity*, New York: Oxford University Press.
- Kingdon, J. (1995), *Agendas, alternatives, and public policy*, 2nd edition, New York: Harper Collins.
- Knight, F. H. (1921), *Risk, uncertainty and profit*, Boston and New York: Houghton Mifflin.
- Laffont, J.-J. and Tirole, J. (2000), *Competition in telecommunications*, Cambridge, MA: MIT-Press.
- Laffont, J.-J. and Martimort, D. (2002), *The theory of incentives : the principal-agent model*, Princeton: Princeton University Press.
- Levy, B. and Spiller, P. T. (1996), *Regulations, institutions, and commitments: comparative studies of telecommunications*, Cambridge, UK and New York: Cambridge University Press.
- Li, W. and Xu, L. C. (2002), "The impact of privatization and competition in the telecommunications sector around the world," Working Paper, University of Virginia and World Bank.
- Liebowitz, S. J. and Margolis, S. E. (2002), "Network effects", in M. E. Cave, S. K. Majumdar and I. Vogelsang (eds.) *Handbook of telecommunications economics*, volume 1: 75-96.

- Lindblom, C. E. (1968), *The policy-making process*, Englewood Cliffs, NJ: Prentice Hall.
- Lipsey, R. G. and Lancaster, K. (1956), "The general theory of the second best," *Review of Economic Studies*, 24: 11-32.
- Longstaff, P. (2003), The puzzle of competition in the communications sector: Can complex systems be regulated or managed? Program on Information Resources Policy Working Paper, Harvard University, July.
- Lucas, R. E. (1987), *Models of business cycles*, Oxford: Blackwell.
- Luhmann, Niklas (1994), *Soziale Systeme: Grundlagen einer allgemeinen Theorie*, Frankfurt: Suhrkamp.
- Macho-Stadler, J. and Perez-Castrillo, D. (2001), *An introduction to the economics of information: incentives and contracts*, Oxford: Oxford University Press.
- Madden, G. (ed.) 2003), *The international handbook of telecommunications economics*, 3 volumes, Cheltenham: Edward Elgar.
- Mansell, R. E. and Steinmueller, W. E. (2000), *Mobilizing the information society: strategies for growth and opportunity*, Oxford; New York: Oxford University Press.
- March, J. G., and Olson, J. P. (1976), *Ambiguity and choice in organizations*. Bergen, Norway: Universitetsforlaget.
- Mayntz, R. and Hughes, T. P. (eds.) (1988), *The development of large technical systems*, Frankfurt am Main: Campus.
- Melody, W. H. (2003), "Can the Internet economy be governed and if so, how?" Lecture given at the London School of Economics, May 1, 2003, available at <http://www.lse.ac.uk/objects/2003/08/15/20030815t1601z001.pdf>.
- Mokyr, J. (2002), *The gifts of Athena: historical origins of the knowledge economy*, Princeton, NJ: Princeton University Press.
- Morçöl, G. (2002), *A new mind for policy analysis: toward a post-Newtonian and post-positivist epistemology and methodology*, Westport, CT: Praeger.
- Morgan, M. Granger and Henrion, M. (1990), *Uncertainty: a guide to dealing with uncertainty in quantitative risk and policy analysis*, Cambridge, UK: Cambridge University Press.
- Mueller, M. (2003), *Ruling the root*, Cambridge, MA: MIT Press.
- Natalicchi, G. (2001), *Wiring Europe: reshaping the European telecommunications regime*, Lanham, MD: Rowman & Littlefield Publishers.
- NCTA (2004), "Balancing responsibilities and rights: a regulatory model for facilities-based VoIP competition," Washington, DC: National Cable and Telecommunications Association.
- Nelson, R. R. (1994), "The coevolution of technologies and institutions," in R. W. England (ed.), *Evolutionary concepts in contemporary economics*, pp. 139-156, Ann Arbor: University of Michigan Press.
- Noam, E. M. (2001), "The next frontier for openness: wireless communications," paper presented at the 2001 Telecommunications Policy Research Conference Alexandria, Virginia October 26.
- Noam, E. M. (2002), *Interconnecting the network of networks*, Cambridge, MA: MIT Press.
- Noam, E. M. (2003), "Current problems of spectrum management," presentation at the FCC-Academia workshop "Formulating a Research Agenda for Communication Policy," December 5, 2003.

- Noam, E. M. (2004), "The internet: still open and competitive," keynote presentation at the Fifth Quello Communications Law and Policy Symposium, Washington, DC, February 25.
- North, D. C. (1990), *Institutions, institutional change, and economic performance*, New York: Cambridge University Press.
- OECD (2003), *Communications outlook*, Paris: Organisation for Economic Co-operation and Development.
- Parlow, J. P. (1996), A declaration of the independence of cyberspace, Davos, Switzerland, February 8, available at <http://www.eff.org/~barlow/Declaration-Final.html>.
- Peltzman, S. (1976), "Toward a more general theory of regulation," *Journal of Law and Economics*, 19(2): 211-240.
- Prieger, J. E. (2004), "Unbundling requirements, state regulatory policies and broadband internet access", paper presented at the AEA conference, San Diego, CA, January.
- Ragin, C. C. (1987), *The comparative method: moving beyond qualitative and quantitative strategies*, Berkeley: University of California Press.
- Ragin, C. C. (2000), *Fuzzy-set social science*, Chicago: University of Chicago Press.
- Reese-Schäfer, W. (1999), *Niklas Luhman: Zur Einführung*, Hamburg, Germany: Junius Verlag.
- Rizzello, S. (1999), *The economics of the mind*, Cheltenham: Edward Elgar.
- Ros, A. J. (1999), "Does ownership or competition matter? The effects of telecommunications reform on network expansion and efficiency," *Journal of Regulatory Economics* 15: 65-92.
- Rosser, J. Barkley, Jr. (1999), "On the complexities of complex economic dynamics," *Journal of Economic Perspectives*, 13(4): 169-192.
- Samuels, W. J. (2002), *Economics, governance and law*, Cheltenham: Edward Elgar.
- Sappington, D. E. M. And Weisman, D. (1996), *Designing incentive regulation for the telecommunications industry*, Cambridge, MA: MIT Press.
- Schenk, K.-E. (2003), *Economic institutions and complexity: structures, interactions and emergent properties*, Cheltenham: Edward Elgar.
- Schneider, V. (2001), *Institutionelle Evolution as politischer Prozess: Die Entwicklung der Telekommunikation 1800-2000*. Frankfurt: Campus.
- Sen, A. K. (2002), *Rationality and freedom*, Cambridge, MA: Belknap Press of Harvard University Press.
- Shy, O. (2001), *The economics of network industries*, Cambridge, MA: Cambridge University Press.
- Sidak, J. G. and Spulber, D. F. (1997), *Deregulatory takings and the regulatory contract: the competitive transformation of network industries in the United States*, Cambridge, U.K.; New York: Cambridge University Press.
- Simon, H. A. (1982), *Models of bounded rationality*, Cambridge, MA: Cambridge University Press.
- Skidelsky, R. (2000), *John Maynard Keynes: fighting for freedom, 1937-1946*, New York and London: Viking.
- Stigler, G. J. (1971), "The economic theory of regulation," *Bell Journal of Economics and Management Science*, 2: 3-21.
- Stiglitz, J. E. (1986), *Economics of the public sector*, New York: W. W. Norton.
- Theil, H. (1964), *Optimal decisions rules for government and industry*, Amsterdam: North Holland.

- Tinbergen, J. (1952), *On the theory of economic policy*, Amsterdam: North-Holland.
- Trebing, H. M. (1994), "The networks as infrastructure – the reestablishment of market power," *Journal of Economic Issues* 28(2): 379-389.
- Tsebelis, G. (2002), *Veto players: how political institutions work*, Princeton, NJ: Princeton University Press.
- Waldrop, M. M. (1992), *Complexity: the emerging science at the edge of order and chaos*, New York: Simon and Schuster.
- Wallsten, S. J. (2001), "An econometric analysis of telecom competition, privatization, and regulation in Africa and Latin America," *Journal of Industrial Economics* 49: 1-19.
- Williamson, O. E. (2000), "The New Institutional Economics: taking stock, looking ahead," *Journal of Economic Literature* 38:595-613.
- WSIS (2003), Declaration of Principles, World Summit on the Information Society, Geneva, December 2003, available at http://www.itu.int/dms_pub/itu-s/md/03/wsis/doc/S03-WSIS-DOC-0004!!PDF-E.pdf.

Previously published manuscripts

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