Towards new regulatory regimes in globalized infrastructure

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Abstract: The internationalization of infrastructure raises the issue of internationalization of regulatory governance. By internationalization of infrastructure, I mean the presence if not predominance of cross-border interconnections, ownership, interdependencies, spillovers, and the like. Such cross-border relationships are not new, but are growing in their significance. In several instances, this internationalization of infrastructure has led to internationalization of regulatory activity, such as the International Telecommunications Union (ITU), international cooperation among competition authorities, and supranational regulators – for example, the European Union (EU) or the Eastern Caribbean Telecommunications Authority (ECTEL). The formal authority of these arrangements ranges from completely voluntary organizations, such as associations of regulators or cooperative committees, to institutions with coercive power. There is interest in expanding international regulation with greater coercive power. I examine the issue of the scope of regulatory institutions in the presence of international infrastructure. I do not find a pressing need to internationalize additional regulatory institutions for infrastructure, but I do see a need to leverage the co-evolution of service providers, customers, and governance institutions to learn through experimentation.

All organizations are perfectly aligned to get the results they get.
Arthur W. Jones (Butler-Jones 2009)

Introduction

There are numerous examples of regulatory institutions being created or reformed in response to changes in technology or industry structure. In the United States, changing technologies for natural gas production and transport led policymakers in the 1900s to replace municipal regulation with state regulation, and to supplement state regulation with federal regulation (Phillips 1993: 692-99; Natural Gas Supply Association 2008). The United Kingdom recently dissolved its telecommunications regulatory agency, Oftel, and formed Ofcom with powers to oversee a broader array of

converging information communications technology (ICT) services. Sometimes institutions and technologies can become misaligned, with potentially disastrous results, such as the energy crisis in California (Borenstein 2002). Proper alignment between institutions and technologies is called coherence (Künneke 2008).[1]

Recent trends in the internationalization of infrastructure raise the issue of whether the sectors are undergoing fundamental changes that imply a need to realign regulatory institutions. There are several examples of internationalization of infrastructure: Telecommunications is an increasingly global business, as was evident from the ripple effects that the 1984 breakup of AT&T had across the world (Carpentier et al. 1992: vii) and from the expansion of the European telecommunications companies Telefonica, France Telecom, and Vodafone across the globe. Electricity crosses national boundaries, as Canadians and U.S. citizens learned during a grid failure in the northern United States, and as the countries neighboring South Africa are learning as they deal with Eskom. Environmental issues related to infrastructure, most recently climate change, also seem not to respect national boundaries.

Infrastructure internationalizes through interconnections that cross national borders. The physical cross-border interconnections create or result from interdependencies and spillovers, sometimes provide economies of scale, and sometimes involve network effects. In addition to the physical network interconnections, there are financial interconnections: Some UK utilities ran into financial difficulties because of unproductive international investments (*The Independent* 1997). Gazprom has demonstrated that strategies cross national boundaries and sometimes blur the business-political boundary (Hoovers Online 2009; *Spiegel Online International* 2006).

This internationalization of infrastructure raises the issue: Are existing infrastructure regulatory institutions capable of dealing with these changes or do we need realignment? This is the issue I examine, although limiting my attention to traditional utility sectors of electricity, natural gas, telecommunications, and water. I find that current regulatory institutions appear adequate to address the issues raised by internationalization of infrastructure, but that the dynamic changes occurring in infrastructure call for experimentation with alternative institutional arrangements.

I reach these conclusions by first revisiting the purposes of regulation and the design of regulatory institutions. I then examine the internationalization of infrastructure. I find that while internationalization appears to be growing in magnitude, there are no new features of internationalization that would seem to require

[1] Künneke's concept is technical coherence, which focuses on aligning regulatory institutions with technologies so that, in instances where technology was controlled by a single decision making system, a regulatory institution would encapsulate the entire control system. There appear to be at least three other forms of coherence that might be relevant. Effect coherence involves ensuring that the regulatory institution's geographic and legal reach are sufficient to accomplish the purposes of regulation. Capacity coherence refers to the information and expertise of the regulatory institution. Array coherence refers to the number and types of operators with which the regulatory agency engages.

new forms of regulatory intervention. Finally, I develop a framework for adaptive learning in regulatory institutional design.[2]

Regulatory institutions: Purposes and structure

Purposes of regulation

Regulation of infrastructure developed for several reasons, including controlling market power, ensuring industry stability, redistributing wealth, extracting rents from service providers, limiting opportunism, and overcoming information asymmetries. I describe these in this section to lay a foundation for analyzing how internationalization of infrastructure may impact them.

The first two reasons for regulation that I will address – controlling market power and ensuring stable supply – have their roots in the public interest theory advanced by institutional economists such as Martin Glaeser and Harry Trebing.[3] The central idea is that infrastructure industries are affected with the public interest in that the effects of inefficiencies and instabilities in infrastructure have unusually disproportionate, cascading effects throughout the rest of the economy (Phillips 1993: 1-2, 83-121; Glaeser 1927: 170-171). Utility sectors were thought to be unstable because the high fixed costs led to destructive competition (Sharkey 1982: 24-28). Although as I will describe below, some people are skeptical that regulation developed primarily to serve the public good. There is evidence that infrastructure industries are affected with the public interest as defined by the institutionalists. Empirical research has consistently supported the idea that advancing telecommunications infrastructure is important for

[2] To elaborate on this point, there is reason to be skeptical that a researcher has sufficient institutional and systems knowledge to observe all of the relevant information, interpret the situation, and appropriately intervene by instructing people on what should be done. It naturally follows that any conclusions by a researcher on this topic should be considered as tentative. Observation-interpretation-intervention, which is our scientific approach, is a complex process that is often done with an end in mind. I do not believe I have ever encountered an analysis that was not guilty to some degree of this sequence of thought: (1) anticipation of prescription; (2) gathering of data consistent with the *ex ante* prescription; (3) interpretation of data as anticipated or nearly so; and (4) arrival at or near the anticipated prescription. I do not mean to imply that this approach is inherently wrong or inappropriately biased. Indeed, Conklin (2006: 14) argues that the above four-step sequence is appropriate and must be repeated often for organizational learning to occur. Indeed, we should be doubtful of anyone who claims to begin an investigation without bias as such a person would by definition begin with a blank slate, meaning that the person would have no discernable motivation for launching an investigation, no basis for knowing which data might be appropriate for the investigation, and no framework for organizing the data into a logical story. This implies that it is not our biases that distort our conclusions, but our learning process if the process excludes new understandings of how the world does and should work.

[3] See, for example, Glaeser (1927) and Trebing (1984, 1987).

economic development.[4] Furthermore, the rapid growth of the economies of China and India provides evidence that such economic expansion goes hand in hand with utility infrastructure growth.

There is also substantial support for the notion that infrastructure industries tend to be characterized by market power. For example, governments generally grant exclusive licenses for electricity and gas distribution. There are also situations where infrastructure markets that are open to competition nonetheless are marked by dominant firms. For example, broadband markets in the United States generally have two dominant players, a fixed line provider and a cable television provider (FCC 2008). But this is not always the case: Ward (1995) finds that the degree of market concentration in the U.S. telecommunications long distance market in the early 1990s was comparable to that in most areas of the economy.

The evidence supporting the notion that infrastructure markets are sufficiently unstable to warrant government intervention and that regulation improves stability is out-of-date at least for the United States because regulation has been in place for such a long time. Perhaps it is time to experiment again to see if this idea remains true.

The notions of rent seeking and taxation by regulation come from neoclassical economics (Peltzman 1976; Posner 1971). These theories are not normative notions of why we should regulate, but are positive theories trying to explain how the self-interest of government actors, such as politicians, might motivate the formation of regulatory institutions. These ideas hold that regulation occurs because of its distributive effects, namely its ability to transfer wealth from less politically powerful stakeholders to more politically powerful ones. There would seem to be very few who would argue that such transfers do not happen through regulation. Although there are exceptions, it seems to be a rule that rural areas dependably benefit from cross subsidies effected through regulation, that regulated entities are frequently protected from competition, and that labor unions benefit by sharing in the monopoly rents made possible by market protection. Studies of developing countries consistently show that it is the wealthy, not the poor, who benefit most from universal service subsidies (Estache 2006), and this would appear to hold true for the United States.[5]

Another reason for regulation, namely to limit political opportunism, has substantial empirical support. Spiller (2005) explains that utility industries are especially vulnerable to opportunism because the technologies are characterized by large, sunk investments that are specific to the purpose of providing the utility service, the technologies often have economies of scale and scope, and their services are consumed by large portions of the population. Regulation by what we call independent regulatory agencies helps effect a system of checks and balances that limit politicians' abilities to expropriate at least some of the value of sunk infrastructure investment for short-term political gain. Empirical research has consistently supported this notion, finding that

[4] See, for example, Van Ark and Inklaar (2005), Röller and Waverman (2001), Waverman et al. (2005), and Crandall et al. (2007).

[5] See Hazlett (2006) and Holt and Jamison (2007) for extensive critiques.

infrastructure providers – both privately owned and publically owned – make more investment when there is a strong, independent regulator, and that customers benefit because the additional investment leads to more service, which customers willingly purchase.[6]

Another reason for developing expert regulatory agencies is to address the problem of information asymmetry. This line of reasoning holds that infrastructure providers have private information, such as their innate abilities and unobservable efforts, and that expert agencies have better skills than politicians for observing at least some of the private information and for establishing economic incentive mechanisms, such as price cap regulation, that can reward service providers for using their private information in a way that benefits customers (Sappington and Weisman 1996: 2-4). Although this theory is generally associated with neoclassical economics and Austrian economics, it can be found in Martin Glaeser's 1927 institutionalist book on public utility economics (Glaeser 1927: 714-724).

Structure of regulatory institutions

Having addressed the issues of why we have regulation and regulatory institutions, I now turn my attention to the determinants of the scope of authority of regulatory institutions: Why are there both state and federal regulators in the United States and Brazil, but not in most other countries? What explains the scarcity of regulation by cities? Why are there instances of supranational regulators?

As one would expect, institutional design generally falls directly from regulatory purpose because, in essence, institutional design is a component of the technology of human work. To keep this analysis manageable, I will focus on the scope of authority of the agency and not on the internal processes. Also, because I have limited my study to utility regulation, I am addressing regulatory organizations with coercive power, that is, the authority to punish someone or some organization for violating regulatory rules.[7] This omits from my consideration institutions that are somewhat voluntary in

[6] See for example Spiller (2005), Henisz and Zelner (2001a, 2001b), and Gutiérrez (2003).

[7] There are many possible regulatory institutional frameworks. Within a sovereign jurisdiction, there can be regulatory agencies with varying degrees of independence, coercive power, and flexibility. Above the sovereign level, there are other possible frameworks, including regulatory associations and extra-jurisdictional committees that serve to allow regulators to share information, engage in joint planning, and learn through interactions and sponsored training courses. Such cooperation can also occur without a formal structure, such as the World Forum on Energy Regulation. Competition regulators from multiple countries will sometimes form committees of their key staff for purposes of coordinating cases, discussing emerging issues, or simply maintaining knowledge of what is happening in each others' countries. There are limits on what can be done through associations and committees because some regulatory laws have specific process and evidence requirements that cannot be met through such cooperative endeavors. Furthermore, some international organizations can become debating societies with their own bureaucracies far from the stakeholders most affected by their influences. But nonetheless, these regulatory communities have become important in addressing cross-border regulatory issues. Treaties and other formal agreements can create formal multilateral bodies that perform regulatory functions.

nature or serve primarily as forums for resolving issues. The aspects of regulatory authority that I will address include say-so over prices, financing, decision making, and particular issues, as well as the number and range of service providers.

Because two of the leading drivers of regulation are control of market power and industry stability, it is almost always the case that regulatory institutions have ratemaking authority and often have authority to require a uniform system of accounts and financial reporting. In some jurisdictions, the agency can impose financial quality on a utility, such as requirements for liquidity, maintenance of performance bonds, capital structure, and ring fencing. When these cannot be directly imposed, a regulator might be able to encourage financial quality through rewards or penalties provided through the ratemaking process, such as the adoption of penalties or rewards on the allowed rate of return. Some regulators even have authority to approve or deny the issuance of debt, which helps limit utility exposure to extra-jurisdictional ventures.

The regulator's authority to make decisions is affected by the regulator's independence, which simply means that the regulatory agency operates under laws rather than decrees; manages its own budget, subject to legal limits imposed by law; and makes decisions that are reviewable only by an independent judiciary and not by ministries, parliament, or the government. Furthermore, decision makers such as commissioners serve fixed terms that do not coincide with political terms; decisions makers cannot be removed from office except for cause, such as a violation of ethical rules; and decision makers do not engage in anything that might be a conflict of interest, such as seeking employment with a regulated utility, having a financial stake in a utility, or having financial or other ties to other stakeholders. Independence limits opportunism and regulatory capture.

The regulator can affect its degree of independence by choices it makes regarding transparency, credibility, and legitimacy. Transparency affects independence because participation in regulatory processes and seeing how regulators reach decisions give the public confidence that the regulator can be trusted to be a legitimate overseer of the operators and not captured by them. Transparency also limits opportunities for favoritism and corruption because such activities often melt when exposed to sunshine. Credibility, which relates to the regulator's authority and dependability from the operator's perspective, impacts independence because it influences whether the operator will cooperate with the regulator or seek to use the political process to constrain the regulator.

Agency authority is also defined in terms of the types of issues that the regulator resolves versus those that the political bodies solve. In effect, this is a division of labor between politicians and bureaucrats (Alesina and Tabellini 2007). The underlying theory holds that the Darwinian process for politicians results in political representatives who benefit those stakeholders who can and do keep those

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The Eastern Caribbean Telecommunications Authority (ECTEL) in the Caribbean performs regulatory work for the member states, but it is up to the individual countries to act on what ECTEL recommends. The European Union (EU) has a supranational competition regulator, and there has been work on supranational telecommunications and energy regulators.

representatives in power. This is not a new thought: It was raised by de Tocqueville many years ago and has been highlighted by libertarians as a flaw of government. What Alesina and Tabellini add to our understanding is that politicians may find it efficient for some government functions to be performed by expert bureaucratic institutions who are rewarded not for redistributing wealth, but for facilitating the creation of wealth.

The reach of a regulatory institution, in terms of geography and service providers, is determined by need for coordination, concerns with capture, economies of scale for the regulatory institution, and correspondence of control. The International Telecommunications Union (ITU) is an example of a regulatory institution whose jurisdiction is determined in part by the desire for wireless infrastructure that crosses international boundaries to have some common standards. The ITU works through collaboration and negotiations among the members, but can enforce some of the agreements. The ITU's deliberative processes are sometimes criticized for being slow and lacking teeth, but regulatory agencies with greater powers can also be very slow, such as the U.S. Federal Communications Commission's (FCC's) long delays in licensing radio spectrum for cellular phones.

The evolution of U.S. regulatory agencies serves as an illustration of the importance of institutional design to avoid capture, exploit scale economies, and effect a correspondence of control. In the United States, cities were the initial regulators of utility services, but in the early 1900s, most states elected to move regulation to the state level. There were three reasons for this. First, there were instances of corruption with municipal regulation because a single operator would serve the entire city and so would have a strong interest in developing non-transparent relationships with the city government officials. Some city officials were willing participants in such arrangements because of opportunities to advance political careers or gain personal wealth. A second reason was to gain scale economies in regulation so that staff expertise could be strengthened. Third, state agencies were formed because sometimes utilities were able to engage in activities, such as affiliate transactions and the creation of service bottlenecks that were beyond the jurisdiction of cities. Cities did not have jurisdiction perhaps because states did not delegate the authority to cities and perhaps because city charters did not grant city governments such authority. This is the correspondence of control issue, namely, that the regulatory agency should have authority to protect ratepayers from adverse decisions made by the utility, its affiliates, or its allied organizations. For example, if a utility makes or participates in a decision that affects costs or market structure within a regulator's jurisdiction, then the regulator should have authority to disallow the ratepayer impacts of that decision.

Federal regulation of utilities in the U.S. formed in part because of this correspondence issue. In some instances, utilities engaged in transactions that were beyond the jurisdiction of the states, such as the selling of electricity or gas across state boundaries. States are explicitly prohibited from regulating interstate commerce, so federal regulators were needed.

More recently, federal jurisdiction has expanded to limit stakeholder influence, such as the not-in-my-back-yard issues, where a decision that might be suboptimal for any one state to make on its own might be optimal as a joint decision, especially if there are side payments. Federal jurisdiction has also expanded when it was perceived as easier by advocates of some policies, such as certain environmental issues, to obtain federal legislation than to convince state legislatures that such policies were needed.

I do not claim to be an expert or even well informed on European regulation, but my impression has been that supranational competition regulation formed to ensure that the concept of a single European market was steadily enforced in competition law. I think there was some skepticism at one time that some member states would have difficulty giving up national champions and thus frustrate the European Union (EU) intentions. With respect to infrastructure regulation, the expert regulatory working groups in Europe appear to have provided for consistent policy analysis across the union, which has helped harmonize regulators' compliance with EU directives.

Dominica, Grenada, St. Christopher (Kitts) and Nevis, St. Lucia, and St. Vincent formed a supranational regulator the Eastern Caribbean Telecommunications Authority (ECTEL) for scale economy reasons. Each member state was very small and so lacked resources that could be devoted to telecommunications regulation. The formation of ECTEL allowed the countries to share work.[8] Furthermore, the countries all regulated Cable & Wireless and believed that they could be more effective together than apart in dealing with such a large, multinational corporation. The Economic Community of West African States (ECOWAS) secretariat is another example of regional cooperation where a network of sovereign states in Africa gave a supranational institution coercive power to oversee the development and operation of a regional transmission grid (Berg and Horrall 2008).

The processes that led to the development of these regulatory institutions were not without their errors and evolutions: Experimentation with municipal regulation provided lessons that led to the formation of state regulation in the United States, and the shortcomings of state regulation led to the formation of federal regulation. Municipal regulation was largely dissolved, but state regulation continues, and its boundaries are a constant concern of state and federal regulators. The successes of telecommunications regulation by ECTEL has led to an interest in regional electricity regulation. I explore this experimentation and learning process more thoroughly below.

Internationalization of infrastructure

I now turn my attention to the internationalization of infrastructure and, based on the preceding discussion about regulatory purposes, draw conclusions about needs for institutional reform. Internationalization of infrastructure occurs through

[8] The country populations are Dominica, 73,000; Grenada, 91,000; St. Christopher (Kitts) and Nevis, 41,000; St. Lucia, 160,000; and St. Vincent, 105,000.

interconnections or links that cause interaction among infrastructures. These interconnections take many forms.

Physical interconnections

Physical interconnections are those we are most familiar with and include telecommunications traffic, electricity transmission, natural gas pipelines, and liquefied natural gas shipping, and the like. Here the cross-border issues include agreements on technical standards, geographic locations, payment amounts, payment systems, transmission rights and obligations, and enforcement of contracts or other agreements. The value of the infrastructure service on one side of the border depends on actions taken at the border or on the other side. For example, electricity generation in one Central American country sometimes powers load in neighboring countries. The transmission lines that make this possible depend upon agreements between the government officials, private sector representatives, or both in the countries involved in the construction of the lines, technical standards, availability of load, payment obligations, dispute resolution, and the like. These international interconnections occur for many of the usual reasons, including issues of (1) comparative advantage, where one country may be in a better position to produce natural gas or generate electricity than another; (2) scale economies, where the market size needed to permit economic viability of service provision may be larger than a single country; and (3) network effects, where the opportunity to communicate across borders increases the value of the network service. International interconnections have given rise to international regulatory institutions to address issues of control coherence. ECOWAS in Africa, the Nordic Power Pool, and the ITU are examples.

Logical interconnections

Logical interconnections go hand in hand with physical interconnections and are those related to the intelligence and controls across the system. Telecommunications numbering and Internet naming conventions would fall into this category and result in institutions such as the Internet Corporation for Assigned Names and Numbers (ICANN).

Financial interconnections

Financial interconnections include those where a multinational infrastructure firm's performance in one country is affected by its ventures in another country, where firms seek to hide or double report costs or revenues through transactions with international affiliates, and perhaps where there are scale economies in financing operations. Here the cross-border issues include ring fencing the finances of domestic operations (including rules on debt guarantees and property rights claims on cash flows), regulatory access to and use of financial and accounting information, and constraints on regulators' behaving opportunistically by effectively, although perhaps not

deliberately, excluding certain costs from recovery or counting more than once revenues from supra-jurisdictional operations.

Financial interconnections raise effect, control, and capacity coherence issues. Effect coherence can be accomplished by governments giving their regulatory agencies sufficient powers to obtain information, disallow costs, ring fence, and the like. Control coherence might be required if multinational operators, for example, develop relationships that limit regulators' access to information central to the regulators' tasks.

Strategic interconnections

Strategic interconnections are those where decisions across jurisdictions are strategically interrelated. Natural gas pipelines and supply across Eastern Europe provide recent examples where contract decisions appear to have been tactics in larger economic and geopolitical strategies. Infrastructure regulation appears to be inadequate to the task of addressing such a problem regardless of the regulator's international scope. At one level, the challenge with natural gas supply in this region could appear to result from limited jurisdiction because transactions and agreements outside of the Republic of Georgia, for example, for a period of time limited the country's energy regulator's ability to limit retail prices. But at another level, it appears that governments were intimately involved in setting up the situation, with the result that political negotiations have been needed to resolve supply and price restrictions. So the issues have not been beyond government control, but have been beyond the jurisdiction allowed the regulator. Another strategic interaction would be multimarket contact by infrastructure providers, with the resultant incentives and opportunities to avoid price competition or to divide markets. Here national competition regulators can step in, if they have authority, to penalize collusive conduct even if some of the anticompetitive agreements involve other jurisdictions.

Strategic interconnections are related to control, effect, and array coherence. Often the issues appear beyond the scope of the utility regulator's job, meaning that control coherence cannot be achieved. When the interconnections are not part of a larger set of international engagements among countries, regulators might need authority over contracts and supply acquisition, as well as cost disallowance.

Policy interconnections

Policy interconnections include spillovers of jurisdictional decisions. Intense price competition and costly, protracted regulatory proceedings in the United States appear to have contributed to the decisions of many U.S. telecommunications firms to withdraw from non-U.S. markets in the late 1990s. Prior to that, however, liberalization of telecommunications in Western economies led to the creation of multiple global telecommunications firms that desired to interconnect with networks in non-liberalized markets, contributing to the eventual effective collapse of the international interconnection and settlement regime and to the opening up of markets in other countries. Telecommunications liberalization led to technology changes that

changed the economics and customer expectations in non-reformed countries, again pressuring policymakers in those countries to liberalize. The creation of a company like Enron, created in part because of utility reforms in the United States, impacted utility services and policies in many countries where Enron negotiated supply contracts.

International regulatory associations play an important role in addressing the capacity coherence issues raised by policy interconnections. At one level, these associations provide avenues for information sharing and dialogue on issues. At another level, they provide opportunities for capacity building (Berg and Horrall 2008).

Internationalization of customers

Internationalization of customers led to changes in infrastructure companies. MCI, for example, coined the term local-to-global-to-local strategy, which summarized a strategy for the company to secure local networking in countries where MCI's multinational customers had operations and to interconnect those local networks through MCI's global network (Jamison 2001). Some multinational energy customers contract with third parties to obtain supply and price guarantees. The resulting issues appear to be largely related to effects and capacity coherence and can be addressed by giving national and state regulators adequate authority over information gathering and cost disallowance.

Environmental interconnections

Environmental interconnections are largely spillovers and externalities related to environmental impacts of infrastructure decisions. Examples of concerns would include acid rain, greenhouse gases, and water extraction. The emerging approach to addressing such issues is to develop international treaties. However, there is interest in giving multinational organizations, such as the United Nations, coercive power over countries that might choose not to follow guidelines preferred by a majority of other nations.

These many forms of interconnection – physical, logical, financial, strategic, policy, customer, and environmental – are all growing. But as can be seen from the examples, these are not new and, as of yet, do not appear to create regulatory issues that are fundamentally different in nature from issues that are addressed by existing institutions.

Systems learning

Above I concluded that internationalization of infrastructure does not create a need for new internationalization efforts for regulatory institutions. However, I could be wrong because my knowledge and comprehension of the myriad of situations are limited. And while others may have more expansive knowledge than I possess, I think it is fair to say that no one possesses all of the knowledge needed to prescribe with

accuracy the types of regulatory institutions we need across the globe. Indeed it is fair to say that we can achieve better results using our collective knowledge than simply relying upon individual knowledge. How can we provide a system where people grow in knowledge together so that the learning embedded in institutions and the system of institutions is consistently greater than individual knowledge and is able to adapt when circumstances change?

The appropriate answer to this question is to create or allow a system of experiments in institutional design and regulatory rules that test assumptions and conclusions, and that examine new ways of addressing known problems. Such a system is needed for adaptive learning, which I define as creating new mental and institutional frameworks that narrow the gap between existing beliefs and reality, by exploring the meaning and implications of novel experiences that expose the people and organizations to conflicts between beliefs and reality (Heifetz 1994: 244-245; North 2005: 66-67).

For example, Chile and Argentina led the world in electricity reforms, but made mistakes that several European countries learned from and, for the most part, avoided repeating. The United States learned as well, but as evidenced by the California electricity crisis, did not learn well enough and created a new set of mistakes that others observed and learned from. Likewise the evolution of regulatory institutions in the United States provided lessons regarding ratemaking authority and independence, the initial understaffing of U.K. electricity regulator provided lessons on developing agency expertise to avoid significant information asymmetries, and New Zealand's attempt to rely solely on competition law illustrated the importance of expert regulatory agencies and *ex ante* regulation of markets with powerful incumbents.

As these examples illustrate, adaptive learning occurs through experiencing and analyzing the results of decisions that run against existing beliefs. For example, at one time public ownership was favored around the world. But then privatization was tested, and the results were positive. Consequently, the public ownership paradigm gave way rather rapidly in the 1980s and 1990s to a preference for private ownership. After it became clear that equity markets would not finance all of the infrastructure that multilateral institutions such as the World Bank believed was needed, and after it became clear that privatization was only a piece of a larger system of reform efforts and that multiple tasks had to be performed well for sector performance to improve, many countries began developing and testing various forms of public-private partnerships. Of course, the key test of which types of ownership and market structure arrangements are most appropriate is the performance of the sector. Thus, some form of benchmarking can be an important instrument of adaptive learning.

Adaptive learning can result from choices made by oneself or by one's organization, but also by being exposed to the consequences of others' experiments. The state of California is an example of a government learning from its own experiment. The U.S. liberalization of telecommunications in the 1970s and 1980s provided opportunities for adaptive learning by other countries. The U.S. telecommunications reform decisions had cascading effects that exposed people in

many countries to novel experiences that became their opportunities for adaptive learning.

The co-evolution that results from institutions interacting and adapting, being terminated, and being created is called systems learning. Systems learning is the sum of adaptive learning within organizations and the adaptations that occur in how organizations interact. Changes in markets and supply chains are examples of systems learning because the knowledge is embedded in agreements (both formal and informal) on how organizations will interact. Mergers, divestitures, and business closures are also examples of systems learning.

For a regulatory system – that is to say, the regulatory and government institutions, service providers, customers, and supporting institutions such as think tanks – to engage in effective adaptive learning, both for organizations and systems, the system needs the following properties.

- Decentralized Control. Formal rules that encompass significant portions of a system are costly to change and reinforce the status quo, making it difficult to engage in adaptive experiments. With extensive formal rules, the burden of proof falls on the entity advocating change. Furthermore, casualties – those organizations that must come to an end for adequate progress to be made – can gain bargaining power if there is centralized control and thus make change costly.
- Multiple Moving Parts. Concepts of static efficiency often imply that industrial organization should emphasize scale economies and transaction costs. However, opportunities for adaptive learning are greater with greater numbers of decision making units, implying that there are times when production economies should be sacrificed for potential dynamic gains.
- Differing Treatment. Asymmetric treatment of service providers allows for learning about how service is affected by regulatory rules.
- Deliberate Experiments. The system should make it easy to suspend rules or establish temporary rules with formalized processes for information gathering and analysis.
- Information Sharing. Regulatory associations should devote time to discussions about how jurisdictions differ, how they are the same, and how regulatory decisions affect sector performance.

This is far from a complete list of attributes needed for optimal systems and organizational learning, but it does point to the importance of limiting the geographic reach of regulatory institutions and of using markets and competition when possible.

Conclusion

I have concluded in this paper that there is no pressing need to reform regulatory institutions to address the increasingly international nature of infrastructure. I have also concluded that experiments and learning with regulatory structures are important both to test my conclusion and to ensure that service providers and regulatory institutions can innovate and adapt with low costs.

It seems that there are several opportunities for adaptive learning in utilities regulation, not all of which are driven primarily by internationalization of infrastructure. Broadband development and measurement are two examples. Some countries are holding onto traditional subsidies and regulatory schemes, even those that have been unproductive in the past, rather than trying policies with less centralized control. Smart grid represents another opportunity to experiment with new business models, economic incentive schemes, and regulatory jurisdiction.

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