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Chapter 5

Infrastructure Services: Lessons from 30 Years of Reform in OECD Countries

The organisation of infrastructure industries in OECD countries has undergone massive changes in the past thirty years. Taken as a whole, their experience constitutes a rich source of information on infrastructure service industries and their governance. Such information can be of great value for the People's Republic of China, where infrastructure development will be one of the major development challenges in the years to come. The aim of this chapter is to provide an overview of the experience of OECD countries in the management of their infrastructure service industries, and draw some lessons of relevance for policy making in China. The first part of the note provides a sketch of the public utility model that prevailed in most infrastructure industries of OECD countries until the end of the 1970s, discusses why and how this model has been challenged and gradually modified in the past thirty years, and illustrates some of the opportunities and risks of the reform process through three examples. The second part proposes a more detailed analysis of the main issues that infrastructure industries pose to policy makers today and some possible responses. The third part summarises the policy lessons drawn from the recent experience of OECD countries and examines what this entails for the management of infrastructure services in China.

Introduction

The term "infrastructure" designates the basic facilities, equipment and supplies that are needed for a country, a region or an organisation to function normally. It usually covers industries such as electricity, gas and water supply, telecommunications, post, transportation by air, rail or road, sewerage and waste disposal.

The organisation of infrastructure industries in OECD countries has undergone massive changes in the past 30 years. Until the mid-1970s, member countries commonly left to state-owned monopolies control of the entire supply chain related to a national infrastructure, from production facilities and distribution networks to retail market activities. Nowadays, most of these integrated monopolies have been privatised and dismantled. Some activities related to infrastructures are still provided by national or local monopolies, while others are organised as competitive markets. The term *infrastructure services* is used in this report as a generic classification for the myriad activities related to infrastructures, regardless of their position in the supply chain or their industrial structure.

One common element of all these changes is a shift of focus from the physical infrastructure to final services. The past model of organisation intended to provide the best conditions for building and operating the considerable stock of capital needed to produce and transport electricity, water, gas, telephone communications, etc. The new model, by contrast, emphasises the price and quality of services that are delivered to the customers, in a context where most OECD countries have very high levels of equipment in infrastructures – even though the maintenance and renewal of this equipment will necessitate a considerable investment effort in the coming decades (OECD, 2006a). New forms of regulation have gradually been developed in accordance with this change of focus, in order to respond to the challenges of restructured infrastructure industries.

These common trends should not overshadow the diversity of national and sectoral evolutions. Industry-specific economic and technological factors have brought about substantial differences between, for instance, the telecom industry, power supply and postal services. In some sectors a new economic equilibrium has emerged, while in others mutations are only beginning. Because of national differences rooted in history and culture, the OECD countries have also adopted different solutions and timings for restructuring their industries. Taken as a whole, their experience constitutes a rich source of information on infrastructure service industries and their governance. Such information can be of great value for the People's Republic of China, where infrastructure development will be one of the major development challenges in the years to come.

The aim of this chapter is to provide an overview of the experience of OECD countries in managing their infrastructure service industries, and draw some lessons relevant to policy making in China. The first section provides a sketch of the public utility model that prevailed in most infrastructure industries of OECD countries until the end of the 1970s; discusses why and how this model has been challenged and gradually modified in the past 30 years; and illustrates some of the opportunities and risks of the reform process through

three examples. The second section proposes a more detailed analysis of the main issues that infrastructure industries pose to policy makers today, and some possible responses. The third and final section summarises the policy lessons drawn from the recent experience of OECD countries and examines what this entails for the management of infrastructure services in China.

The development of infrastructures has been closely related to notions of public utility and service in all OECD countries, an acknowledgement of the fact that the utility of infrastructure services extends to society at large. There is in particular a large consensus over the principle that public utilities should be accessible to and affordable for virtually all of the population, although what this principle exactly entails in terms of prices and capacity has been subject to different interpretations. The dual objective of accessibility and affordability has provided a rationale for public intervention in infrastructure sectors in all OECD countries, in degrees and forms that have varied according to countries, sectors, and periods of history. In this regard, the past 30 years represent a historic shift towards market-based forms of organisation, away from the public utility model that prevailed until the end of the 1970s.

Infrastructure services in OECD countries: The state of play

The public utility model of infrastructure services

The public utility model of infrastructure service provision is characterised by public ownership, a high level of regulatory intervention, and vertically integrated, monopolistic industry structures.

Forms of ownership

Utilities can be owned by the central government, by local governments, by private investors, by their customers (in the form of co-operatives), or by any combination of these (joint ventures, partnerships). It is common that several forms of ownership coexist within the same industry, as in the US electricity sector. Prominent forms of ownership also vary from one industry to the other, often within the same country: in France, for instance, electricity and gas supply and railways belonged to the public sector during most of the 20th century, while water and wastewater services were chiefly provided by the private sector.

However, the model of state-owned enterprises (SOEs) became dominant in utility sectors in most OECD countries (with the exception of the United States) in the aftermath of the Second World War. At that time, public ownership was perceived to be more adapted to the goals of universal access and affordability – enhanced by the development of the welfare state – and to the considerable investment needs of post-war reconstruction. In a context where capital markets were small in most countries and not integrated internationally, financing infrastructure development was in itself a major challenge. As will be explained in greater detail below, this trend reversed in the 1980s.

Regulatory regimes

Utilities can be regulated in terms of prices, entry and exit, investment and service quality. Like public ownership, regulatory intervention was extended particularly following periods of economic disruption, such as the Great Depression or the Second World War. Private providers were then typically blamed for inefficiencies caused by market

fragmentation and excessive costs, and/or for taking undue advantage of their monopoly situations. In state-owned enterprises, prices, service quality and investments in capacity were administered in line with various economic, social and political considerations, often leaving considerable discretion to policy makers. Private utilities would operate under public franchising, which usually provided exclusive rights to supply a given geographic area, against the obligation to serve all customers at prices approved by regulatory authorities.

Regulated prices were supposed to reflect production costs (*cost-of-service* or *rate-of-return* regulations), and remain reasonably low for consumers while at the same time preserving profitability for producers. Both administered and regulated prices involved mechanisms of cross-subsidy among groups of users, to the benefit of low-income or high-cost groups (in particular in rural areas). In the 1970s and 1980s, criticisms of public interventions on the grounds of economic inefficiency led to an unprecedented wave of deregulation in utility sectors.

Market structures

Notwithstanding differences in ownership and regulatory regimes, the same industry model emerged in virtually all infrastructure sectors and countries. Economies of scale related to the capital-intensity of infrastructure services naturally ruled out the presence of many competing firms. Monopolies could be local (water supply and sanitation in most countries, electricity supply in the United States) or national (electricity and gas supply and railways in most European countries).

In addition, in order to meet their obligations in terms of pricing and investment and minimise their risks, producers had an advantage in owning and operating the entire supply chain, from production and storage facilities, through transmission and distribution networks, to retail services. Vertically integrated monopolies were hence the monolithic form of industrial organisation in public utilities until the end of the 1970s (Newbery, 2002).

The paradigm shift of the 1970s-80s

By the late 1970s-early 1980s, the economic and policy context had considerably changed. The persistence of slow growth and high inflation in the 1970s and concern about the productivity slowdown gradually led the governments of OECD countries to put economic liberalisation at the top of their policy agendas. On the international stage, governments adopted a more active stance towards free trade and investment, which in turn supported domestic policies enhancing competitiveness. The movement was initiated in the United States in the late 1970s and reached the United Kingdom in the early 1980s and other OECD countries later. One of its key foundations was the criticism of economic inefficiencies generated by existing regulations, particularly in public utilities (Joskow and Noll, 1994).

Stronger emphasis on regulation-induced inefficiencies

Economic analysis of regulation became an active field of research in the early 1970s. Its message clearly favoured change: the economic case for regulating prices, entry and exits had weakened (if not altogether vanished) in many segments of utility industries, due to changes in technology and demand; the costs of existing regulations were far outweighing their benefits, which were essentially accruing to specific interest groups.

A classic line of criticism of economic theory against price regulation focuses on the distortions it induces in the general allocation of resources – price regulations affect *allocative efficiency*. In an influential paper, Averch and Johnson (1962) pointed to another side-effect of rate-of-return regulations, namely the fact that the utility, when aiming to maximise its profit, has an incentive to overinvest in physical assets, and hence adopt an inefficient mix of capital and labour. The difference between the utility's cost function observed by the regulator and minimum cost function (that would result from an efficient choice of inputs) represents a loss in *productive efficiency*.

A more radical strand questioned the very purpose of regulation, linking it to private interests rather than the general interest. For Stigler (1971), the primary aim of regulation was to provide a rent to producers by protecting them from competition: "regulation is acquired by the industry and is designed and operated primarily for its benefit". Subsequent developments argued that regulation could also be captured by other groups to serve their interests at the expense of general welfare (Peltzman, 1976; Becker, 1983).

These theoretical arguments matched the actual conditions of many regulated industries. The financial situation of state-owned operators in activities such as rail and air transport had considerably deteriorated during the 1970s. While soaring energy prices had been the trigger for their difficulties, inefficiently high levels of employment and overinvestment often took the general blame. The electricity sector, for instance, had large overcapacity in many OECD countries in the 1980s, at a time when demand had slowed. In some cases, transparency requirements and monitoring capacities over SOEs had been clearly inadequate, leaving the door open to low levels of productivity, excessive managerial discretion, opaque subsidy mechanisms and support of "national champion" policies, none of which had a clear link with public welfare. In France, for instance, the monopoly rents of the state-owned telecommunications operator, based on prohibitive pricing of medium- and long-distance calls, were an important source of funding for the government's budget, while the population suffered a shortage of fixed telephone lines until the early 1970s (Cohen and Henry, 1997). Finally, in the context of the 1970s' stagflation, the general feeling that "prices are too high" provided political support to the idea that regulation was at best ineffective (Noll, 1989).

The liberalisation of utilities proceeded through two important policy shifts: deregulation and privatisation.

Unbundling the monopolies

Deregulation consisted in lifting institutional barriers to entry in utility industries whenever it was felt that competition would deliver better results that existing regulated monopolies. In some cases, however, monopoly remained the optimal mode of organisation in one or more segments of each industry, raising concerns about potential issues of vertical control between these monopolies and the competitive segments of the industry. The principal mechanism for addressing these issues has been *vertical unbundling*, through which the various parts of the supply chain in utility industries have been formally separated.

The deregulation wave started in the United States in the second half of the 1970s, first in transportation industries: air transport (Airline Deregulation Act of 1978), railways (Railroad Revitalisation and Regulatory Reform Act of 1976 and Staggers Act of 1980) and trucking (Motor Carrier Act of 1980). An important case of vertical unbundling was AT&T's

divestiture in 1984. Later, deregulation extended to natural gas (Federal Energy Regulatory Commission Order 636 of 1992), telecommunications (Telecommunications Act of 1996) and electricity (Federal Energy Regulatory Commission Order 888 of 1996).

In Europe, a major step was made towards economic integration and competitive markets within the European Community with the adoption of the Single Act in 1986. There were two ways in which this goal was potentially in contradiction with the existence of regulated national monopolies. First, it set forth explicitly competition in infrastructure sectors, to the extent that this was economically possible; second, it ruled out practices in the regulated sectors that would distort market conditions in other sectors. As a consequence, the European Commission's first decisions regarding utility monopolies after the Single Act were to forbid anti-competitive cross-subsidies and to forbid the free use of monopoly rents by governments.

Later, the European Union issued a series of directives extending the rules of the Single Market Act to utility sectors: telecommunications (1990), railways (1991), electricity (1996), gas (1998) and post (2002). These directives introduced the principles of vertical unbundling and competition, and created a common framework for regulation among the EU member states.

Privatisation

In European countries in particular, the ownership structure of utilities has been totally transformed through privatisation. The leading country in this field was the United Kingdom, where privatisation of public utilities started in 1984 with the selling of 51% of the shares of British Telecom by the state, and later concerned British Gas (1986), British Airways and the British Airports Authority (1987), public water and sewage companies (1989), public electricity companies (1990), British Rail (1995), and the nuclear activities of British Energy (1996). In Germany, the Deutsche Bundespost was privatised in 1995, giving birth to two separate private utilities, Deutsche Post AG and Deutsche Telecom AG. In France, the state sold its majority stakes in France Telecom (2004) and Gaz de France (2007), as well as 30% of the shares of Electricité de France (2005).

Economic literature on this topic clearly indicated that ownership does not matter as much as competition and the quality of regulation in producing efficient outcomes (Vickers and Yarrow, 1991; Kole and Mulherin, 1997). SOEs are outperformed by private firms in competitive industries (Boardman and Vining, 1989), but the difference disappears, or even reverses, in sectors where barriers to entry limit competition, which was typically the case of utilities (see for instance Fare, Grosskopf and Logan, 1985). Altogether, only second-order gains, if any, can be expected from privatisation compared to the first-order gains attributed to opening to competition or efficient regulation.

In practice, however, privatisation did not necessarily coincide with the opening of utility sectors to competition and the dismantling of vertically integrated monopolies. Although privatisation provided a unique opportunity to restructure the utility industries, practice in the early cases consisted in preserving the existing structure and simply transferring it to the private sector.[1] Rather than enhancing competition, the driving forces behind privatisation in Europe then seemed to be the general belief that the government should not get involved in business activities, and public finance. With the continuous rise in public debt in most European countries, privatisation was an opportunity to raise exceptional revenues, and to involve the private sector in the financing of future

investment needs in infrastructure activities. Pro-competitive restructuring actually gained momentum only in the 1990s, in particular under the impetus of the European Union's directives.

Successes and shortcomings of three decades of reform

Infrastructure services today do not have much in common with what they were thirty years ago, in particular in terms of market structure. Technological progress and globalisation have, of course, had a huge impact on these industries, but so has regulatory change. There is ample empirical evidence that regulatory reform has led to greater economic efficiency, with net benefits ranging from substantial (in telecommunications) to modest but real (in electricity supply).

In the telecommunications industry, deregulation and dramatic changes in technology have triggered wide-ranging restructuring. Numerous entries and exits and radical changes in firms' organisation recomposed market structures during the 1980s and 1990s. Olley and Pakes (1996) find that following the 1984 divestiture of AT&T, increased competition and the associated reallocation of resources from less productive to more productive firms led to a sharp increase in the aggregate rate of growth of total factor productivity.

In the railways, reforms undertaken in various European countries have increased efficiency compared to the status quo according to Friebel, Ivaldi and Vibes (2003).

In the electricity industry, cost savings have been achieved at plant level through higher productivity of labour and inputs (Fabrizio, Rose and Wolfram, 2007; Bushnell and Wolfram, 2005 for the United States). Admittedly, gains observed are fairly limited (typically, in the order of 5-10%). Fabrizio, Rose and Wolfram (2007) report that "the plant operators most affected by restructuring reduced labor and nonfuel expenses, holding output constant, by 3-5% relative to other investor-owned utility plants, and by 6-12% relative to government- and co-operatively-owned plants that were largely insulated from restructuring incentives". Bushnell and Wolfram (2005) compare fuel efficiency in generation plants in US states that have opened the power generation industry to competition and in those where the status quo has prevailed, and find that competition has increased fuel efficiency by 2%.

But it should be noted that current operating costs to some extent continue to reflect past choices in terms of technology and capital formation. At the industry level, efficiency gains have so far been mainly related to the reduction of existing overcapacity, and only in a few cases to technological shifts.[2] Therefore, more significant gains resulting from efficient investment decisions – such as the development of combined cycle gas turbines – could gradually materialise in the future (Joskow, 1997).

Indications that consumers have actually reaped the benefits from these efficiency gains are more limited. Prices have substantially decreased for long-distance communications, but overall price-cost mark-ups have widened in the telecommunications industry (Bortolotti *et al.*, 2002). Electricity prices have somewhat declined following market liberalisation for industrial consumers, but much less for households (IEA, 2005). In parallel, margins have increased – in some cases very significantly. Market liberalisation has often been followed by a reduction in regulation-induced cross-subsidies between groups of consumers on one hand and increased price differentiation on the

other. Resulting distributional impacts have been identified in the literature (Pollitt and Domah, 2001).

The experience of past years also shows that liberalisation and restructuring entail substantial risks. One of the most consistent lessons of recent developments in infrastructure sectors is that the role of policy, far from being reduced, is actually magnified by liberalisation – and changed. The scope for regulation and competition policies ranges from providing appropriate incentives to the monopoly operators, enhancing competitive behaviours in the liberalised segments, and overseeing vertical relations and co-ordination issues along the value chain to integrating "external" considerations regarding universality of access, environmental impacts, etc.

Three cases can illustrate how the benefits of liberalisation depend absolutely on the quality of the policy framework in which it takes place, and highlight the associated challenges for policy makers.

Electricity sector reform in the United Kingdom

The example of power supply in the United Kingdom demonstrates some of the risks and opportunities associated with infrastructure reforms, and shows that the balance between the two depends entirely on market design and regulatory choices.

The most radical changes took place in England and Wales (Newbery, 2002). Starting in 1990, the Central Electricity Generating Board (CEGB) was unbundled into a grid operator and three independent generation companies. A centralised wholesale market, the Electricity Pool of England and Wales, was created, effectively excluding other forms of trading. The local distribution companies were privatised. In the electricity generation segment, the reform triggered productivity gains and cost reductions that Newbery and Pollitt (1997) estimate at 6% of production costs. However, these gains were retained by the generation companies, whose profits soared for several years while prices remained unchanged. Wolfram (1999) found that between 1992 and 1994, prices exceeded the production costs of the generation unit needed at the margin to balance supply and demand by 25% on average. In fact, the small number of actors enabled collusive bidding on the wholesale market, since only two firms were effectively setting the market price most of the time. This was aggravated by chronic network congestion, which made the overall reliability of the grid dependent on supply from a few plants, thereby giving them considerable (though temporary) market power.

From 1994 onwards, the regulator, the Office of Electricity Regulation, took several rounds of measures to address market power issues, notably by imposing a cap on market prices and requiring the two dominant generators to divest some of their capacity. In 2001, the British government replaced the Electricity Pool by the New Electricity Trading Arrangements (NETA), which were inspired by the experience of countries such as Norway, where trading is less centralised.

The wholesale market became structurally more competitive over time. High margins attracted new entrants, including international generation companies, and by 2001 a *de facto* duopoly had evolved into a relatively competitive industry. Smaller and more efficient generation units were built, using the Combined Cycle Gas Turbine (CCGT) technology. The most modern nuclear power plants were privatised. There is substantial evidence that the strong incentives created by competitive wholesale electricity networks led to lower generator operating costs and improved availability (Fabrizio, Rose and

Wolfram 2007; Bushnell and Wolfram, 2005). In addition, price-cost margins eventually fell dramatically. There is a lively debate about whether it is the reduction in seller concentration or the introduction of NETA that lowered market power in recent years (Evans and Green, 2005).

The restructuring of California's electricity sector

Experience in many countries makes it clear that the transformation of infrastructure industries is a complex task, and that implementing incomplete or ill-designed reforms can have very substantial costs for governments and customers. The restructuring of California's electricity sector illustrates how reform failures happen and what they entail.

The US electricity sector was believed to perform well at the time of its restructuring in the mid-1990s: electricity was available throughout the country with a fairly high level of reliability; investments in new capacity were matching growth in demand; labour productivity was among the highest and prices among the lowest of the OECD countries (Joskow, 2003). Additional gains in terms of productivity and efficiency were thought to be possible but limited. The main motivation for restructuring electricity markets in the United States was that in the early 1990s, retail prices were much higher in some parts of the country (including California) than others. This was due to inappropriate investment choices and procurement decisions made by vertically integrated utilities in the course of the 1970s and 1980s, partly in response to regulatory requirements (White, 1996). On the retail market, supply was governed by long-term commitments with local generators, and regulated prices covered the costs of existing generation facilities. In other words, the regulatory regime consisted in transferring all risks related to sunk costs to the customers. At the same time, on the wholesale electricity market, prices were kept down by the low cost of fossil fuels and an overall excess of generation capacity. Reform then consisted in opening the generation market to competition, and shifting to a regulatory regime where risks related to sunk costs would be borne by the investors – that is, where low-cost production would become more profitable high-cost production. This, however, would happen after a transition period during which utilities would be compensated for their "stranded costs", through mechanisms that varied from one state to the other. In short, one of the principal aims of regulatory reform was then to allow for the phasing out of non-performing generation capacities, and to let future investment choices in electricity generation to be led by market incentives.

While the primary aim of the reform was to lower generation costs through market mechanisms, prices on the national wholesale electricity market suddenly soared in June 2000 to more than twice the levels that had prevailed since the market's opening in April 1998. The utilities, which had to buy electricity on the wholesale market and sell it to their customers at much lower regulated prices, rapidly faced insurmountable financial difficulties. In March 2001, after its largest utility declared bankruptcy, the State of California had to take over electricity purchases on the wholesale market, at prices on average ten times higher than one year before, effectively putting an end to the market's existence at a very high cost. Later investigations showed that even during its first two years of existence, the market was highly unstable, and led to two series of lessons: one specific to California's experience, in particular concerning the faulty design of the wholesale market and the role of a sudden rise in the price of pollution permits; and one more general, regarding the sensitivity of the electricity market to demand and supply conditions, and to issues of market power in electricity generation (Borenstein, 2002).

A report by the US General Accounting Office attributed the collapse of California's electricity market to the exercise of market power by wholesale electricity suppliers (GAO, 2002). The report mentioned that rising input prices contributed to the crisis, but it also underlined the disastrous consequences of the freeze on retail prices in the context of a supply/demand imbalance. All in all, it is clear that poor choices in the design and regulation of the market had both largely aggravated the situation and made corrections more difficult (OECD, 2005a).

The privatisation of British Rail

The UK experience in privatising and restructuring the rail industry illustrates two other challenges of the reform process, namely the importance of a clear and consistent regulatory framework and the need for effective co-ordination among the unbundled segments of the industry.

The transformation of the rail industry was triggered by the 1993 Railways Act, following adoption of a plan for privatisation of British Rail by the government in 1992. British Rail was vertically and horizontally unbundled into more than 100 companies, in a process that separated infrastructure from operations and constituted five main operational components: 25 train operating companies (TOCs), 5 freight operators, 3 rolling stock leasing companies (ROSCOs), 19 maintenance suppliers, and the rail infrastructure operator Railtrack, which first remained under state ownership but was later privatised.

In 2006 train operation franchises were let through an auction process. But because of the lack of competition among bidders, the operators who won the franchises were able to secure themselves very high levels of public subsidy for several years. Prior to the privatisation of ROSCOs, the government also announced that it would guarantee 80% of their leasing revenue, which turned out to be an enormous advantage for the privatised firms. Soon after privatisation, the industry's profits soared. According to calculations made by *The Economist*, the companies that once formed British Rail together recorded GBP 1.1 billion, or 19% of their revenues, in profits in the financial year 1997-98 (*The Economist*, 1999).

Privatisation was also followed by initial improvements in the reliability and punctuality of trains, but from 1997 onwards the situation deteriorated. In the fiscal year 2001-02, an estimated 78% of trains arrived on time, compared with 90% in 1997-98. Punctuality and reliability problems were to a large extent due to deficiencies in the infrastructure, in particular the poor quality of tracks and signalling and the lack of capacity of tracks and terminals.

After years of underinvestment prior to privatisation, investments in infrastructure were an area of concern. Railtrack launched a modernisation programme focusing on signalling systems and control centres. But by the end of the 1990s, broken rails and "gauge corner cracking" had become such widespread problems that Railtrack had to impose hundreds of emergency speed restrictions around the network. The derailment that occurred at Hatfield on 17 October 2000 and killed four people revealed the extent of the problem, and at the same time led to increased speed restrictions, causing large-scale disruption and overcrowding. Congestion, which was in part caused by problems in infrastructure reliability, resulted in large incentive penalty payments by TOCs.

The government had already responded to the situation by putting in place the Strategic Rail Authority in 1997. After the Hatfield accident it launched a recovery

programme that entailed replacement of hundreds of miles of rail, and finally brought Railtrack back into public ownership; it became Network Rail in 2002.

Recent years have seen a sharp increase in the number of passengers (40% since 1997). Although the United Kingdom is still well below countries such as Germany and France in terms of railways usage (International Union of Railways, 2006), congestion problems have continued to seriously affect the network. Capacity is notoriously inadequate in areas such as Greater London. At the same time, rail fares have increased by more than 35% between 1995 and 2005, compared with 20% for motoring costs (*The Economist*, 2007).

The main focus of the industry since privatisation has been on cost cutting. Long-term co-ordination of investment and service choices along the supply chain has been far from adequate, making clear the costs of vertical separation and the need for better contractual mechanisms.

Policy options and challenges regarding infrastructure services

The evolution and current state of infrastructure services in OECD countries cannot be solely attributed to liberalisation. Technological change and demand-side developments have also together exerted influence on the provision of infrastructure services. This will continue in the future, not least in relation to the challenges of climate change, demographic trends, and development. Rather than a one-off liberalisation "big bang", the governance of infrastructure service markets has to be understood as a continuing process.

As a consequence, a case-by-case, adaptive approach is necessary, one that accounts for local conditions such as the state of development of existing infrastructure, technology, regulatory capacities and socio-economic policy objectives. Consistency in the choice of policy options is key. This section reviews in greater detail some of the developments of the past 30 years and the policy challenges and responses that economic theory and regulatory practice have identified.

Raising efficiency in infrastructure monopolies

The traditional view of infrastructure services emphasised the "natural monopoly" aspects of the industries, and the role of regulation in securing an efficient outcome (Box 5.1). The restructuring of public utility sectors in OECD countries has not been based on a rejection of the idea that natural monopolies exist, but rather on a much stricter definition of their boundaries, and the conclusion that the remaining parts of the supply chain can be partly or fully competitive. The domain of monopolistic activities has therefore been narrowed, and at the same time attention to economic efficiency within these activities has been enhanced.

Box 5.1. **Monopoly pricing and regulation under complete information**

Monopolistic activities have traditionally been subject to various types of public intervention, in particular entry, exit and price regulations. These interventions were grounded in the early theory of natural monopolies and efficient monopoly pricing

Box 5.1. **Monopoly pricing and regulation under complete information** *(cont.)*

In economic theory, a natural monopoly is an activity where, at all levels of output serving the market, the average cost of production is decreasing – in other words where, because of large fixed costs of production, there are economies of scale. Fixed costs are said to be sunk in cases where, if a firm had to withdraw from the market, its production assets would lose all or most of their value. Sunk costs generate significant risks for potential entrants. Such risks, together with the existence of economies of scale, act as a powerful barrier to the entry of potential competitors.

When an industry is a natural monopoly, competition is not only unsustainable – it is also sub-optimal. Economic theory states that the most efficient outcome from the standpoint of social welfare is characterised as *i)* production at minimum cost, and *ii)* prices equalling marginal costs. In a natural monopoly, this optimum is reached when a single firm supplies the market, and increases output as long as the price that consumers are willing to pay covers its marginal cost of production. The behaviour of an unregulated monopoly, however, does not conform to these conditions. A monopoly raises the market price to maximise its profits, especially when this can be achieved with a limited loss of output (*i.e.* demand is inelastic, for instance because there are no substitutes to the product). The extraction of a monopoly rent through monopoly pricing leads to an inefficient equilibrium: it entails not only a transfer of welfare from consumers to the firm, but also a net loss, usually called deadweight loss.

Early on the theory of regulation had it that public intervention is necessary to *i)* monitor entries and exits in order to ensure that producers fully benefit from economies of scale; *ii)* control the rent through regulated prices based on marginal costs of production; and iii) if need be, subsidise the monopoly for the difference between its profits and fixed costs. Such intervention was considered the only solution for reaching the economic optimum (*first-best solution*). However, the theory was based on strong assumptions: that the funds used to subsidise the monopoly are raised at no cost to the economy; that the regulator is perfectly informed about demand and supply conditions; and that the regulator's only objective is to maximise social welfare.

As governmental subsidies to commercial activities were recognised as distortive and gradually dismantled, monopolies were constrained to balance their budget. As marginal pricing was no longer a viable solution, alternatives for efficient monopoly pricing were proposed in order to minimise the welfare loss *(second-best solutions)*:

- The *cost-plus* (or *full cost*) price, which comprises the marginal cost and a mark-up to cover fixed costs, was the basis of cost-of-service price regulations.
- The *two-part tariff* is the preferred option when customers can be charged a fixed access fee to cover fixed costs, and a price per unit of output equal to the marginal cost.
- *Ramsey-Boiteux pricing*, finally, is the superior option when the monopoly has multiple products (or can discriminate among different groups of customers), and can set mark-ups in proportion to the elasticity of demand for each product (or each group).

These early facets of the theory of regulation were later criticised on two fronts. Some economists challenged the view according to which regulation was driven by general interest, and showed how private interest groups can influence the outcome of the regulatory process. Others emphasised the importance of information asymmetries between the regulator and the firm, and demonstrated that under incomplete information, the best option for the regulator was to provide the firm incentives to reveal its private information (see *infra*).

Source: Ramsey, 1927; Hotelling, 1938; Coase, 1946; Boiteux, 1956; Baumol and Bradford, 1970.

Redefining "natural" monopolies

The natural monopoly paradigm continues to be dominant for the distribution and transport segments of utility industries, which rely on networks: high-voltage transmission grids and low-voltage wires and transformers for electricity; pipelines and local distribution lines for gas; transmission and switching centres for telecommunications; railway tracks, signals and stations for railways; and sewers, distribution pipes and wastewater collection for water supply and sewerage. Network infrastructures entail considerable fixed costs, which are essentially sunk since assets are largely specific to the utility activity. Economies of scale are also related to the role of the infrastructure operator as co-ordinator of actions throughout the network. In the architecture of power systems, for instance, real-time management of power streams in order to balance demand and supply at all points of the grid is an essential task of the grid operator; it conditions the overall reliability of the system.

In other elements of utilities, fixed and sunk costs also exist, but are more limited: electricity generation plants, gas refineries and storage facilities, water treatment, inter-exchange services and mobile services in telecommunications – as well as maintenance and retail activities in most utilities – all entail some economies of scale, but not enough to rule out competition in a reasonably large market.

Many developments in the economic environment have contributed to changing – usually, restricting – the domain of natural monopolies in infrastructure services over the past 30 years. Among these, the most important has certainly been technological change. Technology influences market structures through at least four channels: it determines the optimal (or minimum efficient) size of production units, transport and storage costs, the costs of new investment, and the time needed to actually enter the market (*i.e.* design, plan, build and operate new production units). In the past, technological change has frequently had a substantial impact on the optimal size of units, in one direction or the other. In recent years it has considerably reduced the optimal size of production units in telecommunications (particularly inter-exchange services) and electricity generation (Bayless, 1994). The impact has been less significant in electricity transmission and distribution and in public transportation, and almost negligible in water distribution.

The telecommunications sector has been revolutionised by the technological burst of optical fibres, Internet platforms and cellular telephones, and continuous productivity improvements in integrated circuits, computers and software. Not surprisingly, the cost structure of the industry has dramatically shifted, and some consider that no segment of telecommunications nowadays appears as a natural monopoly. In 1997, considering that telecommunications had become a fully competitive sector that did not call for specific regulations, the Australian government decided to put an end to the activity of Austel, its regulatory agency for telecommunications. And with the development of "voice over the Internet" alternatives and the considerable challenge they represent for traditional service providers, changes do not seem to be over. For many authors (*e.g.* Hausman and Sidak, forthcoming), the "endpoint" for the industry will be reached with facilities-based competition on local markets among cable, Internet and wireless service providers.

In the electricity industry, smaller-scale units have changed the landscape of power generation. Combined cycle gas turbines (CCGTs) have brought about the most spectacular changes, being both cheap and limited in scale. Importantly, because CCGTs can be built and made operational rapidly, they have enhanced competitive pressures in the generation market well beyond their market share.

Regulating monopolies: The challenge of information asymmetries

The basic problem of monopoly regulation is not simply to let the monopoly recover its (fixed and marginal) costs of production while at the same time limiting its profits. It is also to replicate some of the efficiency-enhancing effects of competition in order to make sure that the monopoly seeks to minimise its costs. The latter has been the motive for intensive regulatory reform in the past 30 years.

As explained earlier, cost-of-service regulations were primarily aimed at controlling monopoly rents. The regulatory process provided some incentives for cost reduction to the monopoly, notably through the time lag between two reviews.[3] But these were generally considered inadequate, as production costs were ultimately transferred to customers. This led some economists to suggest that regulation should use higher-powered incentive schemes or find ways to introduce a degree of competition in utility sectors (Joskow and Schmalensee, 1987).

Already in 1982, with the privatisation of British Telecom, the United Kingdom government had introduced a new model of price-cap regulation, based on the "RPI-X" formula (Littlechild, 1983). The price-cap regulation consists of a commitment by the regulator, over a defined period of time, to allow the monopoly to increase its prices according to a pre-established formula. In the case of RPI-X, this was the difference between inflation (as measured by the retail price index) and an X-factor reflecting the industry's (relative) productivity gains and input price changes. The regulated company has an incentive to further reduce costs and improve productivity in order to increase its profits. The basic price-cap model has been gradually refined, in particular to integrate criteria aimed at preventing deterioration in service quality. Price caps have become the standard in regulation of network operators in the United Kingdom, and in various US industries including telecommunications. In other cases regulators maintained the framework of cost-of-service regulations, but introduced targeted incentives for cost efficiency – for instance by restricting the conditions under which input cost increases were approved.

The introduction of *incentive regulations* has had some positive effects, but has also faced some obstacles. Kridel, Sappington and Weisman (1996) survey empirical studies on the impact of incentive regulations in the telecommunications industry, and estimate that the results are conclusive regarding increases in productivity, infrastructure investment, profit levels and telephone penetration, but not regarding the effects on overall costs and final prices. Ai and Sappington (2002) find evidence of greater network modernisation in the US telecommunications industry with incentive regulations than with former cost-of-service regulations, but the effects on costs depend on the degree of local competition and those on prices are negligible. Knittel (2002) examines the use of incentive regulations in electricity generation in the United States, and concludes that regulatory schemes targeted at plant performance enhanced efficiency while broader schemes, including price caps, had non-significant or even negative effects.

Forecasting the evolution of an industry's productivity and input prices over an extended period has in practice proved particularly challenging for regulators. In the United Kingdom, the regulators for the water industry and for electricity distribution both had to break their five-year commitments over RPI-X formulas, because the operators' revenues seemed inadequate in one case and excessive in the other (Armstrong, Cowan and Vickers, 1994). In that country's electricity sector, the considerable profits made by the

newly privatised Regional Electricity Companies under price-cap regulations led the government to impose a specific lump-sum tax on the industry. As a consequence, the common practice in OECD countries across infrastructure industries is to review price caps on an annual basis (OECD, 2008).

The source of these difficulties is the regulator's limited knowledge of the industry. Demand elasticities, cost structures and technological and organisational innovations are all areas where firms have an informational advantage over regulators. A new theoretical approach, which emerged in the 1980s and became known as the theory of incentive regulation, placed these information asymmetries at the heart of regulation.[4] According to this theory, regulation should be designed as a mechanism that brings the monopoly to truthfully and willingly reveal its information. In order to provide the right incentives, the mechanism has to grant a rent to firms that admit having low costs or better technology. Importantly, the regulator has to commit not to change the terms of the agreement after the firm has revealed its information, and the firm has to deem this commitment credible. The theory of incentive regulation therefore considers that monopoly rents are a price that regulators have to pay in order to induce firms to use their superior information for the benefit of society.

The theory of incentive regulation has attracted considerable interest in academic circles in recent years. However, three features have so far hampered its practical use. First, the optimal mechanism depends on the source of the firm's informational advantage, on the regulator's policy instruments, and on various other factors. This means that the policy recommendations derived from the theory are dependent on the institutional, technological and informational context, and can be highly sensitive to changes in parameters. Second, the theory assumes that in spite of their informational differences, the regulator and the monopoly have some common knowledge (typically, that they agree on the possible values of cost or productivity parameters, and on their probabilities) – but it does not specify how that knowledge is acquired. Since agreement on these assumptions largely determines the regulatory mechanism, it is more than likely that it will involve strategic interactions, and raise legitimacy and acceptability issues (Crew and Kleindorfer, 2002). Third, the theory considers that the regulator can commit to the original mechanism over an extended period, even when it turns out to be too favourable for the firm. In practice, as shown by the examples above, it seems extremely difficult for a regulator to maintain a mechanism in the presence of excessive profits.

Introducing competition into monopolistic markets

An alternative to regulation in monopolistic sectors is the introduction of a dose of competition, or rather of competitive pressures. In a *contestable market*, for instance, the threat of competition is sufficient to force a monopoly to give away part of its rent (Baumol, Panzar and Willig, 1982). Market contestability depends entirely on barriers to entry: a slight change in technology or regulation can have dramatic consequences for market structures if it facilitates the entry of new suppliers. Air transport provides an illustration of the development of market contestability. Local monopolies are commonplace in air transport, since the size of traffic on most routes does not allow for the presence of more than one or two carriers. However, aircraft leasing has significantly reduced the capacity of monopolistic suppliers to exert market power, since a large profit margin on a given route would quickly attract new entrants. This example illustrates how vertical unbundling of formerly integrated activities (ownership and maintenance of aircraft fleets *vs.* operation

of airlines) has eliminated a large part of the sunk costs from the monopoly segment, reduced barriers to entry and achieved some of the advantages of competition.

Even in activities that have a monopolistic nature, competition can be introduced through a process of bidding for limited-duration monopoly franchises, *i.e. competition for the market*. Provided that their number is large enough and there is no collusion among them, competing incumbents can give away a large share of the monopoly rent (Demsetz, 1968). Moreover, franchise renewals act just the same as market contestability in creating incentives for the operator.

It is usually considered that competition for the market is difficult to implement in utility sectors because of the magnitude of information asymmetries and transactions costs (Vickers and Yarrow, 1991). Franchising is conditional on an unequivocal statement of mission and of control procedures regarding its completion.

In complex markets such as infrastructure services, franchise contracts can seldom integrate all possible contingencies. Indeed, the monitoring and enforcement of complex contracts have many of the features of regulation, including in terms of costs (Williamson, 1976). Contracts are therefore incomplete, and can leave substantial rent opportunities to the operator. In such a case, renegotiations would also be at its advantage, and regulators might be tempted to change the rules *ex post* (Williamson, 1975).

In some cases however, it has proved possible to get an operator to reveal private information and to establish appropriate incentives through the use of benchmarking and yardstick competition techniques (Shleifer, 1985).

Policy messages

In conclusion, the view according to which infrastructure services are best provided by integrated monopolies monitored by regulators has been amended in several important ways. The domain of truly monopolistic activities is more limited than previously thought, and continues to be reshaped by changes in the economic environment.

While traditional forms of public intervention in monopoly activities have been shown to be inefficient, better regulation through either the introduction of competition for the market or incentive-based contracts has proved challenging.

Managing the relations between monopoly and competitive sectors

The most significant step in the process of restructuring utilities is the formal separation of competitive and monopoly segments, often called “vertical unbundling”. As part of the unbundling process, minimal conditions for the functioning of competitive markets have to be fulfilled, including unregulated prices, free entry and exit, information enabling consumers to make a choice between suppliers (in particular regarding market prices) and non-discriminatory treatment of competing suppliers. Gathering these conditions entails specific challenges in industries that have been both structured as monopolies and integrated vertically (Joskow, 1997).

Alternatives for unbundling infrastructure sectors

The most clear-cut option for vertical unbundling is to completely disconnect the two sectors by making separated ownership mandatory. Privatisation can provide a convenient opportunity for this type of unbundling, since the ownership of at least one of the entities changes. By contrast, in the case of private sector integrated utilities, ownership separation

can only come from voluntary divestiture decisions. Regulatory authorities can, however, create strong incentives to divest by imposing stringent restrictions on vertical relations between the utility elements. AT&T and British Gas are examples of privately-owned utilities that decided to divest from downstream activities under pressure from regulators. As an alternative to ownership separation, the integrated entities can be separated legally, and required to hold distinct accounts and conform to competitive behaviours. For instance, the Federal Electricity Regulation Commission (FERC)'s Open Access Rule has only imposed legal separation on the United States' electricity industry.[5] In the European Union, directives concerning infrastructure sectors usually encourage member countries to engage in ownership separation, but only make legal separation mandatory.

Unbundling actually happens when customers are given direct access to the competitive segment of the supply chain. This solution has been applied to the restructuring of the electricity industry in a number of countries, including England and Wales, New Zealand, and Norway. Customers can directly select their electricity generation service with competing suppliers, either through long-term contractual arrangements or (for larger customers) on a spot market. The transmission operator and local distributors are responsible for their own services, and electricity prices are unbundled accordingly.

Alternatively, the structure of the retail market can be maintained, with a distributor in charge of delivering a bundled service to the customers of a given area. Distributors then get their supplies from a wholesale market through competitive procurement mechanisms, and integrate the wholesale price into their retail price. This option was chosen for the restructuring of California's electricity market and in other US states.

One of the important lessons from these experiences is that the role of regulators varies from one case to the other, as do their needs in terms of capacity and instruments. Typically, regulators have to monitor vertical relations more closely under functional separation than under ownership separation. Likewise, they need to have a better understanding of market conditions when the end-product is bundled than when customers can make their own choice in the competitive segments of the supply chain. In turn, regulators have a greater capacity to influence outcomes in the competitive segments when unbundling is partial rather than complete. In short, unbundling can be accommodated in a variety of forms, going from the creation of a fully competitive activity alongside regulated monopolies to the limited reduction of regulation in parts of the value chain in utility sectors.

Externalities and access issues

Various forms of interdependency can exist between the different segments of a value chain. This variety of relations is particularly common in infrastructure industries. Within the railways industry, for instance, both positive and negative dependencies have been observed (Cantos, 2001): track infrastructure and passenger operations are cost substitutes – higher track costs lead to lower operation costs by permitting faster services; track infrastructure and freight operations are cost complements – higher track costs increase freight operation costs via higher maintenance costs.

Vertical integration allows accommodating such dependencies within a single organisational structure. In the electricity industry, it has even been argued that complementarities between generation, transmission and distribution were the principal purpose of vertical integration, rather than scale economies (Joskow and Schmalensee,

1983). With unbundled structures, on the contrary, dependencies fall outside the scope of economic decisions. The existence of such externalities is usually associated with socially inefficient private decisions, due to free-riding or co-ordination failures. Cantos (2001) considers that "if important decisions regarding infrastructure are going to be made, rail-operating costs will be notably affected. … if these vertical relationships are present in a vertical unbundling structure, the risk of inefficiencies and loss of co-ordination effects between infrastructure and operations will be extremely high".

A particular co-ordination issue concerns investment. In most infrastructure service sectors, it is critical that production, transmission and distribution capacities develop in parallel with the evolution of demand. For instance, as will be explained in the following section, the congestion of power transmission lines can affect competition in power generation markets, while inadequate generation capacity jeopardises the reliability of the overall power grid. Differences of incentive and time horizon in investment decisions between monopoly and competitive segments further increase the risk of co-ordination failures.

The costs associated with vertical separation can be substantial, and can actually outweigh the benefits of complete unbundling. In the railways industry, for instance, separation can generate a 20% to 40% increase in production costs, according to some estimates (OECD, 2006c). But the balance of costs and benefits is case-specific, and has to be assessed in accordance with market conditions. Shires and Preston (1999) find that in Sweden, operating costs decreased by 10% following vertical separation.

Finally, vertical unbundling of an integrated utility raises the issue of access to the distribution network, which is often still controlled by a monopoly, for the firms operating in the competitive segment of the industry.

Regulating vertical relations

Third-party access to bottleneck networks can be either negotiated or regulated. Regulation is almost inevitable when vertical separation is not complete, *i.e.* the network operator is also a market participant in the downstream segment. This is a common issue in telecommunications, where for example long distance telephone operators have to buy access to the local loop from local telephone companies, which can also provide long distance call services.

As a monopoly operator would tend to charge inefficiently high prices to the firms using the network, access pricing also needs to be regulated. But this has proved to be a very complex issue for regulators. First, there is no unique solution for allocating network costs, and all available options (full cost *vs.* incremental cost, *ex post vs.* forward looking, etc.) involve some drawbacks for incompletely informed regulators. Second, access conditions affect the dynamics of investment, prices and quality of service in both upstream and downstream markets (Guthrie, 2006).

Efficient monopoly pricing would mean selecting buyers of access according to their demand elasticity (Box 5.1). However, such discrimination can violate competition rules, according to which all market participants should be subject to the same conditions of access to the infrastructure. This contradiction was clearly illustrated by the conflict between Germany's railway infrastructure operator Deutsche Bahn AG and the competition authority Bundeskartellampt in 2003 over the possibility for the monopoly to propose a tariff menu as a way to discriminate between infrastructure users.

Two-part tariffs comprising a fixed and a variable charge are commonly used for pricing access in the railways industry. Experience shows that the tariff structure has a strong influence on network usage, investment and transport quality. High fixed charges combined with low variable charges encourage operators to run many trains and inefficiently saturate network capacities. Low fixed charges combined with high variable charges, on the other hand, create incentives for efficient train operation but reduce the monopoly's incentives for investing in network enhancement (Pittman, 2004).

The problem is further complicated by the fact that regulators, when establishing access-pricing regimes, might give priority to affordability objectives over the long-term development of the infrastructure. Through access pricing, regulators can indeed influence both the costs of operating trains and the conditions of entry in the market. Lowering access prices can reduce retail prices directly, by making infrastructure service delivery cheaper, and indirectly, by increasing competitive pressures among operators. However, inadequate access prices prevent the infrastructure monopoly from recovering its fixed costs, and penalise investment. Access price determination therefore imposes a trade-off on regulators between short-term improvement of service affordability and long-term development of network capacity and reliability.

Finally, the presence of strong externalities also provides the rationale for regulatory interventions in the liberalised segments of infrastructure services, usually in the form of minimum requirements and mandatory long-term commitments. In the electricity industry, the infrastructure operator is responsible for assuring network reliability, and can in turn require power generation firms to comply with certain technical criteria. These go from frequency, voltage and stability attributes to operating reserve and long-term capacity obligations (Joskow and Tirole, 2007).

Policy messages

In order to tackle issues such as market power, regulators have to monitor the liberalised segments of infrastructure services and to co-ordinate their interventions all along the supply chain. This issue is discussed in the next section.

It should be noted that supervising the conditions and terms of contractual arrangements between network utilities and downstream operators or directly regulating access conditions and prices gives regulators *de facto* power to influence the downstream market.

Enhancing competition and investment in the liberalised sectors

The overall benefits of restructuring an infrastructure service industry depend on the degree of competition that eventually prevails in the liberalised markets. A host of factors determine if a sector is apt to support competition, including economies of scale, legal barriers to entry (for instance in terms of access to technology), market size, and search and switching costs for consumers. One of the main challenges of restructuring is to evaluate how these factors will affect the market structure in the long term.

For instance, train freight exhibits such economies of density that according to some experts, it can only be supplied by a monopoly, or at best oligopoly, in equilibrium (Pittman, 2003a). This means that decisions to open the freight market, which are being considered in many OECD countries, should be based on the assumption that competition has few chances to prevail in the long term.

Market power

When the number of suppliers on a market is small, each of them can influence market outcome through its decisions, and no longer acts as a price-taker. This behaviour defines market power, which usually leads to welfare losses of the same nature as those caused by a monopoly, with higher prices and lower quantities than the optimum (Box 5.1). As illustrated during the first phase of the liberalisation of England and Wales' electricity sectors (Newbery, 1995), it is crucial to have an adequate number of competitors in the market if prices are to be kept close to the level of marginal costs and an efficient outcome is to be secured.

In some cases, however, even small firms with numerous competitors can have market power, at least locally and/or temporarily. Two conditions favouring the emergence of market power are the existence of bottlenecks in the facilities through which firms supply their markets, and low elasticity of demand. These conditions are generally valid in most infrastructure service industries.

Demand for infrastructure services has the particularity of being highly volatile. Typically, a large share of production and distribution facilities is unused most of the time, and capacities get close to full utilisation only during demand peaks. During short periods, both production and distribution capacities can be saturated.

When distribution lines are congested, suppliers located at certain points of the network can have a monopoly over the supply for local demand. Distribution capacity can therefore limit the degree of competition that actually takes place throughout the network. Equally, in most infrastructure service industries, demand is not highly responsive to price increases. Therefore, when demand nearly saturates supply capacities, marginal suppliers can charge prices well beyond their production cost.

Electricity generation provides an illustration of how congestion and low elasticity of demand can combine to lead to market failure (Box 5.2).

Box 5.2. **Market power issues in electricity generation**

Electricity grids function in such a way that an imbalance between supply and demand at one point can disrupt transmission throughout the grid and lead to a general blackout.

Delivery of electricity, the product consumed, must take place through a potentially congested transmission network. If a supplier owns a portfolio of generation units that are connected at different but relatively nearby locations in the transmission network, how these units are operated can congest the transmission path into a given geographic area; in so doing it limits the number of suppliers able to compete with those located on the other side of the congested interface. According to demand and supply conditions, congestion can appear at various points of a network, in ways that are very difficult to predict. With binding transmission constraints, the electricity market is fragmented into smaller, more concentrated markets. Generators located at specific points of the grid are, alone or collectively, in a position to ensure the reliability of supply, and can therefore impose a scarcity rent for their contribution. In England, prices up to six times the normal level were observed in such conditions (OFFER, 1992).

Box 5.2. **Market power issues in electricity generation** *(cont.)*

Historically, how electricity has been priced for final consumers makes the wholesale demand extremely if not perfectly inelastic with respect to the hourly wholesale price. In the United States, customers are typically charged a single fixed price for each kilowatt-hour (kWh) they consume during the month, regardless of the value of the wholesale price when this kWh was consumed. Part of the reason for this single fixed retail price is the fact that most residential meters are only capable of recording the total amount of kWh consumed between consecutive meter readings. Consequently, a significant barrier to implementing retail electricity prices that reflect wholesale market conditions is the availability of metering technology that records hourly consumption for all hours of the month.

During the few hours of very high demand, the most expensive resources set the price – usually plants with low capital costs and high marginal costs, such as open cycle gas turbines (OCGT).

A generator subject to competition will be willing to produce at a price that pays the cost of each additional MWh, but this marginal cost will not cover depreciation or provide returns on the capital invested. Generation plants recover invested capital during periods in which the price is set by the more expensive plants. Thus, plants with high capital costs must operate most hours of the year to be profitable, even if marginal costs are low. These base-load plants will recover the invested capital when prices are set by plants with higher marginal cost. Plants with low efficiency will only recover the invested capital during hours in which the most expensive resources are setting the price. The most expensive resources are only activated during the very few situations with very tight supply/demand balance.

Thus, the profitability of investment in plants such as OCGTs depends on the possibility to bid at prices above marginal costs. This is not usually a problem because the owner of the facility will have substantial market power in the specific hours within which it is needed, and will therefore be able to collect a scarcity rent. However, this market power may pose a threat to the economic efficiency of the entire market and raise political concerns. An important point for the functioning of the market is that a generator should never be the "supplier of last resort".

All of the above factors also make wholesale electricity markets substantially less competitive if there is a shorter time lag between the date the sale is negotiated and the date delivery of the electricity occurs (Borenstein and Bushnell, 1997). The longer the time lag, the more suppliers are able to compete to provide the electricity. As the time horizon between sale and delivery shortens, more potential suppliers are excluded from the market. For this reason alone, it is not surprising that real-time prices are far more volatile than day-ahead prices, which in turn are far more volatile than month-ahead or year-ahead electricity prices.

Capacity development

The strength of competition and the level of prices also depend on the availability of excess production capacity. It is usually the case that the marginal cost of production rises sharply as available capacity nears saturation. With excess capacity, prices based on marginal costs can be very low, and even temporarily fall below average costs. In a competitive market, the least efficient producers incur considerable losses and can be forced out of the market. Such an outcome was expected from the restructuring of

California's electricity sector in the middle of the 1990s. On the other hand, if production capacity is inadequate, prices based on marginal costs rise above average costs. In a competitive market, the most efficient producers can make very substantial profits. Naturally, if the market is not competitive, profit margins are even larger. This is what happened in California in 2000, as the western US electricity grid went from excess supply to excess demand in the course of the 1990s.

More generally, restructuring and privatisation have been more successful in cases where large investments had already been made, a technologically advanced network was in place, and there was excess supply, than in tight markets (Kessides, 2004).

Timely development of additional capacity is key to the efficient operation of liberalised markets, but it raises specific issues. Peaking capacity is used only when demand is at its maximum, which occurs only occasionally. A normal rate of return on peaking capacity investments therefore entails including a margin larger than usual (sometimes called scarcity rent) in the price of peaking production (Joskow and Tirole, 2006). Such a premium might be difficult to distinguish from the exercise of market power, particularly when demand is inelastic and/or there is congestion. When prices are regulated, scarcity rents cannot be applied, and incentives for the development of peaking capacity are weakened (Brennan, 2005).

Regulating competition

In key industries such as infrastructure services, the exercise of market power can lead to large welfare losses and substantial transfers of income from consumers to producers. Regulatory intervention is required to address such situations or, preferably, to prevent their occurrence. There are a number of ways in which regulators can limit the ability of suppliers to exercise unilateral market power.

The most direct type of intervention consists in penalising firms that appear to exert market power, or in dictating the price that suppliers will receive in market conditions conducive to the exercise of market power. The goal here is to simulate the signals and incentives of a competitive market even when the actual market stops being competitive. One example is the Automatic Mitigation Procedure (AMP) commonly used in US wholesale electricity markets.[6] Under the AMP, a reference price is calculated for each supplier on the basis of its past bids, and is imposed whenever behaviour suggesting use of market power is observed. A supplier is deemed to use market power when it makes a bid in excess of its reference price by a certain (predetermined) margin, *and* this bid causes the market price to increase by more than a certain (predetermined) amount.

The main limitation of such interventions stems from informational deficiencies already discussed in the previous sections. The regulator (or system operator) ignores the exact cost curve of market participants, and can only estimate it (or incite firms to reveal it) at a cost. The regulator's lack of information is one of the foremost reasons that competitive markets are desirable. In the AMP, for instance, incomplete information brings the regulator to determine the reference price on the basis of prices observed in the past. The scheme acts as a disincentive for making low bids in competitive market conditions, since a low bid reduces the expectation of future profits in tight market conditions. It is estimated that the AMP results in higher off-peak prices, on-peak prices still above the competitive price level, and – all in all – a net welfare loss (Wolak, 2007).

Structural interventions aimed at preventing the development of market power – rather than merely mitigating the effects of its exercise – have better chances of success. There is a precondition, however: regulators have been able to come up with a precise diagnosis of the structural roots of market power.

When market concentration appears to hamper competition, regulators can reduce barriers to entry or impose capacity divestiture. For instance, severe problems of market power in the England and Wales power generation industry were in large part tackled when the regulator imposed the divestiture of the three incumbent companies into twelve suppliers.

Local market power due to network congestion points to a geographical mismatch between production and consumption, and has to be addressed by either encouraging the start-up of new production facilities located in the vicinity of large consumption centres, or securing additional investments in transmission capacity.

Ill-designed market rules can also be at the origin of chronic market power issues. When the balance between demand and supply relies heavily on short-term markets (in particular on spot markets), individual producers have increased chances of having a monopoly over the service of residual demand. Long-term arrangements, on the contrary, give buyers additional opportunities to find alternative sources of supply and can even open the door to new entries. Short-term markets of course remain necessary to respond to the volatility of demand and supply, but they should be managed with the aim of avoiding situations where the overall balance between demand and supply relies on a single producer. Improving the mix between spot markets, futures markets and long-term contractual commitments is therefore one of the important tools for enhancing competition in infrastructure service sectors.

Concerning capacity development, a variety of approaches have been tested in the electricity generation industries of OECD countries. Some countries fully rely on the incentives provided by market price signals (Australia, United Kingdom). Others have set up markets for capacity reserves (Sweden, Norway, Netherlands) or established specific payments to generation companies for maintaining peaking capacity (Spain, Korea). Capacity markets are considered an effective mechanism for restoring incentives when wholesale prices are capped, while capacity payments can be costly for consumers and have been subject to manipulation in the past (IEA, 2005).

Finally, regulators can introduce changes in retail markets in order to make demand more responsive to price changes. In particular, there has been a tendency in the past to price infrastructure services uniformly, irrespective of the time of the day or the season in which they are consumed. Consumers did not receive any incentive to reduce the seasonality of demand by shifting on-peak consumption to off-peak periods. In the context of liberalised markets, this means that final demand has been totally isolated from markets signals such as wholesale prices. Over the years, differentiated retail prices have been gradually applied in the electricity sector, in telecommunications and on toll roads. But only air transport and (to a lesser extent) railways have generalised the use of dynamic demand-side management techniques relying on real-time information systems. It is usually estimated that other infrastructure industries have a large potential for increasing the elasticity of demand with moderate costs for consumer welfare, and that this would represent the most fundamental response to market power issues (Joskow and Tirole, 2006).

Policy messages

In conclusion, the experience of OECD countries reaffirms that regulatory interventions are still necessary in the liberalised segments of infrastructure industries, once these are unbundled from natural monopoly segments. The evidence suggests that liberalisation and restructuring generate efficiency gains, but it takes substantial regulatory capacity and efforts to pass those gains through to consumers (Domah and Pollitt, 2000). In many OECD countries, the responsibilities and competence of regulatory authorities were actually extended as state-owned integrated monopolies were gradually dismantled.[7]

While long-term efficiency gains related to better investment decisions were perhaps the greatest benefit expected from liberalisation, adequate capacity development is likely to be one of its greatest challenges in the coming decades (OECD, 2007). Drawing lessons from liberalised electricity markets, the International Energy Agency considers that "investments in power generation seem to be the big test for the development of robust and sustainable markets" (IEA, 2005).

Providing public goods and universal services

Infrastructure services as public goods

Infrastructure services involve a number of important externalities that have not been mentioned in the previous discussion.

The positive influence of infrastructures on productivity and growth is acknowledged, although it is difficult to measure empirically (OECD, 2008). In particular, infrastructures reduce transport, transmission and communication costs, and facilitate the diffusion of technology. As a consequence, they are believed to play an important role in regional development through their positive influence on a region's attractiveness for external investors and workers. In many OECD countries, infrastructure expansion has been closely linked to growth and regional development policies.

Health and environmental externalities, both positive and negative, are of paramount importance in infrastructure sectors such as electricity, gas, water, sewerage, railways, airlines and road transport. Some health and environmental benefits of infrastructures are classical public goods (Box 5.3), and it is usually considered that market mechanisms do not properly account for their value in the absence of regulatory action.

Increased attention to the use of natural resources and to environmental impacts, notably in the context of global warming, is expected to strongly influence policy interventions in infrastructure sectors in the coming decades. In electricity generation, many countries have already developed high-profile actions in favour of technologies based on renewable resources. In the water and wastewater industries, OECD countries are expected to move towards dispersed small-scale systems in order to optimise the use of scarce resources (Palaniappan *et al.*, 2007).

Infrastructure services have a well-documented impact on poverty reduction (see for instance ADB, 2005). Poverty is often defined as deprivation from a bundle of goods and services considered a minimum living standard (either relative to a society's living standards, or in absolute terms). Power, water, sanitation, communication and transport are usually considered both part of this bundle, and important factors determining the capacity of individuals to afford it (*e.g.* by improving their health and mobility).

Box 5.3. **Public goods**

Whether an economic good has the nature of a public good depends on two criteria (Samuelson, 1954): first, it should not be possible to prevent people from using it (*non-excludability*); second, its use by some people should not reduce the capacity of others to use it (*non-rivalry*). National defence, for instance, is a pure public good that benefits all citizens and is available for everyone irrespective of the degree to which it is used. By contrast, a good is a pure private good when people can be totally excluded from its usage and when using it reduces the amount available for others. Although pure public goods exist, mixed goods, which have features of both a public and a private good, are more commonly found. In particular, a good is called a *common good* when its usage is non-excludable but is rivalled (*e.g.* hunting), and a *club good* when its usage is not rivalled but is excludable (*e.g.* cable TV).

Because of these two features, the supply of a public good is typically lower than it should be from a social welfare standpoint if solely individual decisions determine the outcome. Indeed, the potential for opportunistic consumption reduces the incentives to provide the good privately, since any person could use the good and refuse to pay for the benefits they get from it (*free-riding*). Hence public intervention is needed to ensure that the supply of public goods is optimal. Various forms of supply of public goods have existed in OECD countries, from direct public provision and public/private partnerships to private sector delivery (under procurement or regulation).

Determining the appropriate level of supply is a daunting task, whichever form of public intervention is actually chosen. According to economic theory, the optimal level of supply is such that the cost of producing an additional unit of good equals the sum of the individuals' willingness to pay for it. However, the price that a person would be ready to pay for a unit of public good is not observable, and individuals are not inclined to provide that information willingly if they can benefit from the good at a lower cost. The producer of public goods therefore has to design specific mechanisms to make individuals reveal their preferences (Laffont, 1987).

In the presence of positive externalities, public intervention is needed to account for the difference between the social and the private benefits of infrastructure provision, and secure an adequate level of investment. Intervention can take the form of direct provision, investment subsidies or incentives.

Infrastructure services as rights

A closely-related notion is that of infrastructure services as *merit goods*, a type of public goods for which *non-excludability* is ethical and political more than technical. Various authors have highlighted the role of public utilities in providing individuals with the capacity to effectively benefit from freedom and fundamental human rights (Dasgupta, 1986).

The essential importance attributed to infrastructure services in democratic societies is one of the reasons they were often structured as public or social services. State intervention in utility sectors aimed, among others, at levelling prices and access geographically (*e.g.* between urban and rural areas), either by organising cross-subsidies between groups of users (usually to the benefit of the rural population or low-income groups), or by using monopoly rents to compensate for cost differences related to economies of density (Peltzman, 1989).

Subsidised prices for specific population groups have been a common feature of infrastructure services in OECD and non-OECD countries. Economists usually consider that targeted subsidies distort prices, provide incentives for inefficient use of infrastructures, and altogether constitute poor tools for income redistribution. Recent research shows, however, that targeted subsidies, in particular cross-subsidised prices, are on the contrary effective and that their efficiency costs are often moderate (Ravallion, 2003).

Efficiency-increasing reforms have had some adverse effects on the affordability of and access to infrastructure services, in particular in developing and transition countries. The dismantling of cross-subsidy mechanisms has had regressive effects, as observed for instance during the restructuring of Chile's telecommunications industry (Armstrong and Sappington, 2006). Similar impacts have been documented in transition economies and in developing countries (Lovei *et al.*, 2000; Romanik, 1998). Governments have often been unable to compensate the adverse effects on poorest regions or population groups through direct subsidies. In some cases they have applied policies that in fact tended to aggravate those effects – such as increases in indirect tax rates applied to infrastructure services (Estache, 2004b). Negative effects have been more severe when infrastructure reforms were associated with a fall in government capital expenditures, because of the complementarity between private and public investment in infrastructures (Calderon, Easterly and Serven, 2003).

Regulating the provision of universal services

The challenge for regulators is to replace the broad cross-subsidy schemes of former utilities by mechanisms for the delivery of universal services that can be sustained in the context of liberalised infrastructure service industries. This entails defining and enforcing service obligations that assure access and affordability, and compensating operators in charge of delivering universal services while preserving a level playing field.

The European Union's doctrine in this area is an interesting case in point. It gradually emerged in the course of the 1990s through the directives that liberalised infrastructure services, decisions of the European Court of Justice, and new treaties and common declarations of the member states. It entailed replacing the broad notion of public service by the more focused notions of universal service and services of general economic interest.

The term *universal service* was first coined in the Council Resolution of 7 February 1994 on the telecommunications sector, and later used in all directives concerning telecommunications, electricity and the post. Through it, the European Union recognised "that the maintenance and development of a universal telecommunications service, ensured through adequate financing, are a key factor for the future development of telecommunications in the Community" and "that the principles of universality, equality and continuity are the basis for such a service to permit access to a defined minimum service of specified quality to all users everywhere and, in the light of specific national conditions, at an affordable price" (Resolution 94/C48/01). The subsequent directives indicate a list of such services in each of the concerned sectors. For instance, Directive 98/10/EC on telecommunications stipulates that member states must require each operator to provide, as a minimum, a connection to the landline network, itemised bills at no extra charge, free use of an emergency number, and so on. In Directive 97/67/EC, universal service is defined as the collection, sorting and transport of delivery of postal items up to 2 kilogrammes and parcels up to 20 kg for any user on any working day and at least five days a week. Importantly, however, the directives define only a baseline, and member states are free to specify additional services as part of the universal service, such as the

density of infrastructure over their territory, or lower tariffs for specific groups of customers.

In its decisions over the cases Paul Corbeau (C-320/91), and Municipality of Almelo and others (C-393/92), the European Court of Justice acknowledged that services of general economic interest could justify derogations to the general rules of competition in the EU. Following these decisions, it was deemed that the necessity to maintain – and finance – a network of post offices over the territory of member states justifies the maintenance of a monopoly over baseline postal services (up to 350 grammes until 2006, up to 50 grammes henceforth) and the possibility for post operators to offer financial services (with tax advantages). Since it was estimated that these advantages were fair compensation for the social objectives imposed on monopoly operators, other segments of postal services were opened to competition.

These principles were enshrined in the Treaty establishing the European Community as amended in Amsterdam in 1997: "Without prejudice to Articles 73, 86 and 87, and given the place occupied by services of general economic interest in the shared values of the union as well as their role in promoting social and territorial cohesion, the Community and the member states, each within their respective powers and within the scope of application of this Treaty, shall take care that such services operate on the basis of principles and conditions which enable them to fulfill their missions." The European Charter of Fundamental Rights, proclaimed in 2000, states: "The Union recognises and respects access to services of general economic interest as provided for in national laws and practices, in accordance with the Treaty establishing the European Community, in order to promote the social and territorial cohesion of the Union."

Policy messages

One of the potential downsides of the general increase in efficiency brought about by the reforms of the 1990s is reduced access to infrastructure services and lower affordability for the poor. The policy response to this risk lies in the definition, clarification and extension of universal service obligations. It should be stressed that a key change in this area, particularly in Europe, has been to make regulation conditional on a clear statement of its justification and objectives. Implementing and enforcing such missions within the framework of reformed infrastructure sectors remain important challenges for regulators.

Limiting the risk of regulatory failure

The initial intent of the promoters of infrastructure industry restructuring was to roll back regulation. What has actually happened is, rather, a process of continuing regulatory reform, where regulatory interventions are constantly put to the test by rapidly changing economic conditions.

The preceding sections highlighted some of the issues that regulators at large have to tackle in this new environment: integrating high-powered incentive schemes in the regulation of monopolies; understanding interactions along the supply chain and co-ordinating upstream and downstream regulatory interventions; in particular, striking a balance between the interests of the infrastructure operator and those of the liberalised segment of the industry when determining the conditions and price of access to infrastructure networks; identifying market power issues at an early stage and providing effective responses; determining and enforcing appropriate universal service obligations; and accounting for the environmental costs and benefits of infrastructure development.

In addressing these challenges, regulators are often in possession of limited information, have limited instruments at their disposal, and face the contradictory expectations of the industry, policy makers and the public at large.

Regulatory quality and flexibility

Regulatory quality hinges on the ability of regulators to monitor and understand market conditions, swiftly identify important changes and adapt regulatory measures accordingly.

Joskow and Tirole (2007) consider that many non-market mechanisms have been imposed on emerging competitive wholesale and retail electricity markets, often carried over from the old regulated regime without much consideration for their appropriateness in a market context. According to these authors, a broad range of regulatory interventions are not adapted to restructured electricity markets, such as wholesale market price caps, capacity obligations placed on Load Serving Entities, frequency regulation, operating reserve and other ancillary service requirements enforced by the system operator, procurement obligations placed on system operators, protocols for non-price rationing of demand to respond to shortages, and administrative protocols for system operators' management of system emergencies.

Similarly, Hausman and Sidak (forthcoming) observe that in telecommunications, the regulatory process has often failed to take sufficient notice of the importance of new product and service innovation. They observe: "Telecommunications differs in an important respect from many other regulated industries because of the rapidity of technological change. Telecommunications regulators have found it difficult to adapt to these changes and outdated regulatory policies may create perverse economic incentives for investments in new technology."

Although the regulatory design process has to account for the specific circumstances of each case, a number of elements are always necessary for its success:

- To clearly define the issue that regulation is supposed to tackle, and the main objectives.
- To examine whether and how regulation can reach these objectives; determine if its expected benefits balance its costs; and establish that there is no better alternative.
- To identify the specific regulatory actions needed to achieve the objectives.
- To select legal and institutional solutions adequate to these actions.

Credibility and commitment abilities

The need for regulators to flexibly adapt to changing circumstances should, however, be weighed against the need to be credible. The perception of a risk of regulatory change typically leads to underinvestment by private providers. To avoid this, a regulator needs to be able to make credible commitments that it will not change the rules – especially when contracts have a long duration and the potential gains from a change are major.

Institutional and political settings clearly have a strong influence on the risk of administrative expropriation and the credibility of regulators. Levy and Spiller (1994) consider that "performance can be satisfactory with a wide range of regulatory procedures, as long as three complementary mechanisms restraining arbitrary administrative action are all in place: *i*) substantive restraints on the discretion of the regulator, *ii*) formal or

informal constraints on changing the regulatory system, and *iii)* institutions that enforce the above formal – substantive or procedural – constraints."

In OECD countries, there has been a marked trend towards independent regulatory agencies in the past years (OECD, 2005a). There are two main reasons for governments to delegate regulatory or quasi-regulatory powers to independent agencies: to reduce decision-making costs, for example by taking advantage of agency expertise; and to enhance the credibility of long-term policy commitments, by isolating regulatory decisions from short-term political considerations (OECD, 2004b).

But the credibility of regulators also depends on their ability to adopt courses of action that will prove sustainable in the long term. A counterexample is given by the privatisation of British Gas, where according to Armstrong and Sappington (2006) the government maximised its present revenues at the expense of regulatory consistency in the future.

Dynamic consistency of regulation, in turn, highlights the importance of reform timing.

Friebel, Ivaldi and Vibes (2003) find that reforms in the railway sector are associated with efficiency gains, but that their effect depends on sequencing. In particular, they observe that introducing multiple reforms in one package has at best neutral effects, while sequential reforms enhance efficiency.

Clearly, there are irreversibilities in a reform process (*e.g.* privatisation tends to "freeze" the market structure), and minimising the cost of these irreversibilities can justify delays in the reform agenda (Kessides, 2004). In particular in developing countries, investors' management of "political and regulatory risks" leads to contractual rigidities for future regulatory decisions: independent power producers (IPPs) are "protected against political risks – including regulatory ones – often by explicit government guarantees. These risks are passed on to the off-taker…" (Albouy and Bousba, 1998).

In the United States, deregulation and vertical unbundling in the electricity sector were anticipated, and the way paved, by important regulatory initiatives taken from the second half of the 1970s onwards in order to spur the development of the wholesale electricity market. Two prominent examples are the 1978 Public Utility Regulatory Policy Act and the 1992 Energy Policy Act (Joskow, 1997).

Legitimacy, accountability and capture

The theory of regulatory capture has highlighted an additional risk inherent in regulation: that regulatory bodies can be unduly influenced by the industry or other interest groups (Stigler, 1971, Peltzman, 1976, Becker, 1983). The key factor is that a small stakeholder group can have high stakes in regulation, and consequently devote large resources to collecting information and lobbying regulators, whereas potential benefits for the general public are dispersed among many individuals and hence receive lesser support from each of them.

Laffont and Tirole (1991) show that the risk of capture can itself have unexpected effects. In response to the risk of capture, regulators might have to reduce the stakes of regulation, in particular to favour low-incentive schemes. Even in the absence of collusion between interest groups and regulators, therefore, the risk of capture can be a source of regulatory inefficiency.

Besley and Coate (2003) find evidence of a form of capture among state-level utility regulators in the United States. They observe that, since regulation becomes bundled with other issues in the choice of a government, regulators who are appointed by the government are more likely to represent the interests of specific stakeholders than directly elected regulators, who focus on consumer interests.

Competent regulators with adequate resources, backed by mechanisms to enhance their credibility and accountability, are naturally less exposed to the risk of capture. If, on the contrary, the institutional capacity for good regulation is not in place from the onset of reform, there are considerable risks of capture, resulting in important welfare losses (documented in sub-Saharan Africa by Auriol and Blanc, 2008).

Policy messages

Liberalisation and restructuring of infrastructure industries increase the importance of good regulation, but at the same time generate complex regulatory issues. Regulators have to adapt to a rapidly changing economic environment, and detect and address emerging issues before they develop into large-scale crises. But they also need to have the ability to make long-term commitments, and to be protected against the risks of capture.

In order to conform to these requirements, regulators need to develop a high level of expertise, have at their disposal accurate information they can rely on, and have adequate funding. But good regulation also depends on institutional design and the capacity of governments to adopt a consistent strategic approach to infrastructure reform.

Lessons for the reform of infrastructure governance in China

Summary of policy messages

Perfect competition and perfect regulation are, in theory, two equivalent ways of achieving an optimal economic outcome, where production costs are at their lowest and prices reflect marginal costs. In the case of infrastructure services, both of these solutions are out of reach. Because of their cost structure and the existence of positive externalities, infrastructure services cannot be fully competitive industries. Regulators, for their part, have incomplete information, and their decisions are not always aimed at maximising public welfare. The available policy options therefore represent different mixes of imperfect competition and imperfect regulation. The experience of OECD countries in reforming infrastructure industries provides a number of lessons with regard to these options.

First, there are benefits to introducing competition into infrastructure service industries, but strong regulatory capacity is needed to ensure that these benefits will accrue to consumers. Regulators can be faced with severe problems of market power, vertical restraint, or underinvestment. They need to co-ordinate their interventions all along the supply chain, and to balance conflicting interests.

Second, the costs of regulatory failure can be large. Regulators can err, both on the side of too much intervention (or inappropriate intervention), thereby generating inefficiencies and discouraging investment; and on the side of excessive laissez-faire, which can eventually lead to monopoly rents.

Third, rather than a one-off liberalisation "big bang", the governance of infrastructure service markets has to be understood as a continuing process, in which institutional design

and the timing of reform are critical to securing the credibility of regulators and preventing risks of regulatory capture.

Fourth, a case-by-case, adaptive approach is necessary, one that accounts for local conditions such as the state of development of existing infrastructure, technology, regulatory capacities and socio-economic policy objectives.

The importance of information and the role of information asymmetries are a central theme in these lessons – and also emphasised by recent developments in economic theory. Lack of information not only imposes serious limits on the effectiveness of regulators; it also indicates what achievements regulators can aim for, and how. Because of information asymmetries, high-powered incentive schemes are the most efficient tool for regulating infrastructure service activities. Effective incentive systems in turn call for regulators who have a very clear understanding of industry conditions and a high degree of credibility. Finally, institutional arrangements that support the competence and credibility of regulators appear to be the backbone of efficient infrastructure services.

The best "model" is the one best adapted to the specific needs of each industry and to the economic, social and institutional conditions of China.

The criteria for determining which infrastructure model works "best" might vary with social and economic conditions. For instance, while developed countries are seeking to optimise well-developed infrastructure systems, developing countries may be more concerned with network reach and expanded access and usage (Armstrong and Vickers, 1994).

In developing countries that have opened up infrastructure industries to private participation, there is widespread concern that the provision of infrastructure services has suffered as a consequence of the retrenchment of the public sector and the insufficient response of the private sector. In Latin America, for instance, overall infrastructure investment has fallen and private sector participation has been mostly confined to the telecommunications industry. However, there is considerable disparity across countries. Countries most successful in attracting large volumes of private investment (Chile, Colombia, Bolivia) are precisely those where public investment has remained high (Calderon and Serven, 2004).

A recent report by the International Energy Agency concerning power sector reforms in China states:

> Competitive power markets are not an end in themselves; rather they are a means to an end: access to environmentally sustainable electricity services to achieve China's social and economic welfare objectives. To serve as an effective instrument, many electricity policies must be considered simultaneously: regulatory policies and structures must integrate competition principles and cost-reflective, competition-based pricing alongside policies to encourage energy efficiency and policies for the environment. Without a holistic approach, competitive markets can raise problems for demand management (*e.g.* dispersing incentives to reduce demand) and the environment (*e.g.* because environmental costs and benefits are not yet appropriately reflected in power pricing and investment decisions, system dispatch sometimes favours dirtier plants). China's progress towards competition should proceed carefully. Important actions should be taken now to improve economic and energy efficiency

without compromising the long-term goal, and to lay a sound basis for a fully competitive market in due course (IEA, 2006).

Reforming the governance of China's infrastructure service industries should therefore be seen as an open-ended process where success depends critically on the existence of a coherent strategy and the adoption of a gradual approach.

China's strategy in the years to come will be oriented towards infrastructure development and modernisation rather than efficiency gains.

China's economic development has been spectacular. Two decades of sustained economic growth at an average rate of 9.5% per year have resulted in a sixfold rise in China's GDP. With several hundred million people lifted out of poverty in the past 20 years, China has accounted for over three-quarters of poverty reduction in all developing countries, and achieved the best performance by any single country in recorded history. The country's economic boom is expected to continue in the coming years. The IEA's long-term projections, for instance, are based on an average annual growth rate of 6% by 2030 (IEA, 2007).

It is increasingly clear that the development of infrastructure services will be a crucial element of continued economic growth. This will impose unprecedented levels of investment in infrastructure industries, but also very significant modernisation efforts, in particular with regard to pollution. The electricity and water industries can help to illustrate the issues.

In 2004, the Chinese electricity system was the world's second largest, with installed capacity of about 440 gW (IEA, 2006). Since 1995 China has also become the world's second-largest electricity consumer. In 2000 the total installed capacity of electric equipment for final use was more than twice the total generating capacity. Power generation and consumption are both currently above 2 trillion kilowatt-hours.

However, on a per capita basis, electricity consumption is still very low. In 2002 it was close to 1 000 kWh, about twelve times less than in the United States and five to six times less than in major European countries (World Bank, 2002). Millions of rural Chinese still have no access to electricity. Economic development and rising standards of living are therefore expected to stimulate growth in electricity consumption for several decades to come. To match the growth in demand, huge investments in power generation, transmission and distribution will be needed. According to some estimates, China's cumulative electricity investment needs by 2030 amount to USD 2.8 trillion (2006 dollars), and represent 20% of the world's total (IEA, 2007). In addition to securing such levels of investment, which have never been reached before, over the long term the authorities will have to try to avoid the kind of boom and bust cycles that have been observed in the past.

Transmission bottlenecks have been and will remain a difficult challenge. China's energy resources are mainly located in the north (coal mines) and the west (hydro), while the large urban centres are in the south and the east. Congestion of transmission grids explains in large part the chronic power shortages that have affected 26 of the country's 31 provinces since 2000.

Coming to water infrastructures, the 11th Five Year Plan (2006-10) has set the target of providing access to safe drinking water to 98% of the urban population and 60% of the rural population. However, urban water systems alone require USD 250 billion of investment according to some sources, while USD 10 billion are needed to build wastewater treatment

facilities (China Economic Net, 2005). Only half of wastewater is currently treated, and only a third of existing systems are considered to be well functioning.

In order to facilitate the financing of these needs, Chinese authorities have taken measures to encourage investment and participation by national and foreign companies in the water industry. These efforts have been particularly targeted towards the poorer inland provinces where the lack of infrastructure is most severe. International institutions such as the World Bank and the Asian Development Bank have also taken initiatives to improve water supply and treatment facilities in these regions. Still, private participation remains low. A key factor in attracting foreign investment in the future will be the capacity of the government to reshape its role into that of a regulator responsible for price, quality, rights and competition in the water industry (Ashley and Cashman, 2006).

The benefits of infrastructure development for the Chinese people will be a key factor in support for reforms.

Between 1950 and 2000 the urban population increased by over 500% and now accounts for some 40% of the total (United Nations, 2002), with 72% of growth due to rural migration. By 2030 about 60% of the population – some 883 million people – will be urbanised (OECD, 2005b).

Such growth is placing enormous burdens on urban electricity, water supply and sanitation systems, and generating large-scale pollution.

In the electricity industry, energy efficiency and pollution are two areas where large improvements will be necessary. The level of energy efficiency is 20% to 40% lower than in OECD countries in various sectors, and policy reforms have fallen short of improving incentives in this area (IEA, 2006). The electricity industry is the primary source of air pollution and greenhouse gas emissions. Air pollution levels are already extremely high: five of the ten most polluted cities in the world are Chinese, and acid rains affect one-third of the territory. Greenhouse gas emissions are still limited on a per capita basis, but growing rapidly.

Monitoring of local pollution and enforcement of health and environment protection laws are also problem areas, in particular due to weak institutional capacity. Devolution of authority in this area, together with insufficient resources and supervision, has weakened law enforcement and led to serious corruption problems. Resource problems are aggravated by the lack of adequate financing instruments (Turner *et al.*, 2003; McGill, 1999). As a consequence, water pollution is high, with a third of major water basins declared highly polluted. Extensive use of water resources is beginning to pose problems for economic development and competition for available water resources (Economy, 2005). The lack of water for arable land might generate millions of "environmental refugees" flowing into the cities in the coming years. However, there seem to be large margins for improving efficiency in the use of water, *e.g.* for irrigation (OECD, 2005b).

With this background, improvements in the population's access to basic infrastructure services such as water, sanitation and electricity will be an important test for the reform process.

Trade-offs between efficiency and fairness in the restructuring of infrastructure services should be examined in this light. On the one hand, price discrimination in favour of the poor to achieve equity concerns has well-known undesirable efficiency consequences. Cross-subsidies have long been criticised for this specific reason. On the

other hand, when the ability of the government to finance direct subsidies is limited, some argue that cross-subsidies may be unavoidable if the social concerns should prevail over efficiency goals (Estache, 2004a).

A second related trade-off involves the allocation of efficiency gains between users and operators, while maintaining the incentive of the operator to maximise these efficiency gains. If all gains must immediately be passed on to the users, there is no incentive for firms to cut costs, since cost cutting frequently has a high initial cost (staff, equipment, investments). At the other extreme, allowing the firm to keep all efficiency gains achieved in the delivery of infrastructure services will be socially and politically unrealistic, even though the government might benefit from such rents through taxation.

Most of these issues will have to be addressed by regulators. Strong, accountable regulators will aim at ensuring a fair and transparent balance in the handling of such trade-offs. More of the benefits will then eventually be passed on to all users, in particular the large low-income category. Weak regulators, on the contrary, are very unlikely to maximise efficiency gains while at the same time controlling rents – a situation that can ultimately generate considerable social discontent and economic costs.

In the short term, priority should be given to building a sound regulatory framework and strong regulation capacity.

The crucial role of regulation in the success of a competition-based model can be particularly difficult to achieve in a country where "modern" regulatory institutions do not exist and where the institutional setting is expect to substantially evolve under the action of "exogenous" factors in the coming years.

The importance of good regulation is enhanced by China's decentralised political system, which is prone to weak governance and political opportunism (Guasch, Laffont and Straub, 2007).

China is still a politically centralised system, although there is now a considerable degree of decentralisation of power at national, provincial, prefectural, county and community levels. Legislative and regulatory powers as well as planning and development are the responsibility of national government, but the management and maintenance of infrastructure systems are the responsibility of the various lower tiers.

The structure and governance of the electricity industry have undergone important changes in recent years. The vertically integrated utility has been unbundled into two grid operators (one of which covers most of the country) and five generation companies. A number of other firms have entered the generation segment, and several regional wholesale electricity markets have been launched on a trial basis. A State Electricity Regulatory Commission (SERC) has been created.

However, the price-setting system is still the source of economic inefficiency. On the generation side, the electricity purchasing price varies greatly according to different power plants costs (Development Research Centre, 2002). On the supply side, the final price of electricity varies for different categories of consumers and partly reflects the policy priorities of different regions, leaving room for local government abuses. The State Development Planning Commission, which sets the initial price schemes at local level, seems to have little control over the actual pricing policies of provincial and local governments.

Further reform proposals exist, particularly as regards pricing, but have not yet been implemented. The 11th Five Year Plan calls for expanding electricity structural and price reforms but does not provide the details of specific measures or timetables.

Concerning water and wastewater, municipalities are primarily responsible for service provision, and own and manage more than 60% of water capacity. Responsibility at central government level is shared between the Ministry of Water Resources and the Ministry of Environmental Protection. State-owned water companies further complicate the picture. The government has passed a number of reforms to clarify responsibilities, improve co-ordination, strengthen property rights and enhance efficiency in the management of public water systems. Importantly, regulation has been distinguished and separated from supply. Recently, government funding has been conditioned by the introduction of full-cost pricing in some specific cases (Ashley and Cashman, 2006).

However, several factors raise concern about the future of the reform process. Structural reforms aimed at increasing economic efficiency have often stopped before completion. Environmental policies lack an integrated approach and clear definition of roles and responsibilities. The institutional framework needed to support a decentralised market economy is also still lacking. In particular, regulators such as the SERC have not yet been empowered to actually play their role in supervising markets. The resulting gaps and uncertainties "possibly raise questions about the current strategic thrust of the reform process" (IEA, 2006).

All in all, institutions – and their legal and political underpinnings – may matter more than ownership or market structures for the future of China's infrastructure industries.

Notes

1. For instance, Newbery (2002) cites the case of the United Kingdom's monopolies in telecommunications, gas, water and sewerage.
2. On such case is the England and Wales electricity market, where the shift from coal- to gas-fuelled plants was the main source of efficiency gains (Newbery and Pollitt, 1997).
3. By reducing its costs below the level approved by the regulator at a review, the monopoly could increase its profit until the efficiency gains were observed and passed through to prices at the next review. Joskow (1974) and Hendricks (1975) showed that regulatory lags could be used as an incentive mechanism.
4. See the seminal paper by Baron and Myerson (1982), and a complete view of the approach in Laffont and Tirole, 1993.
5. United States Federal Electricity Regulation Commission, Order 888, 1996.
6. The AMP is actually applied by the transmission system operator.
7. See for instance the evolution of the United Kingdom's Monopolies and Mergers Commission (later replaced by the Competition Commission), discussed in Armstrong, Cowan and Vickers, 1994.

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