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# Infrastructure Investment: Links to Growth and the Role of Public Policies

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# INFRASTRUCTURE INVESTMENT: LINKS TO GROWTH AND THE ROLE OF PUBLIC POLICIES

**ECONOMICS DEPARTMENT WORKING PAPER No. 686**

**By Balázs Égert and Tomasz Koźluk and Douglas Sutherland**



**English - Or. English**

## ABSTRACT/RÉSUMÉ

### Infrastructure investment: links to growth and the role of public policies

Investment in network infrastructure – the energy, water, transport and telecommunication networks – which performs a vital role for the functioning of the economy, can contribute to raising growth and social welfare. But more is not always better. While the paper shows that investment in the network industries has had a positive effect over and above the addition to the capital stock, there is evidence that investment in the past has sometimes been misallocated. This paper identifies the policy framework that promotes investment that is conducive to growth and ensures the appropriate use of infrastructure. Central aspects of this framework are identified as a robust decision making process, improving the selection of investment projects, the introduction of competitive pressures through the reduction of barriers to entry and vertical separation when this is appropriate. In addition, efficient investment can be promoted by the combination of regulator independence and the application of incentive regulation.

*JEL Classification:* H40; L90; O40; Q48.

*Keywords:* Infrastructure; growth; network industries; investment; regulation.

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### L'investissement dans les réseaux d'infrastructure : liens à la croissance et le rôle des politiques publiques

L'investissement dans les réseaux d'infrastructure, l'énergie, l'eau, le transport et les télécommunications jouant un rôle vital pour le bon fonctionnement de l'économie, peut également contribuer à la croissance économique et au bien-être social. Néanmoins, plus d'investissement n'est pas toujours bénéfique. Nous montrons que l'investissement d'infrastructure a bien eu des effets positifs allant au-delà de celui de l'accumulation du stock du capital, mais qu'il existe parfois des signes de mauvaise allocation de l'investissement dans le passé. Cette étude identifie le cadre de politique économique qui encourage l'investissement favorable à la croissance économique et conduit à un bon usage des réseaux d'infrastructure. Les éléments centraux de ce cadre sont : un processus de prise de décision robuste, une amélioration de la sélection des projets d'investissement, l'introduction de pressions compétitives par le biais d'une baisse des barrières à l'entrée et de l'intégration verticale si nécessaire. De plus, l'efficacité de l'investissement peut être augmentée en combinant indépendance du régulateur et régulation incitative.

*Classification JEL :* H40 ; L90 ; O40 ; Q48.

*Mots Clefs :* Infrastructure ; croissance ; industrie de réseaux ; investissement ; régulation.

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# INFRASTRUCTURE INVESTMENT: LINKS TO GROWTH AND THE ROLE OF PUBLIC POLICIES

By Douglas Sutherland, Sonia Araujo, Balázs Égert and Tomasz Koźluk[1]

## 1. Introduction

1. This paper assesses how policies can influence investment in infrastructure and how much infrastructure contributes to growth. The analysis focuses on infrastructure in energy, water, transport and communications. These sectors are chosen not only because of their importance to the economy, but also because they rely mainly on fixed networks to deliver their services, with investment being lumpy and largely irreversible. As a result, in these sectors public policies are often key to ensure that investment is socially appropriate, efficient and conducive to quality services for consumers. Against the background of projections suggesting substantial investment needs in core infrastructure over the coming decades (OECD 2006a, 2007a, IEA 2007) and past episodes of over-investment, it is important to ensure that the policy framework promotes infrastructure investment and use that is conducive to better living standards.

2. These issues are addressed by first considering the linkages between the provision of network infrastructure and growth and then examining the interactions between policy settings and investment. The first section briefly examines trends in infrastructure provision by looking at available indicators of the volume and quality of infrastructure in OECD countries. The following section provides a framework for highlighting the economic issues that surround infrastructure investment and looks at some empirical evidence of the link between measures of physical infrastructure and growth. Issues related to the policy drivers of efficient infrastructure provision are then examined in detail in the final section, which looks at how decision-making, ownership, regulation as well as means to harness the private sector in the provision of public goods can ensure that investment is adequate, efficient and conducive to the provision of quality infrastructure services.

3. There are three main limitations to this work. The first is the relatively narrow focus that is a result of concentrating on the network industries. The analysis is also often complicated by data limitations, which also make it difficult to distinguish between the public and private sector. Third, limited information on the quality and congestion of infrastructure impairs cross-country comparability and the resulting policy insights in some cases.

4. Despite these limitations, a number of conclusions can be drawn from the analysis:

*Trends*

- The network industries are important parts of the economy, particularly with respect to investment, where they can account for between one-tenth and one-quarter of economy-wide investment. Over the past two decades the investment rate has been falling in energy, water and

1. The authors were all members of the Economics Department of the OECD. This paper is a revised version of a document prepared for the October 2008 meeting of Working Party No. 1 of the OECD Economic Policy Committee. The authors are indebted to the participants of the meeting, and also to Jorgen Elmeskov, Jean-Luc Schneider, Giuseppe Nicoletti, Fabio Schiantarelli, Giuseppe Berlingieri and Irene Sinha as well as members of the Economics Department. The opinions expressed in this paper are those of the authors and are not necessarily shared by the OECD.

transport in most OECD countries. More recently, investment in the telecommunication sector has been growing rapidly in all OECD countries, albeit from a low base.

- While the physical level of infrastructure provision has generally increased for all sectors other than rail, it may be that the rate of growth has not kept pace with output growth in some sectors and countries, though comparison is hampered by the absence of comparable national account data on infrastructure stocks. At the same time, there is some evidence that the quality of the infrastructure has been improving in energy and, particularly, in telecommunications.

- Congestion has become a key concern in many types of transport and also more recently in the energy sector. Urban traffic congestion has increased in a number of countries over time and interconnection capacity in electricity networks is often congested.

*Link to growth*

- The impact of infrastructure on output is difficult to pin down and the direction of causality hard to determine empirically. However, there is some evidence, from annual and multi-year growth regressions, that investment has positive effects that go beyond the impact to be expected from a larger capital stock.

- Furthermore, infrastructure investment appears to have a nonlinear effect with on average a stronger long-term effect on growth at lower levels of provision. At the same time, these effects are not commonly shared across OECD economies, where there is some evidence suggesting episodes of both under- and over-provision and of both efficient and inefficient use of investment.

*Policies*

- Before undertaking investment in new capacity, it is important to ensure that best use is made of existing infrastructure. User fees and congestion charges can play a key role in ensuring efficient use of scarce infrastructure and also give more accurate signals of where additional capacity may be warranted. Curbing anti-competitive practices of incumbent infrastructure operators can also increase effective availability of capacity.

- Incentive regulation, such as setting price caps for infrastructure services, can help ensure that investment is cost reducing and mimics a competitive environment. Independence and accountability of the sectoral regulators can help establish a stable and credible framework for infrastructure investment. Empirically, there is evidence that price-cap regulation when combined with regulatory independence boosts investment, especially in electricity and telecommunications. However, setting access prices for users of infrastructure is challenging for the regulator, with the possibility of too low a price leading to underinvestment and too high a price leading to inefficient bypass.

- A competitive environment is generally supportive of more efficient use of resources and there is evidence that removing barriers to entry – such as requiring vertical unbundling and establishing regulated third part access regimes – can foster higher rates of investment in the network industries. Such barriers appear to be harmful for investment, especially in the energy and telecommunication sectors, with vertical integration curbing firm-level investment in the electricity sector.

- Another important challenge for regulators is to establish a framework that prevents insufficient interconnection capacity at both the domestic and international levels from leading to barriers to competition and efficient investment. This is particularly relevant for future developments in energy markets.

- Past experience has shown that exclusive public sector ownership and provision can lead to inefficient investment decisions. Different organisational forms have been increasingly used in the network industries that would permit more private sector involvement. Furthermore, new contracting techniques, such as public-private partnerships (PPPs), are also on the rise, especially in the United Kingdom, Spain and Korea, and can potentially harness the private sector effectively in the provision of infrastructure. However, these contracts are not suitable for all projects and their design is important for ensuring adequate and efficient investment. Policy settings vary considerably across countries, suggesting in some cases ample scope to improve policy in this area. In particular:

  - The decision making about the use of concessions and PPPs should be transparent to ensure that they are the most appropriate method of investment.

  - Contract specification should share risk appropriately between the parties and investment incentive mechanisms should be specified throughout the concession period.

  - Monitoring of investment decisions and performance evaluation throughout the contract period are important to guarantee value for money.

## 2. Measures of infrastructure

5. The infrastructure sectors of energy, water, transport and communications can account for a sizeable share of economy-wide value-added, ranging from around 4%-5% in Ireland and the United States to above 10% of GDP in Turkey, the Czech Republic and the Slovak Republic. Employment in these sectors also varies widely from 4%-5% in Portugal and the United States to around 10% in Hungary, Greece, Hungary and the Slovak Republic (Figure 1, Panel A). Due to their highly capital-intensive nature, these sectors' investment can account for a substantial share of economy-wide investment and at times be extremely large relative to sectoral value added (Figure 1, Panel B). For instance, in the Slovak Republic and Ireland, investment in the energy and water sector appears to have exceeded sectoral value added around the turn of the century.

**[Figure 1. Network infrastructure sectors]**

6. There are two main types of measures of the stock of or investment in infrastructure. First, there are various estimates of investment flows (and less often of capital stocks), which are frequently made in the context of national accounts. Second, there are various physical measures of the provision of infrastructure. The two sets of measures, which are described in turn below, can give somewhat different pictures that may not be strictly comparable across countries (Box 1).

**Box 1. Data issues**

**Estimates of capital stock and investment in infrastructure**

A limited number of national statistical offices in the OECD publish capital stock data. National estimates of gross or net capital stocks are often not strictly comparable (or the comparability is uncertain) being based on different methodologies and often lack a significant time series dimension.[1] In some empirical applications, researchers have used measures of the public capital stock or government investment as proxies for infrastructure. However, these data can vary according to coverage. General government gross (fixed) capital investment excludes investment made by public corporations and thus potentially misses a large part of infrastructure investment. Partly as a result, the direct comparison of measures such as public capital stock across countries is potentially problematic as different types of infrastructure may be included for one country but not in another. In addition, comparison over time is also problematic as a result of privatisation in the network industries. Furthermore, core infrastructure, such as telecommunications may be entirely excluded from these partial measures of capital stocks.

**Physical measures of infrastructure provision**

Physical measures of infrastructure can complement or substitute for the estimates of capital stock and capital formation, particularly when estimates of capital stock are unavailable and consistent investment data are only available for short time periods. One problem with physical measures is that there is no simple way to aggregate the various measures of infrastructure. A further obvious shortcoming of physical measures is that they fail to capture the quality of the infrastructure, which may vary systematically across countries. (SNA data may also fail to capture differences in quality of investment flows.) In some cases the efficiency of the use of existing infrastructure varies substantially across countries. As such a straight comparison between two countries may be misleading without additional information.

**Problems of interpretation**

There are two types of problems of interpretation for both types of measures of infrastructure that make the comparison of trends and levels across countries difficult. First, an investment at the margin in a network industry could have more-than-proportional effects by enhancing (or, in a special case for electricity transmission, undermining) the operation of the rest of the network. After the main network effects have been captured, the impact of additional investment may decline markedly. However, the connection of two networks may have very large effects. In this light, simple comparisons of trends in various measures of infrastructure may fail to capture the non-linear effects of investment. A second problem for comparing indicators across countries is the need to bear in mind the importance of geography. For example, differences in geographical size, the geology of the country (such as the importance of mountainous regions) and the dispersion of population may alter the optimal level of a given type of infrastructure.

**Implications for this paper**

The approach adopted in this paper is based on the available data rather than constructing new series. In particular, the preference for longer time series and broader country coverage for some parts of the analysis in this paper has led to the use of physical measures of infrastructure provision, whereas analysis of investment behaviour is based on investment flows. In some cases, such as in Section 3 which examines the linkages between infrastructure and growth, the unit of measurement is the physical measures of infrastructure provision. In other cases, most notably in Section 4 of the paper which analyses firm and sectoral investment, the unit of measurement is wider than infrastructure provision as the possible degree of disaggregation of investment cannot discriminate between investment made by network operators and network users.

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1. This is in part due to the transition from SNA68 to SNA93/ESA95, which introduced new concepts and methodology for the estimation of capital stocks. These issues affect the interpretation of (gross) capital stock data included in the STAN and the EU KLEMS databases. An alternative approach could use estimates based on the perpetual inventory method. Such data, however, are sensitive to the set of assumptions that are needed to generate the series, such as depreciation rates (or age-efficiency profiles) and the length of asset life, both of which are often assumed to be identical across countries, as well as often an estimate of the capital stock to anchor a investment series (this is necessary due to the long service life of infrastructure and short time series for investment).

### *2.1 The rate of investment*

7. The rate of investment has displayed somewhat different dynamics across the network industries surveyed in this paper. Generally, the rate of gross fixed capital formation in the energy and water supply sectors has declined continuously since the 1970s; on average falling from a rate around 1½% of overall GDP to below 1% of GDP (Figure 2, Panel A). However, the rate of investment has remained comparatively high in some countries, such as Iceland and Korea. In the broad category of transport, storage (which includes facilities such as cargo storage) and communication, investment as a share of GDP has remained relatively stable in most countries, on average above 2% of GDP (Figure 2, Panel B). But, more recently, the investment rate in this broad category has picked up in many countries, generally reflecting a marked increase in investment in telecommunications.

**[Figure 2. Investment in infrastructure sectors]**

8. Over the past two decades, concern over the provision of infrastructure has often focussed on the fall in public investment. This reflected a decline in public investment in both countries with traditionally high and low public investment rates between the early 1980s and late 1990s, though it has subsequently stabilised (Figure 3). In some cases the apparent fall in investment may be exaggerated due to accounting conventions.[2] There are difficulties in comparing the rate of public sector investment across countries, given the different scope of governments. In this light, comparisons of public gross fixed capital formation can be deceptive, both when made across time and across countries.[3]

**[Figure 3. Government gross fixed capital formation]**

### *2.2 Physical indicators of capital stocks*

9. The physical indicators of capital stocks generally show that capital stocks have risen since the 1970s (Figure 4). However, the overall trends mask differences across both countries and types of infrastructure.

- Electricity generation capacity, which is used as a proxy for network infrastructure, has grown in all countries since the 1960s. Given the lumpiness of investment in new generation capacity, the evolution of capacity often shows stepwise increases followed by plateaus.[4] In a number of countries, there appear to have been relatively little net addition to generation capacity since the late 1980s.

- Within the transport sector available physical indicators show unsurprisingly that the provision of roads has generally increased. Road density (road length per 1 000 square kilometres) is particularly high in countries with high population density, such as Belgium and the Netherlands.[5] The share of motorways in total roads has increased particularly strongly in recent

2 . As gross fixed capital formation is the sum of additions less disposals, in countries where there is significant privatisation, it can fall and even become negative as assets change ownership.

3. Gross fixed capital formation will capture investment in some activities (which may or may not be related to the network sectors being considered here) that are predominantly the responsibility of the state in some countries and of the private sector in others. The public/private investment mix is partly related to corporatisation and privatisation of infrastructure activities.

4 . See Caballero (1997) on the importance of infrequent and often clustered investments by large firms for aggregate investment.

5 . The per capita provision of roads is high in those countries with low population density and long distances between settlements, such as Australia and Canada.

decades. In contrast to the road sector, rail track density has generally fallen in most OECD countries, though remaining quite high in central European ones.

- In the communications sector there was generally a substantial increase in fixed line provision to the population since the 1970s, often reaching a plateau in the late 1990s and sometimes falling thereafter. The rapid expansion of mobile telephony since the late 1990s has more than compensated for the modest fall in fixed-line subscriptions, with the number of mobile subscriptions accounting for the majority of total subscriptions in every OECD country by the early 2000s, except in the United States and Canada. In addition, broadband (DSL) and cable subscriptions have grown rapidly more recently with annual growth rates for the OECD as a whole above 20% in the first half of the decade (OECD, 2007b).

- In the water sector, there are few comparable data on the network other than connection rates to water supply and waste water treatment plants. In general almost all OECD households are connected to water supply and sewerage systems; and sewerage systems are increasingly widespread (Figure 5). The share of the population that was connected to municipal waste water treatment plants rose from around 50% in 1980 to over 70% in 2005 (OECD, 2008a).[6] However, significant challenges remain in meeting environmental standards (which are increasingly demanding), changes in the structure of water supply and demand as well as replacing ageing networks.[7]

**[Figure 4. Physical measures of infrastructure provision]**

**[Figure 5. Water supply and sewerage indicators]**

### *2.3 Developments in infrastructure service provision*

10. Over and above the quantity aspect, available information suggests that there has generally been improvement in the quality of infrastructure supporting energy and telecommunications services.

11. In the electricity sector, there is some evidence of improvements for many countries in terms of system performance. To the extent that distribution losses reflect the effectiveness of the use of the existing stock, there have been on average positive trends across the OECD since the 1970s (Figure 6a).[8] However, while the average has improved, in some countries – such as Turkey, Mexico, Hungary and New Zealand – distribution losses as a percent of electricity supplied have risen substantially more recently. Moving to a different indicator, unplanned outages in Europe show a decline (Figure 6b). When electricity generation capacity is measured by reserve margins (generation capacity relative to requirements needed to meet peak demand) there has been on average a modest decline, as installed capacity has not grown as quickly as peak load demand (Figure 6c). In some cases, this may reflect lower desired reserve margins (as a result of technical change or greater interconnection, for example) or working off previous excess capacity.

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6 . One potential measure of the quality of the infrastructure is the rate of water leakages. However, these statistics are difficult to interpret, as they vary across countries and time due to factors such as water pressure in the system (Ofwat, 2007).

7 . Most pipelines in the United States need to be replaced over the next two decades (CBO, 2002).

8 . Lower transmission losses may reflect switching to higher voltage transmission lines and also changes in the relative locations of generation and consumption shortening the length of transmission lines.

**[Figure 6. Developments in electricity systems]**

12. Telecommunications networks have undergone rapid technological changes in recent years, leading to changes in the structure and quality of access to communications. These changes include the increasing availability of broadband to telephone subscribers. For example, by 2005, DSL coverage exceeded 90% of households or population in 22 OECD countries. In other countries, cable networks are able to offer broadband services. Furthermore, telecom operators are increasingly renewing their networks using fibre (OECD, 2007b). The quality of the fixed line networks has also improved in other respects. For example, the number of errors per 100 lines per year has declined in the OECD member countries, for which data are available (Figure 7).

**[Figure 7. Developments in telecommunications networks]**

## 3. Factors affecting investment in infrastructure

13. Addressing market failure has been a major motive for public intervention in infrastructural sectors. Governments have intervened to prevent the under-provision or non-provision of infrastructure, when externalities or public good features are predominant or to limit the exercise of market power to the extent to which a natural monopoly is present. The resulting decisions about ownership and regulation are important factors affecting the supply and demand of infrastructure (these are summarised in Figure 8).

**[Figure 8. Factors affecting investment in infrastructure]**

14. The structure of infrastructure supply depends on the nature of the market failure. Where supply entails a natural monopoly, the private sector will usually be willing to provide the service, though normally at a level that is below, and a price that is above, the social optimum. This will often result in some type of arm's length regulation. Investment will depend on standard investment determinants, such as the cost of capital, but due to the often extremely large fixed costs and the irreversibility of investment decisions, investment decisions are also particularly sensitive to the regulatory environment.

15. The public sector is involved in the supply of infrastructure for two other sets of reasons. When the network provides a service for which the costs of exclusion may be prohibitive or technically infeasible the infrastructure may not be supplied at all in the absence of government intervention. For example, until relatively recently, the cost of collecting user charges from more than a few roads would have been unwarrantedly expensive. The government may become involved in supply when there are network externalities and distributional concerns. For example, government intervention has addressed consumption-related externalities (such as health) or environmental concerns in the expansion of water supply and sewerage networks. Distributional concerns have included providing access to infrastructure-related services at uniform and affordable prices.[9]

16. When the government is involved in infrastructure provision, investment decision making should use the standard criterion of setting the level of provision that equates the marginal social benefit to the marginal social cost, which is related to the marginal costs of public funds and production costs (King, 1986; Mayeres and Proost, 1997). However, due to the characteristics of networks, the marginal benefits of additional investments are often low and declining, but not always, particularly in well-developed networks. This implies that investments need to be carefully evaluated on an individual basis. One caution is the potential for interaction with other policy objectives, such as enhancing competition or consumer protection, which may outweigh the benefits from encouraging more investment. The interaction between

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9 . Other rationales have included macroeconomic stabilisation and job creation. Perceived "strategic assets" may also have encouraged the public sector to acquire ownership.

these objectives may be sector specific and in some cases may act to reinforce one another. Ultimately, the regulator will have to balance these objectives (see below).

17. There are a number of different delivery modes involving the public or private sector to a greater of lesser extent. These include public ownership and procurement, which has often characterised the water supply and road networks; concessions and public private partnerships, which are increasingly involving the private sector in the delivery of infrastructure; and fully privately-owned companies, which has often been the case in the energy sector.

18. The decisions of regulatory institutions concerning the desired market structure (reflecting the degree to which competition is possible), access regimes and pricing play important roles in determining infrastructure supply and use. In particular, the regulator often needs to set user costs, access prices or final prices, depending on whether the network provider is vertically integrated and competition is feasible. Under certain conditions, setting the price equal to the marginal social cost would be welfare maximising and when the networks are characterised by constant returns to scale this form of pricing would also cover investment costs. However, marginal cost pricing will not cover capital and operating costs if investment is characterised by increasing returns to scale.[10] In this context, subsidisation or government provision may be warranted when the marginal social benefits arising from additional infrastructure outweigh the marginal social costs. Alternatively, the regulator may adopt an alternative pricing structure to cover investment costs. For example, multi-part tariffs can help preserve pricing that reflects short run marginal costs while recouping investment costs.[11] In other cases, so-called Ramsey pricing, which allows prices to vary in line with elasticities of demand for different services, will minimise the welfare losses arising from deviations from marginal cost pricing. Given the importance of pricing to investment decisions, the credibility and consistency of the regulatory framework are important determinants of infrastructure investment.

19. Infrastructure in the network sectors is also often a congestible public good with congestion raising production costs and reducing individuals' utility. In this light, the benefits from investment can be large. When pricing is introduced the optimal toll – determined by the difference between the marginal social cost (reflecting congestion costs and wear and tear of the infrastructure) and private costs – will reduce demand and by enhancing the efficient use of existing infrastructure will damp the need for investment in additional capacity.[12] Efficient investment decisions would then equate marginal costs to the marginal benefits of infrastructure capacity and quality, which the revenues from the congestion toll would indicate when additional investment is warranted. When investments are lumpy, such as the additions of runways at airports, congestion costs rise before the investment and fall thereafter, meaning the optimal tariff will fall with the investment (see Oum and Zhang, 1990).

## 4. Links to growth[13]

20. In supplying infrastructure an important question is the extent to which infrastructure investment has effects on output over and above those from simply adding to the productive capital stock.

10 . Borger and Proost (2008), suggest that this may applicable for rail track and canals.

11 . In some cases, non-linear access prices have attractive features (Gans, 2001). The access price typically includes a charge equal to the short-run marginal cost and a second component that levies a fixed charge on access. The setting of the fixed charge is the important aspect of the pricing regime with respect to investment incentives while the variable charge should help encourage more efficient.

12 . Demand for different infrastructure services will also vary across countries given differences in income, population growth and density, as well as the country's geography and economic structure.

13 . This section draws on the work reported in Égert, Koźluk and Sutherland (2008).

Infrastructure can have additional effects through a number of different channels, such as by facilitating the division of labour, competition in markets, the diffusion of technology and the adoption of new organisational practices or through providing access to larger markets, new resources and intermediate products. While infrastructure can have growth-enhancing effects, the relationship has been difficult to establish empirically and often attention has been focussed on just public capital (following controversial findings of Aschauer, 1989, which suggested substantial marginal returns to public investment). One feature of those studies has been the wide range of estimates. Over time the estimated marginal returns to public infrastructure have tended to decline while still being positive.[14] Comparatively little attention has been paid to the contribution of infrastructure proper (both public and private) to growth. In the following analysis, growth regressions are estimated to explore different aspects of the linkages between network industry infrastructure and economic growth, independent of the source of financing and ownership.[15]

### *4.1 Annual time-series growth regressions*

21. To examine the relationship between infrastructure and growth, estimations in this paper use the different physical indicators discussed in Section 2.[16] The empirical specification includes both the stock of infrastructure and the combined investment rate in infrastructure and non-infrastructural capital (Box 2). As such, the specifications capture mainly the impact of infrastructure capital on GDP over and above its affect by increasing the capital stock.[17] This helps focusing attention on the possible externalities that provision of infrastructure can have on output.

14 . Previous related work in the OECD Economics Department includes Ford and Poret (1991) and Englander and Gurney (1994a, 1994b), which demonstrated that the relationship was weak and unstable. Related results for OECD countries have focused on regional datasets. For example, Bonaglia *et al.* (2000) find that infrastructure makes a positive contribution to productivity growth in some Italian regions, but that the cost saving generated are insufficient to offset the costs of financing and depreciation.

15 . An alternative approach could include growth accounting, but this requires particularly strong assumptions when considering the sectors covered in this report. One study (Koszerek *et al.* 2007), using the EU KLEMS database, shows strong positive contributions of telecommunications and the electricity, gas and water sectors to both US and EU productivity growth between 1996 and 2004. The evidence for transport is weaker, with air transport making a small positive contribution in the United States and inland and water transport making a small positive contribution in the EU.

16 . By using physical indicators the approach is related to that of Calderón and Servén (2004). The approaches differ due to limiting the analysis to just OECD economies, where quality differences in infrastructure stocks may be less pronounced, and by using a different estimation procedure.

17 . In the case of Norway, a considerable part of total GDP is related to petroleum extraction. The use of total GDP may thus cloud the relationship between investment that is important for the domestic (or mainland) economy and growth.

**Box 2. Annual time-series growth regressions**

The theoretical framework for the approach adopted is based on Mankiw, Romer and Weil (1992). The underlying exogenous growth model is based on a Cobb-Douglas production function with decreasing returns to capital. The authors modify the model in order to account for human capital as an additional, separate production input. Infrastructure capital can be incorporated in an analogous way relying on the idea that its effect on output can be different than the average effect of capital due to different economies of scale, network externalities or the market access enhancing effect of infrastructure, as discussed in the main text. The right hand side of the steady state equation can include the investment rates on both types of capital, or with one investment rate and one stock variable, both specifications being equally valid. To put the emphasis on physical infrastructure stocks, the latter is chosen for this paper. Hence, the equation underlying the estimations is:

$$\ln(\frac{Y_{it}}{L_{it}}) = \ln(A_{i0}) + git + \frac{\alpha}{1-\alpha}\ln(s_{it}^{K}) + \frac{\beta}{1-\alpha}\ln(\inf_{it}) - \frac{\alpha}{1-\alpha}\ln(n_{it} + g + \delta)$$

where *Y/L* is GDP per capita in country *i* (in PPPs), $s^K$ is the investment to GDP ratio, *inf* is the total per capita physical stock of infrastructure of a given type, *n* is the population growth rate and *t* is the linear time trend intended to proxy for technological progress. Due to the exogenous growth specification of the underlying model, the right hand side variables can affect long run output levels and short run growth rates. The equation is estimated in a heterogenous, fixed effect cross-country panel framework, using an Engle and Granger (1987) two-step error correction model approach. The sample is unbalanced and consists of subsets of OECD countries (maximum 24) over the period 1960-2005 (with a minimum of 16 observations per country).

The time series properties of the variables are not clear a priori, but empirical unit root and cointegration tests cannot reject the assumption that the levels of the variables are non-stationary while the long run relationship is cointegrated. Thus the long run equation is estimated using Dynamic Ordinary Least Squares as in Stock and Watson (1993). This entails including lags and leads of first differences in order to obtain estimates with favorable asymptotic and finite sample properties. The residuals from this equation are then plugged into the first-difference short run specification with a lag.

The infrastructure variables, such as length of roads, motorways and rail tracks, number of telephone mainlines and electricity generation capacity, are included one by one. There is an unavoidable element of double counting as investment into infrastructure capital will be included in total investment, which was not obvious in the case of human capital in the original MRW specification. Statistical tests are used to assess the homogeneity of the infrastructure coefficients across countries and rejection of this hypothesis leads to an analysis of individual country results instead of the so-called mean-group estimates.

The robustness of the estimates to different specifications is checked by using different measures of investment (total and private) and by including additional control variables such as human capital, trade openness and tax revenues. The validity of the estimated coefficients in the recent years of the sample has been tested by introducing end-of-period non-linearities on the infrastructure variable, allowing the coefficients to change towards the end of the sample.

22. The results of a parsimonious specification (to ensure wide country coverage) are summarised in Table 1 for 6 different measures of infrastructure (other results are given in Égert *et al*. 2008). The so-called "mean group coefficients" reveal that lagged investment has the expected *common* positive and significant effect on growth and long-run output levels, while population growth and human capital are insignificant, which may reflect the specification including a trend variable.[18] The mean group estimates for the measures of infrastructure are insignificant, indicating that there is no strong *common* effect across the sample. However, individual country coefficients reveal a variety of effects (Figure 9). As the

18 . There are a number of reasons that may contribute to the finding that the human capital variable is positive but insignificant. First, there may be an element of multicollinearity due to inclusion of the human capital and physical infrastructure variables, which both tend to trend in many OECD countries during the sample, as well as the deterministic trend. Second, the mean group estimates tend to have wider confidence intervals than country-specific estimates. Third, estimates of Dynamic OLS also tend to have wider confidence intervals than other estimation techniques.

empirical specification already includes infrastructure investment in the variable for total investment, a positive (negative) coefficient indicates that the effect on output is greater (lower) than the effect arising to the augmentation of the capital stock. The main features of the empirical analysis are:

- *Energy*. The coefficients for electricity generation are positive and significant for the majority of countries, suggesting that investment in generation capacity has been associated with higher output levels. In Australia, Ireland, Korea and New Zealand there is evidence of negative spillovers from additional investment, which could reflect past over-investment if the link with growth is non-linear (see below), suggesting that reallocating investment to other sectors may have boosted output, or inefficient use of infrastructure.

- *Roads*. Positive coefficients are found for New Zealand and the United Kingdom for total road length per capita. On the other hand, increasing the stock of roads is estimated to have a negative effect in France, Greece, the Netherlands and Spain. The coefficient estimates for motorways are generally more often positive, possibly reflecting the more recent development of these networks and the fact that they provide services that are more specifically business-related.

- *Rail*. Positive significant effects are found for a number of countries (Australia, Austria, Greece, Korea, New Zealand, and the United Kingdom) suggesting that investment in railtrack was associated with higher output levels. Conversely, estimates suggest that additional investment in railtrack would have negative spillovers on output in found for Belgium, Portugal and Spain. Again, this may indicate that there has been over-investment in the sector if the link between infrastructure and output is non-linear or inefficient use of infrastructure.

- *Telecommunications*. The picture for telecommunications is quite mixed. The coefficients for fixed mainlines suggests that additional investment would have negative externalities in Australia, Iceland, New Zealand and the United Kingdom, and positive ones in Austria, Greece, Italy, Mexico, Norway and Spain. However, when an alternative measure of infrastructure is used (total subscriptions, including mobile telecommunications) many of these relationships are reversed, suggesting that considerable caution is required in interpreting these results, mainly due to the technological change the sector has experienced.

**[Table 1. Annual time series growth regressions]**

**[Figure 9. Infrastructure coefficient estimates from growth regressions]**

23. Given the sensitivity of the results to different infrastructure variables robustness analysis was also conducted.[19] The results are presented in Figure 10, which summarises the share of significant coefficients (positive and negative) found in all the different specifications. The results tend to support the associations of electricity generation capacity and motorways with higher output levels as well as the rather country-specific relationship between the telecommunication indicators and output.

**[Figure 10. Share of significant positive and negative infrastructure coefficients in growth regressions]**

24. These results, if taken literally, would provide an indication of where additional investment has *over time* had effects on output beyond those implied by additions to the capital stock. However, they do not explicitly address the issue of whether additional investment today would bring about these effects. In order to explore whether recent levels of infrastructure provision were significantly different from the expected long-run relationship, the same regressions were estimated with the inclusion of an interaction

19 . The robustness analysis was conducted using two different specifications of the overall investment variable and using a variety of different specifications, which augment the basic specification reported in Table 1.

variable to assess whether the relationship has changed more recently. These results suggest that there is no significant separate effect in more recent periods. If anything, in a few cases, such as for electricity generation capacity in Austria, roads in New Zealand and railtrack in the Netherlands, the effect estimated on average would be significantly lower over the recent past.

### *4.2 Cross-section growth regressions based on long period averages*

25. Looking at cross-country growth regressions using two to four multi-period averages per country asks a slightly different question by placing more emphasis on whether differences in the level of infrastructure provision can contribute to explain differences in average growth rates across countries, over long periods of time. However, one drawback – and an overarching difficulty in growth regressions – is the difficulty in establishing causality convincingly. For example, given the capital intensive nature and long asset life of different types of infrastructure investment, decisions to invest may be made when expectations of future growth are revised upwards. Alternatively different types of infrastructure services may be luxury goods. In the empirical work long lags have been used in an attempt to minimise this problem, though this does not fully avoid it.[20] A second difficulty arises in determining a parsimonious model given all the potential candidate variables to explain cross-country differences (Sala-i-Martin, 1997).

26. Given the uncertainty about which variables affect long-run growth, there are a number of ways in which the robustness of the effect of each candidate variable can be assessed. Two main approaches were taken in this paper. The first, sensitivity analysis, examines whether the estimated effect of infrastructure is robust to the inclusion of other variables that are also thought to affect growth. The second approach, Bayesian model averaging, examines whether inclusion of infrastructure improves the explanatory power of all the possible models of growth. These results are summarised in Box 3. The resulting estimates consistently show that measures capturing the level of provision of energy and telecommunications infrastructure are positively related to growth.[21]

27. The cross-section also allows examination of possible non-linearities. As pointed out by an increasing number of empirical studies, the relationship between infrastructure and growth may change with the level of infrastructure (*e.g.* due to threshold effects in network externalities). For example, Fernald (1999) finds that roads matter for the United States development, but once the main inter-state network was in place subsequent effects on productivity have been much smaller.[22] Hurlin (2006), using panel-data econometric techniques to assess threshold effects, shows evidence that linkages between infrastructure and output growth are non-linear. Roller and Waverman (2001) find for a panel of OECD economies that

20 . Using a panel of 5-year averages (to allow more lags), difference GMM was also estimated. These results are sensitive to the specification but tend to support to the results of multi-annual growth regressions using 5-year averages (These results are reported in Égert *et al.* 2009).

21 . The measure is a principal component of an analysis of variance of measures of physical infrastructure, including motorway and railtrack length, telecom line subscriptions and energy consumption or generation. For telecommunications, the measure used excludes developments in broadband due to data limitations. This is essentially due to its very recent nature and the inability to include them in the estimation framework (as the sample ends in 2006 and the estimation procedure uses 8 and 10 year lags there are no data for the earlier period). A number of other studies, while not directly targeting infrastructure, have examined the contribution of ICT to growth (Schreyer, 2000), which is generally shown to have played an important role for productivity growth in the late 1990s

22. Delgado and Álvarez (2007) find similar spillover effects from roads between Spanish regions.

the impact on output is higher when the penetration of telephone main lines per capita approaches the level consistent with universal service.[23]

28. When these threshold effects are allowed for the various types of infrastructure covered by the empirical analysis, there is evidence that effects are larger when the broad measure of telecommunication and energy provision reveals lower levels of infrastructure (the "lower regime" countries shown in Figure 11, Box 3). These results provide an explanation for the finding from the time-series regressions that in a number of countries there appears to be some evidence of negative effects on growth from additional investment in energy and telecommunications infrastructure.

**[Figure 11. Countries with relatively low levels of infrastructure provision]**

23 . Bougheas *et al*. (2000) included a quadratic term for infrastructure in growth regressions. The results suggested that the relationship with growth initially rises but then falls beyond some level.

**Box 3. Multi-annual growth regressions**

For the cross-section growth regressions and subject to data availability, non-overlapping 5, 8, and 10 year averages were computed covering the period 1975 to 2006 for 29 OECD countries. Only results based on four 8-year averages are reported here, but results for other periods are broadly comparable.

**Model selection**

There are several approaches to analysing the robustness of a given variable. One is to see how robust the estimated coefficient of a variable is in a number of different specifications. In this approach, a number of models are estimated that always include the explanatory variable of interest (the measure of infrastructure in this case) and contains a set of other explanatory variables drawn from a larger set of potential explanatory variables. This can be performed by extreme bounds analysis or model averaging in the spirit of Sala-i-Martin (1997).[1]

Another approach is the so-called Bayesian model averaging that assesses whether the inclusion of a particular variable improves the explanatory power of all possible models. The decision to include a variable or not is then based upon whether it contributes to improving model fit more than would be expected *ex ante*. The prior inclusion probability of a variable is 50% if all possible combinations of the candidate explanatory variables are considered. A variable is selected if the estimated inclusion probability is higher than 50%. The results presented in Table 2 show whether a given *variable* tends to improve the fit of all the different possible models rather than identifying the “best” model.

**Non linear effects**

To take possible non-linearities of the infrastructure variable into account, the Bayesian model averaging approach is modified to consider split regime models. This is done in two ways. The first considers the variables that have been selected in the linear Bayesian model averaging approach and examines whether a two regime split of the infrastructure variable improves the explanatory power of the model. The second considers linear, two-regime and three-regime models in the general model average framework: all possible combinations of linear and non-linear models are estimated and inclusion probabilities of the different regimes are analysed.

The top panel of Table 2 reports the average size of the coefficient for different variables that could potentially affect long-run output (the reported significance is whether including that variable improves the overall fit of the model). The estimation results show that important drivers of GDP per capita growth include, as expected, initial per capita income as well as openness, life expectancy and human capital. Government investment (a proxy for the tax burden on the economy) as well as investment price inflation relate negatively with economic growth. These results are broadly in line with earlier findings (OECD, 2003a; Sala-i-Martin *et al.* 2004).

The bottom two panels show the same results for two measures of infrastructure; one that mainly covers transportation and the other that mainly captures energy and telecommunications. The results for the infrastructure variables show that the principal component based measures have a positive relation with output. Furthermore, the average coefficient estimates are larger when initial infrastructure provision is low (low regimes).[2]

1. A possible alternative approach to model selection – not pursued here – is the so-called general-to-specific modeling (also called the LSE approach, see Hendry, 1997).

2. The finding of non-linear effects is more robust for electricity and telecommunications when different time periods and measures of infrastructure are used.

**[Table 2. Estimated effects of infrastructure on growth, results from model averaging]**

## 5. Policy drivers of efficient infrastructure investment

29. The empirical evidence reviewed in the previous section suggests that the impact of infrastructure investment on growth is largely country-specific, reflecting *inter alia* the pre-existing level of provision. Among the factors driving this variation the framework policies that encourage an efficient level, allocation and quality of infrastructure investment are likely to be particularly important. Against this background and following the framework outlined in Figure 8, this section provides evidence on how such policies can help ensure that infrastructure meets societal needs without unduly burdening taxpayers and

distorting the allocation of resources, on who are the most appropriate providers of infrastructure and on what kind of regulatory policies will help ensure that investment is efficient. Much of the country-specific information on policy settings used in this section is taken from country replies to an *ad hoc* Infrastructure Investment questionnaire or from the recently updated OECD Product Market Regulation database.

### *5.1 Investment decision making*

*Assessing costs and benefits of new investment*

30. When infrastructure investment remains a public responsibility, including when public corporations are investing,[24] or when subsidisation may be warranted, the government needs to examine the case for investment or support. The decision should be based on cost-benefit analysis, preferably conducted on a case-by-case basis.[25] Important overarching information needed to underpin the decision making includes defining both project objectives and alternative options for attaining these objectives.[26] In the case of subsidisation, the government should ensure that subsidies are targeted, transparent and non-discriminatory. A recent initiative in Australia has been the establishment of a separate fund to support infrastructure investment, *Building Australia*. Such a fund can help prioritise investment and overcome any tendency of spending ministries to consider only a limited set of investment options. Care is needed in the financing of such funds as there is a danger that they become pro-cyclical, which the Australian Loan Council is charged to guard against. When revenues are earmarked (such as highway funds) there is a danger that spending is no longer strongly linked to need. Decision making concerning the use of such funds should be transparent in project selection as they may give rise to considerable lobbying.

31. When undertaking cost-benefit analysis, the relevant costs and benefits are often difficult to determine. The difficulties include, *inter alia*, the choice of appropriate discount rates and valuation methods, which importantly includes accounting for the benefits if new infrastructure generates cross-jurisdictional spillovers.[27] Given the nature of networks, insufficient or poorly-integrated investment may fail to capture the full benefits. For example, local investment in roads may not capture potential network externalities if it is not based on an accurate assessment of impacts in other areas. In electricity networks, insufficient transmission capacity can induce spontaneous flows which can potentially undermine the stability of the network.[28] These types of problems are likely to be a particular concern fiscal-federal

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24 . In these cases, the implicit or explicit government guarantee can lower the cost of capital these companies face and contribute to unwarranted investment. For example, in the case of Network Rail in the United Kingdom, the Financial Indemnity Mechanism essentially allows the so-called Company by Guarantee to borrow at the risk-free rate hold (Palmer and Newbery, 2006)

25 . OECD (2006d) *Policy Framework for Investment* examines framework conditions to ensure that infrastructure investments are sound.

26 . For example, *The Eddington Transport Study* (2007) criticised the failure to specify the problem and consider alternative solutions in some investment proposals in the UK transport sector.

27 . See OMB Circular No. A-76 and OECD (2006c) for a discussion of some of these issues.

28 . For example, fluctuations in wind power in northern Germany can induce flows to the south of Germany via the Belgium and Netherland grids. These grids require larger reserve margins as a consequence (Van Werven and van Oostvoorn, 2006). In Australia, an energy market review of 2002 identified that the assessment of transmission focussed too narrowly on technical efficiency of individual projects, missing the impact on system-wide development of the network (Productivity Commission, 2006).

relations devolve a significant amount of investment decision-making to the sub-central government level, or even at the national level when taking into account supra-national infrastructure priorities (Box 4).[29]

**Box 4. Fiscal federalism and inter-jurisdictional spillovers**

Failure to take into account inter-jurisdictional spillovers is a danger in countries where fiscal-federal relations decentralise infrastructure investment decision-making to the sub-central government level. For example, in the United States, Cohen and Paul (2003, 2004) find evidence of positive spillovers on costs from airport expansion in linked hubs and intra-state highway building, stemming from lower input costs and the substitution of private inputs by public infrastructure. This kind of spillover may also occur between countries.

Positive spillovers can influence neighbouring jurisdictions' investment decisions, with competition between states to attract economic activity or strategic under-provision as possible outcomes. In the United States, some evidence suggests that states enjoying positive spillovers from the increased provision of highways in neighbouring states may cut back on their own highway spending (Bruce *et al.* 2007). On the other hand, the finding of negative spillovers on industry in regions neighbouring those with high capacity roads may signal that some investment was designed to lure economic activity (Delgado and Alvarez, 2007).

When confronted by possible co-ordination failures, higher levels of government may wish to induce sub-central governments to internalise inter-jurisdictional spillovers to a greater extent. To this end, higher levels of government can use various tools ranging from matching grants to implementing the infrastructure investment themselves. For example, in the European Union, the so-called Trans European Networks are specifically designed to counteract some of the deficiencies in networks, such as bottlenecks or missing links, which were the result of previous segmented decision making, with the aim of enhancing the operation of the internal market as well as economic and social cohesion. In addition, the European Investment Bank since the 1960s has granted loans for infrastructure projects with broader geographical impacts and, the Structural and Cohesion Funds, which are designed to address relative underdevelopment, are often channelled into transportation infrastructure and may help overcome any bias towards under-provision (Bougheas *et al*. 2003). However, some weaknesses have emerged. Short and Kopp (2005) noted that decision-making processes for transportation linkages across Europe failed to make sufficient use of economic analysis and was biased towards large projects. The impact of structural funds is difficult to determine (OECD, 2004) and may depend on the quality of institutions (Ederveen *et al*. (2006) or autonomy of the recipient region (Bahr, 2008).

32. Due to the potential widespread benefits, scale and/or side-effects (such as environmental) of infrastructure investment, governments often need to determine whether more private sector infrastructure investment is justified. In this context, national plans for investment – which a number of governments report having – can help frame infrastructure objectives. Over and above the ability to co-ordinate network investments, governments may also need to overcome vested interest groups when granting licenses and permissions.[30] In some systems, this presents a greater or lesser challenge, to the extent that even large and widely spread benefits from a project can be challenged by particular interest groups that are sometimes given political clout by particular institutional arrangements, often at sub-central levels of government.

### *5.2 Ownership and provision*

#### *5.2.1 Public ownership and provision*

33. Until the late 1980s, public ownership was the dominant ownership form for many network industries. According to OECD indicators, public ownership only declined in importance in some of them

29 . Other types of co-ordination bodies can emerge such as transit authorities, bringing together the central business districts with the local authorities of the outlying commuter belts, or river basin authorities that oversee investment in water networks covering several jurisdictions.

30 . Historically, one aspect promoting public ownership has been the resolution of political conflict between owners and users of key infrastructure in the absence of sustainable forms of regulation (Newbery, 2004)

quite recently (Figure 12). In the water sector, which is not covered by these indicators, public ownership characterised the ownership structure in two-thirds of OECD countries quite recently (OECD, 2004).

**[Figure 12. The declining importance of public ownership in network utilities]**

34. The decline of public ownership partly reflects increasing recognition among OECD governments that it can create conditions contributing to inefficient investment in infrastructure. For instance, overinvestment may occur as public managers engage in “empire building” behaviour to strengthen their support with the politicians that appointed them (*e.g.* by expanding capacity and employment in public enterprises). Indeed, some telecom operators cut back ambitious plans to expand fibre-optic networks in the wake of privatisation. At the other extreme, underinvestment may occur, if public authorities pay insufficient attention to the long-term benefits of investment in a context of fiscal pressures. Public investment may also lead to the misallocation of resources across regions and sectors. For example, policymakers may allocate resources to a given region or project at the expense of other potentially higher return investments in more deserving regions or projects.[31] Investment may also be allocated sub-optimally over time if it is allowed to be influenced by the electoral cycle.[32]

35. Public ownership can also create disincentives for privately-operated firms to invest in network industries. First, the lack of a level playing field – often due to the state-owned company’s soft budget constraint – is a disincentive for private firms to invest. Second, there may be confusion between the role of the state as the regulator and owner, which serves to amplify regulatory discretion and risk (this is discussed below). Finally, state ownership can be a *de facto* barrier to foreign direct investment.

36. Against this background, private sector provision has become increasingly attractive. First, in some sectors – such as telecoms and electricity – the extent of the natural monopoly element has been redefined, in part as a result of technical progress or as a result of sunk costs having already been incurred, opening the door to competitive private provision. Second, refinements in regulatory techniques have made “arm’s length” regulation of private providers of infrastructure more desirable than direct public provision. Similarly, new contracting techniques were designed, which made contracting out of infrastructure provision more attractive than in the past. Finally, particularly in the presence of mature networks, specific distributional objectives were often found to be more efficiently achieved by other mechanisms, such as targeted social transfers.

### *4.2.2 Introducing private provision through concessions and PPPs*

37. Instead of direct public provision, private provision either through concessions, franchises and public-private partnerships (PPPs) or directly by the private sector coupled with arm’s length regulation and, possibly, public service obligations has become increasingly common. In some cases (such as for example air transport and mobile telephony in some countries), the resulting market structure has even allowed regulation to be lifted leaving the competition authorities as the sole agency preventing the exercise of market power. Where competitive pressures are sufficient, this type of regime was generally found to preserve efficient investment incentives.

**38. Franchises and concessions[33] in the infrastructure sectors are reasonably common and through the recent development of PPPs such types of arrangements are becoming widespread in OECD economies (Box 5, Figure 13). The results from the infrastructure investment questionnaire reveal that franchises and**

31 . For example, Cadot *et al.* (2006) and Castells and Solé-Ollé (2005) report evidence of the importance of political factors influencing the allocation of infrastructure investment across regions.

32 . The political cycles effects on the prices and investment of a public monopolist in a network industry follows from the opportunistic business cycle theory developed by Nordhaus (1975). See Özatay (2005) and Paiva and Moita (2006) for recent empirical support of political cycles in regulated industries.

**concessions are commonly used for transportation infrastructure, water supply, the electricity sector and to a lesser extent gas production and distribution (Figure 14). In the telecommunications sector, franchises and concessions are relatively rare outside the operation of mobile services.**

**[Figure 13. Value of announced public-private partnership deals, 1994-2007]**

**[Figure 14. Prevalence of Franchise and Concessions in OECD economies]**

**Box 5. Public-private partnerships (PPPs)[1]**

Infrastructure PPPs have recently gained importance in many OECD countries, and indeed recorded value of deals have increased relative to the beginning of the decade, albeit declining more recently (Figure 13). The number of infrastructure projects covered by PPPs has increased, roughly doubling between the beginning of the decade and 2007, with the median size remaining relatively stable at around $200-$300 million. The apparent fall in the value of recorded deals since the beginning of the decade reflects fewer extremely large projects, typically in transport. For example, individual projects – such as the UK's channel tunnel rail link in 1999, the London Underground in 2002 and the Italian Autostrade in 2003 – accounted for around one-third of total announced investment in these years.

Project finance deals were recorded in 23 of the OECD countries by the end of 2007, but only a small number of countries account for the majority of projects. In particular, the United Kingdom accounts for around 30% of the total number of recorded PPPs and the cumulative volume of deals in the OECD area, which together with projects in Spain and Korea account for over half of all recorded PPPs. More recently, PPP deals in Korea and the United States have become more frequent.

Other features of completed PPP deals include:

- The majority of projects that detail their structure are so-called Design Build Finance Operate (DBFO), accounting for 40% of all deals, the next most frequent are Build Operate Transfer (BOT) that account for around 10% of all projects. Other arrangements are less frequently used.
- The concession period is on average around 30 years, though it can range from just 3 years to over 100 years in exceptional cases.
- Most PPPs are in the transportation sector, particularly roads (Table 3). There have been very few in the telecommunications and energy sectors. While PPP projects are relatively frequent in the water and sewerage sectors, they tend to be comparatively small.

1. The analysis in this box draws on data from the Dealogic Projectware database, which gives a broad range of information on the use of public-private partnerships in OECD countries. In total this database contains information on nearly 2 000 PPPs, of which around one-fifth are in infrastructure sectors. These data are based on project finance data, which covers: "The financing of long-term infrastructure, industrial projects and public services based upon a non-recourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cashflow generated by the project."

**[Table 3. PPPs in infrastructure]**

39. There are a number of reasons for seeking the involvement of the private sector in the provision of infrastructure investment. They include:

- *Introducing competitive pressures*. Tendering introduces an element of competition *ex ante*, for the market (Demsetz, 1968).[34] Auction design can have an important consequence on *ex ante*

33 . Franchises and concessions are used interchangeably in this section.

34 . The decision to appoint a private sector firm can be influenced by the design of a cost-benefit analysis or value for money evaluation. For example, estimates of the cost of public provision are often too optimistic (over time and over budget) and may use higher discount rates for private sector proposals than may be warranted (Grout, 1997).

competition, as demonstrated by the disparity of outcomes during the auctioning of UMTS or "third generation" mobile-phone licences at the beginning of the decade (Klemperer, 2002).[35] Geographical franchises may be amenable to benchmark or yardstick competition between franchises; both domestic and abroad.[36] The results from the OECD Infrastructure Investment questionnaire reveal that there are few restrictions on bidding for franchises or concessions. Only two countries (Ireland and Mexico) limit competition to preferred bidders and only in certain sectors. Only two countries (Finland and Korea) note that there are constraints on international bidders. Most countries report legal obligations to determine and publish the criteria for winning a tender (15-16 out of 19, respectively). Furthermore, most countries also allow the decision of the contract authority to be challenged in court.[37]

- *Sharing the risk.* The risk attached to the investment can in principle be shared between private operators and the state, with each bearing the type of risks – and associated incentives – for which they are most suited. Generally, risk that is difficult to control or forecast should not be borne by the contractor, which is often the case for demand side risk. In some cases, governments have assumed demand side risk, such as subsidising the contractor if demand falls below a certain level. Construction risk and availability risk are more appropriately borne by the private sector and the involvement of the private sector can lead to a better risk management.[38]

- *Increasing cost effectiveness*. In contrast to traditional procurement, a particular attraction of PPPs arises due to the "bundling" of construction and operation when quality of service provision is more easily determined than construction quality (Hart, 2003). In particular, bundled projects, by concentrating on the service to be provided, will provide incentives for the private firm to internalise in the construction phase cost reductions that will be felt during the operations phase.[39] This attraction obviously depends on the ability to specify outputs.

- *Budgetary pressures*. Finally, there may be an interest in using PPPs to disguise pressure on public finances. However, in such cases, investment decisions - by precluding appropriate alternative investment arrangements - will lead to suboptimal outcomes.[40] This suggests that the approach to using PPPs must rely on a proper and transparent assessment of their expected long-term impact on public finances (OECD, 2008b). A stark example occurred in Hungary with major PPPs for motorways recorded off budget in 2005 and 2006, despite the partnership involving a state-owned enterprise. Eurostat ruled in 2006 that these expenditures be reported, which boosted the deficit by almost a full percentage point of GDP in that year.

35 . While auction design was one factor, others included differences in market potential, which was being reassessed downwards during the period of the auctions, and market structure (OECD, 2003b).

36 . For example, in the United Kingdom, the so-called public finance initiatives (PFIs) can use benchmark competition during the operation of the concession.

37 . There is one caveat with ensuring competition that arises when quality is poorly observable but an important determinant of cost. In this case there may be a danger of awarding the concessions to the lowest-quality provider.

38 . For example, the private sector will likely have a better appreciation of project risks, both due to better project management and the frequent requirement for conduct due diligence.

39 . For example, Winston (1991) reports that small increases in pavement thickness can dramatically lengthen the life of the pavement and reduce maintenance costs.

40. This remains the case when PPPs are used to circumvent fiscal rules that constrain government investment, which may be justified when taking into account longer time horizons (Blanchard and Giavazzi, 2004).

*Issues in the design of concessions and PPPs*

40. Private provision raises a number of general issues for the regulatory authorities in order to ensure that appropriate investment incentives are in place.

- *Overall investment incentives*: One means to bolster investment incentives is to grant the franchise for a long period (though specifying the contract for such long periods is problematic). On average most franchises or concessions are set for 20-30 years though they can be substantially longer in some cases, such as air transport infrastructure in Hungary (75 years) and Mexico (50 years). In other cases contracts have included no-compete or exclusivity clauses, usually with the intention of minimising demand risk for the franchise holder.[41] The questionnaire responses reveal that 8 out of 20 countries permit no-compete clauses. Third geographical exclusivity rights are granted in eighteen of the respondent countries, being more pervasive in the electricity (transmission and distribution) and water sectors. Of course, granting such conditions can conflict with other policy objectives and have undesired negative consequences, such as low productivity and service quality. In this light, the extent to which such conditions are offered needs to be carefully tailored to investment requirements.

- *Pricing policies*: Pricing policies should compensate the private operator for investments throughout the concession period, without creating incentives for over-investment. Almost all countries (except Japan and Sweden) reported that pricing policies reflect investment needs, particularly in the electricity and gas sectors. To avoid overinvestment, after a cost-reducing investment, prices should only be modified at the next round of contract revision and should not fully compensate the operator. In most countries the timing of compensation is sector specific. Price adjustments at the next round occur particularly in the electricity, gas and railroad sectors. The evidence is mixed with respect to compensation, though full compensation is pursued in a number of sectors in a few countries (Norway, Portugal).

- *Monitoring performance*: To deal with the potential for under-investment during the concession period, the regulator can set quality standards, use performance indicators, rely on benchmark competition and specify bonuses and penalties. Questionnaire responses suggest that the contractor often establishes quality standards and translates these into measurable output indicators. The use of benchmarking to promote competitive outcomes and the use of bonuses and penalties to give franchise holders stronger incentives to care about quality is less common, though generally more prevalent in the transport sector. An alternative or additional means to ensure that the contract holder at least maintains infrastructure quality is to allow greater say to users on investment. In some sectors, such as telecommunications, rail and electricity, established arbitration procedures to settle disputes between operating and using companies over investment and maintenance of the network are relatively more prevalent.

- *Dealing with hold up potential:* A hold-up problem can lead to under-investment when the concession is approaching renewal.[42] One approach to mitigate this problem is to bias renewal in favour of the incumbent (Laffont and Tirole, 1993). However, only the Slovak Republic

41 . However, when demand growth is significant this type of contract structure can limit the ability to counteract congestion as has been reported for some US highways.

42 . The hold-up problem as part of rebidding for concessions is likely to be severe for the water industry, given the very long asset life and highly specific nature of the investment. Paradoxically concession lengths are comparatively short in this sector, averaging 15 years.

responded that the incumbent is treated as a preferred bidder.[43] Furthermore, rolling over contracts in favour of incumbents is less common than transferring assets to the state or re-contracting. A second approach is to compensate the franchise holder for the residual value of the assets, but only one third of countries that transfer assets to the state compensate the franchise holder. An alternative approach is to require reinvestment of profits, which out of 17 countries is only included in contracts in Belgium and Mexico (only in the water sector).

41. With respect to PPPs, which are generally susceptible to the same problems of concessions and franchises, additional considerations, which often require considerable expertise to address, include:

- *Decision-making framework:* The decision-making framework is important in ensuring that the PPP is the appropriate investment structure and not a means to evade fiscal constraints. Most countries (except Norway and Turkey) report that they compare PPP and traditional procurement methods before contracting out infrastructure investment. Roughly one half of questionnaire respondents noted that the government will consult with an independent body over the desirability of a PPP in infrastructure, but only three countries report that performance is evaluated *ex post* by an independent body. The full fiscal implications of PPPs do not seem to be accounted for in all cases, only nine countries reporting that PPPs are accounted for as contingent liabilities in government accounts.

- *Minimising the costs of PPPs:* PPPs can be costly to negotiate and may be subject to delays and costs overruns. Due to transaction costs, concessions, franchises and PPPs are generally not suitable for all types of projects, particularly small projects. While the majority of such projects in infrastructure are large, there are areas where size may involve economies of scale in transaction costs. For example, Chong *et al.* (2006) find some evidence of the importance of transaction costs for French water distribution. However, only a handful of countries report setting minimum limits on the size of PPP contracts (Austria, Belgium and Portugal). One possible approach to minimising costs is to bundle small projects together, as is reported in questionnaire responses from Austria and Belgium. Delays in obtaining planning permission as well as necessary local authority and environmental approvals can cause time delays and cost overruns in PPPs contracts (Monteiro, 2005). However, only eight countries reported obtaining all of these permissions before calls for tender; ten countries reporting that environmental licences are obtained and two countries reporting that neither licences nor planning permissions are obtained before calls for tender (Denmark and Netherlands).

- *Ensuring value for money:* Ensuring value for money requires attention in a number of areas:

  - Contract design is not always structured so as to exploit the potential advantages of PPPs, frequently based on input rather than output specifications. In the questionnaire responses, 12 countries reported setting input specifications against 16 setting output specifications.

  - Given the long-term nature of PPP contracts, the contractual relationship between the public and the private partner needs to be flexible. When it is possible to anticipate the conditions that may affect the adequacy of the initial contractual clauses (*e.g.* changes in capacity), these should be regulated by the initial contract. Thus, in the IT sector, where demand and technology evolve quickly, PPPs are less likely to bring efficiency gains.

43 . There may be other ways that the incumbent may benefit, however. Klein (1998) notes that a discount rule used in the French water industry typically meant that the concession was re-awarded to the incumbent.

- Given that the government is in fact the provider of last resort and contractors are aware that public authorities cannot afford an extended period of service disruption (which could also result because re-tendering a PPP contract is a lengthy and costly process), contracts should contain clauses relating to risks. While most countries reported that they imposed limits on the debt (imposes ), fewer countries (9) reported that PPP contracts contain revenue sharing clauses and only seven countries reported that the contracts specify minimum revenues from sales.

- As for concessions and franchises, enhancing investment incentives throughout the contract period should be a primary concern when designing a PPP contract, creating a stable institutional environment to avoid problems of possible opportunism and uncertainty. The existence of mechanisms that formalise contract renegotiation may help in this regard,[44] though only nine countries reported that contracts specify such conditions. Arbitration mechanisms may also help and sixteen countries reported that PPP contracts contain such clauses.

- One of the normal features of a PPP contract is that at end of contract the assets revert to the government. To ensure that the contractor keeps investing, especially as the end of the contract approaches, the contract should also contain rules to guide the definition of the asset residual value. Only ten countries reported that contracts typically contain such clauses.

42. Taking these considerations into account, an indicator was constructed using the responses to the infrastructure investment questionnaire following the structure of the issues raised above (Figure 15 Panel A).[45] Confidence intervals were estimated using the random weights procedures.[46] The results (Figure 15, Panel B) suggest that there is marked heterogeneity in policies dealing with PPPs across countries. Policy settings look relatively favourable in the Czech Republic, Austria and Portugal, which has accumulated considerable experience in using PPPs. On the other hand, policies in the Slovak Republic, Turkey, Norway, Spain and, to a lesser extent, Australia, the United States, and Japan appear less conducive to effectively exploiting the benefits of PPPs.

**[Figure 15. Indicators for Public-Private Partnerships]**

### *5.3 Unbundling and market structure*

43. Greater private provision and competitive pressures for efficient infrastructure investment can also be introduced through the unbundling of the natural monopoly elements of networks. The implications of vertical separation and of the ownership of the "core" network (the particular segment that is a natural monopoly also sometimes termed "essential facility", see Table 4) are important for investment. An attraction of coupling entry liberalisation in competitive markets with vertical separation of the network industries is that the private sector will determine the appropriate level of investment in the competitive segment of the industry. For example, while a vertically-integrated firm may innovate, particularly if there are first mover advantages (see below) and the market is contestable, more competition creates incentives

44. This is termed "hidden rent backloading" by Maskin and Tirole, (2008). Empirically, at least in Latin America, this appears to be a common form of hold-up (Engel *et al.* 2006).

45 . The coding of these indicators is given in Araujo and Sutherland (2009).

46 . Starting from the low-level indicators that feed into the overall indicator, the random weights technique uses 10 000 sets of randomly-drawn weights to calculate 10 000 observations for the indicators. The random weights are drawn from a uniform distribution and normalised to sum up to one. The resulting distribution of indicators reflects the possible ranges of values given no *a priori* information on the most appropriate value for each of the weights.

to expand capacity and may give sharper incentives to invest in cost-saving technologies and organisational forms (as observed, for instance, in the development of low-cost air transport and innovations in mobile telephony after liberalisation). However, appropriate ownership and regulatory settings would still be needed to ensure an efficient level of investment in the core network.

**[Table 4. Market structures in network industries]**

44. The argument for retaining a vertically-integrated firm largely depends on the loss of economies of scale and scope and possible coordination problems and higher transaction costs in a vertically separated industry. In some sectors, such as mature electricity and gas networks, these factors are not crucial, supporting their unbundling, which was implemented especially in the electricity sector of OECD countries over the past decade. Furthermore, empirical evidence lends support to the notion that vertical integration in the electricity sector acts to depress firm-level investment behaviour (Box 6). In the case of railroads a large range of options exist across the OECD, running from vertically-integrated public enterprises to vertically-separated private companies.[47] In this sector, the problems created by vertical separation are arguably severe. Train operating companies are relatively unconcerned with lowering high marginal costs for the network operator, and the network operator - not benefitting from higher revenue from train operators - has little incentive to improve its services. Not only may this constellation of incentives lead to under provision of rail track services, some studies suggest that the resulting losses of economies of scope increase production costs by between 20% and 40% when the sector is separated fully (OECD, 2006b).

47 . For instance, the French and Spanish public sectors have maintained responsibility for investment in infrastructure (Barea *et al.* 2007).

**Box 6. Determinants of infrastructure investment: firm level analysis**

To allow for firm-level analysis, a panel was constructed of companies operating in 18 OECD economies over the period 1983-2005 in the following sectors: electricity, gas, rail and telecoms (Araujo, 2009).

The analysis of firm-level investment follows closely a specification used in a previous project of the OECD Economics Department on Tax and Economic Growth. The following equation is estimated:

$$\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{icst} = \beta_1\left(\frac{I}{K}\right)_{ics,t-1} + \beta_2\left(\frac{I}{K}\right)^2_{ics,t-1} + \beta_3\left(\frac{Y}{K}\right)_{ics,t-1} + \beta_4\left(\frac{CF}{K}\right)_{ics,t-1} + \beta_5 UC_{cs,t-1} + \beta_6 REG_{cs,t-1} + \gamma_{ct} + \varepsilon_{icst}$$

where, I denotes gross investment, K last year's capital stock, Y output, CF cash-flow and UC tax-adjusted user cost of capital, REG a set of sector specific regulatory indicators and γ country-year fixed effects. All variables were lagged once. The analysis does not evaluate operating cost or service provision.

Firm-level variables come from the Worldscope (Thomson Financial) database, while the sector specific tax-adjusted user cost variable was drawn from the OECD Tax and Economic Growth project. The regulatory variables used in this analysis were drawn from the OECD indicators of regulation in network industries and replies to the OECD Questionnaire on Infrastructure Investment.

The results are shown in Table 5. The quadratic adjustment costs (lagged investment-to-capital ratio and its square) are significant, as is the output-to-capital ratio. The cashflow-to-capital ratio, which would indicate the possibility of liquidity constraints, is positive but the effect is very small. The measure of the user cost of capital is often significant, but wrongly signed.[1] Turning to the indicators capturing regulatory policies, the main results are:

1. *Barriers to Entry*: This indicator focuses on third party access (TPA) and the extent of choice of supplier for consumers in electricity, gas, railroad and telecom sectors. In the aggregate equations shown in Table 5 Panel A, barriers to entry have a negative impact on firm-level investment activity (column 2). As the barriers to entry are often sector specific, when they are allowed to vary by sector it is apparent that they have a negative effect in all sectors with the exception of railtrack (column 5).

2. *Vertical Integration*: This indicator focuses on the extent to which competitive activities (such as electricity generation, gas production, electricity and gas supply) are separated from segments of the sector that remain natural monopolies. This indicator is available for electricity, gas and railroad and in the sector specific regressions reported in Panel B it is apparent that vertical integration is associated with lower firm-level investment in the electricity sector, where there are less likely to be compelling reasons not to unbundle than is the case for rail. The regressions in Panel B also show that other than the variable for lagged investment the empirical specification performs poorly in explaining investment behaviour in the rail sector, which may reflect the capital intense nature of the sector and the often public nature of railtrack financing.

3. *Regulatory Independence:* The indicator for regulatory independence is constructed from questionnaire responses as a dummy variable equal to "1" if the sectoral regulatory authority is independent from the executive and has its own legal status and budget, "0" otherwise. At the sectoral level (Panel C), the independence of the regulator appears to be positively related to firm-level investment behaviour in the telecoms (and to a lesser extent the electricity) sector, where regulatory independence is most prominent.

4. *Public Ownership*: This indicator addresses the degree of public ownership in the electricity, gas, railroad and telecom sectors, but in the aggregate equations reported in Panel A, column 3, the effect is insignificant, which is consistent with past findings. For example, Bortolotti (2002) show that for the telecommunications the concurrent changes in regulatory regime, rather than privatisation per se, are the drivers of changes in firm behavior.

5. Finally, the OECD indicator for overall sectoral regulation is negatively related to firm-level investment rates

(Panel A, column 4).

6. When these significant effects are evaluated by computing the long-run elasticities (at mean sample values), the impact of barriers to entry and overall sector regulation are around -0.3, while the positive impact of regulatory independence is 0.25 and 0.79 for electricity and telecommunications, respectively. In terms of the effect on the investment rate, these elasticities imply that a change in barriers to entry equivalent to moving from unregulated to regulated third party access could lift the investment rate by up to 6 percentage points while the introduction of an independent regulator could raise the investment rate by up to 11 percentage points.

1. The user cost is likely to be picking up differences in firm investment behaviour across sectors.

**[Table 5. Estimated effects of regulation on investment at the firm-level]**

45. In some parts of the network industries, there may be reasons for maintaining a vertically-integrated firm, such as allowing facilities-based competition to emerge in the long run while allowing service-based competition in the short run to create pressure to increase cost efficiency (in parts of telecommunication networks, for example). In this case, the network operator provides wholesale services to downstream competitors, which may blunt incentives to invest in quality (Auriol, 1998). The resulting regulatory problems are severe, and firms need careful monitoring to prevent the exercise of market power with care also needed in setting the appropriate access regime and price as this is complicated by the firm operating in both regulated and unregulated markets (see below).

46. When vertical separation is desirable, a central question concerns the ownership structure of the core network. Countries differ markedly with respect to different organizational forms. In the electricity sector, for example, the electricity transmission grid is privately owned and operated in the United Kingdom and Germany, privately owned and operated by an independent company in some parts of the United States, state-owned and run by an independent company in Italy and state owned and operated by a state-owned enterprise in the Netherlands. In some cases, the regulatory authorities have mandated that the "essential facility" be operated by a different entity than a user (to prevent foreclosure, see below). The different types of organisational forms have potentially different consequences for investment (OECD, 2001).[48]

- *Accounting and legal separation:* Formal separation has generally been insufficient to change the behaviour of the incumbent, often amounting to *de facto* vertical integration, and does little to relieve the regulator's burden in determining the appropriate level of investment. For example, in the early 1990s, the UK competition authorities found that a greater degree of separation was desirable for British Gas, then a vertically integrated gas company. Accounting and legal separation characterises industry structures in energy, rail and telecommunications in many EU countries that implemented the minimum requirements set by EU directives.

- *Operation separation:* This occurs when an independent entity controls the non-competitive component. A key element is whether this entity should be allowed to generate profits. If the governing entity has no interest in the profitability of the non-competitive component it may have little incentive for efficient and innovative investment in the non-competitive activity. Operational separation is a form used in the US electricity industry. But in the United States,

48 . There are also organisational forms where the network is separated into reciprocal or smaller parts, which can be introduced with cellular telephony. While this choice can have implications for competition, the direct influence on investment is less clear cut.

electricity retailing companies have complained that (operationally-separate) transmission companies have not been responsive to changes in demands nor innovative (OECD, 2001).

- *Ownership separation*: In this case, the owner of the network will not discriminate among users and thus many of the competition problems that can arise in other organisational structures are mitigated. An example is the National Grid in the United Kingdom. In the absence of co-ordination problems, creating appropriate investment incentives depends on the regulatory framework and the setting of access prices, which are discussed below.

- *Club ownership:* Club ownership – when the core network is owned by a consortium of firms using the network – will help align incentives for network operators and downstream competitors. However, when the number of downstream competitors is small, collusion and foreclosure may result and when the number of competitors is large there may be principal-agent problems. Many EU countries have chosen club ownership between the major airlines and the slot allocation function at major airports or for electricity transmission in Italy.

### *5.4 Regulation and other framework conditions*

47. Regulation - which is prevalent in network industries - and other framework conditions will play an important role in investment decision making through their effect on determining the return on investment as well as ensuring efficient use and expansion of infrastructure through the effects of pricing. This section discusses how these policies can be designed to support such incentives, considering in turn institutional arrangements for the regulator, network access conditions and the pricing regime.

#### *4.4.1 Effective regulatory institutions*

48. An important factor affecting investment in regulated network industries is the nature of the regulator. The regulator faces potential difficulties both in its relations with the government and the sector it is regulating – including political and private interest pressures – as well as problems related with lack of credibility and asymmetries of information (see OECD, 2005). Ensuring the regulator's independence is central to preventing regulatory capture and enhances the stability and credibility of the regulatory framework, in a context where accountability to the government, the legislature and consumers should nonetheless be preserved. To facilitate independence, desirable features for the regulator's operation include providing a legal mandate (including criteria and procedures for over-ruling decisions), ensuring the regulator is separated and autonomous from the government, and defining how appointments and dismissals of regulators are to take place to minimise the possibility for pressure being applied to members.[49] As can be seen in Figure 16, regulator independence across sectors and countries varies substantially.

**[Figure 16. Independence of the regulator]**

49. When it is appropriately designed, regulatory independence should help both improve the quality of regulation and, by holding the regulator accountable for implementing its mandate, reduce the discretion that the regulator can exercise. In this framework, regulated firms will have greater certainty about regulatory outcomes over time (policy consistency) and may also be more willing to share information with the regulator than it would be the case with the government. Excessive use of discretionary powers by

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49. Greater independence of the regulator has been a common recommendation to promote product market competition (Gonenc *et al.* 2001; Høj *et al.* 2007). Edwards and Waverman (2006) find that greater regulatory independence is important in telecommunications.

regulators can introduce uncertainty, with detrimental effects on investment incentives (Box 7).[50] Uncertainty may ultimately delay investments and skew them towards less capital intensive projects than is socially optimal.[51] Empirical evidence, presented in Box 6, suggests that in the electricity and telecommunication sectors, regulator independence is associated with more firm-level investment activity.

**Box 7. Uncertainty and investment**

In the presence of uncertainty, delaying an irreversible investment until new information arrives is preferable to investing once the net present value of a project is positive, which is the decision rule in a standard neo-classical investment framework. In essence, the difference is that investing immediately and thereby losing the option of investing later is equivalent to incurring a sunk cost (Pindyck, 1991). This interaction between uncertainty and irreversibility is particularly pertinent for infrastructure investment because investment into the monopoly segments is often almost completely irreversible, often extremely lumpy due to indivisibilities and scale economies and subject to non-linear and difficult-to-predict network externalities.

Due to the uncertainty and irreversibility of the investment, the premium or so-called "hurdle rate" of return on capital exceeds that of the standard investment decision. Estimates of the premium for telecommunications suggest that the rate is around 10% (Bernstein and Mamuneas, 2007). In the case that a price cap is binding, the monopolist may delay investment when demand rises even if the price cap has been set to meet the rate of return on a reversible investment (Dobbs, 2004).

Regulatory uncertainty will raise the hurdle rate for investment.[1] For example, regulatory action *ex post* that grants competitors access to essential facilities will truncate potential upside returns. In this context, commitment devices that minimise regulatory policy risk are therefore factors that help support investment. For example, the regulator should endeavour to signal in advance changes in the regulatory regime. In addition, consultation with industry participants on changes to aspects of the regulatory regime may help mitigate potential uncertainty. For example, these are important considerations for climate change policies that require a restructuring of different aspects of infrastructure.

On the other hand, there are a number of considerations which may alter the interactions of uncertainty and risk. First the degree of uncertainty is markedly different across sectors and within sectors. For example, technological change is comparatively low and demand arguably less volatile in the water sector than in telecommunications, while within the telecommunications sector the degree of uncertainty is significantly higher in the development of next generation networks. In this light, it may be more appropriate to use standard investment models in the former case, when assessing the appropriate cost of capital. Second, market structure may allow a first mover advantage and thus offset the option value. Third and also related to market structure, the service provider may attempt to claim lost monopoly rents as opportunity cost (Funston, 2006).

1. The uncertainty over regulation is also apparent with respect to the development of broadband with the debate unsettled on whether regulatory intervention is needed to prevent the emergence of monopoly power (Crandall *et al*. 2004). This debate centres on the "last mile" bottleneck that current telephone operators control.

50. Policymakers can try to overcome the potentially negative implications of regulatory uncertainty for investment in infrastructure in a number of ways. One approach is to determine the duties of the

50 . The actions of the regulator may also have adverse consequence for the functioning of markets. For example, Borenstein *et al.* (2007) argue that fear of heavy sanctions by the regulator of interruptions to supply natural gas will lead participants to hoard reserves when the spot market is tight.

51 . An example of such uncertainty followed the introduction of the US Telecommunications Act of 1996. While this act intended to introduce competition in local telephone services, implementation was left ambiguous, giving considerable discretion to the Federal Communications Commission. The uncertainty compounded by legal challenges made by incumbents discouraged large-scale investments needed for the roll out of fibre-optic services to individual residences (Couper *et al.* 2003).

regulator in legislation, the requirements of the licence holders and procedures for dispute resolution, either through the courts or by appeal to the competition authorities. In other cases, such as the United States, well-defined administrative procedures govern how regulators act, make decision and can be challenged (Newbery, 2000). In both cases, one aspect of the mechanism to counter unexpected changes in regulation is the ability to appeal against the regulator's decisions. In Figure 17, it is apparent that legal challenge is generally more developed than arbitration procedures.[52] In both cases, country responses report these mechanisms are more prevalent in the energy and telecommunications sectors than transport and water. Another approach would be to embed regulatory reactions to changes in market conditions in a predictable framework. For example, revenue sharing rules for when firm profits rise above thresholds could mitigate the uncertainty arising due to the fear that high profits could provoke a change to the regulatory regime.

**[Figure 17. Dispute settlement with the regulator]**

### *5.4.2 Access conditions and pricing*

51. Barriers to entry and anti-competitive behaviour by incumbents can create obstacles to efficient investment. These issues are in the purview of the competition authorities and sector regulators, which track abuses of dominance and determine access conditions and pricing to existing infrastructure, respectively.[53] Levelling the playing field requires, *inter alia*, liberalising entry through vertical separation, where appropriate, and introducing regulated third party access. In OECD economies there has been substantial progress in implementing such policies and removing other barriers to entry (Figure 18).

- This is particularly the case in telecommunications during the 1990s, when most legal restrictions were lifted on both fixed and wholesale services. On average in 2007, the market share of new entrants in mobile telephony exceeded 50%, with only Mexico noticeably lower. For international calls, new entrants' market share was slightly less on average at around two-fifths with progress in opening up this market much slower in some countries, such as Turkey and the Slovak Republic.

- Substantial easing of entry barriers also occurred in the electricity sector, where in 2007 almost all countries had implemented regulated third party access (TPA), with only Germany and Switzerland using negotiated TPA and Mexico without a TPA regime at all. Furthermore only a handful of countries – Japan, Korea, Mexico, Switzerland and the United States – permit vertically-integrated firms in the electricity sector. However, bottlenecks in interconnection capacity restrain new entry.

- Progress in the gas sector has been less dramatic, but barriers to entry have begun to fall. In the gas sector, both vertically-integrated firms and negotiated third party access are more common than in the electricity sector. In many countries storage remains largely dominated by incumbents and bottlenecks in interconnection capacity restrains new entry.

- In rail, where reforms have tended to be more recent, few countries have implemented full vertical unbundling possibly recognising the severe coordination problems that can arise.

52 . Legal appeals can often be time consuming, however (OECD, 2005)

53 . Other than through full unbundling and *ex post* application of competition law, there are a number of options available to the regulators to restrain *ex* ante such incumbents from abusing their monopoly power on the wholesale market. These include setting quality standards and introducing rewards and penalties or implementing parity standards (the vertically-integrated firm is obliged to offer to its competitors the same quality of service that it offers to its own downstream affiliate).

Reforms when they have occurred have tended to be for freight rather than passenger transport. However, most countries have imposed legal or accounting separation.

**[Figure 18. Barriers to entry in the network industries]**

52. Empirical evidence suggests that policies that reduce barriers to entry (such as introducing regulated TPA regimes) in network industries have enhanced sectoral investment (by users as well as infrastructure providers). Multivariate cross-sectional evidence using sectoral data reveals that when barriers to entry are lower the rate of investment is higher (Box 8). In time-series regressions using sectoral data reported by Alesina *et al.* (2005) lowering barriers to entry is also found to boost the investment rate, potentially raising the investment rate by 1½ percentage points on average in the countries covered by the study (the average investment rate being around 7%) if barriers to entry fell by a significant amount, taking a country from the third quartile to the first quartile of the country distribution of barriers to entry (as measured by the OECD indicators). Firm-level evidence (Box 6) further supports the importance of reducing barriers to entry in network industries.

**Box 8. Determinants of infrastructure investment : sectoral level**

For the sectoral-level analysis, investment data for energy and water (electricity, gas and water), transportation (rail, road, and water and air transportation) and telecommunications were available for 13 countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, United Kingdom and the United States). Data were available for 1995-2006 and non-overlapping 6-year averages were computed.

The investigation of investment determinants uses an investment equation with sectoral investment as a ratio to gross value added (Égert , 2009). The estimations use both country fixed effects and then country fixed effects as well as the explanatory variables lagged one period. The structure of the estimated equation is:

$$I_t^{VA} = \beta_1 I_{t-1}^{VA} + \beta_2 OG_{t-1} + \beta_3 RIR_{t-1} + \sum_{i=1}^{2}\sum_{j=1}^{k}\beta_{3+j} X_{j,t-i} + \sum_{l=1}^{country}\delta_l FE^C + \sum_{m=1}^{I}\phi_m FE^I + \varepsilon_t \quad (4)$$

where ( $I_t^{VA}$ ) is the ratio of investment to sectoral value added, (OG) the output gap to control for business cycle fluctuations, (RIR) the real interest rate to capture the impact of the cost of capital on investment and (X) variables capturing aspects of the regulatory environment, ( $FE^C$ ) and ( $FE^I$ ) denote country and industry fixed effects. The regulatory environment variables include a measure of barriers to entry and public ownership, a measure of regulatory independence and whether the sector had no price regulation as well as a variable that captured whether the sector was subject to incentive regulation. The last variable was also interacted with the regulatory independence variable to assess whether the consistency in policy stance is important. The regulatory variables as well as the controls are lagged to address potential endogeneity arising between them and the investment ratio. An exception is the variable capturing incentive regulation because observations are only available for the most recent period.

The main findings are presented in Table 6. A simple OLS regression shows that three variables are significantly correlated with investment: these are lagged investment, the measure of barriers to entry and the interaction term for regulatory independence and incentive regulation. Barriers to entry are found to influence investment negatively. The interaction term has a positive coefficient while, when taken separately, regulatory independence and incentive regulation appear to have no effect on investment. This suggests that a consistent policy mix is important in underpinning efficient investment incentives in network industries.

As a robustness check of the simple OLS results, Bayesian model averaging was carried out, using the same approach as discussed in Box 4. Table 6 also reports the main results for the different regulatory variables. The measures of barriers to entry and the interaction term combining incentive regulation with regulatory independence consistently contribute to a better fit of the model. These results hold both when country and industry fixed effects are used and for all sub-samples (when one country at a time is dropped). The results also reveal that the absence of price regulation is correlated with lower investment, which is consistent with rate-of-return regulation, other things being equal, boosting investment. However, this result is sensitive to the inclusion of observations for the United States.

In terms of the economic significance of the results, the estimated coefficient for the interaction term suggests that reforms can have a large impact on investment. The size of the coefficient estimates for the different subsamples suggests that on average a 1 step change in the interaction term (*e.g.* a change that would be slightly smaller than that of fixed line telecommunications adopting incentive pricing when the regulator is independent) would induce an average increase of the investment ratio of 5.3 percentage points. Given that the observed investment ratios are between 18% and 74%, the impact of such a reform is potentially sizeable. Similarly, a one-step decrease in the measure of barriers to entry (which would be somewhat larger than the impact of introducing regulated third party access) would be related to an average rise of 1.6 percentage points in the investment ratio. Given the expected influence of barriers to entry to specific sectors (mainly telecommunications and parts of the energy sector – see main text) these figures likely masks differences across sectors.

**[Table 6. Estimated effects of regulation on investment at the sectoral-level]**

53. Rules that determine the access conditions to the core network and its pricing have particularly important implications for infrastructure utilisation and investment. Regulated or negotiated third party access (TPA) regimes have been established in OECD countries, with regulated access being considered the most favourable to the development of competition in unregulated services. The effects of these regimes on infrastructure investment are intimately related to dispute resolution in the case of negotiated TPA and the terms of access conditions in the case of regulated TPA. In some cases, such regulations have been waived or adapted in energy markets where security-of-supply considerations are important (Box 9).

**Box 9. Security of supply and investment**

Regulators in different energy markets have taken a number of steps to address security of supply concerns.

**Transmission, Storage and Interconnection**

Regulators have waived open access requirements for natural gas or liquefied natural gas storage facilities. For example, Article 22 of the EU Gas Directive and the FERC "Huckberry Decision" relax open access requirements with the aim of promoting investment incentives (Von Hirschhausen, 2007). This is a particular issue in the United Kingdom where natural gas storage facilities are needed to meet fluctuations in seasonal demand as the gas fields are less able to play the role of a "swing field". Storage facilities that are sufficient to deal with seasonal fluctuations imply huge sunk costs (Codognot and Glachant, 2006). [1]

As interconnection capacity can increase security of supply in electricity markets and also strengthen competitive pressures, regulators have exempted new interconnection capacity from regulation (Brunekreeft *et al*. 2004).[2] Interconnection can also enhance investment incentives for other market participants. For example, IEA (2008) expects that enhancing interconnection in the European gas market will – through the effect of enlarging markets – induce new entry and investment in areas such as storage facilities, which in turn will further enhance security of supply. In some cases, regulatory authorities may need to intervene to ensure that sufficient investment is made. This is particularly the case when transmission is incorporated in a vertically-integrated company. In practice, regulators that have this power have typically shied away from forcing investment.

**Electricity generation**

Security-of-supply concerns also arise with the difficulties encountered in guaranteeing a sufficient return on investment for peaking capacity in the electricity sector. While generation generally can be competitive and does not require price regulation, the peculiarities of the industry and security-of-supply consideration can require regulatory intervention as short-run marginal revenues may not rise sufficiently to cover fixed costs. Joskow (2006) argues that as only a tiny proportion of demand is sensitive to price changes in real time, the network operator *inter alia* often resorts to non-price rationing to prevent network outages or calls on capacity using out-of-market contracts. Furthermore, given short-run demand inelasticity, regulators have imposed price caps to counter the possible exercise of market power. Countries have tried different approaches to ensure their peaking capacity is maintained to underpin security of supply. These include:

- Capacity payments have been used in Korea, Spain, and the United Kingdom, while some networks in the United States (PJM, NYPP and New England) use capacity requirements.
- Reserve capacity markets were introduced to address concerns about meeting peak winter demand in Norway and Sweden.
- Since 2002, energy markets in Australia had a price cap set at the estimate of the Value of Lost Load (VoLL), but to counteract the lack of incentives to invest, the market operator could sign contracts for reserve generation and demand side management. If the market operator calls on this capacity it must conduct a "what if" analysis to determine what prices would have occurred in the absence of this supply so as not to blunt the incentives for other generators to invest. (NERA, 2002).

1. Gans and King (2004) suggest that access holidays of between 10 and 20 years would be appropriate for infrastructure with a lifespan of 30 to 50 years.

2. Borenstein *et al.* (2000) show for electricity networks that even small additions to interconnection capacity can have marked

effects on raising the extent of competition between networks. Without this capacity, incumbents in one region could exert market power by reducing output to induce congestion on the interconnection. One implication is that once the interconnection capacity is in place, the generator exerting market power increases output and use of the interconnection may be smaller than anticipated.

*Access conditions*

54. Where facilities-based competition is viable, such as with airports and maritime ports and mobile telecommunications, ensuring a level playing field through appropriate competition policy enforcement is crucial to encouraging efficient infrastructure investment. Moreover, when the incumbent remains vertically integrated, but competition in the unregulated sectors is possible, new entrants can face considerable difficulties with implications for investment:

- Strategic behaviour of a vertically-integrated incumbent can limit access to its regulated infrastructure for competitors in unregulated upstream or downstream markets by either foreclosing practices or insufficient expansion (or retention) of capacity.

- Even when the incumbent does not implement anti-competitive practices, new entrants wishing to invest in infrastructure may still be put at a competitive disadvantage relative to the incumbent, at least initially. This type of outcome has been a feature of telecom liberalisation where the incumbent often enjoyed economies of scale or scope.[54]

*Pricing regimes*

55. The regulator will need to set access prices when there is a vertically-separated firm (such as some electricity transmission grids) and also when service-based competition is feasible with the vertically-integrated firm (such as in telecommunications). In addition, when core network providers have monopoly power, the regulator will need to set the final price (such as in the water sector or operators of toll roads, bridges and tunnels) or a basket of prices (such as for rail).

56. There are two broad approaches to pricing; either basing prices on costs (so that prices may change also to reflect the costs of investment) or using incentive-based pricing policies (where, at least for a period, prices do not vary in response to investment decisions). Figure 19 shows that, where prices are regulated, cost-based prices are generally predominant, particularly in the electricity and gas sectors, and to a lesser extent in fixed-line telecommunication networks and rail.

**[Figure 19 Pricing regimes]**

Cost-based pricing

57. Cost-based pricing – such as rate-of-return regulation – sets prices to cover production costs and allow a permissible margin, which should allow the firm to recover investment costs and can specifically relate to the return the firm is allowed to earn on its capital. In ensuring efficient investment a critical regulatory parameter is the so-called "rate base" on which the rate of return is calculated (Box 10). As

54 . The incumbent often benefits from inertia of its customer base, which enjoys the economies of density of the incumbent's network, as well as the "branding" advantages of being the universal service provider (OFTEL, 1995). In this context, Cave (2006) advocates adopting a "ladder approach" whereby the regulator progressively opens the market to competitors, allowing them to establish their network infrastructure in stages and thus not face the huge disadvantage of competing with the incumbent in all parts of the market at once.

discussed in Box 12, measuring costs, particularly the common costs that are shared across products, is a difficult task.

**Box 10. The rate-base issue**

If the rate base includes all assets of the firm, the firm will have an incentive to over-invest to boost its profits. To avoid this, regulators select which investments are to be included in the rate base. First, the regulator may include only investment that it considers "used-and-useful", which is largely subjective. This approach has been used for instance in the United States telecommunication industry. An alternative approach is for the regulator to include investment in the rate base only if it contributes to the reduction of operating costs. If the regulator assesses investment *ex post,* it will use information that was not available at the time of the investment decision and may not allow the inclusion of the whole investment in the rate base (called a cost disallowance). In this case, the regulated firm will be more prudent *ex* ante and only choose those investment projects that are subject to low future shocks.[1] For example, cost disallowances had important implications in the United States when they were applied to nuclear power plant operators. Subsequent investment in nuclear plants was depressed but not other types of generation (Lyon and Mayo, 2005).

1. Thus firms would be less prone to investment projects with long lags to completion, such as large projects that offer economies of scale or if they are operating in industries facing fast technological progress, which are more likely to be hit by shocks. A second type of disincentive may occur if an upper bound on the rate of return discourages high-return but more risky investments.

58. On the whole, the empirical evidence suggests that the outcome of cost-based regulation has tended to lead to inefficient investment and a slow rate of technological progress. Cost-based pricing provides limited incentives for the firm to invest in cost-reducing technologies and encourages over-investment if the allowable rate of return exceeds the cost of capital (Averch and Johnson, 1962). Over-investment and the ensuing excess capacity may also be used as a strategic tool to deter potential entrants. Starkie (2006) reports evidence of this happening in the European gas industry and in the UK airport sector. Finally, firms have often continued to depend on government subsidies because of the poor incentives to eliminate inefficiencies.

Incentive-based pricing

59. Against the background of the difficulties in determining costs and the specific rate of return, incentive-based pricing regimes – such as price caps – have gained popularity and often accompanied deregulation and privatisation. In its most basic form of a price cap, prices are set with no explicit consideration of a specific rate of return. The underlying idea is to give firms "high-powered" incentives to invest in cost-saving technology and at the same time simulate competitive conditions which constrain firms' monopoly profits in the long run. To this end, the regulator specifies a price basket that is allowed to increase in line with an exogenous measure of input costs minus a pre-determined factor reflecting expected efficiency gains, possibly allowing as well for expected increases in quality of service.

60. Price cap reviews are made at regular intervals and, when they are not too frequent, this price regime creates incentives for firms to engage in long-term cost-reducing investment.[55] However, in practice price reviews are held frequently in many OECD countries, both for incentive-based pricing and cost-based regimes (Figure 20). In most sectors, countries report that they normally review prices at an

55 . The price in both cost-based and incentive-based regimes is the outcome of a sequence of regulatory reviews, with investments more likely to be deferred to the next period as the next price review approaches (Joskow, 1973). Investment may also be deferred if the monopolist believes that high levels of profitability will provoke early price reviews (Joskow, 1974).

annual frequency. Only in the United Kingdom and Italy are prices reviewed less frequently – around 4-5 years – on a systematic basis across sectors.

**[Figure 20. Frequency of price reviews]**

61. In comparison with cost-based regulation, incentive regulation shifts some risk from consumers to the shareholders and consequently raises the riskiness and the cost of capital of the regulated firm. The implications are that if the regulated firm is not allowed to earn a return on its capital that incorporates the higher risk the regulated firm faces, it may tend to under invest relative to a cost-based regime. Alexander and Irwin (1996) show that a measure of volatility of a firm's returns is higher for firms subject to price caps and imply higher costs of capital of about 1 percentage point than a firm subjected to rate-of-return regulation. An additional problem with incentive-based pricing is that quality may be compromised. A price cap that does not account for quality changes can give incentives to reduce quality (Box 11).[56]

**Box 11. The quality issue**

In order to prevent the firm reaping extra profit by *reducing* quality, the regulator can adjust the regulated price by some measure of quality, which would allow firms to charge correspondingly higher prices.[1] One complication with explicitly targeting observable quality is that the regulated firm may over-supply quality for "high-valuation" customers – as they would be prepared to pay higher prices for better quality (Sappington, 2005). One solution to this problem is to introduce minimum quality standards or to cap the price of the high quality product.[2] In practice, replies to the OECD questionnaire suggest that the use of quality standards is very heterogeneous across countries: for example, France and Luxembourg make little use of them while they are extensively applied in Korea, Italy and the United States (Figure 21). Quality standards are most frequently applied in the water supply sector, downstream energy markets and in fixed line telecommunications.

Instead of using the quality adjustment factor, the regulator can resort to direct financial incentives reflecting consumer preferences. In practice, such as for water and sewerage, services penalties can take the form of rebates or discounts on services with sub-standard quality. This is especially helpful when quality is not verifiable by the regulator but can be observed by the consumer. In such a setting, the consumer is rewarded for pointing out deficient quality and in this way is given a stronger incentive to monitor service provision.[3]

1. If an exogenous shift in demand led to congestion (a deterioration in service quality), the regulator may want to raise prices.

2. Setting minimum quality standards too high may have detrimental effects. To the extent that quality increases are translated into higher prices, aggregate consumption and welfare may fall. They may also constitute barriers to entry if fulfilling them is more costly for new entrants than for incumbents.

3. When the regulator cannot observe or infer the quality of the service Laffont and Tirole (2001) argue that the regulator may want to opt for rate-of-return regulation.

**[Figure 21. The use of quality standards]**

62. Generally, case studies suggest that incentive pricing can help the adoption of cost-saving technology, but the overall impact on the investment rate is uncertain.[57] For example, a review of the

56 . While there is a case that incentive pricing may create incentives for firms to reduce quality, there are limits to this process. Reduced quality can reduce demand and/or induce entry. Vogelsang (2003) reviews available evidence and notes that that quality need not necessarily deteriorate.

57 . If firms move from a regulatory environment that controls the rate of return the firms earns, in some cases removing that constraint may reduce the desired capital stock and hence investment. However, even in the case of lower investment, less feather-bedding and better use of existing resources may contribute to more efficient investment. The studies in OECD (2001) found that prospective as well as effective competition

effects of incentive regulation on investment reported that price-cap incentive regulation may have spurred investment in the telecommunications sector (Kridel *et al*. 1996).[58] Using questionnaire responses, cross-country industry-level estimations looking at the effects of different types of price regulation on investment were estimated. The results (reported in Box 8) suggest that incentive price regulation has a positive impact on investment in infrastructure only when it is accompanied by an independent regulator. This would imply that a number of countries could enhance investment incentives by enhancing the consistency of their policy framework. Synergies between the regulator's independence and price regimes, for instance, could be enhanced in the electricity and (parts of) telecommunication sectors if France, Portugal, Spain and the United Kingdom moved to incentive regulation, while greater independence of the regulator in the Danish, Japanese and Norwegian telecom sectors could enhance the effects of the incentive price regulation that is in place.

*Setting access prices to infrastructure networks*

63. With respect to prices set at the price reviews, the central challenge for investment is to ensure that it encourages efficient use of scarce network capacity while at the same time preserving incentives to maintain quality and expand capacity where appropriate. In practice, regulators can adopt a number of approaches to setting access prices (Box 12). Setting the wrong price and access conditions can run the risk of inefficient utilisation, which in turn can generate either over or under-investment:

- Not only may excessively high access prices induce the incumbent to overspend to develop its own infrastructure, but they may also encourage new entrants to over-invest in alternative networks to bypass the existing infrastructure. While bypass is potentially a serious threat in telecommunications it is less so in other industries such as water and sewerage and railroads where the sunk costs of duplicating the network are extremely high.

- Setting prices too low leads to underinvestment for opposite reasons and by preventing the incumbent from recovering investment costs, depresses its investment activity. Furthermore, if the access charge is determined without taking into account the option value of delaying investment by potential new entrants, the net present value of using the incumbent's network is higher than building a competing network (Crandall, Ingraham and Singer, 2004).

- Low access prices may also have spillover effects on investment in the upstream or downstream markets. For example, if the services provided by train operators depend on the quality of the railroad network, a lack of investment in the network will tend to depress train operators' investment. Strategic cooperation between the network operator and the train operators may provide a way out.[59]

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induces productivity and quality improvements. Evidence on the effects of privatisation on productivity is mixed (see, however, Nicoletti and Scarpetta, 2003).

58 . In some cases, the firm has incentives to "over-produce" in the regulated market if there are shared costs (Guthrie, 2006).

59 . For instance, in the United Kingdom, Virgin Trains and Railtrack signed a contract to upgrade the West Coast Main Line and agreed to share both the investment costs and future revenues (Affuso and Newbery, 2000). Similar arrangements are sometimes used for terminal capacity expansion at airports. The danger in such arrangements is that they may establish *de facto* vertical integration.

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**Table 1. Annual time-series growth regressions**

Using Dynamic OLS

Panel A. Transport infrastructure - total length per capita

| | Roads | | | | Rail | | | | Motorways | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | | Coefficient | | Coefficient | | Coefficient | | Coefficient | | Coefficient | |
| | | | | | ***Long run (mean group)*** | | | | | | | |
| Investment | 0.46 | ** | 0.3 | * | 0.53 | *** | 0.39 | ** | 0.42 | *** | 0.4 | *** |
| Population growth | 0.032 | | 0.019 | | 0.013 | | -0.007 | | 0.019 | | -0.005 | |
| Human capital | | | 0.18 | | | | 0.08 | | | | -0.03 | |
| trend | 0.02 | *** | -0.03 | | 0.03 | *** | -0.08 | | 0.02 | *** | -0.11 | |
| | | | | | *Country specific long run coefficients for infrastructure* | | | | | | | |
| Australia | 0.17 | | 0.07 | | 0.46 | *** | 0.50 | *** | | | | |
| Austria | -0.13 | | 0.07 | | 2.27 | *** | 1.04 | *** | 0.30 | *** | 0.17 | *** |
| Belgium | 0.27 | | 0.12 | | -1.01 | *** | -0.39 | ** | 0.18 | *** | 0.12 | |
| Canada | | | | | 0.45 | | 3.02 | | | | | |
| Denmark | 1.19 | * | -0.75 | | -0.20 | *** | -0.11 | | 0.15 | *** | 0.10 | |
| Finland | 1.66 | | -0.32 | | 0.29 | | -0.48 | | 0.01 | | 0.00 | |
| France | -0.81 | *** | -0.52 | *** | -2.52 | *** | 2.21 | ** | 0.14 | *** | 0.09 | |
| Greece | -0.09 | *** | -0.09 | ** | 2.22 | *** | 0.93 | *** | | | | |
| Iceland | -1.45 | *** | | | | | | | | | | |
| Ireland | -2.29 | *** | 0.83 | | 2.02 | *** | 0.03 | | 0.00 | | 0.00 | |
| Italy | -0.28 | *** | -0.04 | | -0.94 | *** | -0.45 | | 0.17 | *** | 0.06 | |
| Japan | 0.64 | | 1.43 | | 2.46 | *** | 0.28 | | 0.17 | *** | 0.13 | *** |
| Korea | 0.17 | | | | 1.06 | *** | | | | | | |
| Mexico | 0.17 | * | | | | | | | | | | |
| Netherlands | -0.45 | * | -0.75 | *** | -0.15 | | -0.91 | *** | 0.12 | ** | 1.00 | *** |
| New Zealand | 1.85 | *** | 2.51 | *** | 0.95 | *** | 1.45 | *** | -0.34 | *** | 0.05 | |
| Norway | 0.75 | * | 1.21 | | -1.37 | * | -0.13 | | | | | |
| Portugal | 0.30 | *** | -0.04 | | 0.09 | | -0.44 | *** | -0.16 | *** | 0.00 | |
| Spain | -0.43 | * | -0.48 | ** | -1.28 | *** | -1.95 | *** | 0.17 | *** | 0.16 | *** |
| Sweden | -0.14 | | -0.35 | | -0.22 | | -0.21 | | 0.23 | *** | 0.16 | |
| Switzerland | -0.55 | * | -0.59 | | -3.65 | ** | 0.70 | | 0.08 | | 0.11 | |
| Turkey | -0.13 | | | | -0.83 | | | | | | | |
| United Kingdom | 0.92 | ** | 1.20 | *** | 0.30 | ** | 0.80 | *** | -0.02 | | -0.12 | |
| United States | 1.86 | | 2.00 | | -0.07 | | 1.31 | *** | -0.10 | | -0.47 | |
| | | | | | ***Short run (mean group)*** | | | | | | | |
| Error correction term (-1) | -0.26 | | -0.39 | | -0.25 | | -0.53 | * | -0.4 | | -0.56 | |
| Adjusted R-squared long run | 0.994 | | 0.995 | | 0.993 | | 0.995 | | 0.995 | | 0.996 | |
| Adjusted R-squared short run | 0.4 | | 0.42 | | 0.4 | | 0.45 | | 0.46 | | 0.47 | |
| F-test | 5.18 | | 4.34 | | 5.38 | | 5.5 | | 5.67 | | 5.96 | |
| Durbin Watson statistic | 1.47 | | 1.68 | | 1.55 | | 1.74 | | 1.75 | | 1.82 | |
| Number of observations | 849 | | 615 | | 845 | | 666 | | 600 | | 529 | |

Note: The top panel gives the mean-group coefficients for the long run as well as the country-specific long-run coefficients for the infrastructure variable; the intermediate panel gives the coefficients for the short-run error correction term; the bottom panel gives regression diagnostics; ***, **, * denote the 1%, 5% and 10% level of significance, respectively; heterogenous coefficients were used as the Wald test on homogenous coefficients was rejected for each regressor variable individually and for all regressors jointly.

The coefficient of the infrastructure stock should be interpreted as the effect in addition to the effect of just adding to the productive capital stock. In this sense, a positive (negative) coefficient implies that the impact on output would be higher (lower).

**Table 1. [Cont]**

Using Dynamic OLS

Panel B. Electricity and telecommunications infrastructure

| | Electricity | | Telephone mainlines | | Telephone subscriptions | |
|---|---|---|---|---|---|---|
| | Coefficient | Coefficient | Coefficient | Coefficient | Coefficient | Coefficient |
| | | | ***Long run (mean-group)*** | | | |
| Investment | 0.39 *** | 0.39 *** | 0.39 *** | 0.42 *** | 0.45 *** | 0.34 ** |
| Population growth | 0.004 | -0.006 | 0.021 | 0.003 | 0.024 | 0.009 |
| Human capital | | 0.08 | | 0.15 | | 0.68 |
| trend | 0.02 *** | -0.11 | 0.02 *** | -0.13 | 0.02 *** | -0.07 |
| | | | *Country specific long run coefficients for infrastructure* | | | |
| Australia | -0.04 | -0.23 ** | -0.46 *** | -0.43 *** | 0.26 | 0.41 *** |
| Austria | 0.40 *** | 0.24 *** | 0.39 *** | 0.21 *** | 0.71 *** | 0.18 |
| Belgium | 0.54 *** | 0.22 *** | 0.37 ** | -0.08 | -0.70 *** | -0.24 * |
| Canada | 0.04 | -0.08 | 0.02 | 0.01 | 0.02 | 0.56 |
| Denmark | 0.26 *** | 0.36 ** | 0.21 * | -0.14 | 0.25 | 0.22 |
| Finland | 0.00 | -0.04 | -0.03 | -0.03 | 1.03 | 0.98 |
| France | 0.31 *** | 0.15 ** | 0.10 *** | 0.01 | -0.26 *** | -0.11 * |
| Greece | 0.31 *** | 0.38 *** | 0.32 *** | 0.34 *** | 0.16 *** | 0.28 *** |
| Iceland | 0.25 *** | | -0.60 *** | | 0.29 *** | |
| Ireland | -0.40 *** | -0.40 *** | -0.56 *** | -0.19 | -1.19 *** | -0.05 |
| Italy | 1.15 *** | 1.13 *** | 0.42 *** | 0.32 *** | -0.14 *** | -0.11 |
| Japan | 0.54 *** | 0.40 ** | 0.33 *** | 0.12 | -0.25 *** | -0.13 *** |
| Korea | -0.23 *** | | 0.02 | | 0.03 | |
| Mexico | 0.58 *** | | 0.68 *** | | 0.87 *** | |
| Netherlands | 0.25 *** | 0.21 | -0.12 * | 0.00 | -0.31 *** | -0.75 *** |
| New Zealand | -0.28 *** | -0.29 ** | -0.80 *** | -1.06 *** | 0.18 *** | 0.11 *** |
| Norway | 0.14 *** | 0.34 | 0.10 | 0.13 ** | -0.19 | -0.34 * |
| Portugal | 0.26 *** | -0.04 | 0.31 *** | 0.07 | -0.30 *** | -0.26 *** |
| Spain | 0.35 *** | 0.37 *** | 0.19 | 0.64 *** | -0.57 *** | -0.75 *** |
| Sweden | 0.03 | -0.01 | -0.11 | -0.02 | -0.01 | 0.14 |
| Switzerland | 0.08 | -0.16 | 0.13 | -0.32 | -0.04 | 0.03 |
| Turkey | 0.26 *** | | 0.08 | | 0.28 ** | |
| United Kingdom | 0.09 | 0.49 *** | -0.21 *** | -0.29 *** | -0.39 *** | 0.64 *** |
| United States | -0.08 * | -0.18 | 0.55 * | 0.24 | 0.31 ** | 0.47 |
| | | | ***Short run (mean group)*** | | | |
| Error correction term (-1) | -0.24 | -0.41 | -0.24 | -0.49 | -0.35 | -0.58 |
| Adjusted R-squared long run | 0.996 | 0.996 | 0.996 | 0.996 | 0.997 | 0.998 |
| Adjusted R-squared short run | 0.43 | 0.41 | 0.45 | 0.45 | 0.42 | 0.45 |
| F-test | 4.85 | 5.1 | 6.58 | 5.74 | 5.53 | 3.75 |
| Durbin Watson statistic | 1.55 | 1.69 | 1.63 | 1.7 | 1.5 | 1.64 |
| Number of observations | 961 | 700 | 958 | 697 | 912 | 669 |

Note: The top panel gives the mean-group coefficients for the long run as well as the country-specific long-run coefficients for the infrastructure variable; the intermediate panel gives the coefficients for the short-run error correction term; the bottom panel gives regression diagnostics; ***, **, * denote the 1%, 5% and 10% level of significance, respectively; heterogenous coefficients were used as the Wald test on homogenous coefficients was rejected for each regressor variable individually and for all regressors jointly.

The coefficient of the infrastructure stock should be interpreted as the effect in addition to the effect of just adding to the productive capital stock. In this sense, a positive (negative) coefficient implies that the impact on output would be higher (lower).

**Table 2. Estimated effects of infrastructure on growth, results from model averaging**

Results giving the average size of the coefficient from the models that include the variable and the probability that a variable improves the explanatory power of cross section growth models run on regressions for 28 countries using four 8-year time periods

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *Lagged variables* | | | | |
| Income per capita | -7.14 ** | -7.41 ** | -7.82 ** | -8.95 ** |
| Life expectancy | 0.15 ** | 0.20 | 0.1 | -0.01 |
| Inflation rate | 0.01 | -0.01 | 0 | -0.01 |
| Regulation | -0.02 | -0.02 | 0 | -0.02 |
| Labour force growth | -0.01 | 0.00 | -0.02 | -0.01 |
| Openess | 0.03 ** | 0.01 | 0.04 ** | 0.03 ** |
| Government investment | -0.15 ** | -0.19 ** | -0.12 ** | -0.32 ** |
| Investment price inflation | -0.03 ** | -0.02 | -0.02 | -0.01 |
| Human capital | 0.95 ** | 0.87 ** | 0.92 ** | 0.83 ** |
| *Lagged infrastructure variables* | | | | |
| Transport principal component | 0.23 ** | | | |
| of which, low level of provision | | 0.54 ** | | |
| of which, high level of provision | | 0.25 ** | | |
| Energy and telecoms principal component | | | 0.96 ** | |
| of which, low level of provision | | | | 2.71 ** |
| of which, high level of provision | | | | 1.31 ** |

Note: The top section of the table gives the average of the coefficient estimates from models that include different lagged variables. Those variables that improve the overall fit of the model when they are included are marked with an**. The next section of the table gives the same information for aggregate measures of infrastructure, which are based on principal components. The bottom section of the table reports the same information as column (2), but allows the effect to be non-linear with the effects different for countries where the level of infrastructure is either lower or higher. The likelihood ratio test supports the non-linear model over the linear model

**Table 3. PPPs in infrastructure**

Cumulative total by sector, 1994-2007

| | | Share by value | Number of projects |
|---|---|---|---|
| Energy | | 1.75 | 17 |
| Water | | 2.05 | 45 |
| | Road | 51.76 | 163 |
| Transport | Rail | 26.60 | 38 |
| | Other | 14.37 | 49 |
| Communications | | 0.86 | 6 |
| Other | | 2.61 | 44 |
| Sum | | 100 | 362 |

*Source*: Dealogic Projectware database (data extracted 19/2/08)

**Table 4. Market structures in network industries**

| | Natural monopoly segment | Potentially competitive sector |
|---|---|---|
| **Energy** | | |
| Electricity | Transmission grid and distribution | Generation and retailing |
| Gas | Pipelines and distribution | Extraction, storage and retailing |
| **Telecoms** | | |
| Fixed line network | Local network and switches | Long distance and telecom services |
| Mobile | Call termination | Telecom services |
| **Transport** | | |
| Road | Physical network | Transport services |
| Rail | Tracks and stations | Passenger and freight services |
| Maritime/water | In some cases, ports | Transport services |
| Air | In some cases, airports | Transport services |

**Table 5. Estimated effects of regulation on investment at the firm level**

Data for 18 countries covering the period 1983-2005

The estimated empirical model is:

$$(I/K)_{Icst}=\beta_1(I/K)_{ics,t-1}+\beta_2(I/K)^2_{ics,t-1}+\beta_3(Y/K)_{ics,t-1}+\beta_4(CF/K)_{ics,t-1}+\beta_5UC_{cs,t-1}+\beta_6IRA_{cs,t-1}+\beta_7ETCR_{cs,t-1}+\gamma_{ct}+\varepsilon_{icst},$$

Panel A. Cross country panel evidence

| Dependent variable: Investment-to-capital ratio | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Investment-to-capital ratio (t-1) | 0.136 *** | 0.138 *** | 0.139 *** | 0.139 *** | 0.139 ** |
| Square of investment-to-capital ratio (t-1) | -0.002 *** | -0.002 *** | -0.003 *** | -0.002 *** | -0.003 |
| Output-to-capital ratio (t-1) | 0.010 *** | 0.023 *** | 0.023 *** | 0.022 *** | 0.025 *** |
| Cashflow-to-capital ratio (t-1) | 0.000 | 0.002 *** | 0.002 *** | 0.002 *** | 0.002 |
| Tax adjusted User cost (t-1) | 2.786 *** | 2.750 ** | 3.377 *** | 3.004 ** | 2.070 |
| Independent regulator (t-1) | 0.006 | -0.003 | 0.008 | 0.005 | |
| Barriers to entry (t-1) | | -0.008 *** | | | |
| Public ownership (t-1) | | | -0.009 | | |
| Overall sector regulation (t-1) | | | | -0.012 *** | |
| Barriers to entry (t-1) * Electricity | | | | | -0.006 *** |
| Barriers to entry (t-1) * Gas | | | | | -0.021 *** |
| Barriers to entry (t-1) * Railways | | | | | 0.001 |
| Barriers to entry (t-1) * Telecoms | | | | | -0.010 * |
| Country*year effects | Yes | Yes | Yes | Yes | Yes |
| R-squared | 0.093 | 0.122 | 0.118 | 0.120 | 0.128 |
| Observations | 4575 | 3623 | 3623 | 3623 | 3688 |

Panel B. Sectoral evidence: Vertical integration

| Dependent variable: Investment-to-capital ratio | Electricity | Gas | Railway |
|---|---|---|---|
| Investment-to-capital ratio (t-1) | 0.282 *** | 0.515 *** | 0.552 ** |
| Square of investment-to-capital ratio (t-1) | -0.126 | -0.210 *** | -0.749 |
| Output-to-capital ratio (t-1) | 0.036 *** | 0.033 * | 0.179 |
| Cashflow-to-capital ratio (t-1) | 0.025 | 0.055 ** | 0.088 |
| Vertical Integration (t-1) | -0.016 *** | -0.002 | 0.033 |
| Country*year effects | Yes | Yes | Yes |
| R-squared | 0.307 | 0.338 | 0.595 |
| Observations | 1464 | 1156 | 196 |

Panel C. Sectoral evidence: independent Regulator

| Dependent variable: Investment-to-capital ratio | Electricity | Gas | Railway | Telecoms |
|---|---|---|---|---|
| Investment-to-capital ratio (t-1) | 0.402 *** | 0.511 *** | 0.629 ** | 0.107 *** |
| Square of investment-to-capital ratio (t-1) | -0.202 ** | -0.220 *** | -0.865 | -0.002 *** |
| Output-to-capital ratio (t-1) | 0.003 | 0.030 * | 0.182 | 0.006 |
| Cashflow-to-capital ratio (t-1) | 0.044 ** | 0.076 *** | 0.142 | 0.000 |
| Independent regulator (t-1) | 0.010 * | 0.008 | 0.009 | 0.112 *** |
| Country*year effects | Yes | Yes | Yes | Yes |
| R-squared | 0.340 | 0.322 | 0.608 | 0.273 |
| Observations | 1618 | 1297 | 144 | 1041 |

Note: In the estimated empirical model *(i)* $(I/K)_{icst}$ denotes the investment-to-capital ratio; *(ii)* $(I/K)_{ics,t-1}$ its lag; *(iii)* $(I/K)^2_{ics,t-1}$ its squared lag; *(iv)* $(Y/K)_{ics,t-1}$ the lag of the output-to-capital ratio; *(v)* $(CF/K)_{ics,t-1}$ the lag of the cashflow-to-capital ratio; *(vi)* $UCtax_{cs,t-1}$ the lag of the tax adjusted user cost; *(vii)* IRA a variable capturing whether the sectoral regulator is independent; *(viii)* ECTR indicators of barriers to entry, public ownership and overall sector regulation in the network industries and $\gamma_{ct}$ country-year fixed effects. Robust standard errors corrected for clustering at the country-sector level in parentheses. * denotes significant at 10%; ** at 5%; *** at 1%

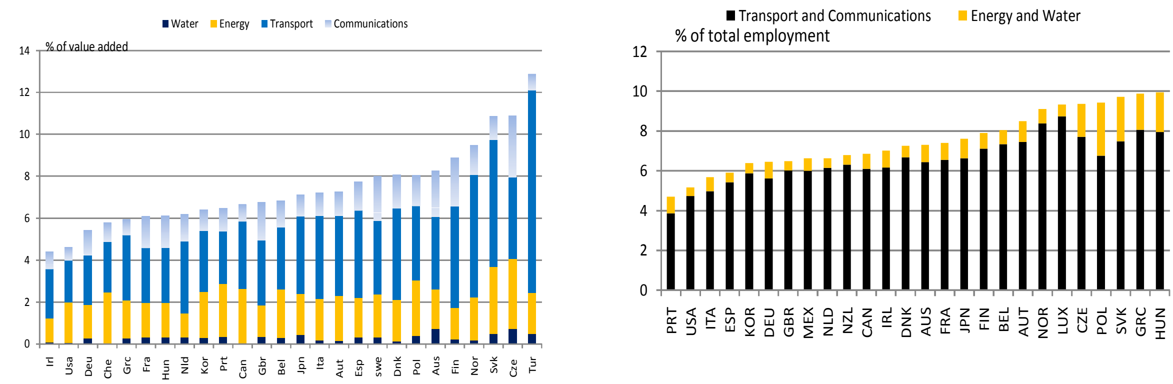
**Table 6. Estimated effects of regulation on investment at the sectoral level**

| | OLS | | Bayesian averaging | |
|---|---|---|---|---|
| | coefficient | p-value | posterior inclusion probability | posterior mean conditional on inclusion |
| Investment (-1) | 0.865 | 0.000 | 1 | 0.880 |
| Real interest rate | 0.009 | 0.130 | 0.654 | 0.006 |
| Barriers to entry | -0.046 | 0.008 | 0.998 | -0.043 |
| Public ownership | 0.004 | 0.701 | 0.151 | 0.000 |
| Reg. independence | -0.026 | 0.556 | 0.184 | -0.004 |
| Incentive regulation | -0.003 | 0.866 | 0.141 | 0.000 |
| No price regulation | -0.016 | 0.133 | 0.975 | -0.015 |
| Incentive*Reg. independence | 0.060 | 0.002 | 0.996 | 0.053 |
| Adj. R-squared | 0.741 | | | |
| regressions run | 1 | | 256 | |
| prior inclusion prob. | | | 0.5 | |

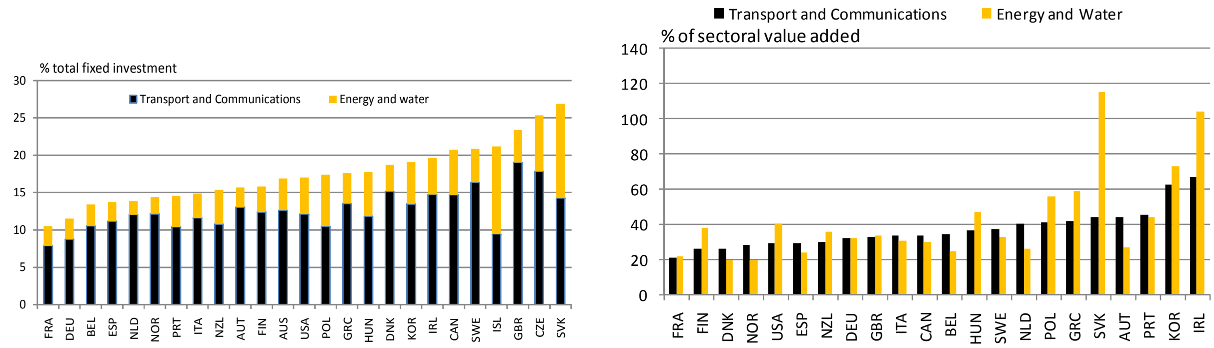
Notes: The OLS regression used country and industry fixed effects and included all variables. Bayesian averaging refers to the Bayesian averaging of classical estimates. All possible combinations (256) of the listed variables were estimated. The posterior inclusion probability is the sum of the inclusion probabilities estimated for each combination. If the posterior inclusion probability is higher than the prior inclusion probability of 50%, one can conclude that the specific variable will be included in the model. The posterior mean conditional on inclusion is the probability weighted coefficient estimate.

**Figure 1. Network infrastructure sectors**

A. Sectoral value added as a share of total value added in 2000 or latest available year (LHS) and Employment relative to total employment, average over last 5 years available (RHS)




B. Sectoral investment as a share of total fixed investment and relative to sectoral value added (Averages over last 5 years available)

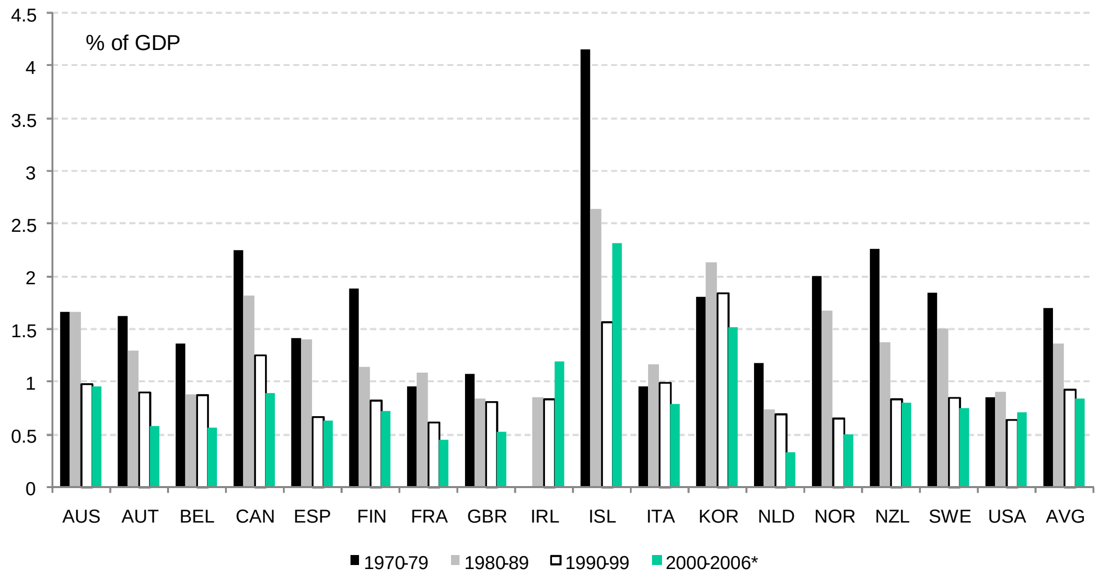



Note: The latest years used in calculating the averages were 1999 to 2003, with the exception of Australia, Denmark New Zealand and Policy for which 1996 to 2001 were used and France, the Slovak Republic and Spain for which 1997 to 2002 were used. The latest available year was 2000 with the exception of Norway and Switzerland (2001), Australia, Greece and Portugal (1999), Ireland and Turkey (1998), and New Zealand (1995)

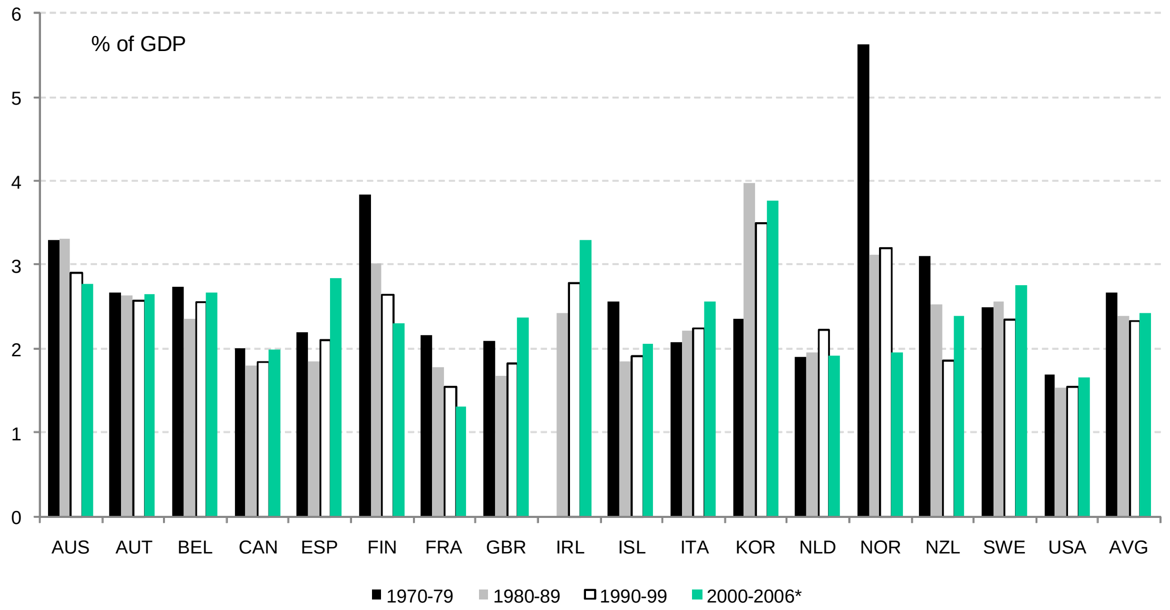
Source: OECD Input Output tables, STAN

**Figure 2. Investment in infrastructure sectors**

A. Electricity, Gas and Water

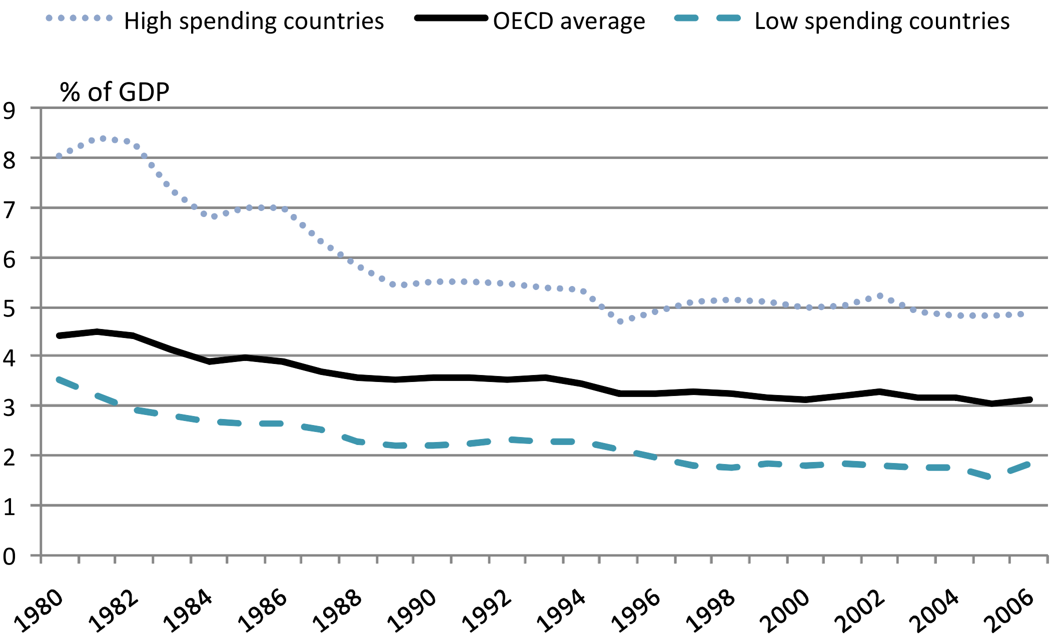



B. Transport, Storage and Communications




Source: STAN

**Figure 3. Government gross fixed capital formation**



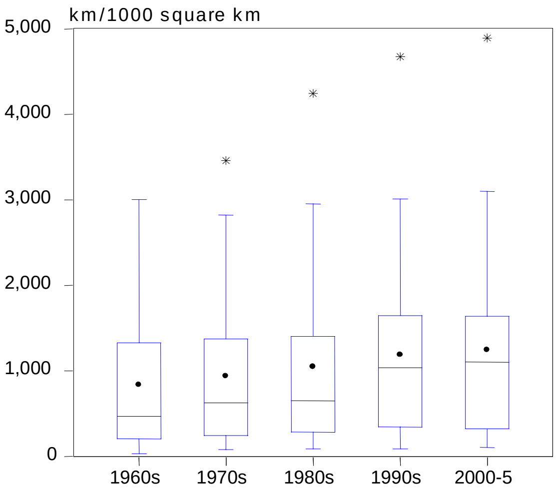

Note: The series for high and low public spending are the means of public gross fixed capital formation as a share of GDP for 5 countries, which on average over the period had the highest or lowest public investment rates. The high-spending countries are Japan, Korea, Mexico, New Zealand and Turkey. The low-spending countries are Australia, Belgium, Denmark, Germany, and the United Kingdom.

Source: SNA

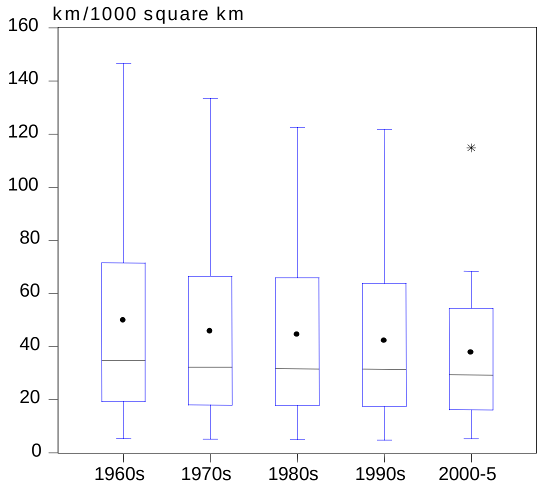
**Figure 4. Physical measures of infrastructure provision**

Box plots of selected OECD countries from 1970 to 2005,

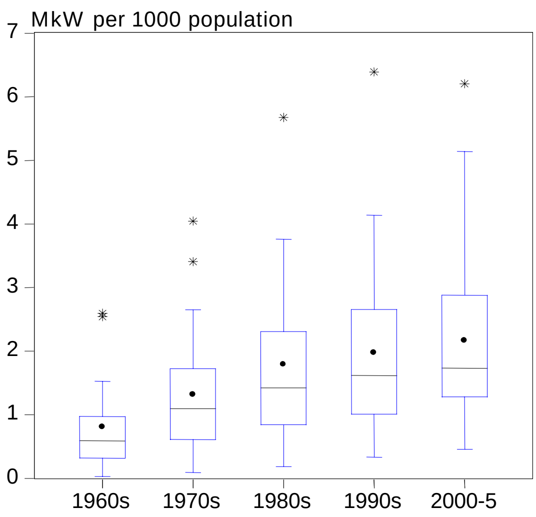
A. Road density
(29 countries)



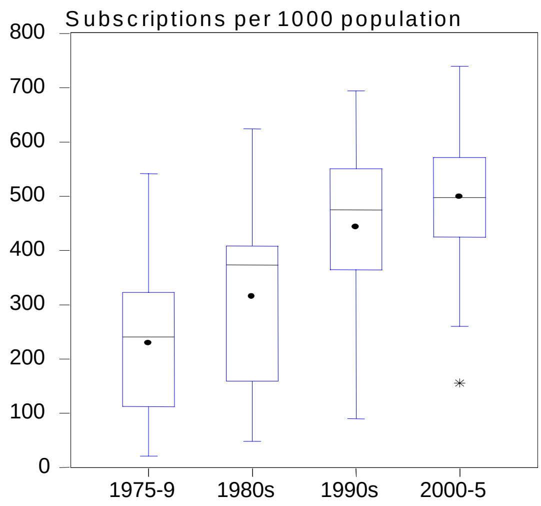

B. Rail track density
(23 countries)




C. Electricity generation capacity
(28 countries)




D. Fixed-line and mobile subscribers
(30 countries)




Note: The box plots display the box that covers the observations between the 1st and 3rd quartiles, as well as the median (the horizontal bar) and the mean (the point). The whiskers extending from the box give the range that captures the observations which lie within 1.5 times the inter-quartile range from the 1st and 3rd quartiles. Points outside this range are considered outliers.

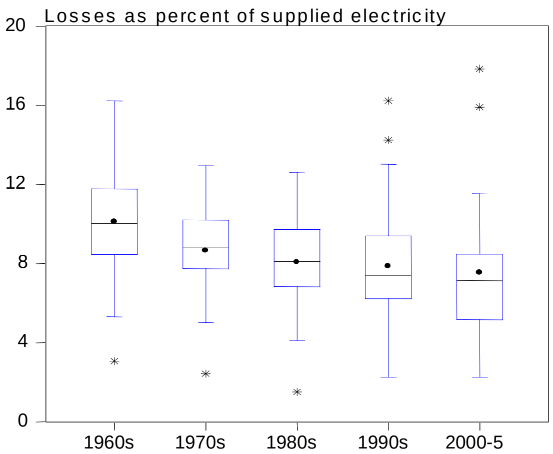
Source: IRF/ECMT, ITU, Eurostat, OECD

**Figure 5. Water supply and sewerage indicators**

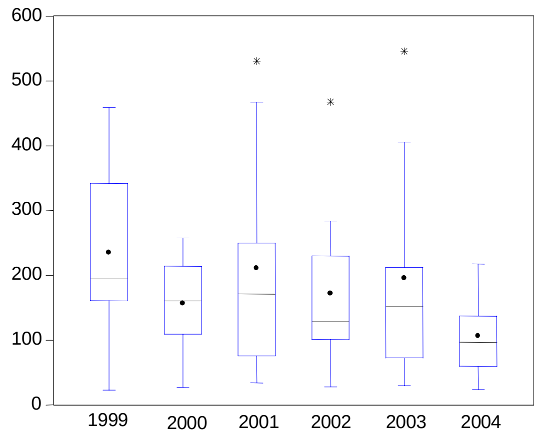

Source: OECD Environmental Compendium, March 2007

**Figure 6. Developments in electricity systems**

A. Transmission system distribution losses;
(26 countries in 1960s, 30 countries thereafter)

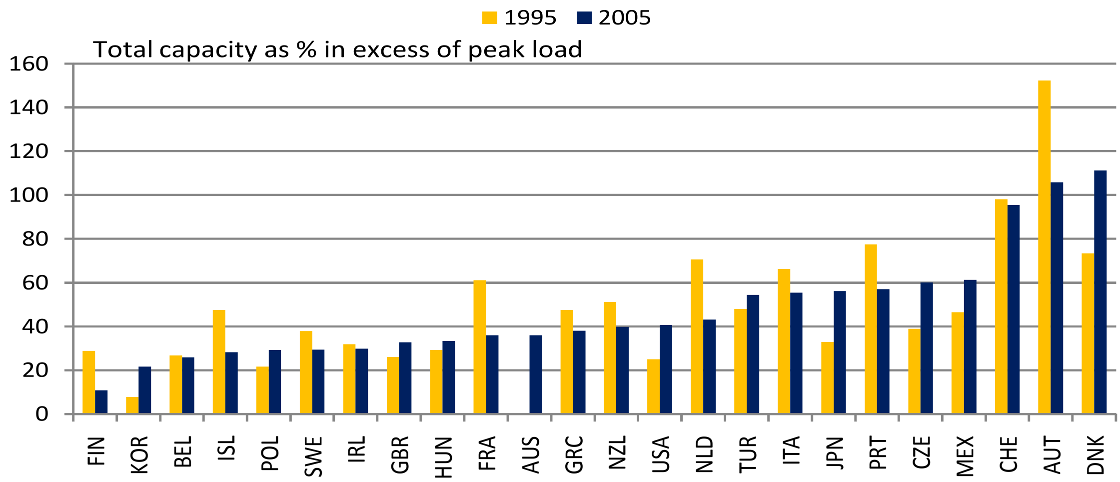



B system average interruption duration index (SAIDI)
(10 countries)




C. Generation capacity reserve margins

Total capacity as a percent in excess of peak load



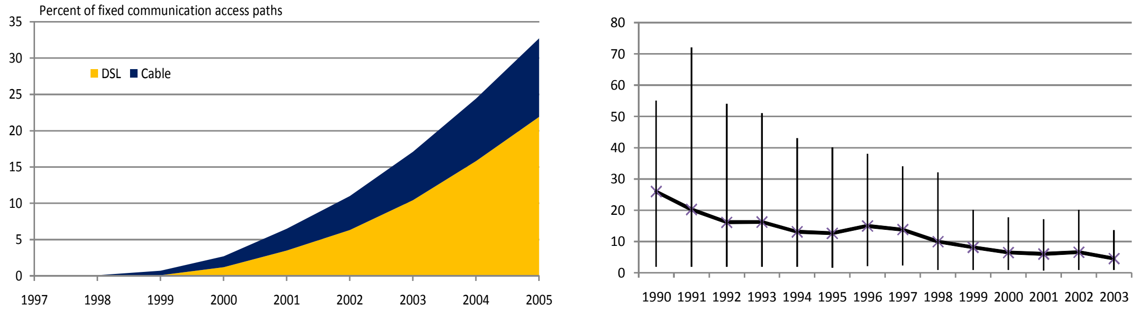

Note: The box plots display the box that covers the observations between the 1st and 3rd quartiles, as well as the median (the horizontal bar) and the mean (the point). The whiskers extending from the box give the range that captures the observations which lie within 1.5 times the inter-quartile range from the 1st and 3rd quartiles. Points outside this range are considered outliers and marked by an asterisk.

The countries included in panel B are Finland, France, Hungary, Italy, Ireland, the Netherlands, Portugal Spain, Sweden and the United Kingdom.

Source: IEA Electricity Generation and Capacity 2005, Electricity Information 2007

**Figure 7. Developments in telecommunications networks**

Broadband subscriptions as a percentage of fixed communications access paths (LHS)
Faults per 100 lines per year in selected OECD countries (RHS)




Note: in the right hand panel the line gives the average number of faults, while the bars give the range from the country with the lowest number of faults to the country with the highest number of faults.

Source: OECD Telecommunications Outlook, 2007; Telecommunications database 2005.

**Figure 8. Factors affecting investment in infrastructure**

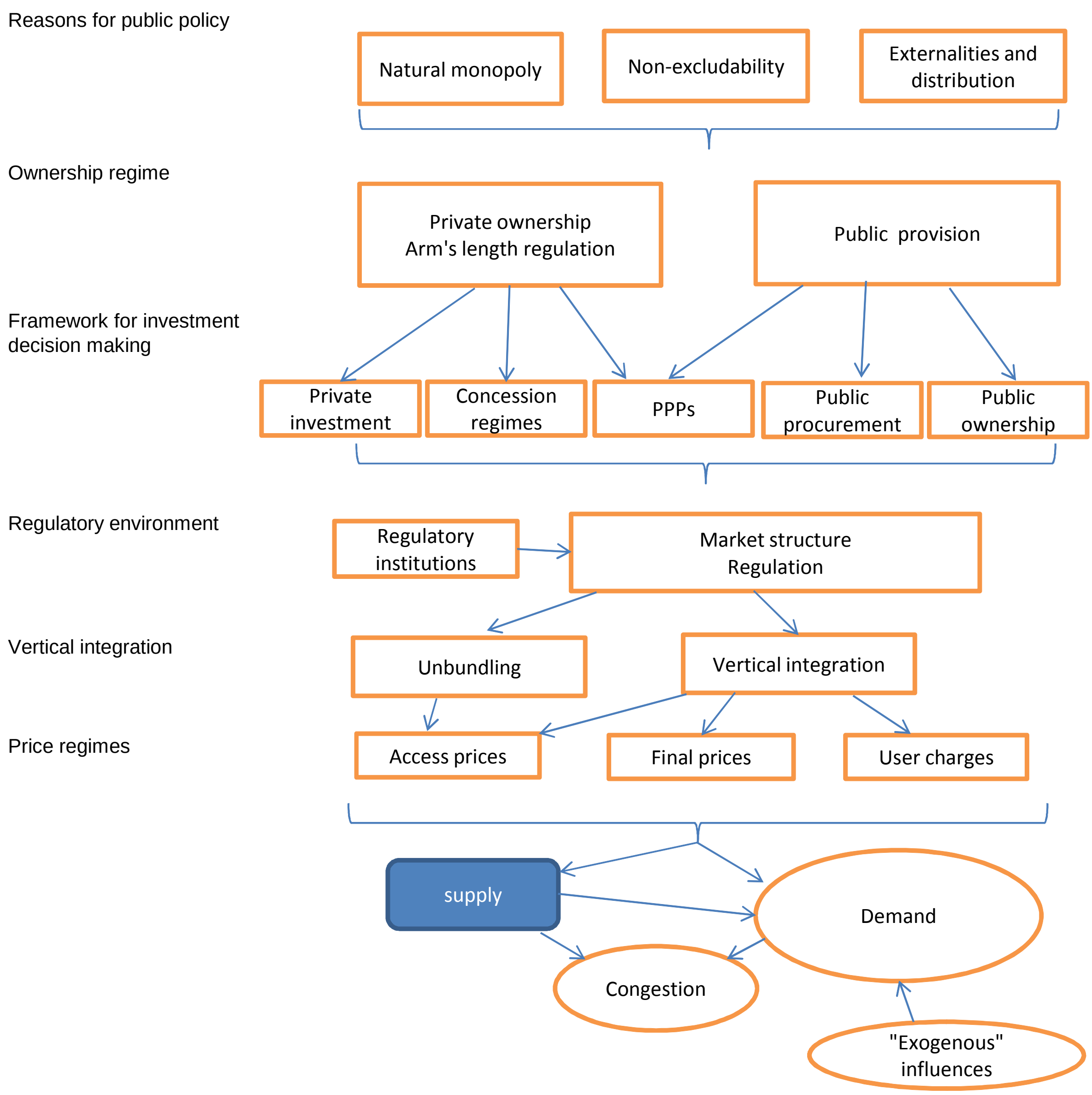


**Figure 9. Infrastructure coefficient estimates from growth regressions**

Coefficient estimate and 90% confidence intervals

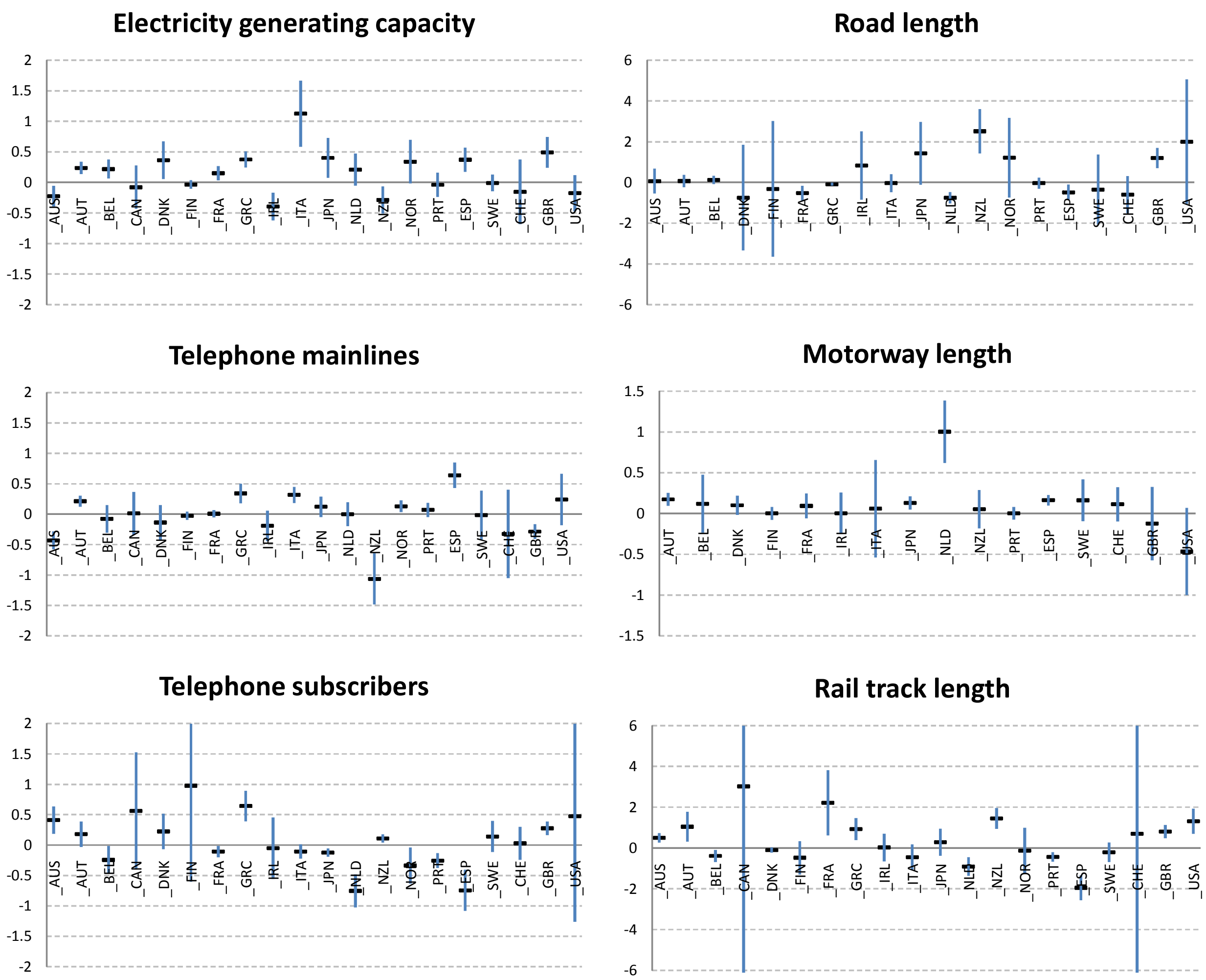
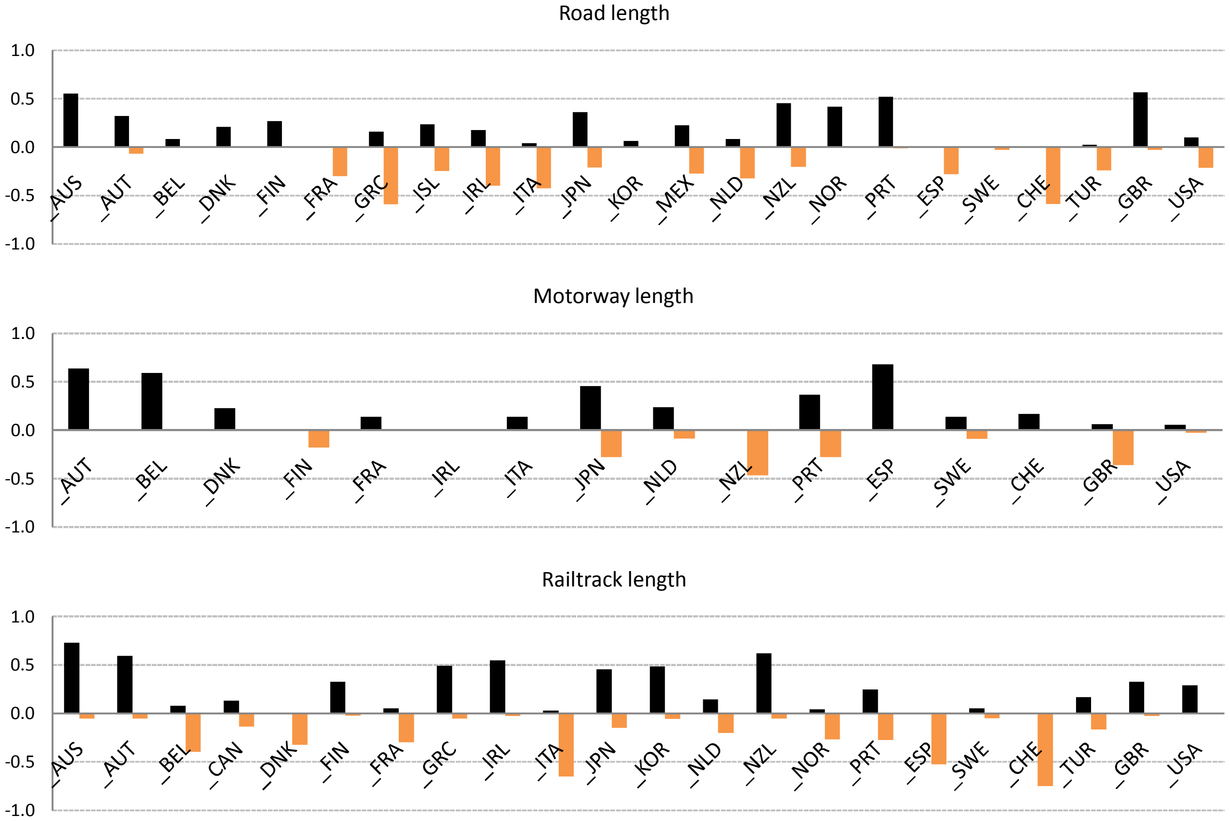


**Figure 10. Share of significant positive and negative infrastructure coefficients in growth regressions**

PANEL A: Transportation, per capita

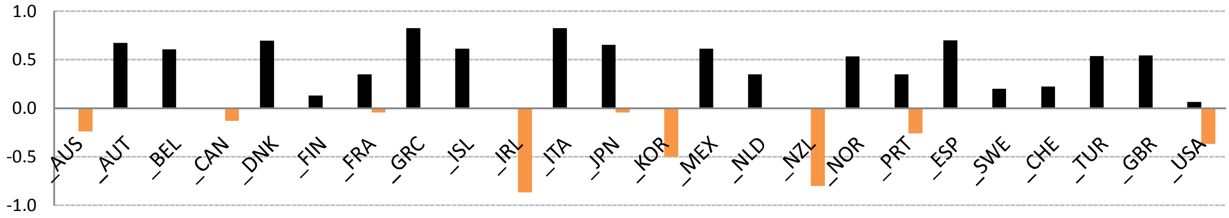



Note: The black bars represent shares of significant (at 90%) positive coefficients across different specifications. The lighter coloured negative bars give the share of significant negative coefficients across the different specifications.

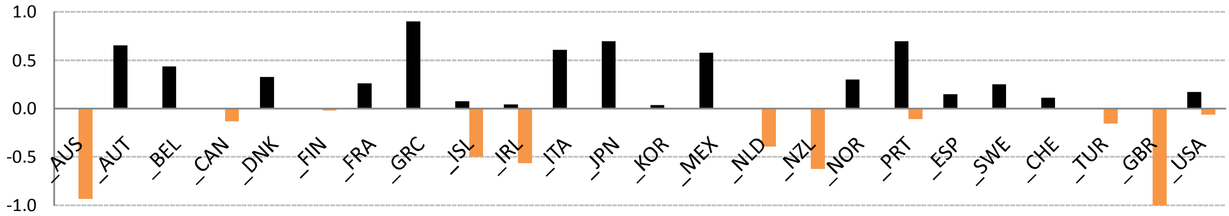
**Figure 10 (cont)**

PANEL B: Energy and Communications, per capita.

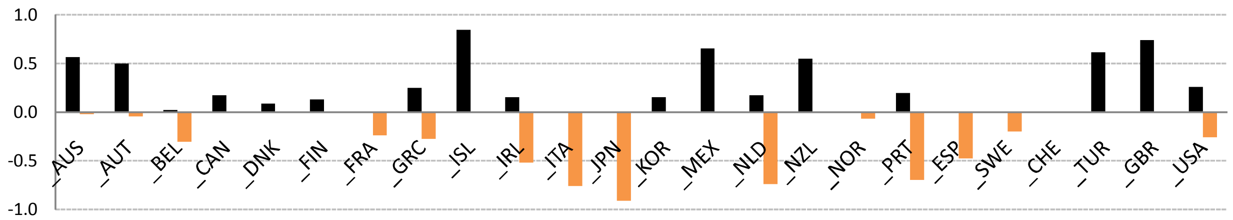
Electricity generation capacity




Telephone mainlines




Telephone subscriptions (fixed+mobile)

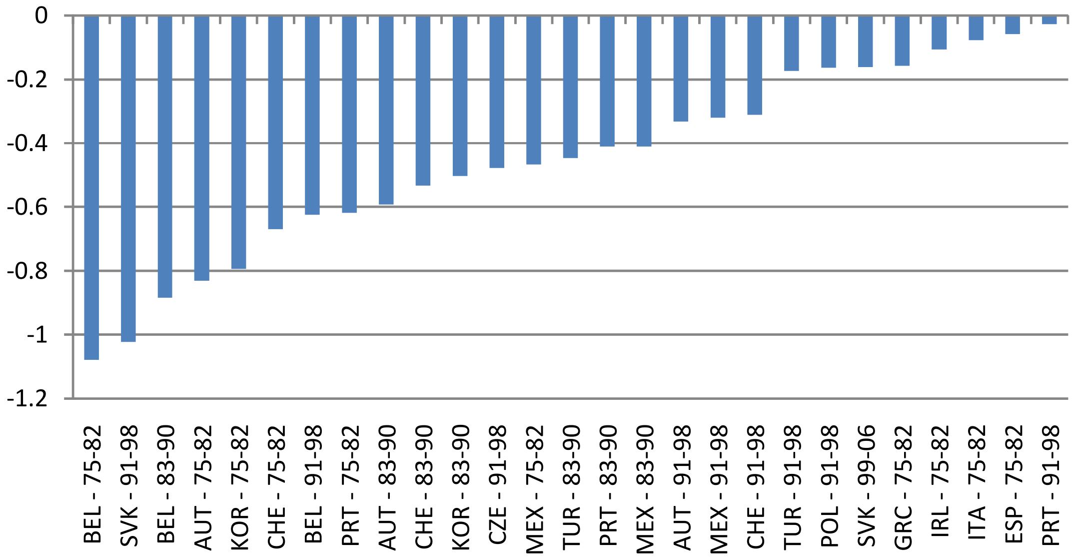



Note: The black bars represent shares of significant (at 90%) positive coefficients across different specifications. The lighter coloured negative bars give the share of significant negative coefficients across the different specifications.

The different specifications included using different measures of investment (total and private) and by including additional control variables such as human capital, trade openness and tax revenues to the basic specification.

**Figure 11. Countries with relatively low levels of infrastructure provision**

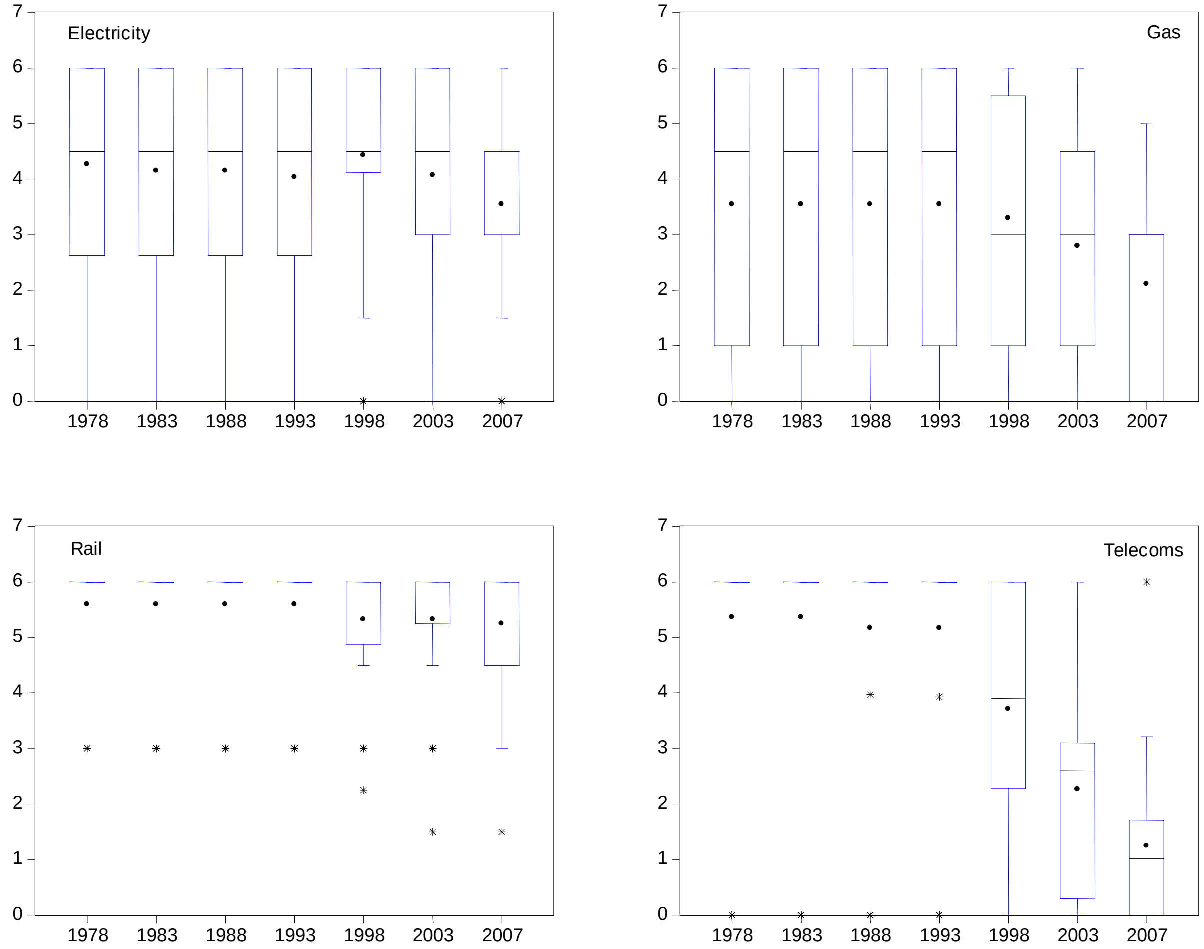
Normalised distance from the "threshold" of infrastructure provision beyond which infrastructure investment in the electricity and telecommunications sectors is estimated to have the highest impact on GDP in the periods: 1975-1982, 1983-1990, 1991-1998, and 1999-2006




Note: This figure gives the distance of countries from the "threshold" between regimes, which is measured by the principal component of electricity and telecommunication investment (the actual threshold value is -0.74 and the range of values is between -1.69 to 2.71). The numbers following the country abbreviation gives the 8-year period of this finding.

**Figure 12. The declining importance of public ownership in network utilities**

(scale 0-6 from lowest to highest degree of public ownership)

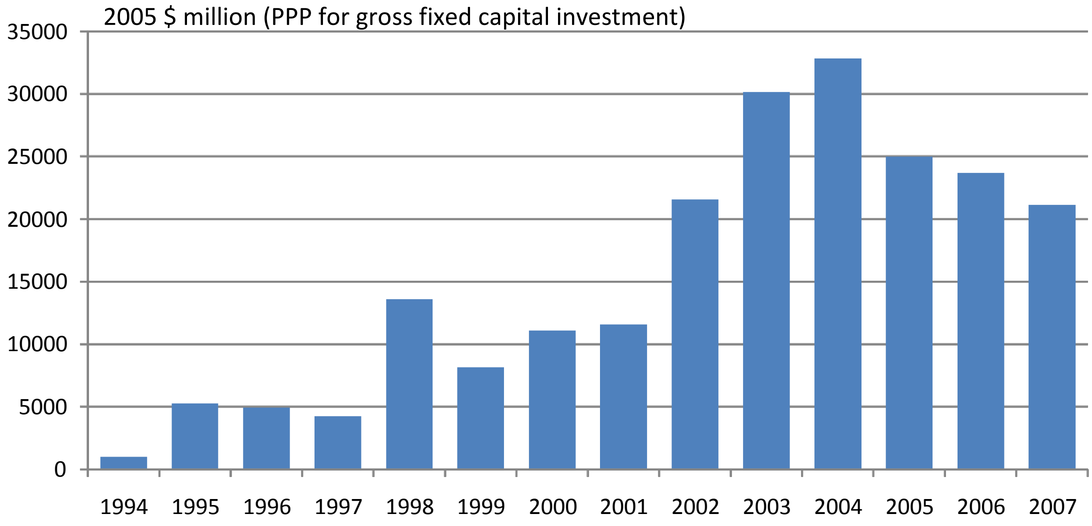



Note: These plots display the box that covers the observations between the 1st and 3rd quartiles, as well as the median (the horizontal bar) and the mean (the point). The whiskers extending from the box give the range that captures the observations which lie within 1.5 times the inter-quartile range from the 1st and 3rd quartiles. Points outside this range are considered outliers, which are marked by an asterisk.

In the rail and telecommunication utilities, public ownership was predominant until the early 1990s in almost all countries.

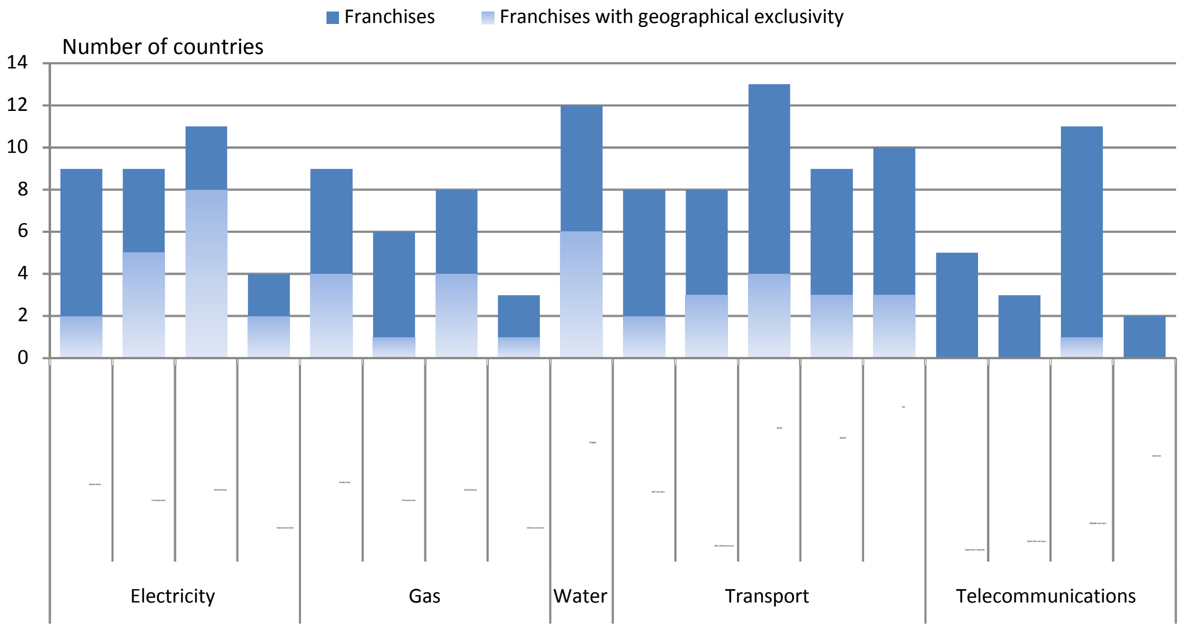
Source: OECD

**Figure 13. Value of announced public-private partnership deals, 1994-2007**




*Source*: Dealogic Projectware database (data extracted 19/2/08)

**Figure 14. Prevalence of Franchise and Concessions in OECD economies**

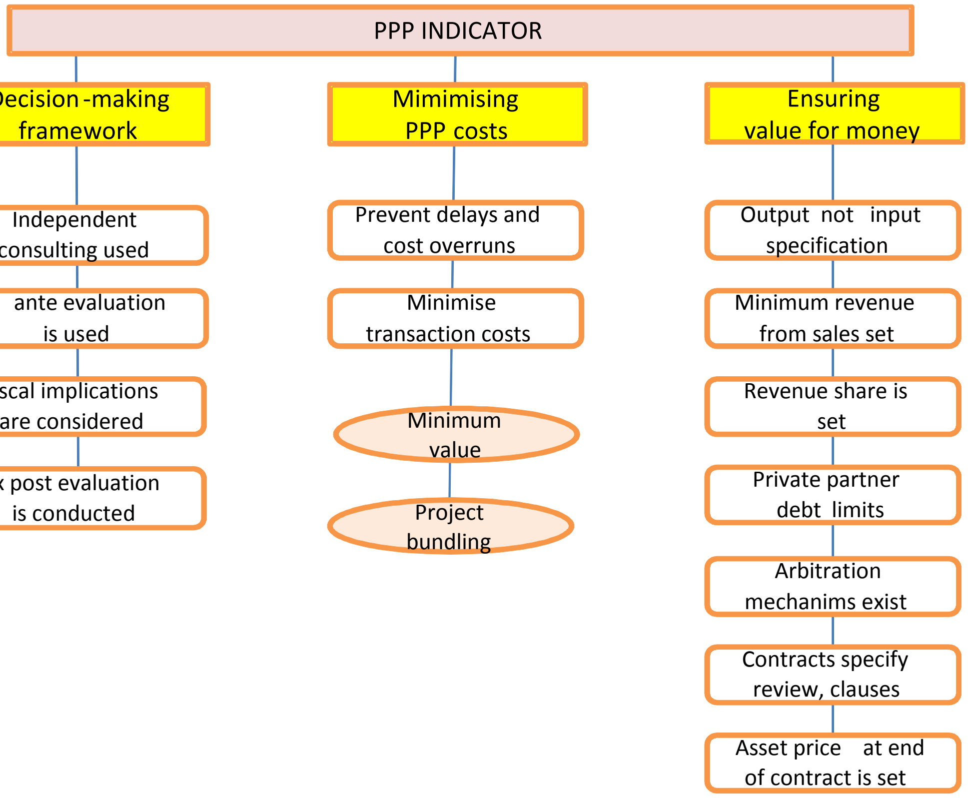



Note : 24 countries out of the 27 countries responding to the questionnaire noted that private participation in the form of franchises or concessions was permitted.

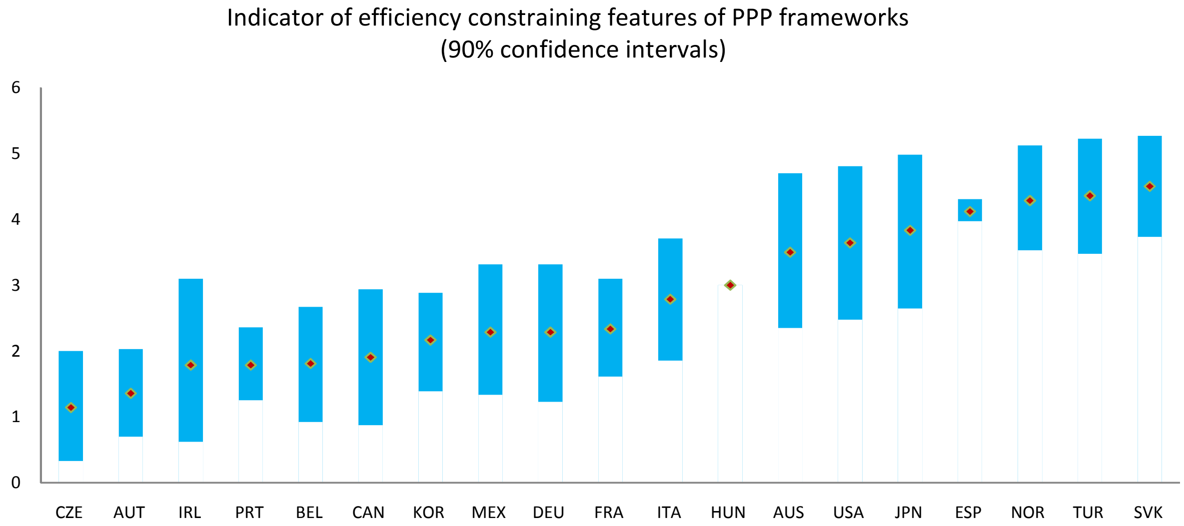
Source: OECD Infrastructure investment questionnaire responses

**Figure 15. Indicators for Public-Private Partnerships**

Panel A. Indicator structure



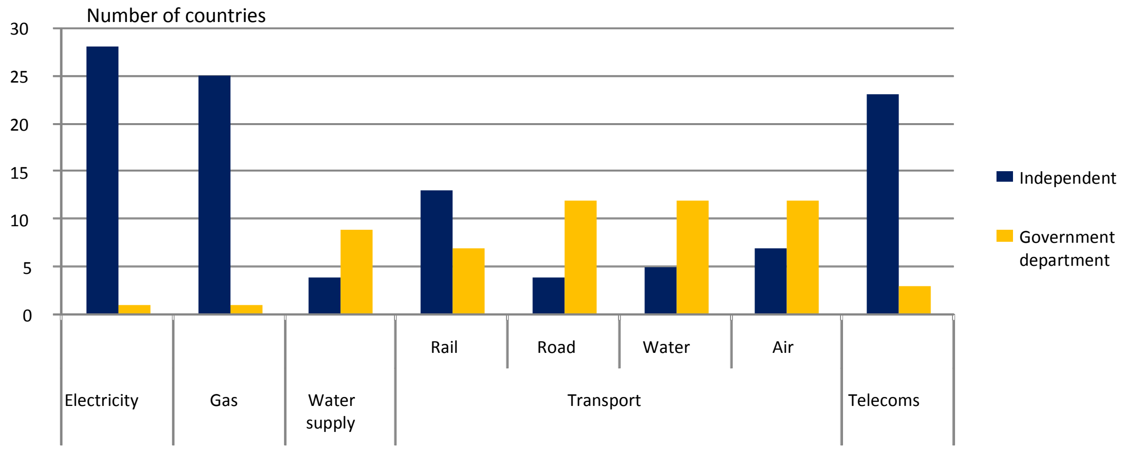

Panel B. Indicator values
(scale 0-6 from most to least conducive to efficient investment)




Note: The indicator is calculated for the 19 countries providing a sufficient number of answers on PPPs in the infrastructure investment questionnaire. The figure gives the average indicator value and 90% confidence intervals, which are calculated using random weights.

**Figure 16. Independence of the regulator**

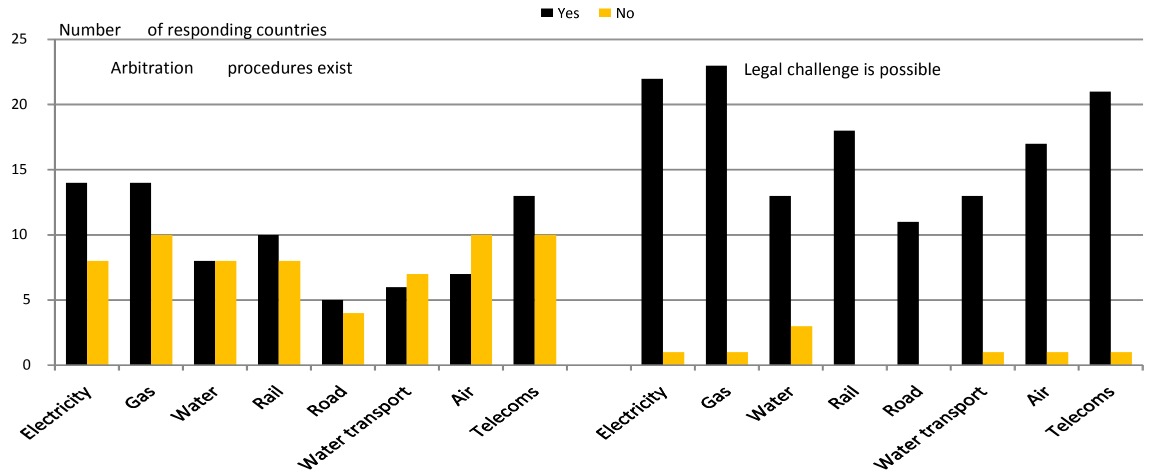
Panel A. Questionnaire responses



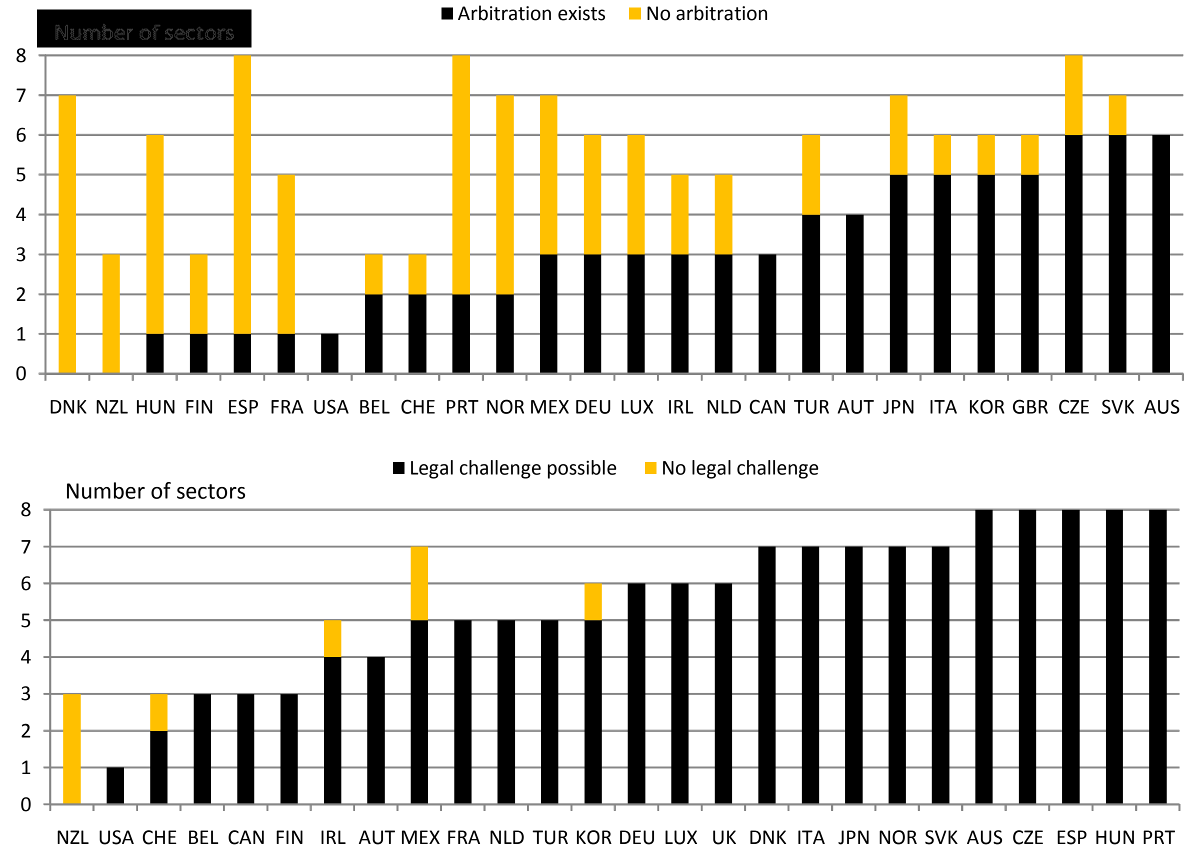

Source: Questionnaire responses

**Figure 17. Dispute settlement with the regulator**

Panel A: By sector




Panel B: By country

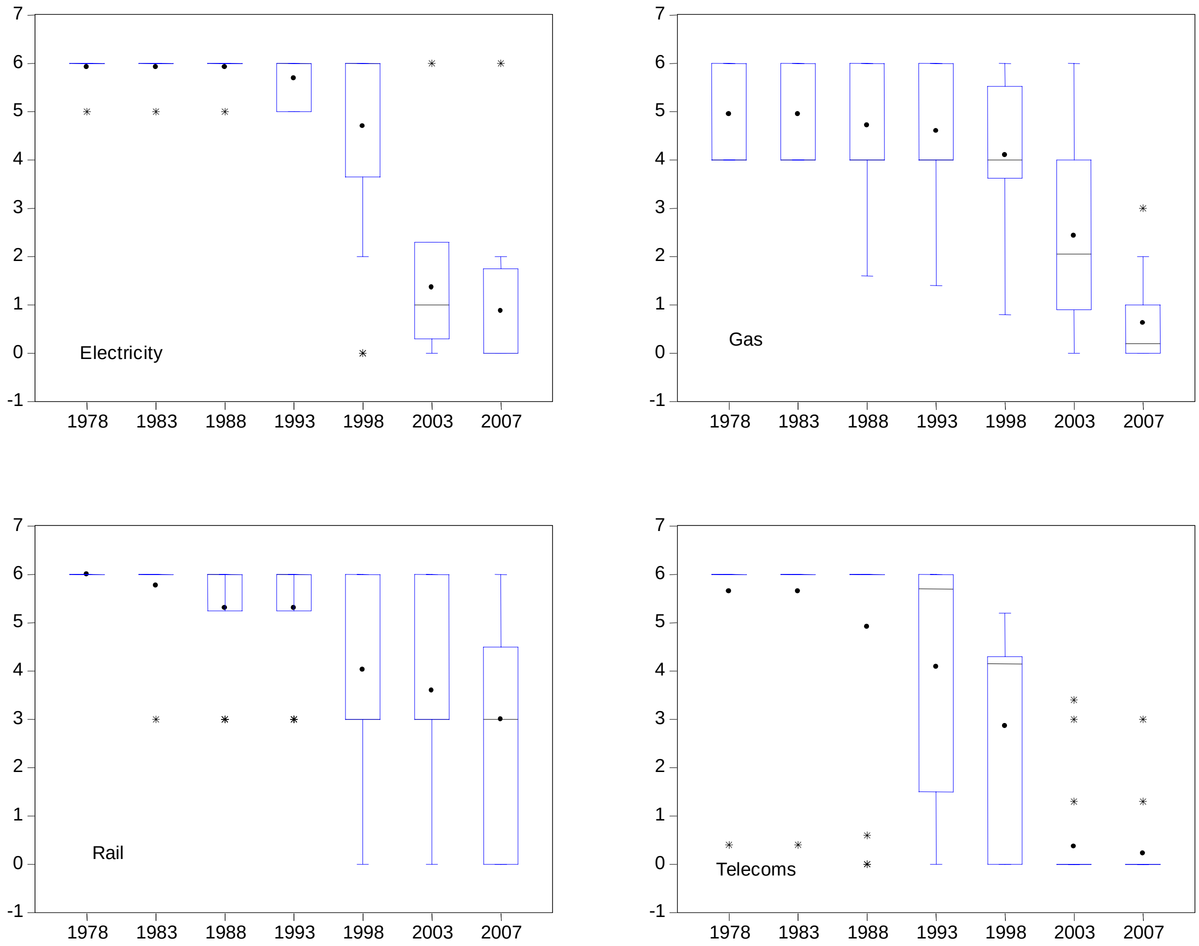



Note: The number of sectors is the number for which responses were given (maximum = 8).

Source: Questionnaire responses

**Figure 18. Barriers to entry in the network industries**

(Scale 0-6 from lowest to highest degree of barriers to entry)




Note: The box plots display the box that covers the observations between the 1st and 3rd quartiles, as well as the median (the horizontal bar) and the mean (the point). The whiskers extending from the box give the range that captures the observations which lie within 1.5 times the inter-quartile range from the 1st and 3rd quartiles. Points outside this range are considered outliers, which are shown as an asterisk.

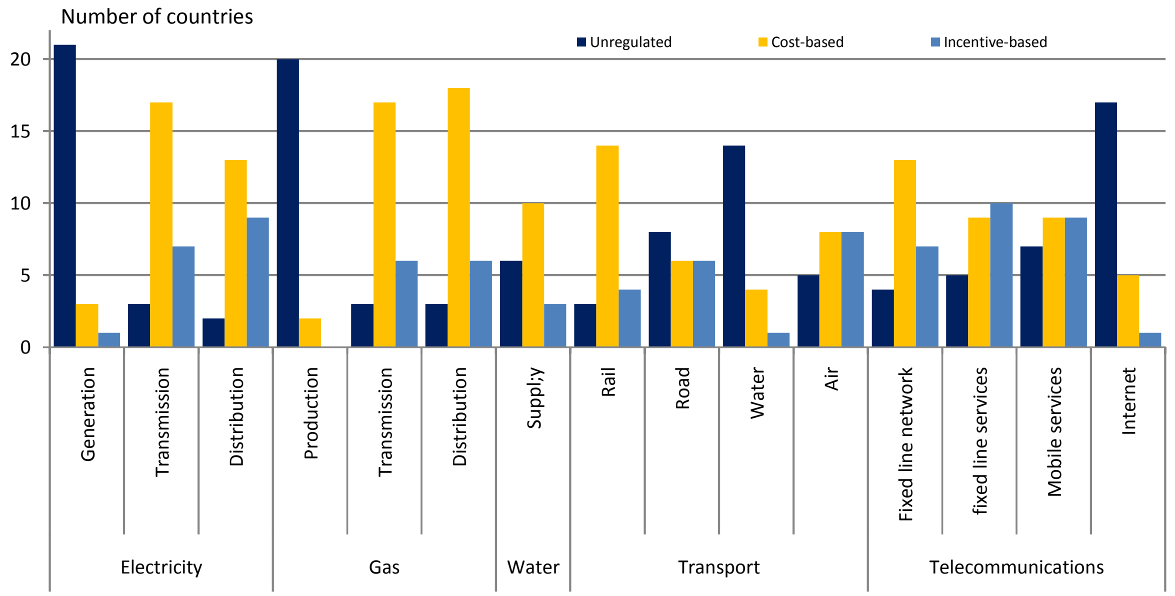
The Barriers to Entry account for policies such as whether there is third part access regime in the energy sector and whether entry is free or franchised in the rail and telecoms sector. See Conway and Nicoletti (2006) for a full description.

The figures show that barriers to entry were high in the electricity, rail and telecoms sectors prior to the beginning of the 1990s.

Source: OECD Indicators

**Figure 19. Pricing regimes**

In late 2007, early 2008

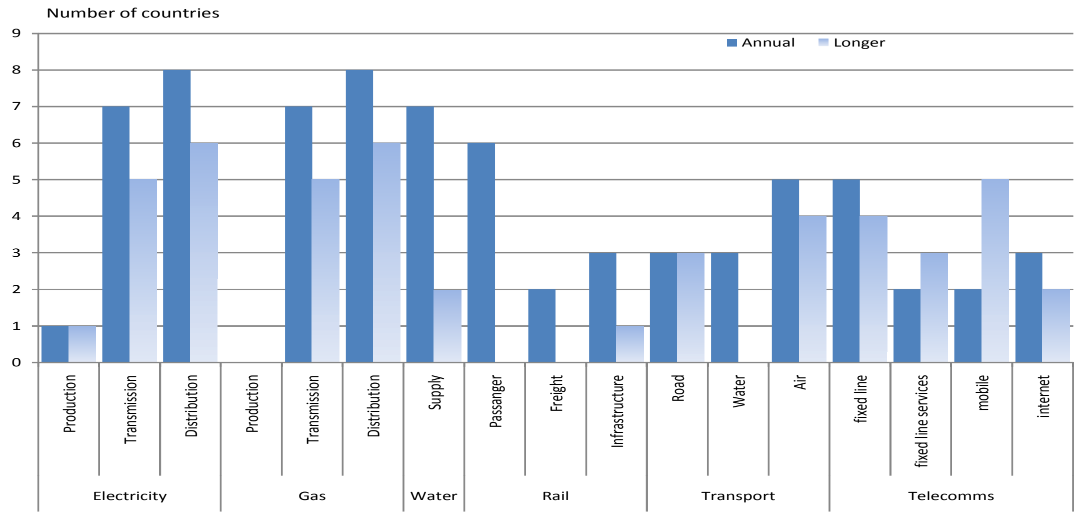



Note: costs-based pricing allows prices to change to reflect the costs of investment, whereas using incentive-based pricing policies prices do not vary in response to investment decisions.

Source: Questionnaire responses

**Figure 20. Frequency of price reviews**

In late 2007, early 2008

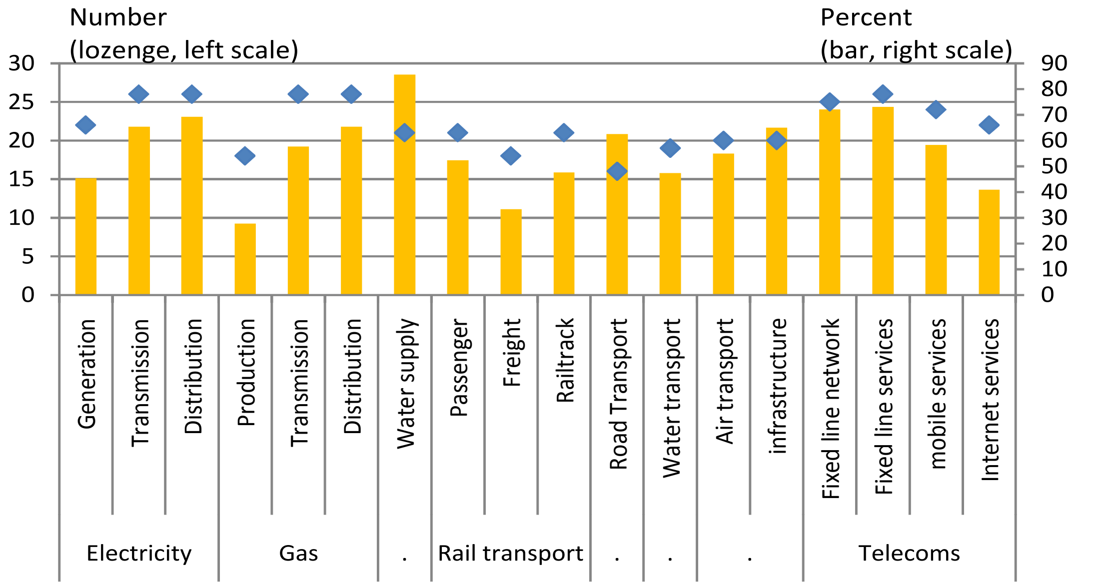



Note: The price reviews covered in this figure include both final prices and access prices.

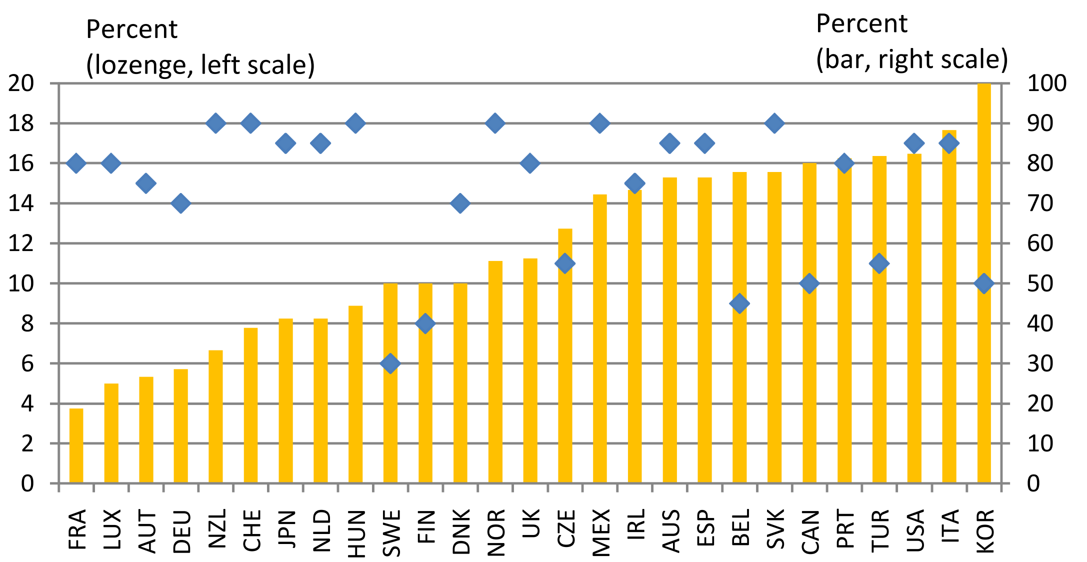
Source: Questionnaire responses

**Figure 22. The use of quality standards**

A. By sector




B. By country



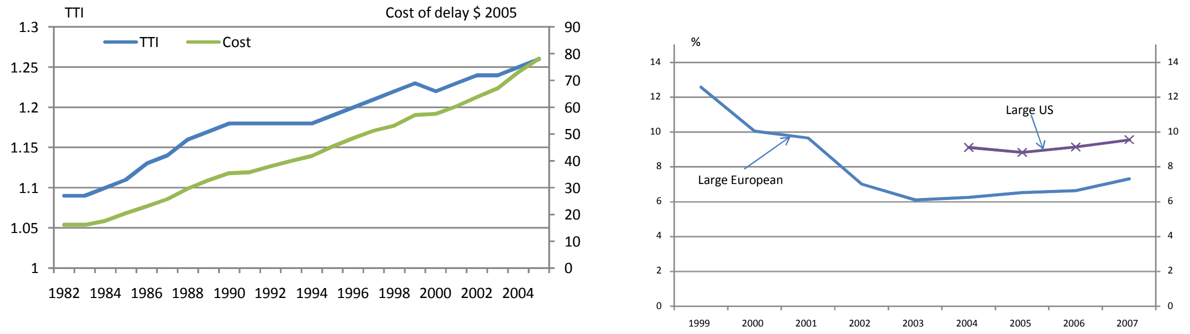

Note: The top panel shows the percentage of countries where the sector regulator sets quality standards. The number of countries responding for each sector is also shown. The lower panel gives the percentage of sectors that each country reported for that the regulator sets quality standards. The number of sectors that each country responded for is also given

Source: Questionnaire responses

**Figure 23. Road congestion and flight delays**

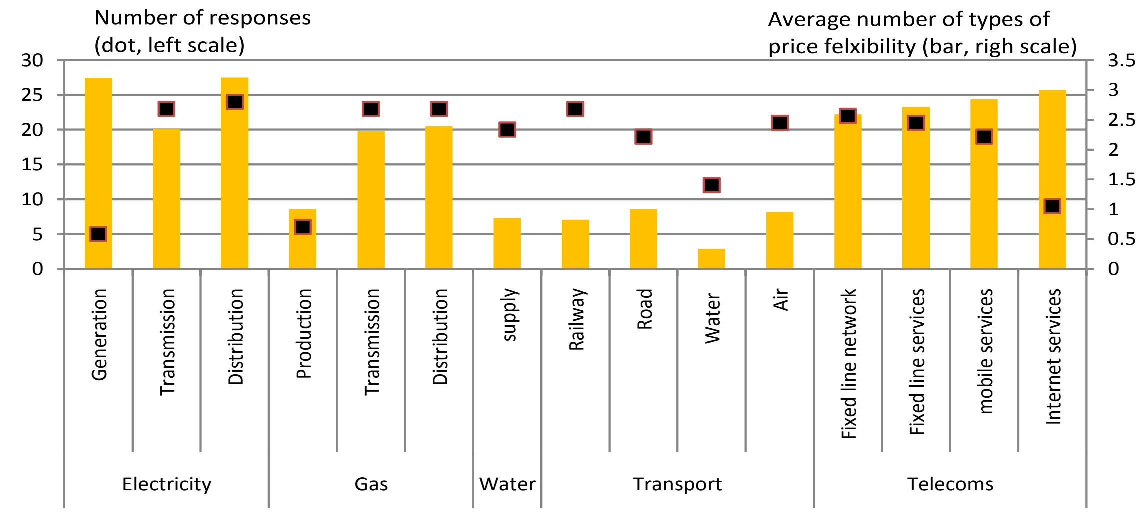
Travel time index (TTI) and estimated costs of road congestion in the United States (LHS panel)

Percent of flights delayed due to airport or air traffic control related causes (RHS panel)
Flights within Europe for major European flights and all flights by major US carriers

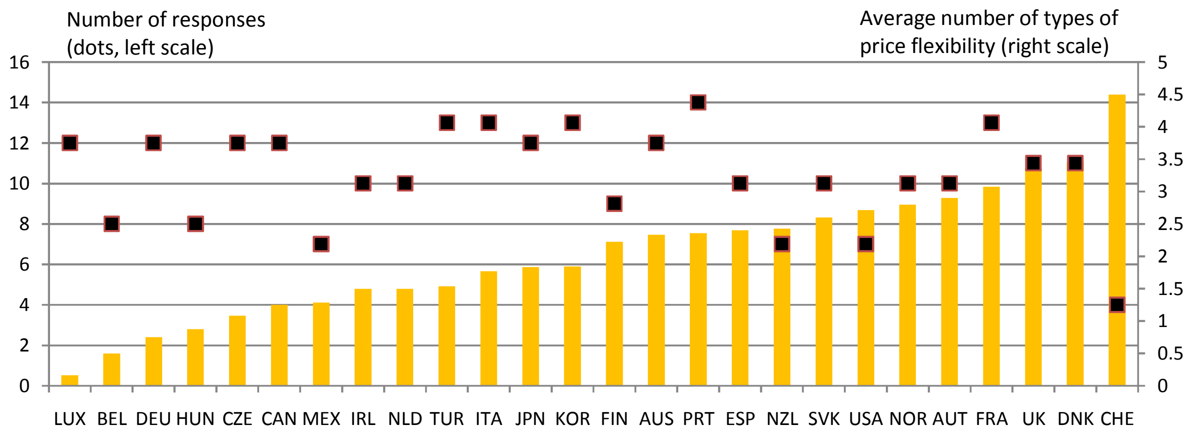



Source: Schrank and Lomax (2007); BTS RITA database, Association of European Airlines annual reports (various years)

**Figure 24. Price flexibility in network industries**




Panel B: By country




Note: The top panel gives the average number of types of price flexibility (out of a possible 6) for each sector (bars) and also gives the number of countries responding for each sector (dots). The lower panel gives the information by country showing on average how many types of price flexibility for the 15 different sectors (bars). The number of sectors that each country responded for is also given (dots).

The types of price flexibility are whether prices can vary: during the day to reflect congestion; over the year to reflect fluctuations in seasonal demand; over space to reflect difference in demand, the distance to the customer and the costs of transmission, as well as the type of customer:

Source: questionnaire responses

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