Regulation, Market Structure and Performance in Telecommunications

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REGULATION, MARKET STRUCTURE AND PERFORMANCE IN TELECOMMUNICATIONS

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by
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ABSTRACT/RÉSUMÉ

The paper uses an original international database on regulation, market structure and performance in the telecommunications industry to investigate the effects of entry liberalisation and privatisation on productivity, prices and quality of service in long-distance (domestic and international) and mobile cellular telephony services in 23 OECD countries over the 1991-1997 period. The data on regulation and market structure is analysed by means of factor analysis techniques in order to group countries according to their policy and market environments. Controlling for technology developments and differences in economic structure, panel data estimates show that prospective competition (as proxied by the number of years remaining to liberalisation) and effective competition (as proxied by the share of new entrants or by the number of competitors) both bring about productivity and quality improvements and reduce the prices of all the telecommunications services considered in the analysis. No clear evidence could be found concerning the effects on performance of the ownership structure of the industry (as proxied by both the public share in the PTO and years remaining to privatisation).

JEL Classification: C23, K23, L5, L96, L11, L32
Keywords: Models with panel data, regulated industries and administrative law, regulation and industrial policy, telecommunications, market structure, firm strategy and market performance, public enterprise

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A partir d'une base de données originale sur la réglementation, la structure de marché et les performances dans l'industrie des télécommunications, ce document étudie les effets de la libéralisation, de l'ouverture des marchés et de la privatisation sur la productivité, les prix et la qualité du service pour les services de téléphonie fixe (interurbains et internationaux) et mobiles (cellulaires) pour 23 pays de l'OCDE au cours de la période 1991-1997. Les données sur la structure de marché et la réglementation sont analysées au moyen de techniques d'analyse factorielle afin de grouper les pays en fonction des politiques suivies et les caractéristiques de leurs marchés. En utilisant comme variables de contrôle les différences dans la technologie et la structure économique, les estimations réalisées sur les données de panel montrent que les anticipations de la concurrence (en utilisant comme *proxy* le nombre d'années restant avant la libéralisation) et la concurrence effective (en utilisant comme *proxy* la part de marché des nouveaux entrants ou le nombre de concurrents) entraînent des améliorations au niveau de la productivité et de la qualité et réduisent les prix pour tous les services de télécommunications considérés. Aucun résultat clair ne peut être trouvé au sujet des effets de la privatisation (en utilisant comme *proxy* la part publique dans l'OPT et le nombre d'années restant avant la privatisation).

Classification JEL : C23, K23, L5, L96, L11, L32
Mots Clés : Modèles de panel, industries réglementées et droit administratif, télécommunications, structure de marché, stratégie d'entreprise et performance, entreprises publiques

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REGULATION, MARKET STRUCTURE AND PERFORMANCE IN TELECOMMUNICATIONS

Olivier Boylaud and Giuseppe Nicoletti[1]

1.   Summary and conclusions

1.   Over the past two decades, the institutional and regulatory framework of the telecommunications industry has changed radically. In most OECD countries, public telecommunications operators (PTOs) have been fully or partially privatised and regulations concerning access to telecommunications markets, provision of services to users and pricing mechanisms have been overhauled. Institutional and regulatory reform was generally spurred by the rapid evolution of both telecommunications technology and the structure of demand for telecommunications services, which has eliminated virtually all natural monopoly conditions, making it possible and efficient for a multiplicity of operators to supply these services to businesses and consumers. In turn, the new market and regulatory environment is having a substantial impact on the structure and organisation of the industry.

2.   Technical progress and regulatory changes are generally presumed to have brought about improvements in the amount, the range, the quality and the prices of telecommunications services in the OECD. The size of the communications industry is relatively small, but it has been increasing over the past two decades. In the mid-1980s, the industry represented around 2.5 per cent of GDP, 1.5 per cent of consumer expenditure, between 1.5 and 2.5 per cent of total inputs in industry and services and 3 per cent of goods and services trade in the OECD area. Despite significant reductions in its relative price, in the mid-1990s the share in consumption and trade had remained broadly constant while the share in GDP had risen to around 3 per cent and (partly as a statistical phenomenon due to increasing contracting out by firms) the share in total inputs grew by around one percentage point in most OECD countries. Therefore, as a result of changes in technology, industry organisation and the structure and level of prices, the volume of communication services grew rapidly.

3.   While there is a broad consensus that regulatory reform in telecommunications is beneficial for businesses and consumers, cross-country empirical evidence is still lacking and a number of policy-relevant issues remain unresolved. A first set of issues concerns the general linkages between ownership, regulation, market structure and performance: Is competition conducive to productivity improvements and price reductions in the whole range of telecommunication services? Is it potential competition or actual changes in market structure that bring about the beneficial effects of liberalisation? Does privatisation generally lead to gains in efficiency and consumer welfare? A second set of issues (which take the benefits of competition for granted) concerns regulatory design: What is the regulatory framework which is liable

to lead more quickly and more effectively to the development of competition? Is facilities-based competition (in which new entrants are encouraged to build their own infrastructure) superior to service-based competition (coupled with the unbundling of access by third parties to basic network elements and services)? What is the best regulatory framework for interconnection rights and access pricing? How can equal access by consumers to multiple telecommunications operators be ensured? What is the desirable degree of vertical and horizontal integration in the telecommunications industry?

4.   This paper deals only with the first set of issues. Its main focus is on the economic effects of changes in regulation that increase the role of market mechanisms in the telecommunications industry by eliminating barriers to entry or redefining the role of public enterprises. To this end, the paper empirically investigates the linkages between regulatory regimes, market environments and performance in three services supplied by the telecommunications industry: domestic long distance, international long distance and mobile telecommunications. Based on the comparative experience of a large set of OECD countries over the 1990s, it provides empirical evidence that liberalisation of entry and the development of effective competition in telecommunications services generally lead to higher productivity, lower prices and better quality. To a large extent, the analysis in the paper is of historical interest: its main policy relevance lies in finding (as yet lacking) cross-country empirical support for the entry liberalisation policies that have been adopted by the vast majority of OECD countries during the past two decades. The paper does not address the finer issues related to regulatory design that arise after basic entry liberalisation has been implemented, for which available cross-country information is too recent and sparse to allow in-depth empirical analysis.

5.   Country-specific evidence on the economic benefits of market and regulatory changes in the telecommunications industry abounds, but few studies have attempted to look at these effects from a comparative, OECD-wide perspective.[2] Focus on single countries was partly related to the lack of internationally comparable data on regulatory and market structures. The comparative approach of this paper was made possible by the construction, in the context of OECD-wide work on regulatory reform, of a data set including cross-country benchmark indicators of sectoral regulation, market structure and performance for 23 OECD countries over the 1991-97 period.[3] These data were used to investigate the linkages between regulation, market structure and performance by means of cross-country/time-series estimation techniques.

6.   The rest of the paper is divided into two parts. The next section describes the evolution of the regulatory and market environment in the telecommunications industry using the data collected and the indicators constructed for the analysis of the effects of regulation and market structure on performance. Section 3 presents the analytical framework, examines the data used to proxy for the various dimensions of performance (considering also their limitations), and discusses the results of the panel estimates for the individual services and overall. Throughout the paper, the description of cross-country patterns and trends in the various dimensions of performance is kept to a minimum - extensive discussion of patterns and trends in the telecommunications industry can be found in the *OECD Communications Outlook 1999*, which is the main source for the performance data.

7.   The main empirical findings are as follows:

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2.   Early attempts to link regulation to performance in the telecommunications industry across countries include OECD (1995) and OECD (1996a). These studies used descriptive methods rather than econometric techniques.

3.   The regulatory indicators were derived from the replies of Member countries to *The OECD Regulatory Indicators Questionnaire* and the information contained in the *OECD Communications Outlook* (various issues). The performance indicators are largely based on the *OECD Telecommunications Database*.

− Despite widespread privatisation and liberalisation, large segments of the industry still remain dominated by incumbent PTOs, in which the state often maintains controlling shares.

− However, partly due to the demonstration effects of successful liberalisations and European Commission directives, regulatory and market structures are increasingly similar across OECD countries. The typical country is characterised by free entry in most services; a small but rising share of new entrants exerting significant competitive pressure on the PTO; a sectoral regulatory agency managing pre-established interconnection rights, setting terms and conditions for network access, overseeing (mostly incentive-based) retail and (mostly cost-based) access price regulation and sharing with a government department entry, pricing and consumer policies, as well as dispute resolution.

− In 1995, several foreign operators existed in most countries, often as members of alliances and/or joint ventures with domestic operators. There are no consistent data on the share of the domestic markets which they serviced, but there is some evidence that their number is positively related to the size of telecommunications markets.

− Using cluster and factor analysis, several groups of countries could be identified based on their experience with reform over the sample period, the most liberal being Canada, Japan, the United Kingdom, the United States, Sweden and Australia, and the most restrictive Greece, Switzerland, Austria, Luxembourg, Iceland and Turkey.

− Even controlling for the influence of technological developments, increasing product market competition (proxied by the share of new entrants or by the number of competitors) generally brings about productivity and quality improvements and reduces the price of all the telecommunications services considered in the analysis.

− The prospect of competition (as proxied by the number of years remaining before liberalisation) generally has a strong positive effect on the productivity and the quality of services and a strong negative effect on prices. The mere prospect of an imminent liberalisation prompts significant adjustments by incumbents to the new competitive environment.

− While these results hold for the industry as a whole, the three telecommunications services considered in the paper sometimes have specificities that may make the relationship between actual and prospective competition and performance more complex.

− Due to the lack of data, the effects of difference governance mechanisms (such as the corporatisation of the PTO) could not be tested. However, no clear evidence could be found concerning the effects on performance of the ownership structure of the industry (as proxied by both the public share in the PTO and years remaining to privatisation).

− In some cases, prospective privatisation appeared to be associated with relatively low productivity; at the same time, there is evidence that the presence of foreign operators in domestic markets is associated with relatively low productivity and relatively high prices. These results could be explained by an endogeneity problem: on the one hand low productivity may make privatisation urgent and, on the other, foreign operators are attracted by situations in which there are margins for productivity gains and the possibility to gain market shares through price reductions (but since their role remained marginal over the sample period, these efficiency gains and price reductions do not show up at the industry level).

8.   From the policy point of view, these results confirm that the economic benefits of liberalisation and regulatory reform in the telecommunications industry are large and relatively quick to come about. Some benefits derive from adjustments triggered by the mere perspective of liberalisation but their depth and scope depend on the establishment of effective competition in telecommunications markets. Therefore, final and intermediate users of telecommunication services are likely to gain a lot from an acceleration of liberalisation initiatives and regulatory practices that make it possible for new foreign and domestic operators to compete effectively.

2.   Regulation and market structure in telecommunications: a cross-country perspective

9.   The telecommunications industry provides many services to businesses and consumers, using a growing variety of technologies and spanning an increasing range of communications media (voice, image, data, etc.). Ideally, the effects of competition on performance ought to be studied at the level of the single markets in which these services are supplied and demanded. However, due to data constraints, a trade-off exists between the chosen level of disaggregation and the possibility to perform cross-country comparisons. Furthermore, some services (such as local fixed voice telephony) are still largely monopolistic in a vast majority of countries while others (such as value added services) have generally been competitive throughout the nineties. Analysis of these services would not yield insights on the relationship between competition and performance. Therefore, the analysis focuses on three broadly-defined services that have undergone significant changes in regulation, market structure and/or performance in recent years: domestic long-distance fixed telephony ("trunk"), international long-distance fixed telephony ("international"), cellular mobile telephony ("mobile"). In addition, in view of the role played by leased lines in the development of new voice and data communications services, such as the Internet, the effects of changes in the regulatory and market structure of trunk services on the prices of leased lines services ("leasing") is also analysed. Figure 1 shows the relative shares of some telecommunications services in total telecommunications revenue in 1992 and 1997.

[Figure 1. Breakdown of telecommunications revenue by service]

10.   In the following, changes in regulation and market structure across countries and over time are described in some detail, using the data collected and the indicators constructed for the analysis of the effects of regulation and market structure on performance.

2.1   *Past trends in regulatory reform*

2.1.1   *The reasons for change*

11.   Traditionally, the telecommunications industry has been heavily regulated in OECD countries. Government interference in this industry has spanned virtually all dimensions of business activity: ownership, entry, pricing and output choices. In the vast majority of countries and up until the beginning of the 1980s, the provision of telecommunications services was ensured by state-controlled enterprises generally enjoying a legal monopoly in the markets where they operated. These firms, which were often exempt from private company law provisions, were usually subject to strict restrictions on the range, the amount and the prices of the services provided. Typically, both the structure and the level of prices were regulated to meet social (and sometimes even macroeconomic) goals as well as implicit or explicit constraints on rate of returns, and universal service obligations were imposed.[4]

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4.   In some countries macroeconomic goals included the control of inflation (see, for instance, OECD, 1994).

12.   Regulation of telecommunications was generally advocated on two main grounds: natural monopoly and externalities. Natural monopoly characteristics were related to the fixed cost of establishing the network needed to provide telecommunications services as well as the costs related to the sharing of the infrastructure among several service providers. Externalities were related to both the so-called "network" effects and the spill-over effects on public goods such as health, information and defence.[5] Large economies of scale relative to demand would justify the establishment of price-regulated legal monopolies and externalities would justify particular kinds of output and price restrictions. With the exception of North America, where regulation of private monopolies had a longer tradition, a majority of countries enforced these regulatory restrictions through direct ownership of the PTO. Direct public ownership and/or restrictions on foreign investment in the telecommunications industry were also viewed as a way to meet the defence or "strategic" implications of public telecommunications policies.

13.   An assessment of the soundness of past regulatory practices in telecommunications is beyond the scope of this study, but it is useful to point out some general issues. It is highly controversial whether all segments of the industry had the natural monopoly characteristics that were claimed in justifying restricted entry and regulated prices, but in any case developments in technology over the past two decades, leading to a sharp decline in costs and the possibility to bypass the fixed-link network even to reach final users, suggest that many of the natural monopoly characteristics have disappeared.[6] These phenomena are reinforced by the changes in the level and the structure of demand, which make even the sunk costs of establishing new networks sustainable for a multiplicity of operators. At the same time, there seem to be a consensus that externalities may have justified (and in some cases still justify) regulatory intervention on some of the output and pricing choices of telephony operators in some services and segments of the industry (such as the provision of basic life-line and interconnection services). However, the coming to maturity of the industry (in terms of mainline penetration) and progress in regulatory techniques suggest that the kind of command and control regulations used in the past may not be the best solution. Given that the breadth and scope of both externalities and scale economies appear to be much less extensive than was originally thought, the case for public ownership or, for that matter, foreign investment restrictions appears to be very weak. In addition, public enterprises are subject to well-known governance problems which may cause inefficiencies and rigidity in business behaviour.[7]

14.   This kind of considerations has led to a radical change in the approach to regulating telecommunications in OECD countries over the past two decades. In the light of the positive outcomes of regulatory reform in first-mover countries, a large consensus emerged that excessive state interference and unduly restrictive and obsolete regulations were preventing consumers from reaping the benefits of technical progress and that the lack of competition in telecommunication services was hampering innovation, product differentiation and the translation of lower costs into final prices. In the perspective of a more competitive environment, state-owned and foreign-protected PTOs were increasingly seen as being not only unable to innovate and adjust with sufficient flexibility compared to their private counterparts, but

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5.   Loosely speaking, a market is termed a "natural monopoly" when a single firm can meet demand at a lower average cost than two or more firms. "Network externalities" occur when the social value of connecting an additional individual to a network exceeds the private value of connection for the individual (see, for instance, Katz and Shapiro, 1994). Spill-over effects result, for instance, from the difference between the private and social value of providing emergency services (see, for instance, OECD, 1996b).

6.   For a summary of studies on the economic characteristics of the telecommunications industry, see Productivity Commission (1999).

7.   The recognition of these problems spurred a movement towards corporatisation of state-owned PTOs well in advance of liberalisation and privatisation initiatives. For an extensive discussion of the influence of public ownership on business behaviour, see World Bank (1995). Cross-country evidence of the negative influence of public ownership on cost-efficiency in the electricity supply industry can be found in Pollitt (1997).

also a potential barrier to entry in competitive telecommunications markets. Traditional price regulation was thought to be conducive to resource misallocation, favouring overcapitalisation and inefficiency and distorting the price structure away from underlying costs. As a result, regulatory reform has involved large-scale privatisation of former state monopolies, the elimination of entry restrictions in all segments of the industry and the increasing adoption of incentive-based regulatory techniques to deal with remaining pricing and service restrictions. In this context, in most countries a process of "price rebalancing" was set in motion. The stated aim of this process was usually to reduce the cross-subsidisation of local service by long-distance service, thereby bringing the price structure more in line with costs and making it possible for the incumbent to compete in liberalised long-distance markets.[8]

2.1.2   The regulatory and market environment at the end of the 90s

15.   Despite the general movement towards regulatory reform, the timing and the pattern of change have differed considerably across countries and, while significant progress has been made towards a more flexible and competitive environment, the telecommunications industry is still characterised by the heritage of past regulatory policies in many countries. For instance, state control through share ownership retains an important role, incumbent PTOs are still dominant in many segments of the industry and price structures are still heavily distorted. As a consequence, price regulations remain binding for many telecommunications services and many countries are still undergoing a process of price rebalancing that is often guided by regulatory authorities. Tables 1-5 provide an overview of the current market and regulatory environment in OECD countries as well as key dates of liberalisation and privatisation.

16.   As shown in Table 1, entry conditions in trunk, international and mobile services had been substantially relaxed by 1998. As few as six OECD countries maintained legal monopoly conditions in trunk and international services (the new Central European members, Greece, Portugal and Turkey) and in all cases liberalisation is foreshadowed. No country maintained a legal monopoly and only eight countries had less than three competitors in mobile services. However, the timing of entry liberalisation was very different. In most continental European countries, as well as in Korea and Mexico, full liberalisation occurred quite recently.[9] In common-law countries, Japan and some Nordic countries, legal barriers to entry in telecommunications services were removed earlier, as early as the beginning of the 1980s in the United States and the United Kingdom.[10]

[Table 1. Regulation of entry and foreign investment, 1998]

17.   Moreover, although some countries still retained restrictions on foreign investment, either *de jure* (sector-specific FDI constraints or limitations to foreign acquisitions of PTO equity) or *de facto* (through state control of the PTO), in the vast majority of them a plurality of foreign operators were established already in 1995. The available data show a tendency for the number of foreign operators to be positively associated with the size of domestic telecommunications markets. On the whole, constraints on new entry (such as FDI restrictions) are rare, but constraints on foreign ownership and/or control of PTOs are still widespread. These range from explicit limitations on the acquisition of shares by foreign operators to

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8.   However, since in many cases the allocation of costs to services that are jointly provided is controversial, rebalancing may also have been used by incumbents to pre-empt entry by new competitors in some markets, while continuing to exert market power in markets where competition takes longer to roll out.

9.   Liberalisation in most European countries resulted from the application of the so-called "Full competition" EC directive (96/19), which required the elimination of all remaining legal barriers to entry in telecommunications markets by January 1st 1998.

10.   In the context of this paper, the term "common-law countries" is a short notation for the United States, the United Kingdom, Canada, Australia and New Zealand.

restrictions on the size of any single ownership share and requirements that the PTO should remain controlled by the government (both these measures affect domestic and foreign investors alike). In addition, in a number of instances, the PTO is shielded from foreign (and domestic) investment merely because privatisation is not envisaged.

18.	Experience in the first-mover countries showed that it can take very long to translate changes in legislation into changes in market structure. In the transition from monopoly to competition the incumbent PTO often maintains a competitive advantage which can be exploited (sometimes through practices which violate competition laws) to preserve a dominant position.[11] This partly explains why in most countries market structure is still very concentrated, especially in trunk and international services (Table 2). Despite extensive liberalisation, the PTOs retain on average market shares of over 90 per cent in trunk services, 86 per cent in international services, 93 per cent in mobile analogue services (which however are being phased out in most countries) and 66 per cent in mobile digital services. Nonetheless, in some countries, such as the United States, the United Kingdom and Finland, in which entry has been going on for a longer time and/or where aggressive liberalisation policies were implemented, these shares are substantially smaller and market structure has changed more radically.[12]

[Table 2. Market structure, 1998]

19.	A similar pattern can be observed for public ownership (Table 3). In most countries, the sale of equity to private investors was started relatively recently and, more importantly, it did not involve the complete loss of control by the state, which generally maintained the largest single share of the PTO's capital and sometimes retained special voting rights in the privatised enterprises (Table 2). While, overall, the amount of PTO capital divested in the OECD area was large, implying a decline of the average share held by the state from around 80 in 1992 to around 55 per cent in 1998, only in nine countries privatisation policies reduced the state shareholdings below 25 per cent.[13]

[Table 3. Ownership and privatisation of PTOs, 1998]

20.	Given the predominance of incumbents, especially in trunk and international services, it is not surprising that price regulation aimed at limiting the exercise of market power is still widespread in OECD countries. Table 4 provides a summary of price regulation approaches, distinguishing incentive-based (such as price-cap) from cost-based regulations and regulations which apply to all operators from regulations applying only to dominant operators or PTOs.[14] Two main conclusions can be drawn from the table. As for basic voice services, the vast majority of countries regulates both retail prices and interconnection charges and requires these charges to be made public. Retail price regulation is often incentive-based, usually through some variant of the price-cap mechanism, while regulation of

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11.	Although infractions to competition law are eventually sanctioned by antitrust authorities, entry deterrence by incumbents and the need to resort to antitrust action imposes significant costs on new entrants.

12.	The resilience of market structure to liberalisation initiatives that was observed in the past may not carry over into the future. The development of new technologies (which sometimes make it possible to bypass the incumbent's network) and the refinement in regulatory techniques (which evolved on the basis of the experience of first-mover countries) could imply more rapid changes in market structure as liberalisation is implemented. Some of these developments can already be observed in the aftermath of the liberalisation of fixed voice services in the EU.

13.	The average PTO market and public ownership shares are somewhat smaller if cross-country differences in the size of telecommunications markets are accounted for (for instance by weighting them by the share of each country in total OECD telecommunications revenue).

14.	More detailed country-by-country information can be found in the annex (Table A.1).

interconnection charges is cost-based. These regulations concern mainly the PTO or other dominant operators. By contrast, countries have quite different approaches towards mobile services, probably reflecting the more heterogeneous market environments. A majority of countries does not regulate retail prices, but some countries do regulate them, sometimes based on incentive price cap mechanisms. On the other hand, a majority of countries regulates interconnection charges, by cost-based mechanisms. It should be noted that in most countries the move to incentive-based regulation of retail prices and cost-based regulation of interconnection charges is quite recent. Unfortunately, comparative historical data on price regulation is lacking, but it would seem that, with few exceptions (such as the United Kingdom and some of the United States), retail price controls were predominantly based either on variants of the rate of return regulation or on discretionary considerations until the mid 1990s.

[Table 4. Synopsis of telecommunications price regulation, 1998]

21.   In most OECD countries, regulatory reform has also concerned the policy and institutional setting. Table 5 summarises regulatory institutions and their main competencies.[15] The first thing to notice is the wide diffusion of sectoral regulators, which are usually somewhat independent from the legislative and executive bodies, sometimes acquiring a semi-judiciary role.[16] In many countries, sectoral regulators are an institutional innovation, which was implemented shortly before the liberalisation of telecommunications services. Another interesting feature is that, in the vast majority of countries, basic competencies are shared among three institutions: a ministry department, the sectoral regulator and the competition authority. The first two are often jointly responsible for entry, prices, dispute resolution and consumer policy. The competition authority often has exclusive competencies for merger activity.[17]

[Table 5. Synopsis of regulatory institutions, 1999]

2.2   Summarising regulatory reform for empirical analysis

2.2.1   The choice of indicators

22.   As suggested by the above discussion, regulatory reform in telecommunications has involved a variety of changes to institutions, laws, property rights, administrative procedures and enforcement mechanisms. By relaxing previous constraints, imposing new ones and affecting the business incentives of network and service providers, these changes have affected input, output and price decisions either directly or by stepping up actual or prospective competitive pressures. For the purpose of evaluating the effects of regulatory reform on performance it is useful to focus on a limited set of indicators that catch the main movements in the regulatory environment and their repercussions on market structure. In general, the choice of indicators was dictated by a) the possibility to turn the qualitative information on regulatory provisions into quantitative variables; b) the possibility to rank cross-country differences in the regulatory provisions along a meaningful and (possibly) uncontroversial scale; c) the availability of historical information for a long enough period of time; and d) the existence of sufficient variability over time and across countries.

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15.   More detailed country-by-country information can be found in the annex (Table A.2).

16.   The precise degree of independence varies from country to country and is difficult to ascertain, since it depends crucially on the details of the laws and statutes and may also evolve through case law.

17.   However, in a number of countries (*e.g.* the United States, Japan, Germany, Canada, Portugal and Korea) sectoral regulators and ministry departments retain a word on mergers, especially when these have license implications.

23.   Arguably, the features of the pricing regime, the governance mechanisms of the PTO and regulatory institutions can have important effects on performance. However, price regulation, governance and institutional change failed to satisfy some of the criteria listed above. Historical information on pricing regimes was not available for a sufficient number of countries and a meaningful and uncontroversial ranking of different regimes of price regulation was hard to establish. Similarly, information was lacking on both the timing of corporatisation of government-owned incumbent PTOs and the actual independence of sectoral regulators from industry or political pressures. In addition, the current regulatory environment, for which data are available, is characterised by a relatively low cross-country variability of those features of price regulation and institutions that can be used in empirical analysis. These dimensions of regulation and governance were therefore ignored in the analysis.

24.   The focus was set on three main issues: actual and prospective entry conditions; actual and prospective state ownership; and market structure. The following indicators of the market and regulatory environment were constructed over the period 1991-1996 for each of the telecommunications services considered in the analysis (Table 6).[18]

  – the degree of liberalisation (liberalisation index), measured by ranking the legal limitations on the number of competitors allowed in each market;

  – the degree of state control in the telecommunications industry (index of state ownership), based on the share of the PTO's capital owned by the state and the presence of special voting rights;

  – the degree of internationalisation of domestic markets, measured by the number of non-resident operators participating in alliances, joint ventures or cooperation agreements with domestic operators aimed at providing services in the domestic telecommunications markets in 1995;

  – the actual market structure, measured by the market share (in total traffic) of new entrants in trunk and international services and by the number of competitors in mobile services.[19]

[Table 6. Indicators of regulation and market structure for empirical analysis]

25.   In addition, two indicators were used to proxy for anticipations of future changes in regulatory policies:

  – the prospect of liberalisation, measured by the number of years remaining before liberalisation of each market;

  – the prospect of privatisation, measured by the number of years remaining before the first sale of PTO shares by the government.

26.   The effect of anticipated changes in public policies on business behaviour is particularly relevant in the context of regulatory reform of the telecommunications industry.[20] Indeed, one of the reasons put

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18.   It should be stressed that these indicators are a selection from the larger set of data collected to perform cross-country comparisons of regulatory environments in telecommunications.

19.   Data on the market share of new entrants in mobile services is available only for a single period. To preserve the time dimension (essential in panel estimates), the degree of actual competition was proxied by the number of competitors.

forward for regulating PTOs is that the threat of entry cannot effectively discipline their output and price choices (see, for instance, Joskow and Rose, 1989). Moreover, past regulatory policies have generally left a heritage of distortions in the price structure of the PTOs which needs to be brought closer to the cost structure to enable them to meet competition, especially when the sequence of the liberalisation process starts by opening up markets in which they have a price disadvantage. However, for a number of reasons (including political economy considerations), redressing distortions and reducing the associated cross-subsidies generally takes time. Therefore, if PTO's are sensitive to the threat of competition, it is likely that adjustments in inputs, outputs and prices will start well in advance of the date of liberalisation. To the extent that privatisation implies a change in governance mechanisms, for instance by altering business goals, tightening business constraints and making management more accountable to shareholders, the same reasoning can be applied to the expectation of changes in the ownership structure of the PTO.

2.2.2 *Positioning countries along the reform process*

27. The indicators of regulation and market structure can be used to describe the cross-country patterns of regulation and market structure characterising over the sample period the subset of 23 OECD countries covered by the empirical analysis. This supplements (on the basis of a set of summary indicators) the earlier depiction of the current situation and provides a basis for assessing the empirical content of the indicators that are later used in the econometric analysis. The aim is twofold: to identify the main factors that determined the position of each OECD country along the reform process; and to group countries according to these factors. To this end, factor and cluster analysis are applied to the indicators over the 1993-1997 period (see Box 1).[21]

Box 1. Using multivariate data analysis to assess regulation patterns

Cluster and factor analysis are used to summarise patterns of regulation and market structure in the telecommunications industry. Factor analysis is a statistical technique aimed at finding the minimum number of "latent" variables which explain the maximum amount of the overall covariance of the observed variables. The factors, which are linear combinations of the observed variables, can be interpreted in economic terms (*e.g.* market and regulatory environment in fixed telephony). Each factor is characterised by a set of coefficients (factor loadings) expressing its correlation with the observed variables and the variables are assigned to the factor in which they are most "loaded". As a result, the regulatory and market structure indicators are split into disjoint sets, each of which is associated with one factor. The estimated factor loadings applied to the country-specific regulation and market structure indicators make it possible to "score" countries according to each of the factors, so that rankings of countries can be obtained in terms of factor-specific scores. It is standard practice to retain a number of factors which cumulatively explain a substantial part of the overall covariance.

Cluster analysis is used to investigate the similarity of OECD countries based on the country scores on each of the estimated factors. Starting from the values taken by the scores in each country, this technique progressively groups countries in clusters of increasing size based on (multidimensional) pair-wise comparisons. At each step in the clustering process, an index of intergroup similarity measuring the distance between the clusters being joined is calculated. It is standard practice to stop the clustering procedure (i.e. select the relevant number of clusters) when the distance between clusters becomes sizeable. The tree-like graphical representation of all the clusters formed along the clustering procedure is called a "dendrogram".

For more details on the use of cluster and factor analyses for studying cross-country patterns in regulation and market structure see Nicoletti *et al.* (1999).

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20. Years remaining to privatisation or liberalisation can proxy for anticipations since the intentions of governments were generally known by agents over the relatively short period covered by the sample. For instance, the timetable for liberalising EU telecommunications markets was laid out in 1993 in a "Green Book" of the European Commission.

21. The sample period is determined by the wish to include in the analysis the mobile services, for which no complete data is available before 1993.

28.   Four main factors are found to describe best the cross-country variance in the set of indicators of regulation and market structure. By looking at the indicators most closely associated with each of the factors (which are shaded in Table 7), these can be given a straightforward economic interpretation: the first factor (associated with liberalisation and market structure in trunk and international services, state ownership and internationalisation) expresses the market and regulatory environment in fixed telephony,[22] the second (associated with prospects of liberalisation in all services) expresses the timing of the liberalisation process; the third (associated with liberalisation and market structure in mobile services) expresses the market and regulatory environment in mobile telephony; and the fourth (associated with prospects of privatisation) accounts for the timing of the privatisation process. Internationalisation of domestic markets is strongly related to the market and regulatory environment of both fixed and mobile telephony given the large number of foreign operators participating in alliances or joint ventures in the mobile market in the reference period (1995).

[Table 7. Regulation and market structure: the discriminating factors, 1993-1997]

29.   Using the country-specific values of the regulatory and market structure indicators, countries can be scored along each of the four factors (a high score implying a liberal regulatory and market environment) and the average scores over the 1993-1997 period constitute the basis for positioning countries along the regulatory reform process. Figure 2 suggests that the OECD area can be subdivided into four main groups and a few outlier countries: a group including most common-law countries, Japan and Sweden; a group including Finland and New Zealand; a group including most continental European countries; and a group including Austria, Iceland and Switzerland. Outlier countries are Greece, Luxembourg and Turkey.

[Figure 2. Grouping countries according to regulation and market structure (dendrogram]

30.   The position of countries in the various groups can be elucidated by looking at the period averages of the country scores along some of the estimated factors. Focusing for simplicity on the first three factors, Figure 2 plots the (period) averages of country scores in the market and regulatory environment of fixed telephony against the scores in the timing of the liberalisation process (Panel A) and the market and regulatory environment in mobile telephony (Panel B). In Panel A two groups of countries can be identified[23]: the "liberal" countries, in which trunk and international telephony have been liberalised early on and new entrants have significant market shares (the common-law countries, Japan and some Nordic countries); and the "middle-of-the-road" countries, in which trunk and international telephony had undergone little liberalisation over the sample period, but committed to liberalise soon (basically the continental European countries). Turkey and Greece stand on their own since liberalisation has been postponed to a more distant date. In Panel B the situation is complicated by the different stages of development of mobile telephony across the OECD and the influence of the internationalisation indicator on country scores along the mobile telephony factor. Due to a relatively low degree of internationalisation and a low number of competitors in the mobile market, Finland and New Zealand are isolated from the group of liberal countries and Switzerland, Iceland and Luxembourg are isolated from the group of middle-of-the-road countries. Moreover, a subset of countries with particularly liberal environments in mobile telephony but restrictive fixed telephony environments (including Germany, France, Portugal and Greece) can also be identified.

[Figure 3. Cross-country patterns of reform, 1993-1997]

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22.   As expected, the coefficient of state ownership appears with a negative sign, thereby reducing country scores along the first factor.

23.   The grouping of countries was done by applying cluster analysis separately to the two sets of factor scores plotted in the figure.

3. Evaluating the effects of regulatory reform on performance in telecommunications

31. Most of the available empirical evidence concerning the economic effects of different kinds of regulatory arrangements in the telecommunications industry is country-specific and concerns the experience of the United States. A small number of studies looked at the effects of entry regulation in telecommunications markets, generally in the context of the regime change implied by the 1983 break-up of ATT.[24] Some of them found that the liberalisation of trunk and international services created competitive pressures (in both trunk and local markets) that generated productivity gains and improved allocative efficiency of previously regulated firms. However, it was unclear whether the significant price reductions that followed liberalisation were the result of these pressures or of changes in price regulation that imposed a significant rebalancing of prices (see Taylor and Taylor, 1993). Outside the United States, two studies found that the increase in competitive pressures implied by entry liberalisation had positive effects on an index of innovation in the OECD area and on mobile penetration in Europe (see van Cuilenburg and Slaa, 1995, and Gruber and Verboven, 1999).

3.1 The empirical approach taken here

32. The approach taken in this paper is to infer the effects of deregulation on performance by exploiting the variation of regulatory regimes and market outcomes over both time and countries. The empirical analysis is concerned with the effects of "deregulation" on performance, by comparing regulated outcomes against a benchmark in which regulation of entry and direct state ownership are reduced or eliminated.[25] To this end, the variation in regulatory regimes and market structures identified in the previous section is related to a set of performance measures after controlling for other non-regulatory effects potentially explaining the observed variation in market outcomes. The focus was set on three measures of economic performance - labour productivity, prices and quality. Cross-country productivity differentials are taken to signal gaps in the efficient use of the labour input by the industry. Clearly, this inference is correct only under the (admittedly strong) assumption that the input mix is the same across countries.[26] Differences in prices are assumed to reflect in part efficiency gaps as well as other market distortions (such as the exercise of market power) and carry important implications for consumer welfare. Quality is relevant not only in its own right, because it affects consumer welfare, but also because it may

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24. See, for instance, Ying and Shin (1993) and Oum and Zhang (1995) and, more recently, Gort and Sung (1999). Other studies looked mainly at the effects of alternative forms of price regulation (see, for example, Kridel *et al.*, 1996 and Braeutigam and Panzar, 1993).

25. However, it would be misplaced to consider telecommunications as "unregulated" and perfectly competitive in countries that reduced these forms of state interference. Most often, they will be simply subject to a form of regulation that deals with the characteristics of the industry in a different way. For example, "deregulation" of entry in mobile telecommunications generally consisted in replacing legal monopolies by a system of multiple franchises that are generally assigned discretionally by the government.

26. Looking at total factor productivity was not feasible in the context of this study, since TFP can hardly be estimated at the level of the individual telecommunications services even for single countries. Alternative approaches to estimating overall productive efficiency may either involve the estimation of x-efficiency measures by means of Data Envelope Analysis or the examination of cross-country differences in profitability and the ratio of output to input prices. High profitability can result either from high productivity or a high output to input price ratio. Therefore, in countries where profitability is relatively high and this ratio is relatively low, the overall productivity performance must necessarily be relatively good (see Productivity Commission, 1999). Both these alternatives are promising avenues for future research.

be traded off against prices: consumers may be willing to pay higher prices for higher quality telecommunications services (or vice versa).

33. For each performance measure the following reduced-form model was defined, expressing for each country i, sector s and period t the dependent variable y_{ist} as a function of a) country-specific effects, f_i; b) a set of exogenous economic characteristics that are assumed to influence performance independent of regulation and market structure, $Z_s[i,t]$; c) a set of market structure indicators, $M_s[i,t]$; and d) a set of regulatory indicators, $R_s[i,t]$:

$$ y_{ist} = c + \alpha_{is} f_i + Z_s' \beta_s + M_s' \gamma_s + R_s' \delta_s + \varepsilon_{ist} \qquad [1] $$

The model is estimated for each service and for all services pooled using panel data techniques, considering countries as the relevant individuals. For estimates pooling all sectors, sectoral dummies catching sector-specific effects are added.

34. In general, the exogenous characteristics are assumed to account for country specificities in economic structure (*e.g.* income levels, population density, input costs and price structures) and technology (*e.g.* the quality and intensity of capital), over and above the country-specific effects. Table 8 describes the economic structure and technology indicators used in the empirical analysis. Due to data limitations, the capital intensity and input costs proxies relate to the telecommunications industry as a whole. On the other hand, the quality of the capital stock is measured exclusively by the percentage of digital technology in place. A "price rebalancing indicator" has been constructed to proxy the extent to which the price structure deviates from underlying costs.[27] The indicator, which concerns fixed voice local and long-distance telephony services, is an important control in assessing the effects of regulation and market structure on prices, since an observed decline in prices could be partly due to a tariff readjustment, perhaps imposed by the regulatory authority, rather than to entry liberalisation or competitive pressures *per se*. Similarly, observed cross-country differences in prices could reflect different stages in the rebalancing process rather than differences in regulation or market structure.

[Table 8. Indicators of technology and economic structure for empirical analysis]

35. Measurement of performance, regulation and market structure is necessarily approximate. As explained in the previous section (and in contrast with standard practice), the indicators of regulation and market structure are not simply dummies but variables constructed with the aim of obtaining some idea of the variation of regulatory regimes over time and across countries, thus potentially increasing the precision and reliability of the coefficient estimates. However, several potential sources of errors in variables should be noted.[28] First, the performance indicators may suffer from problems of comparability and interpretation (see below), such that cross-country patterns should be seen as indicative. Second, it is possible that the explanatory variables are not truly exogenous to performance. For instance, the choice of technology may

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27. The indicator was constructed using the prices for telecommunications at different distances (local, 27km, 110km and 490km). In constructing the indicator, the price structure of the United Kingdom in 1998 was chosen as the benchmark assuming that, after a relatively long period of market competition, prices broadly reflect the underlying cost structure.

28. Errors in variables generally make the coefficient estimates of the mis-measured variables biased and inconsistent. When errors concern only a single variable, estimates will tend to be biased downwards. In general, the presence of errors in some variables will also bias the coefficient estimates of the variables which are measured correctly.

depend on both the performance of the industry and the regulatory regime; similarly, the degree and timing of changes in regulation may be influenced by industry performance.[29] Third, regulation, market structure and technology may be closely related to each other, possibly because of the influence of omitted variables that are unobservable to the econometrician. Fourth, the lag between regulatory changes and the actual enforcement of the new regulatory provisions, may make the dating of regulatory changes inappropriate. To some extent, this problem is lessened by the account made for changes in market structure and expectations of liberalisation and privatisation.

3.2   *The performance data*

36.   The precise definition of the performance measures was dictated by the availability of data and Table 9 provides a description of how these measures were constructed empirically. Productivity of service industries is hard to define, and telecommunications is a prominent example of that. Telecommunications output may include the number of users serviced, the number of minutes of communication supplied, the number of bytes transmitted, the range and the quality of services provided as well as the (generally unmeasurable) network externalities. Due to data constraints, a relatively narrow definition of output was adopted including the number of subscribers (for the trunk and mobile services) and the number of minutes of outgoing telecommunications (for the international service).[30] Data constraints also led to a partial definition of productivity, focusing on the labour input only, but caveats should be noted. Partial productivity measures could be misleading because they are unable to account for cross-country productivity differences induced by the use of different factor proportions. Moreover, while data on employees in the mobile segment of the industry is partially available, it is practically impossible to identify precisely the contribution of the labour input to the provision of the various fixed-link services (*e.g.* international and trunk). As well, companies differ in the use of staff vs. subcontracting.[31]

[Table 9. Performance indicators for empirical analysis]

37.   Quality is a multi-faceted concept which includes relatively objective features such as variety, reliability and serviceability as well as more subjective factors such as user satisfaction. Very few quality indicators are available on a cross-country basis for the services provided by the telecommunications industry. As a result, the quality dimension has been considered for those services in which quality indicators existed for a sufficient number of years and/or countries. In trunk telecommunications quality was proxied by a combination of number of faults per mainline (so-called "call failure rate") and number of faults repaired within 24 hours (so-called "fault clearance rate"); in international telecommunications it was proxied by the percentage of calls completed (so-called "answer seizure ratio"). Fault clearance is a measure of service reliability while call failure and answer seizure proxy network reliability. However, fault clearance and answer seizure have serious problems of interpretation and/or comparability. Both

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29.   These potential endogeneity problems would suggest that the best empirical strategy would be to estimate a model in which performance, technology and regulation are simultaneously determined. This approach is not pursued here and, instead, it is assumed that technology, regulation and market structure are exogenous to performance. While this may be a reasonable assumption for a single country over the relatively short sample period, endogeneity could affect the reliability of the coefficient estimates due to the cross-country dimension.

30.   In recent years, outgoing minutes of telephone traffic capture less and less international telecommunications, particularly in liberal markets where traffic increasingly passes over private capacity.

31.   Some communication services (such as international and Internet services) present the additional problem that their output does not depend only on the use of domestic inputs but, more generally, on the working of the international network.

measures may depend on factors which are outside the control of the industry and fault clearance, especially, is plagued by differences in reporting methods across countries.[32]

38. There are also considerable problems in measuring price performance. OECD tariff baskets do account for a number of cross-country idiosyncrasies, such as different patterns of demand, different average lengths of conversations and different regional distributions of international calls.[33] However, the available price data concern standard rates, which are not always a good indicator of market outcomes, especially in those countries and services more exposed to competition, where discounts are widely applied. Some estimates of price discounts in OECD countries suggest that they can reach up to 25 per cent of standard rates.[34] In addition, cross-country/time-series data on the prices of digital mobile services are lacking. Finally, cross-country differences in observed prices may also reflect differences in price regulation. To account for some of these problems, OECD tariff baskets were supplemented with two measures of "average prices" in the international and mobile services: international revenues per minute of outgoing conversation and mobile revenues per subscriber.[35]

39. Multivariate analysis can help in accounting for some of these measurement problems. For instance the inclusion among the explanatory variables of a proxy for the capital stock may correct some of the measurement error implicit in the labour productivity variable. In addition, other omitted factors (such as, for instance, the extent of subcontracting, the presence of discount plans and different approaches to price regulation) and unexplained cross-country differences in performance may be caught by the country-specific effects.

3.3 Empirical results

40. The effects of regulation and market structure on productivity, prices and quality were estimated from equation [1] for international, trunk and mobile services. For leasing services, estimates of these effects were obtained only for prices, since no data for output and quality were available for this segment of the telecommunications industry. To gauge the aggregate effects on the telecommunications industry the service-specific data were pooled and overall estimates were also obtained. In doing so, the performance data were standardised, in order to make it comparable across services.

41. Each equation was estimated using two regression models: a random effects specification and a fixed effects specification (see Box 2). The random or fixed effects account for any individual specific effect that is not included in the regressions. In each specification, the slope coefficients were assumed to be identical across countries. Full equation estimates, tests for model specification and the results of correcting for potential heteroskedasticity can be found in Annex Tables A.3-A.7.[36]

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32. For instance, average fault clearance may be influenced by weather conditions, the geographical network density or differences in performance across customer groups; answer seizure ratios may be influenced by such factors as unanswered calls, incorrect dialling, technical failure in foreign networks, busy lines, etc.

33. The very correction for these idiosyncrasies could lead to measurement error, since some of them (such as average lengths of conversation) could depend on prices.

34. See Productivity Commission (1999). Standard rates remain an important indicator of price performance because they provide the benchmark against which discounts are established. However, in mobile services, the picture is further complicated by the presence of in-kind offers of terminals.

35. The caveat with mobile revenues per subscriber is that with flexible tariff packages each subscriber's bill reflects changing usage patterns as much as price.

36. The Annex tables present results for both the random and fixed effects specifications. The relevant critical values for the significance of the coefficients are those of the t-distribution for fixed effects specifications

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Box 2. **Panel data estimation techniques**

With panel data, both the random and fixed effects specifications constitute improvements over the simple linear model, which does not adequately account for differences in the characteristics of cross-sectional units. Except for special cases (in which there are no such differences), estimating cross-section/time-series models by OLS yields spurious and biased results (see Moulton, 1986).

In the random effects specification individuals are assumed to constitute a random sample and, therefore, the country-specific effects are assumed to be independently distributed random variables with mean zero and constant variance. In the fixed effects specification, the country-specific effects are assumed to be fixed parameters and the equation estimates should be considered as conditional on the estimated values of these parameters in the particular sample at hand. Conceptually, the random effects specification would seem more apt to deal with large micro data sets (*e.g.* where individuals are households or firms), while the fixed effects specification would seem to be more appropriate in the case of cross-country data. However, the choice between the two specifications can only be made on a case-by-case basis. If the hypotheses of the random effects specification are correct, the corresponding estimator is best linear unbiased (BLUE) and therefore is more efficient than the fixed effects estimator (the latter is BLUE only conditional on the fixed effects in the sample). Moreover, since the fixed-effect estimator (also called the "within estimator") utilises the time variation within each group of individuals, it cannot estimate coefficients of variables that lack the time dimension, whose effect will be incorporated into the general country-specific effect. On the other hand, if the hypotheses of the random effects specification fail to hold, the random effects will generally be correlated with the other explanatory variables and the corresponding estimator will be biased and inconsistent (as in any omitted variable specification).

Several tests have been designed to help discriminating between the simple linear model and the specific effects model as well as between the two specific effects approaches. In this paper, three tests are provided. A simple F-test is used to test the null hypothesis that there are no fixed country-specific effects in the data. Rejection of the test implies that the simple linear model is incorrect and the OLS estimator is biased and spurious. A similar procedure, the Breusch-Pagan test, can be applied to test the random effects specification against the simple linear model. Finally, the Hausman test makes it possible to verify the hypothesis that the random effects are uncorrelated with the explanatory variables. If the test is significant, the random effect specification is incorrect and a fixed effects specification is applied.

Finally, it should be noted that, although it is standard practice to apply the random and fixed effects estimators to small cross-country/time-series databases, the results should be taken with caution. The unbiasedness and efficiency properties of the estimators only hold asymptotically, when either the number of individuals or the number of time periods is large. For small samples, the properties of the estimators are unknown.

For more information on the advantages and limitations of panel data techniques, see Baltagi (1995).

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42.   The variables expressing differences in economic structure and technology generally show the correct sign, but their significance varies according to the service and measure of performance considered (Tables A.3-A.7). There is some evidence of external effects on productivity, which is often positively affected by the *size of the telecommunications sector* (as proxied by telecommunications revenue) relative to population. However, the sign of this coefficient could also depend on the effect of a third (omitted) variable, such as living standards, on both the demand for telecommunications and productivity levels. The negative effect of telecommunications revenue per capita on the ratio of subscribers to employees in the mobile industry suggests that the demand for mobile services is relatively high where the fixed network (which accounts for most of telecommunications revenue) is undersized. External effects on quality are

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and those of the standardised normal distribution for the random effects specifications. The random effects specification was also estimated using a regression technique "robust" to potential heteroskedasticity problems, which could be caused by systematic differences in the scale of some of the variables across countries. With heteroskedastic errors, the random effects estimates are consistent but no longer efficient. Heteroskedasticity is a potential problem in panel data analysis, since cross-sectional units can be of varying size. Given the definition of the performance, economic structure and technology variables, it cannot be excluded that this problem may affect the estimates in this paper.

more difficult to gauge: while the size of the sector is positively related to quality in trunk telecommunications, it would seem that in international telecommunications congestion effects prevail, implying a negative effect of network size. *Technology* (proxied by either capital intensity or digital mainlines) positively affects productivity and quality in all telecommunications services, but its effects are only significant on the productivity of mobile services. Capital intensity negatively affects the average prices of international services but positively affects leasing prices, perhaps reflecting attempts by the PTO to recover its fixed costs. The share of digital mainlines has a strong negative effect on mobile prices. Unsurprisingly, *input costs* (which are the economic structure variable in the price equations) are found to push up the price of most services, although this effect is significant only in international telecommunications.[37] Finally, *price rebalancing* has a significant negative effect on the price of trunk telecommunications, suggesting that achieving a price structure closer to costs generally has implied a reduction in these prices over the sample period.

43.   Turning to model specification, the random effects specification could not be rejected in around half of the regressions, while the hypothesis of absence of country specific effects was uniformly rejected by both the F and Breusch-Pagan tests. In most cases, controlling for potential heteroskedasticity did not change substantially the results.

3.3.1   The effects of regulation and market structure on performance

44.   Table 10 summarises the estimated effects of regulation and market structure on performance for the selected model specifications (*i.e.* those that were not rejected by the tests). Overall, the regulatory and market structure indicators performed quite well, significantly improving the fit of the regressions. The degree of market competition (proxied by the share of new entrants or the number of competitors) and the time to liberalisation, which can be interpreted as the effect of prospective competition, emerged as the two main explanations for the cross-country and time variability in productivity and prices; prospective competition was the only significant explanation for differences in quality remaining after correcting for other country-specific factors. At the same time, the influence of state ownership, time to privatisation and the internationalisation of domestic markets is less clear-cut.

[Table 10. The effects of regulation and market structure on performance]

45.   The pooled estimates broadly suggest that countries having stronger actual and prospective competition tend to have higher productivity levels, lower prices and better quality levels in telecommunications. The role of the time to liberalisation variable is particularly interesting because it would suggest that the mere prospect of competition generates pressures that lead to gains in efficiency and consumer welfare. The obvious implication is that restricting entry (for instance on the basis of "natural monopoly" arguments) in the provision of trunk, international and mobile services is inappropriate. However, the time to liberalisation variable might also be catching other factors that had an important bearing on the performance of incumbents over the sample period and are only partially accounted for in the regression. In many countries the commitment to liberalise in the future has been matched by a process of regulatory and industrial adjustment involving corporatisation, privatisation, changes in pricing practices (with the introduction of price caps and price rebalancing), partial liberalisation (*e.g.* in the terminal and value added services markets) and tolerance of indirect competition (*e.g.* through call-back services).

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37.   For mobile services no proxy for costs could be found. Therefore, economic structure was expressed by telecommunications revenue per capita (instrumented by GDP per capita). The negative coefficient on this variable suggests that mobile prices decline with the size of the fixed network.

46.   The results also suggest that state ownership and prospective privatisation leave prices and quality largely unaffected while, surprisingly, productivity levels are negatively influenced by the time to privatisation. Given that market structure and the degree of liberalisation are controlled for, an explanation can be provided for the lack of significance of these variables in the price equation: it is not ownership *per se* but the presence of market power that tends to be reflected in high prices. At the same time state control has often been associated with highly distorted price structures, since cross-subsidisation tended to be tolerated (and even encouraged) in state-owned public utilities, a phenomenon partly accounted for by the "price rebalancing" indicator. It is also possible that privatisation prospects leave prices unaffected due to the reluctance of governments to reduce prices in the run to privatisation in order to maximise privatisation proceeds. The negative effect of prospective privatisation on productivity is more difficult to explain. It is possible that this finding partly depends on the omission of a variable expressing changes in the governance structure of the PTOs (such as corporatisation), which may be more relevant for efficiency than the change in ownership. The result could also depend on the limited concept adopted for privatisation, which was defined as any initial sale of PTO shares, not necessarily implying loss of control by the state. However, these explanations could at best account for the lack of significance of this variable, certainly not a negative impact. Another explanation is reverse causality: where productivity levels are low, governments accelerate the timing of privatisation hoping that better governance mechanisms will enhance the competitiveness of the national PTO faced with global competition.

47.   Note should also be taken of the regression results for some of the individual telecommunications services. First, the responses of fixed and mobile services to regulatory and market structure indicators are quite different. In mobile services, the degree of actual competition (as expressed by the number of competitors) has little effect on productivity, while it has a strong negative effect on prices. At the same time, the prospect of liberalisation has a positive effect on productivity, but no effect on prices. These asymmetric effects reflect the fact that the mobile industry was generally newer, less regulated and more innovative then the fixed-voice industry over the sample period. Differences in the response of prices to market structure and prospective changes in the regulatory framework can be understood by noting that, in contrast with the international and trunk services, no complicated price rebalancing process was needed for mobile services. High prices generally reflected the exercise of market power rather than cross-subsidisation and no social or political considerations prevented incumbents from adjusting prices quickly to meet competition. Therefore, typically the incumbent waged aggressive price competition campaigns only when the entry of its first competitor(s) was imminent, postponing the downward adjustment of prices until the last minute before liberalisation.[38] On the other hand, given the infant state and high technology content of the industry, productivity was generally high (partly because, over the sample period, most mobile service companies were still expanding their network coverage) and only moderate gains could be expected from actual and prospective competitive pressures.

48.   Second, the effect of state ownership and time to privatisation differs in international and trunk services. While no effect of state ownership on productivity levels could be detected, the presence of the state seems to be associated with high (average) prices in the international service and low (standard) prices in trunk services, perhaps reflecting wider possibilities to cross-subsidise the latter with the former when both services are provided by a state-owned public utility. As for time to privatisation, the stronger negative effect on the productivity of trunk relative to international services tends to provide further support to the "reverse causality" interpretation provided above: to the extent that trunk services are generally affected by larger inefficiencies, they are more likely to be associated with an acceleration of privatisation procedures.

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38.   A similar price behaviour characterised the opening up of domestic routes to airline competition in many OECD countries.

49.   Finally, the effects of the internationalisation of domestic markets on the productivity levels and prices of international services are somewhat counterintuitive. This indicator reports the number of foreign operators participating in alliances or joint ventures aimed at providing telecommunications services in domestic markets in 1995. If it were interpreted as an indicator of openness to international investment, one would expect positive effects on productivity and negative effects on prices. This would have probably been the case if it had been possible to determine the precise date in which alliances were formed in each country. However, this information was not available and the time dimension could not be included.[39] In addition, no account could be taken of the significant increase in foreign investment and in the number of alliances with foreign participation since 1995. Given the current definition of this indicator, an alternative interpretation is that it catches the attractiveness of domestic markets to international operators. In this case, it could be argued that, especially with privatisation and liberalisation envisaged, foreign operators would be attracted to markets where the revenue and market share gains to be reaped from efficiency improvements and aggressive price competition are larger, due to existing inefficiencies and price distortions. This explanation of the results follows the same line of reverse causality as the argument advanced for the effects of the time to privatisation indicator.

50.   In sum, the results provide evidence in favour of liberalisation of entry, whose beneficial effects on productivity and prices are felt as soon as it is announced. They also provide reasonable support for measures aimed at encouraging and accelerating the establishment of new entrants, especially in fixed-voice trunk and international services, where effective competition appears to bring about increases in productivity and downward price adjustments over and above those implied by the mere threat of competition. By contrast, the evidence is inconclusive as to the effects of differences and expected changes in the degree of state control of the PTO as well as concerning the impact of foreign competition on performance.

3.3.2   A further look at telecommunications performance in the OECD area

51.   The results of regression analysis can be used to calculate the relative contributions of, on the one hand, country-specific and structural effects (economic structure and technology) and, on the other, regulatory and market structure effects to explaining differences in productivity, prices and quality across OECD countries. Based on these calculations, cross-country rankings along each of these dimensions of performance can be established, filtering out both the effects which could not be explicitly accounted for in the regressions and the effects which are not related to the regulatory or market structure environment. For the sake of brevity, this discussion focuses on telecommunications as a whole and, therefore, is based only on the results of the pooled regressions. It should be stressed that, since the precise definitions of productivity and quality vary from service to service, these numbers should be interpreted with care. Furthermore, given that structural and technological factors could be partly driven by regulatory reform, the contribution of regulation and market structure to explaining performance may not be correctly identified.

52.   Table 11 reports the relative contributions of the (unexplained) country-specific effects, the structural effects (including economic structure and technology) and the effects of regulation and market structure to the deviation of productivity levels, prices and quality from the OECD averages. For instance, the good price performance of the United Kingdom (Panel B), whose prices are estimated to be 40 per cent lower than the OECD average, can be explained mainly by its regulatory and market environment accounting for 35 percentage points of this deviation. Economic structure effects account for another

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39.   Since this indicator lacks the time dimension, it was possible to estimate its impact only in random effects specifications.

14 percentage points, while country-specific effects alone would have raised prices above the OECD average by 9 percentage points.

[Table 11. Explaining cross-country differences in telecommunications performance]

53.   Three general remarks are in order. First, in many countries, the unexplained country-specific effects (second column) are large (in absolute terms) relative to the deviations of performance from average (first column). As indicated by the F-tests, even after accounting for economic structure, technology, regulation and market structure, a large amount of the cross-country variability in performance remains to be explained, suggesting that the set of explanatory variables used in the regressions could be refined and extended. Second, in general the effects of idiosyncratic economic structures (third column) are dwarfed by the effects of differences in regulation and market structure (fourth column). This would suggest that even countries that are disadvantaged by structural factors can expect to catch up substantially with best-practice countries by liberalising and encouraging new entry in telecommunications markets. Third, the effect of time to liberalisation (column b) is on average much larger than that of the degree of market competition (column a). The implication is twofold. On the one hand, countries that plan to liberalise entry are bound to enjoy large advantages in terms of productivity, prices and quality in the run to liberalisation; on the other hand, competitive pressures originating from the perspective of new entry spur adjustments in performance that outweigh the further benefits to be reaped from pro-competitive changes in market structure. This statement should be nuanced, however, recognising the differences in the industrial characteristics of the fixed and mobile telephony services. For the former, improvements in performance appear to depend more crucially on the size of the market share of new entrants after liberalisation.

54.   Figure 4 shows the results of adjusting observed performance for effects due to either economic structure or other unexplained country-specific factors. Deviations from OECD average performance are ranked according to the adjusted measures. These measures can be interpreted either as "true" performance, after idiosyncratic influences distorting the ranking of productivity, prices and quality have been filtered out, or simply as the contribution of the regulatory and market environment to performance outcomes. For the first interpretation to be acceptable, the estimated country-specific effects must be assumed to account for omitted variables that introduce errors in the measurement of productivity, prices or quality.

[Figure 4. Comparing telecommunications performance across countries]

55.   The adjustments are often quite large and the figure suggests that the multivariate analysis is able to extract information from the data that leads to country rankings that accord with intuition. For all measures of performance, countries that were classified as the more open to competition by the analysis of regulatory and market structure environments (Figures 2 and 3) are found at the top of the scale, while (with the exception of Luxembourg and, possibly, Norway) countries that were classified as being relatively closed to competition are found at the bottom of the scale. The results are particularly striking for the United States, Japan, Australia and New Zealand, which in the absence of adjustments would be classified as having relatively low productivity and, especially, high price levels. In the case of prices, the country-specific effects may catch the presence of discounts which are not accounted for by the available price data. Alternatively, the results would suggest that in these countries the contribution of regulatory reform to performance has been particularly strong. These findings underscore the limits of purely descriptive cross-country comparisons of regulation and performance, insofar as they fail to account for economic and policy developments in different countries, as well as the danger of using such analysis for policy purposes without an understanding of the different markets and their specific characteristics.

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TABLES AND FIGURES

Table 1. **Regulation of entry and foreign investment, 1998**

	Legal conditions of entry			Year of liberalisation			Foreign investment		
	Trunk	International	Mobile (digital)	Trunk	International	Mobile	Number of competitors[4]	FDI restrictions	Restrictions concerning PTO[6]
Australia	Open	Open	Limited by spectrum	91[2]	91[2]	92	4	No	Yes
Austria	Open	Open	Limited by spectrum	98	98	95/96	-	No	No
Belgium	Open	Open	Limited by spectrum	98	98	96	3	No	State control
Canada	Open	Open[1]	Limited by spectrum	90	92	..	5	Yes	-
Czech Republic	Licence 1 firm	Licence 1 firm	Duopoly	2000	2000	..	3	Yes	State control
Denmark	Open	Open	Limited by spectrum	96	96	<92	-	No	No
Finland	Open	Open	Limited by spectrum	93	93	<92	-	No	Yes[7]
France	Open	Open	Limited by spectrum	98	98	89	3	Yes (only for mobile)	State control
Germany	Open	Open	Limited by spectrum	98	98	91	4	No	State control
Greece	Licence 1 firm	Licence 1 firm	Limited by spectrum	2001	2001	93	1	No	State control
Hungary	Licence 1 firm	Licence 1 firm	Duopoly	2002	2002	..	6	Yes[5]	Yes[7]
Iceland	Open	Open	Limited by spectrum	..	..	..	-	No	State control
Ireland	Open	Open	Limited by spectrum	98	98	..	1	No	State control
Italy	Open	Open	Duopoly	98	98	94	3	No	Yes[7]
Japan	Open	Open	Limited by spectrum	86	87	87	9	No	State control[8]
Korea	Open	Open	Limited by spectrum	96	96	..	1	Yes	Yes
Luxembourg	Open	Open	Duopoly	98	98	98	-	No	State control
Mexico	Open	Open	Limited by spectrum	96	96	..	7	Yes	-
Netherlands	Open	Open	Limited by spectrum	97	97	95	-	No	Yes[7]
New Zealand	Open	Open	Duopoly	90	90	..	3	No	Yes[7]
Norway	Open	Open	Limited by spectrum	98	98	92	-	No	Yes
Poland	Licence 1 firm	Licence 1 firm	Limited by spectrum	-	-	..	2	Yes	State control
Portugal	Licence 1 firm	Licence 1 firm	Limited by spectrum	2000	2000	91	2	No	No
Spain	Open	Open	Duopoly	98	98	94	2	No	Yes[7]
Sweden	Open	Open	Limited by spectrum	94	92	86	4	No	State control
Switzerland	Open	Open	Limited by spectrum	98	98	98	-	No	State control
Turkey	Licence 1 firm	Licence 1 firm	Limited by spectrum	2006	2006	97/98	4	Yes	State control
United Kingdom	Open	Open	Limited by spectrum	85	86	84[3]	7	No	Yes[9]
United States	Open	Open	Limited by spectrum	84	84	83	6	No	-

1. Monopoly in intercontinental (as opposed to North America) telecommunications.
2. Initially a duopoly.
3. Duopoly 1984-1991.
4. Number of foreign telecom operators participating in joint ventures or other co-operation agreements with domestic
   market in 1995 [source : E.M. Noam and A. Singhal (1996)].
5. Concession agreements may define a maximum share but the Minister can grant an exemption.
6. State control : government holds majority of shares but no explicit restrictions to foreign ownership.
7. Government has special voting rights.
8. Government to retain at least are third of shares.
9. Government has power to block acquisition of more than 15% of BT and C&W.

Sources : OECD Communications Outlook (various issues); OECD International Regulation Database; E.M. Noam and A. Singhal (1996),
"Supra national regulation",*Telecommunications Policy* , vol20 N 10 pp 769-787 ; EC "Fourth report on the telecommunications regulatory package".

Table 2. **Market structure, 1998**

	Basic voice telephony : Trunk			Basic voice telephony : International			Mobile cellular telephony : Analogue			Mobile cellular telephony : Digital		
	Number of license holders	Share of largest operator	Share of second largest operator	Number of license holders	Share of largest operator	Share of second largest operator	Number of license holders	Share of largest operator	Share of second largest operator	Number of license holders	Share of largest operator	Share of second largest operator
Australia	11	82	16	11	63	22	2	70	30	3	48	33
Austria	11	100	0	13	100	0	1	100	0	3	80	20
Belgium	7	100	0	7	100	0	1	100	0	2	67	33
Canada	13			14			2		.	10		
Czech Republic	1	100	0	1	100	0	1	100	0	2	71	29
Germany	21	100	0	21	100	0	1	100	0	4	44	43
Denmark	8	95		8	75		1	100	0	4	53	
Finland	20	55	40	16	66	24	1	100	0	2	69	31
France	13	100	0	14			2	64	36	3	53	38
Greece	1	100	0	1	100	0	0			3	53	47
Hungary	1	100	0	1	100	0	1	100	0	2	56	44
Iceland	1	100		1	100	0	1	100	0	2	100	0
Ireland	1	100	0	1	100	0	1	100	0	2	65	35
Italy	4	100	0	4	100	0	1	100	0	2	66	
Japan	15	64		21	64		18[2]	51		30[5]	51	
Korea	3	91	9	3	68	23	5[3]	73[3]	21[3]	5[3]	73[3]	21[3]
Luxembourg	1	100		1	100	0	0			2	100	0
Mexico	14	81	9	7	68	11	10	64	23		60	
Netherlands	3	80		3	80		1	100	0	6	64	30
Norway		100	0		95		1	100	0	3	75	
New Zealand	7	77	18	15	72	20	1	100	0	2	83	
Poland	1	100		1	100	0	1	100	0	3		
Portugal	1	100	0	1	100	0	1	100	0	3	50	
Spain	3	97	3	3	97	3	1	100	0	2	70[7]	30[7]
Sweden	15	83		15	68		1	100	0	4	49	
Switzerland	12	100	0	12	100	0	1	100	0	3	100	0
Turkey	1	100	0	1	100	0	1	100	0	2	75	25
United Kingdom	>20	76	10	7	49	16	2			4	34	
United States	621	62		346	49	27	2[4]			6[6]		
Simple Average		90.8			85.7			91.8			65.8	
Weighted Average[1]		75.4			62.7			73.6			52.2	

1. Weighted by the countries share of telecommunications revenue in total OECD revenue.
2. Regional duopolies.
3. Analogue and digital.
4. In most markets.
5. Regional or national.
6. Up to 6 in each market.
7. January 1999.

Sources : OECD Communications Outlook (various issues); OECD International Regulation Database; EC (1999), "Fourth report on the Telecommunications Regulatory Package".

Table 3. **Ownership and privatisation of PTOs, 1998**

	PTO	State shareholdings (%)		Year of privatisation
		1992	1998	
Australia	Telstra	100	67	1996-97
Austria	Post und telekom Austria AG	100	100[1]	1998[1]
Belgium	Belgacom	100	51	1995
Canada	Stentor	0	0	-
Czech. Rep.	SPT Telecom	100	51	
Germany	Deutsche Telekom AG	100	61	1996
Denmark	Tele Denmark	89	0	1992
Finland	Sonera	100	78.8	1998
France	France Telecom	100	62	1997
Greece	OTE	100	65	-
Hungary	Hungarian Telecommunication	100	6.5	1993
Iceland	Telecom Iceland	100	100	-
Ireland	Telecom Eireann	100	80	1996-97
Italy	Telecom Italia	>50	5	1998
Japan	NTT	>66	65	1986
Korea	Korean Telecom	>71	71.2	1987
Luxembourg	PT administration	100	100	-
Mexico	Telefonos de Mexico	0	0	1990
Netherlands	KPN Telecom NV	100	43.8	1994
Norway	Telenor	100	100	-
New Zealand	Telecom New Zealand	0	0	1990
Poland	TPSA	100	100	1998
Portugal	Telecom Portugal	100	25	1995
Spain	Telefonica	35[2]	0	1997[3]
Sweden	Telia	100	100	-
Switzerland	Swisscom	100	100	1998
Turkey	Turk Telekomunikasyon	100	100	-
United Kingdom	British Telecom	22	0	1984
United States	Baby Bells	0	0	-
Simple average		> 77	51.2	
Weighted average[4]		>39	31.3	

1. The mobile service subsidiary of the PTO (Mobilkom Austria AG) was partially privatised in 1997-98.
2. 1991.
3. First tranche privatised in 1924.
4. Weighted by the countries' shares of telecommunications revenue in total OECD revenue.

Sources : OECD Communications Outlook (various issues); OECD International Regulation Database.

Table 4 : **Synopsis of telecommunications price regulation, 1998**

(Number of countries in each category)

	Retail prices		Interconnection/access charges		
	Basic voice[1]	Mobile	Basic voice[1]	Mobile	Publicity of charges required
No regulation	1	12	5	8	6
Regulation	26	7	19	11	18
Incentive-based	18	3	4	3	
Cost-based	3	1	13	8	
Discretionary	4	1	2	0	
Other	1	2	0	0	
Regulation applies to :					
All operators	3	2	4	3	
Dominant operators	5	3	8	7	
Only PTOs	15	2	5	0	
Other	1		1	1	
Number of countries	27	19	24	19	24

1. Long-distance communications domestic and international.

Source: OECD Secretariat.

Table 5. **Synopsis of regulatory institutions, 1999**

(Number of countries in each category)

Institutions	Role		Competencies						
			Division of regulatory responsibilities for licensing			Regulations on interconnection		Regulations on pricing	Regulations on service quality
	Yes	No	Issuing licence	Oversight of licence requirements	Approval of Merger	Authorisation of interconnexion charges of operators with signifiant market power	Dispute resolution		
Sectoral regulator	25	4	16	20	6	18	24	16	23
Ministry department	19	10	14	8	4	5	4	11	4
Competition authority	22	7	0	1	21	1	1	3	1

Source: OECD Secretariat.

Table 6 : **Indicators of regulation and market structure for empirical analysis**

Indicators	Definition	Period	Obs	Coefficient of variation	Minimum	Maximum	Mean	Standard deviation
PROSPECT OF LIBERALISATION								
International	NUMBER OF YEARS TO ENTRY LIBERALISATION	91-97	168	-1.0	-14	0	-3.2	3.3
Trunk	NUMBER OF YEARS TO ENTRY LIBERALISATION	91-97	168	-1.0	-14	0	-3.2	3.3
Mobile	NUMBER OF YEARS TO ENTRY LIBERALISATION	93-97	120	-3.3	-4	0	-0.2	0.6
Leasing	NUMBER OF YEARS TO ENTRY LIBERALISATION-TRUNK	91-97	168	-1.0	-14	0	-3.2	3.3
DEGREE OF LIBERALISATION								
International	ENTRY LIBERALISATION INDEX[1]	91-97	168	1.4	0	1	0.3	0.4
Trunk	ENTRY LIBERALISATION INDEX[1]	91-97	168	1.4	0	1	0.3	0.5
Mobile	ENTRY LIBERALISATION INDEX[1]	93-97	120	0.6	0	1	0.8	0.4
MARKET STRUCTURE								
International	MARKET SHARE OF NEW ENTRANTS	91-97	168	1.7	0	55	8	14.6
Trunk	MARKET SHARE OF NEW ENTRANTS	91-97	168	2.0	0	60	7	14.3
Mobile	MARKET SHARE OF NEW ENTRANTS	1997	24	0.5	0	66	37	18.8
Leasing	MARKET SHARE OF NEW ENTRANTS-TRUNK	91-97	168	2.0	0	60	7	14.3
INTERNATIONALISATION OF DOMESTIC MARKETS								
All services	NUMBER OF FOREIGN TELECOM OPERATORS PARTICIPATING IN JOINT VENTURES OR OTHER CO-OPERATION AGREEMENTS WITH DOMESTIC OPERATORS IN DOMESTIC MARKET IN 1995	1995	168	1.0	0	9	2.5	2.5
PROSPECT OF PRIVATISATION[2]								
All services	NUMBER OF YEARS TO PRIVATISATION	91-97	168	-1.1	-10	0	-4.3	4.1
STATE CONTROL								
All services	INDEX OF STATE OWNERSHIP AND CONTROL OF PTO[3]	91-97	168	0.5	0	1	0.8	0.35

1. Monopoly=0, Duopoly=50, Competition=100

2. Privatisation is defined as the (first) partial or total sale of shares owned by the state in the PTO

3. Scale 0-1 [1:100% public, .8:>=50% public, .7:>=33% public, .5:<33% public and special voting rights,

.3:<33% & >10% public, .2:<10% public and/or special voting right,0:100% private]

Sources : OECD Communications Outlook (various issues); OECD International Regulation Database; E.M. Noam and A. Singhal (1996),

"Supra national regulation", *Telecommunications Policy* , vol20 N 10 pp 769-787.

Table 7. **Regulation and market structure : the discriminating factors, 1993-1997**
Rotated factors loadings

	Market and regulatory environment in fixed telephony	Timing of the liberalisation process	Market and regulatory environment in mobile telephony	Privatisation perspectives
Liberalisation index :				
International	0.86	0.26	0.14	0.19
Trunk	0.88	0.26	0.17	0.19
Market structure :				
International	0.90	0.15	0.25	0.07
Trunk	0.84	0.12	0.06	0.14
State ownership of PTO	-0.60	-0.13	-0.31	-0.14
Liberalisation perspectives				
International	0.55	0.78	0.04	0.00
Trunk	0.55	0.78	0.04	-0.01
Mobile	-0.05	0.85	0.21	0.12
Internationalisation of domestic market	0.62	-0.17	0.62	-0.05
Liberalisation index :				
Mobile	0.12	0.44	0.64	0.49
Market structure :				
Mobile	0.22	0.20	0.88	0.13
Privatisation perspectives	0.26	0.03	0.14	0.92

Notes:
Extraction method: Principal Component Analysis.
Rotation method: Varimax with Kaiser Normalization.
Rotation converged in 10 iterations.

Table 8. **Indicators of technology and economic structure for empirical analysis[1]**

Model	Definition	Period	Obs	Coefficient of variation	Minimum	Maximum	Mean	Standard deviation
TECHNOLOGY : PERCENTAGE OF DIGITAL								
International	%DIGITAL LINES IN TOTAL MAINLINES	91-97	168	0.3	0.0	1.0	0.7	0.2
Trunk	%DIGITAL LINES IN TOTAL MAINLINES	91-97	168	0.3	0.0	1.0	0.7	0.2
Mobile	% OF DIGITAL SUBSCRIBERS	93-97	120	0.8	0.0	1.0	0.3	0.4
TECHNOLOGY : CAPITAL INTENSITY								
All services	TOTAL FIXED INVESTMENT IN TELECOM / TOTAL EMPLOYMENT	91-97	168	0.5	1.0	15	4.1	2.2
All services	TOTAL FIXED INVESTMENT IN TELECOM / NUMBER OF MAINLINES	91-97	168	0.4	57	505	221	91
All services	TELECOM CAPITAL STOCK (CUMULATIVE SUM OF INVESTMENT OVER TEN YEARS) / NUMBER OF MAINLINES	91-97	168	0.4	145	3061	1777	641
ECONOMIC STRUCTURE : INCOME								
All services	TOTAL TELECOMMUNICATIONS REVENUE / POPULATION	91-97	168	1.5	0.6	66	5.2	7.6
All services	GDP / POPULATION	91-97	168	1.7	0.5	33	2.4	4.1
ECONOMIC STRUCTURE : COSTS								
All services	TOTAL OPERATING EXPENDITURE / TOTAL EMPLOYMENT	91-97	168	0.4	85.8	2971	1055	455
All services	TOTAL OPERATING EXPENDITURE / NUMBER OF MAINLINES	91-97	168	0.4	0.7	12	5.9	2.3
ECONOMIC STRUCTURE : PRICE REBALANCING INDICATOR								
All services	DISTANCE OF PRICE STRUCTURE IN COUNTRY i AT TIME t FROM THE PRICE STRUCTURE OF THE UK IN 1998 [2]	91-97	154	0.2	43.3	98	67	13

1. Values are in US$ based on 1993 PPPs

2. The distance was computed as (100-1/4(SUM(ABS(PDISTXit-PDISTXuk98)) where X=local, 27km, 110 km, 490km.
   and PDISTX = price for the distance X

Source : OECD Telecommunications Database.

Table 9. **Performance indicators for empirical analysis**[1]

Model	Definition	Period	Obs	Coefficient of variation	Minimum	Maximum	Mean	Standard deviation
PRODUCTIVITY								
International	OUTGOING MINUTES OF INTERNATIONAL COMMUNICATIONS (MITT)/ TOTAL EMPLOYMENT	91-97	168	1.5	2177	346637	35170	52937
Trunk	NUMBER OF MAINLINES / TOTAL EMPLOYMENT	91-97	168	0.3	77.4	337.8	183	48.2
Mobile	NUMBER OF MOBILE SUBSCRIBERS / MOBILE EMPLOYMENT	93-97	110	2.7	80.0	32196	1288	3458
PRICES								
International	COLLECTION CHARGES (AVERAGE OF PEAK 1 MINUTE TO OECD COUNTRIES)	91-97	168	0.4	0.5	2.9	1.1	0.4
International	REVENUE FROM INTERNATIONAL SERVICE / OUTGOING MITT	91-97	168	0.6	0.1	2.8	0.9	0.5
Trunk	TARIFF BASKET (EXCLUDING TAX)	91-97	161	0.4	375	2530	1138	418
Mobile	REVENUE FROM MOBILE SERVICE / NUMBER OF MOBILE SUBSCRIBERS	93-97	115	0.6	173	2894	775	451
Leasing	OECD BASKET OF NATIONAL LEASED LINE CHARGES : 64 Kbit/s (EXCLUDING TAX)	91-97	161	1.5	19745	1632547	103880	159784
QUALITY								
International	ANSWER SEIZURE RATIO [2]	91-97	168	0.1	36.9	70.7	60.0	7.2
Trunk	SERVICE RELIABILITY (AVERAGE OF CALL SUCCESS RATE AND FAULT CLEARANCE RATE) [3]	91-97	167	0.7	0.8	47.5	16.1	10.7

1. Values are in US$ based on 1993 PPPs
2. The answer seizure ratio is the proportion of international calls that successfully seize an international circuit and are answered in the terminating country
3. The call success rate is defined as one minus the number of faults per mainline. The fault clearance rate is the number of faults repaired in 24 hours

Source : OECD Telecommunications Database.

Table 10. **The effects of regulation and market structure on performance**

Summary of results of panel regressions (1991-1997)[1,2,3]

Panel A. Productivity model

Industry	International	Trunk	Mobile	International, trunk and mobile
Dependent variable[4]	Outgoing minutes per employee	Mainline per employee	Cellular subscribers per employee	Productivity
Number of periods	7	7	5	6.2
Number of countries	24	24	22	70
Number of observations	168	168	110	446
	Random effects	Fixed effects	Random effects	Fixed effects
Market share of new entrants[5]	0.01	0.01	-0.37	0.01
	2.72	*2.83*	*-1.07*	*4.17*
Time to liberalisation	0.05	0.23	0.36	0.17
	3.48	*7.66*	*1.72*	*7.19*
State ownership index	0.11	-0.29	0.03	0.12
	1.10	*-1.07*	*0.09*	*0.65*
Time to privatisation	-0.01	-0.07	-0.06	-0.10
	-0.96	*-2.25*	*-1.82*	*-3.88*
Internationalisation of domestic market	-0.16		0.05	
	-4.53		*0.97*	

1. Full equation estimates are shown in tables A3-A7 in the annex

2. 1993-1997 for mobile services

3. For random effects : z-statistic in *italics;* for fixed effects : t-statistic in *italics*

4. Performance variables were standardised in the pooled regressions

5. Liberalisation index for moblile services

Table 10. **The effects of regulation and market structure on performance** (continued)

Summary of results of panel regressions (1991-1997)[1,2,3]

Panel B. Prices model

Industry	International		Trunk	Mobile	Leasing	International, trunk and Mobile	International, trunk, mobile and leasing
Dependent variable[4]	OECD tariff basket	International revenue / Outgoing minutes	OECD tariff basket	Mobile revenue / Cellular subscribers	National leased line charges (64Kb/s)	Prices[5]	Prices[5]
Number of periods	7	7	7	5	7	5.6	5.9
Number of countries	22	22	22	23	22	65	87
Number of observations	154	154	154	115	154	406	557
	Fixed effects	Random effects	Fixed effects	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Market share of new entrants[6]	-0.01	-0.01	0.00	-0.86	0.00	-0.01	-0.01
	-2.89	*-2.44*	*-0.57*	*-2.76*	*0.22*	*-3.27*	*-3.74*
Time to liberalisation	-0.29	-0.07	-0.10	0.09	-0.08	*-0.17*	*-0.15*
	-8.50	*-2.54*	*-3.47*	*0.52*	*-3.23*	*-6.24*	*-7.40*
State ownership index	-0.38	0.62	-0.66	0.50	0.11	-0.07	-0.06
	-1.17	*2.40*	*-2.43*	*1.12*	*0.06*	*-0.35*	*-0.35*
Time to privatisation	0.05	-0.02	0.02	0.11	0.01	0.03	0.02
	1.30	*-0.83*	*0.61*	*1.33*	*0.34*	*1.11*	*0.84*
Internationalisation of domestic market		0.21					
		2.92					

1. Full equation estimates are shown in tables A3-A7 in the annex

2. 1993-1997 for mobile services

3. For random effects : z-statistic in *italics;* for fixed effects : t-statistic in *italics*

4. Performance variables were standardised in the pooled regressions

5. OECD tariff basket for international prices

6. Liberalisation index for moblile services

Table 10. **The effects of regulation and market structure on performance** (continued)

Summary of results of panel regressions (1991-1997)[1,2,3]

Panel C. Quality model

Industry	International	Trunk	International and trunk
Dependent variable[4]	Answer seizure ratio	Service reliability[5]	Quality
Number of periods	7	7	7
Number of countries	24	24	48
Number of observations	168	167	335
	Random effects	Random effects	Random effects
Market share of new entrants	0.04	0.00	0.02
	1.83	-0.09	*0.74*
Time to liberalisation	1.32	0.86	*1.08*
	9.06	3.03	*6.83*
State ownership index	-0.05	-0.98	-0.44
	-0.03	*-0.29*	*-0.24*
Time to privatisation	0.03	0.03	0.03
	0.17	*0.10*	*0.19*
Internationalisation of domestic market	-0.11	0.57	0.25
	-0.31	*0.71*	*0.60*

1. Full equation estimates are shown in tables A3-A7 in the annex

2. 1993-1997 for mobile services

3. For random effects : z-statistic in *italics;* for fixed effects : t-statistic in *italics*

4. Performance variables were standardised in the pooled regressions

5. Defined as simple average of call success rate and fault clearance rate (see table 6)

Table 11. **Explaining cross-country differences in telecommunications performance**
(Pooled estimates)

Panel A. Productivity[1]

	Productivity	Country specific effect	Economic structure[2]	Regulation and market structure (a+b+c)	Market structure (a)	Liberalisation (b)	Ownership and privatisation (c)
Australia	-0.70	-1.00	-0.09	0.39	0.06	0.44	-0.10
Austria	0.19	0.25	0.12	-0.18	-0.06	-0.12	0.00
Belgium	-0.05	0.46	-0.03	-0.47	-0.09	-0.12	-0.27
Canada	-0.35	-0.40	0.06	-0.01	0.11	0.42	-0.54
Denmark	-0.02	0.37	-0.12	-0.27	0.00	0.15	-0.42
Finland	-0.17	-1.33	0.05	1.11	0.14	0.38	0.59
France	-0.08	0.00	0.13	-0.21	-0.01	-0.10	-0.10
Germany	-0.20	-0.04	0.14	-0.30	-0.01	-0.10	-0.19
Greece	-0.10	0.44	-0.20	-0.33	-0.01	-0.90	0.58
Iceland	-0.29	-0.11	-0.14	-0.04	-0.14	-0.10	0.20
Ireland	-0.73	-0.30	-0.06	-0.37	-0.06	-0.12	-0.19
Italy	0.39	0.56	0.11	-0.28	-0.04	-0.10	-0.14
Japan	0.23	-1.05	0.11	1.17	0.16	0.44	0.57
Luxembourg	2.46	1.82	0.29	0.35	-0.14	-0.10	0.59
Netherlands	0.50	0.80	0.04	-0.34	-0.03	0.03	-0.33
New Zealand	-0.36	-0.39	0.02	0.01	0.09	0.44	-0.52
Norway	-0.53	-0.99	-0.03	0.48	-0.01	-0.10	0.59
Portugal	-0.44	0.23	-0.02	-0.65	-0.01	-0.37	-0.28
Spain	-0.06	0.23	0.04	-0.33	-0.06	-0.10	-0.17
Sweden	-0.14	-1.08	-0.04	0.98	0.03	0.35	0.59
Switzerland	0.75	0.94	0.06	-0.24	-0.14	-0.10	0.00
Turkey	0.47	1.35	-0.26	-0.62	-0.11	-1.10	0.59
United Kingdom	-0.31	-0.25	-0.09	0.03	0.11	0.44	-0.52
United States	-0.28	-0.32	-0.08	0.12	0.22	0.44	-0.54
Average of absolute deviations	0.41	0.61	0.10	0.39	0.08	0.29	0.36
Standard deviation	0.64	0.79	0.12	0.51	0.10	0.40	0.42

1. Deviations from OECD average
2. Including the effect of technology

Table 11. **Explaining cross-country differences in telecommunications performance** (continued)
(Pooled estimates)

Panel B. Prices[1]

	Prices	*Country specific effect*	*Economic structure [2]*	*Regulation and market structure (a+b+c)*	Market structure (a)	Liberalisation (b)	Ownership and privatisation (c)
Australia	0.16	0.70	-0.08	-0.46	-0.05	-0.41	0.00
Austria	0.41	0.33	-0.06	0.14	0.05	0.11	-0.02
Belgium	0.21	0.15	-0.16	0.22	0.08	0.11	0.03
Canada	-0.13	0.23	-0.04	-0.32	-0.10	-0.39	0.17
Denmark	-0.86	-0.65	-0.14	-0.06	0.00	-0.14	0.08
Finland	-0.80	0.07	-0.26	-0.60	-0.12	-0.36	-0.13
France	-0.09	-0.02	-0.17	0.10	0.01	0.09	0.00
Germany	-0.10	-0.04	-0.18	0.12	0.01	0.09	0.02
Greece	-0.07	-0.40	-0.41	0.74	0.01	0.84	-0.12
Iceland	-0.64	-0.77	-0.04	0.16	0.12	0.09	-0.06
Ireland	0.14	0.12	-0.16	0.18	0.05	0.11	0.02
Italy	0.17	0.12	-0.11	0.16	0.03	0.10	0.03
Japan	1.01	1.70	-0.03	-0.66	-0.14	-0.41	-0.11
Luxembourg	3.37	0.00	3.28	0.09	0.12	0.09	-0.13
Netherlands	-0.36	-0.24	-0.17	0.05	0.03	-0.03	0.05
New Zealand	-0.46	0.00	-0.12	-0.34	-0.08	-0.41	0.15
Norway	-0.80	-0.70	-0.07	-0.02	0.01	0.09	-0.13
Portugal	0.75	0.65	-0.30	0.39	0.01	0.34	0.04
Spain	0.53	0.51	-0.18	0.20	0.05	0.10	0.05
Sweden	-0.79	-0.13	-0.17	-0.49	-0.03	-0.33	-0.13
Switzerland	-0.19	-0.42	0.04	0.19	0.12	0.09	-0.02
Turkey	1.63	1.14	-0.52	1.00	0.10	1.03	-0.13
United Kingdom	-0.40	0.09	-0.14	-0.35	-0.09	-0.41	0.15
United States	0.18	0.49	0.13	-0.44	-0.20	-0.41	0.17
Average of absolute deviations	0.60	0.40	0.29	0.31	0.07	0.27	0.08
Standard deviation	0.92	0.57	0.71	0.40	0.09	0.38	0.10

1. Deviations from OECD average
2. Including the effect of technology and price rebalancing

Table 11. **Explaining cross-country differences in telecommunications performance** (continued)
(Pooled estimates)

Panel C. Quality[1]

	Quality	Country specific effect	Economic structure[2]	Regulation and market structure (a+b+c)	Market structure (a)	Liberalisation (b)	Ownership, privatisation and internationalisation (c)
Australia	-3.90	-8.08	0.83	3.35	0.17	2.85	0.34
Austria	0.90	1.47	1.09	-1.66	-0.17	-0.77	-0.72
Belgium	3.16	4.38	-0.38	-0.84	-0.25	-0.77	0.17
Canada	6.91	2.64	0.10	4.17	0.31	2.73	1.13
Denmark	4.83	5.07	-0.78	0.54	0.00	0.98	-0.44
Finland	-0.23	-1.78	-0.35	1.90	0.39	2.48	-0.97
France	5.82	6.63	-0.23	-0.58	-0.03	-0.64	0.08
Germany	0.52	0.01	0.80	-0.29	-0.03	-0.64	0.38
Greece	-20.17	-12.46	-1.12	-6.59	-0.03	-5.88	-0.69
Iceland	-8.59	-5.57	-1.18	-1.84	-0.39	-0.64	-0.80
Ireland	-0.02	0.83	0.46	-1.31	-0.17	-0.77	-0.37
Italy	1.71	1.57	0.74	-0.60	-0.10	-0.68	0.19
Japan	11.65	6.34	0.64	4.67	0.46	2.85	1.36
Luxembourg	4.55	6.04	0.51	-2.00	-0.39	-0.64	-0.97
Netherlands	8.17	9.09	-0.48	-0.44	-0.10	0.19	-0.53
New Zealand	-8.25	-12.38	0.47	3.66	0.25	2.85	0.55
Norway	-0.48	1.36	-0.20	-1.64	-0.03	-0.64	-0.97
Portugal	-8.70	-6.84	0.60	-2.46	-0.03	-2.39	-0.05
Spain	1.48	1.63	0.68	-0.84	-0.17	-0.68	0.02
Sweden	4.61	2.86	-0.69	2.44	0.09	2.31	0.04
Switzerland	1.30	2.05	1.00	-1.76	-0.39	-0.64	-0.72
Turkey	-17.86	-8.47	-1.94	-7.45	-0.32	-7.17	0.04
United Kingdom	2.51	-1.67	-0.53	4.71	0.30	2.85	1.56
United States	10.43	5.62	-0.04	4.86	0.63	2.85	1.38
Average of absolute deviations	5.69	4.78	0.66	2.52	0.22	1.91	0.60
Standard deviation	7.92	6.04	0.79	3.26	0.28	2.62	0.77

1. Deviations from OECD average
2. Including the effect of technology

Figure 1. **Breakdown of telecommunications revenue by service**
(in percentages)

■ International □ Mobile ▨ Local plus Trunk ▨ Leasing plus Other

1992

9.1

5.7

37.6

47.6

1997 [1]

7.8

21.3

19.7

51.2

1. Estimated data.

Source: OECD Communications Outlook (1997) and (1999).

Figure 2. **Grouping countries according to regulation and market structure (dendrogram)[1]**
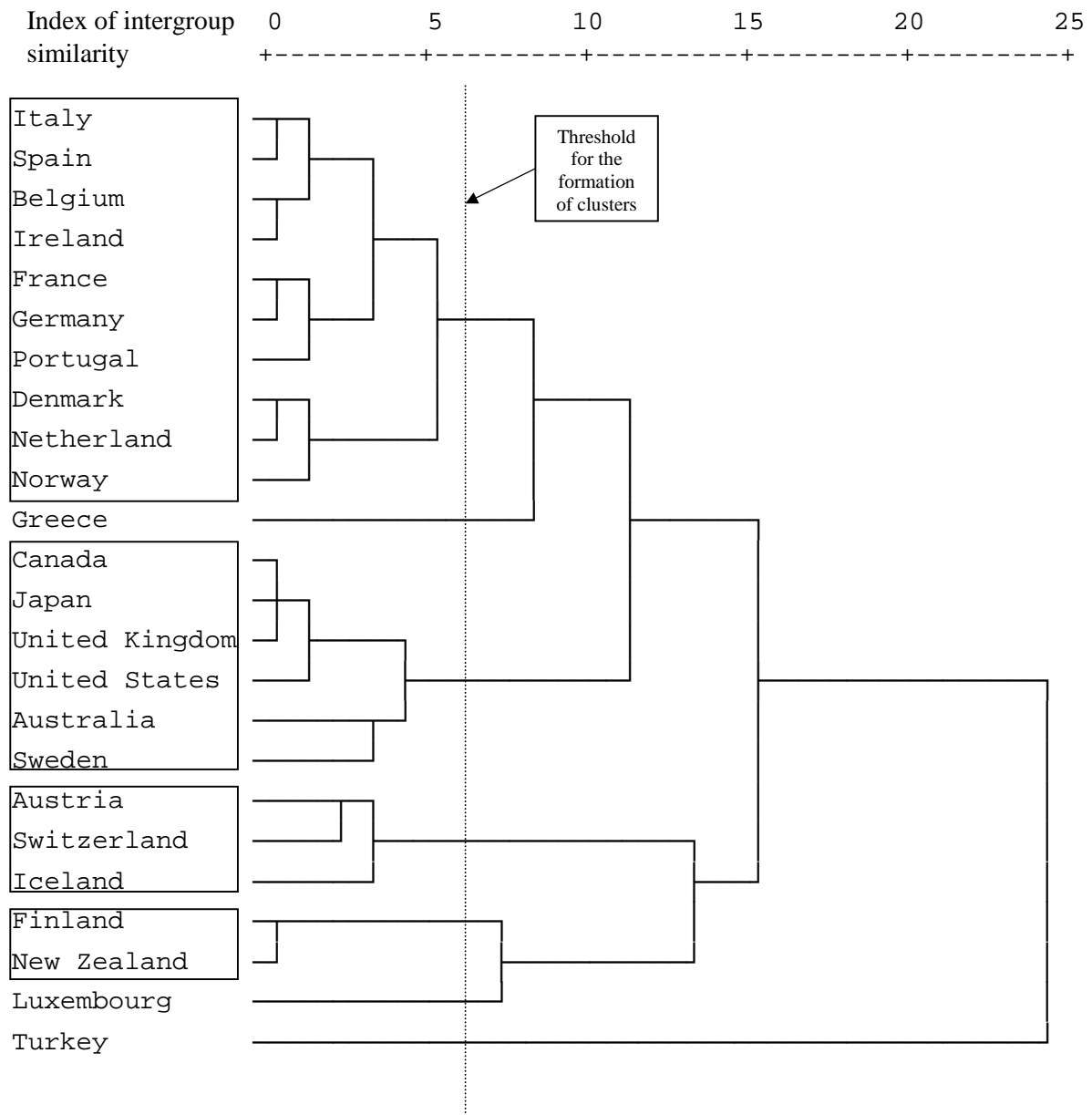
1. Figure should be read left to right. The top index measures the similarity between countries belonging to the same cluster (from most to least similar). Knot numbers indicate the number of clusters at each hierarchical stage and the order in which they are formed (starting with initial clusters containing a single country). For more details see box 1.

Figure 3**. Cross-country patterns of reform, 1993-1997**

Panel A. Fixed telephony and liberalisation[1]
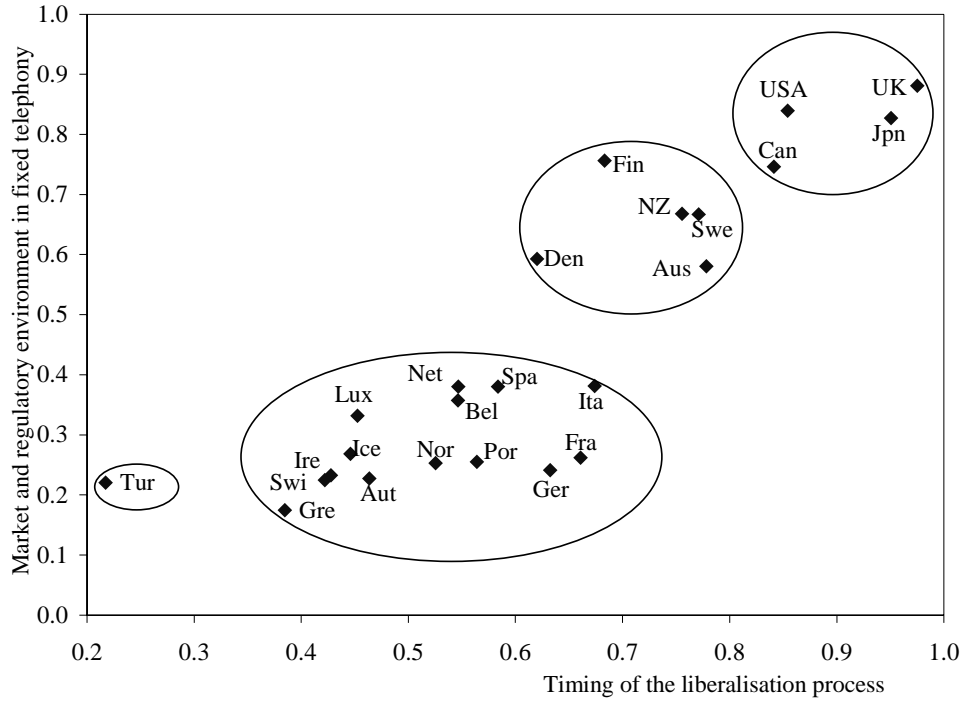
Panel B. Fixed and mobile telephony[1]
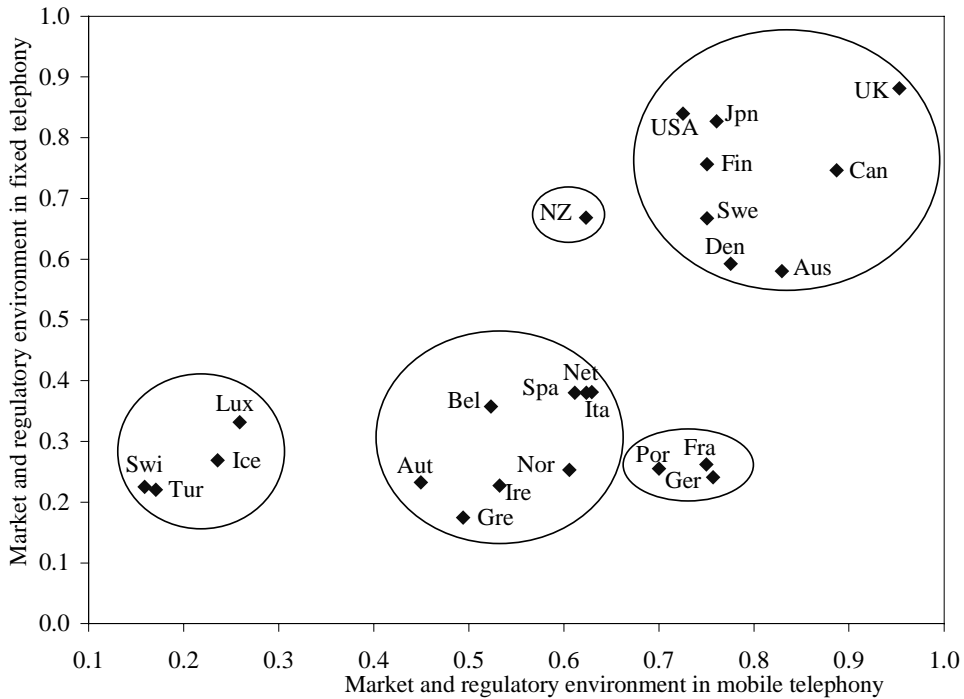
1. Fixed telephony includes only domestic and international long-distance services.

Figure 4. **Comparing telecommunications performance across countries**[1]
(deviations from OECD average)
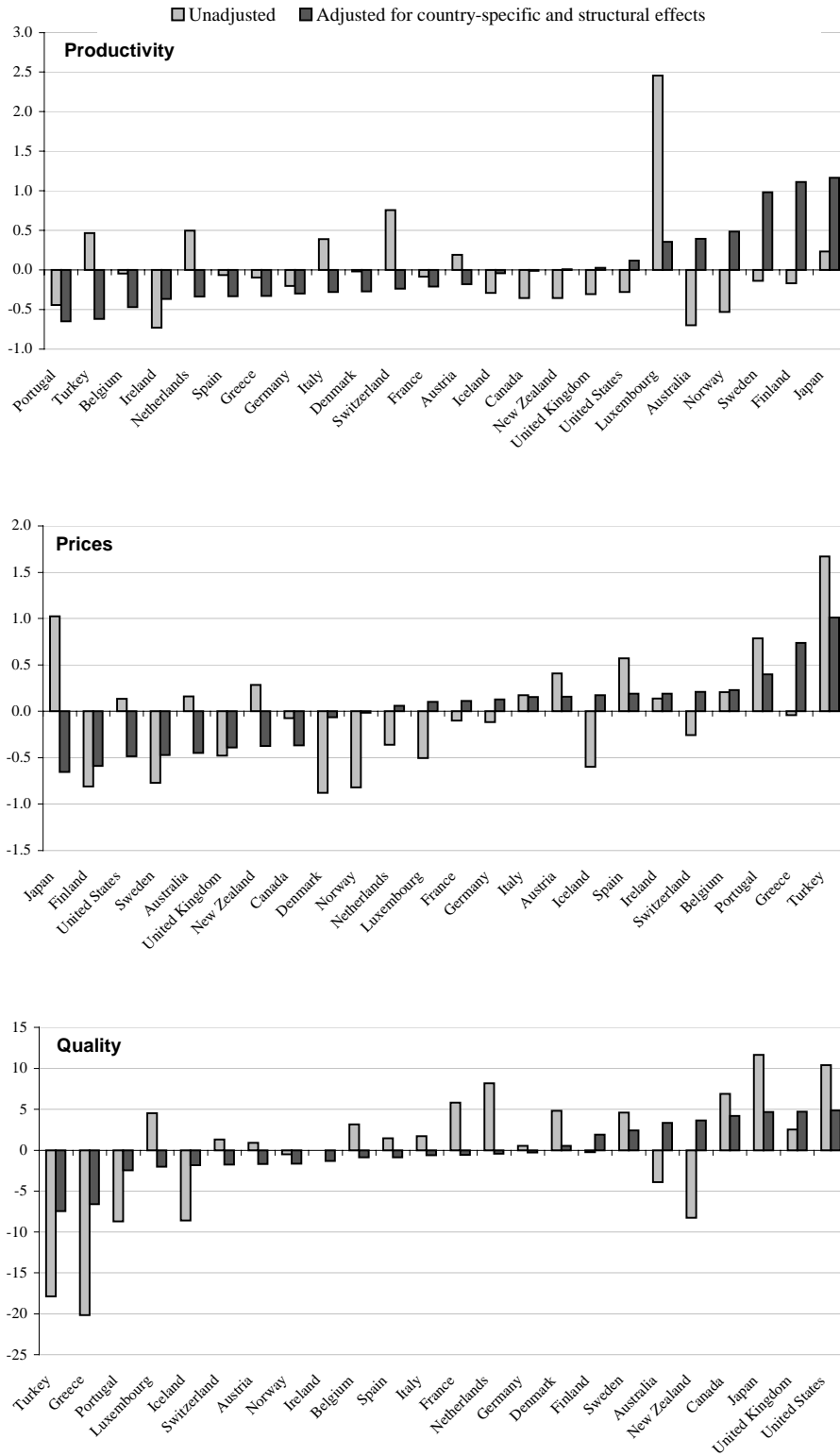
1. Based on results of pooled regressions

ANNEX TABLES

Table A.1. **Price regulation**

|	Retail prices		Interconnection or access charges		
	Basic voice telephony	**Mobile cellular telephony**	**Basic voice telephony (trunk and international)**	**Mobile cellular telephony**	**Mandatory requirement to publish interconnection or access charges**
Australia	Objective benchmark Regulation applies to the incumbent PTO	Objective benchmark Regulation applies to the incumbent PTO	Commercial agreement or access undertaking approved by regulator	Commercial agreement or access undertaking approved by regulator	No
Austria	Discretionary Regulation applies to the dominant operators	No regulation	Cost of the operator Regulation applies to the dominant operators	No regulation	Yes
Belgium	Objective benchmark Regulation applies to the dominant operators	Objective benchmark Regulation applies to all operators	Cost of the operator Regulation applies to the dominant operators	.	Yes
Canada	Objective benchmark Regulation applies to the incumbent PTO	No regulation	.	No regulation	Yes
Czech Republic	Objective benchmark Regulation applies to all operators	No regulation	No regulation	No regulation	No
Germany	Discretionary (Tariff approval) Regulation applies to the dominant operators	Objective benchmark and cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	Yes
Denmark	Objective benchmark Regulation applies to the incumbent PTO	.	Cost of the operator Regulation applies to the dominant operators	No regulation	Yes
Finland	No regulation	No regulation	Cost of the operator Regulation applies to the dominant operators	No regulation	Yes
France	Objective benchmark Regulation applies to the incumbent PTO	No regulation	Cost of the operator Regulation applies to the dominant operators	No regulation	Yes
Greece	Objective benchmark Regulation applies to the incumbent PTO	.	No regulation	No regulation	No
Hungary	Objective benchmark Regulation applies to all operators	.	Objective benchmark and cost of the operator Regulation applies to all operators	.	Yes
Iceland	.	.	.	.	.
Ireland	Objective benchmark Regulation applies to the incumbent PTO	No regulation	Cost of the operator Regulation applies to all operators	Cost of the operator Regulation applies to all operators	.
Italy	Cost of the operator Regulation applies to the dominant operators	No regulation	Objective benchmark Regulation applies to the incumbent PTO	Objective benchmark Regulation applies to the dominant operators	Yes
Japan	Objective benchmark (Local) Regulation applies to the incumbent PTO	Regulation of some prices Regulation applies to all operators	Objective benchmark Regulation applies to all operators	Objective benchmark Regulation applies to all operators	Yes

Table A.1 **Price regulation** (continued)

	Retail prices		Interconnection or access charges		
	Basic voice telephony	**Mobile cellular telephony**	**Basic voice telephony (trunk and international)**	**Mobile cellular telephony**	**Mandatory requirement to publish interconnection or access charges**
Korea	Discretionary (Tariff approval) Regulation applies to the incumbent PTO	Discretionary (Tariff approval) Regulation applies to the incumbent PTO	.	.	No
Luxembourg	.	.	.	.	.
Mexico	Objective benchmark Regulation applies to the incumbent PTO	.	No regulation	.	No
Netherlands	Objective benchmark Regulation applies to the incumbent PTO	No regulation	Trunk : Cost of the operator Regulation applies to the incumbent PTO International : No regulation	.	Yes
Norway	Cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	.
New Zealand	Objective benchmark (residential)	.	Objective benchmark Regulation applies to the dominant operators	Objective benchmark Regulation applies to the dominant operators	Yes
Poland	Objective benchmark Regulation applies to all operators	No regulation	No regulation	No regulation	.
Portugal	Objective benchmark Regulation applies to the incumbent PTO	No regulation	Cost of the operators	Cost of the operators	Yes
Spain	Regulation of some prices Regulation applies to the incumbent PTO	No regulation	Cost of the operator Regulation applies to the incumbent PTO	Cost of the operator Regulation applies to all operators	Yes
Sweden	Cost of the operator	.	Cost of the operator Regulation applies to all operators	Cost of the operator Regulation applies to the dominant operators	Yes
Switzerland	Trunk : Objective benchmark Regulation applies to the incumbent PTO	.	.	.	Yes
Turkey	Discretionary (Tariff approval) Regulation applies to the incumbent PTO	Objective benchmark Regulation applies to the dominant operators	Cost of the operator Regulation applies to the incumbent PTO	.	No
United Kingdom	Objective benchmark Regulation applies to the incumbent PTO	.	Objective benchmark Regulation applies to the incumbent PTO	Cost of the operator Regulation applies to the dominant operators	Yes
United States	Objective benchmark (local)	No regulation	Objective benchmark and cost of the operator Regulation applies to the dominant operators	Cost of the operator Regulation applies to the dominant operators	Yes

Source: OECD Secretariat.

Table A.2 **Regulatory setting, 1999**

	Industry regulator	Regulatory institutions	Competencies							Basis for the evaluation of the firm performance and costs
			Division of regulatory responsibilities for licensing			Regulations on interconnection		Regulations on pricing	Regulations on service quality	
			Issuing licence	Oversight of licence requirements	Approval of Merger	Authorisation of interconnexion charges of operators with signifiant market power	Dispute resolution			
Australia	ACA (Australian Communications Authority) and ACCC (Australian Competition and Consumer Commission)	Independent tel. regulator Competition authority	X	X	X	X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers Independent review is conducted at the end of each price cap period
Austria	TKC (Telecom Control)	Independent tel. Regulator	X	X		X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
Belgium	BIPT (Belgian Institute for Postal Service and Telecommunications)	Independent tel. Regulator Competition authority Ministry	X	X	X	X X	X	X	X X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
Canada	CRTC (Canadian Radio Television and Telecom. Office)	Independent tel. Regulator Competition authority Ministry	X (fixed) X (mobile)	X (fixed) X (mobile)	X X	X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
Czech Republic	CTO (Czech Telecommunications Office)	Independent tel. Regulator Ministry Other	X	X	X	No authorization	X (technical aspect) X (price)	X X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
Denmark	NTA (National Telecom agency)	Independent tel. Regulator Competition authority	X (mobile)	X	X	X	X	X	X	Information provided by the regulated firm Information on comparative performance and costs of firms
Finland	TAC (Telecommunications Administration Centre)	Independent tel. Regulator Competition authority Ministry	X	X	X	X	X	X		Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
France	ART (Autorité de la régulation des Télécommunications)	Independent tel. Regulator Competition authority Ministry	X	X	X X	X	X	X	X	Information provided by the regulated firm and an independent audit
Germany	Teg TP (Regulatory Authority for Telecommunications and Posts)	Independent tel. Regulator Competition authority	X	X	X X	X	X	X	X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sector/market. Other
Greece	EETT (National Post and Telecommunications Commission)	Independent tel. Regulator Competition authority Ministry	X	X	X	X	X	X	X	
Hungary	Communication Authority	Independent tel. Regulator Competition authority Ministry	X	X	X	X	X	X	X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers

Table A.2 **Regulatory setting, 1999** (continued)

	Industry regulator	Regulatory institutions	Division of regulatory responsibilities for licensing			Regulations on interconnection		Regulations on pricing	Regulations on service quality	Basis for the evaluation of the firm performance and costs
			Issuing licence	Oversight of licence requirements	Approval of Merger	Authorisation of interconnexion charges of operators with signifiant market power	Dispute resolution			
Iceland	PTA (Post and Telecommunication Administration)	Independent tel. Regulator Other	X	X		No authorization	X	X	X	
Ireland	ODTR (Director of Telecommunications Regulation)	Independent tel. Regulator Competition authority	X	X	X	X	X		X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers
Italy	AGC (Autorita Garante nelle Communicazioni)	Independent tel. Regulator Competition authority	X	X	X	X	X	X	X	Information on comparative performance and costs of firms in the same sector/market
Japan	MPT (Ministry of Post and Telecom)	Competition authority Ministry Other	X	X	X X	X	X	X	No monitoring	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same market
Korea	MIC (Ministry of Information and Communication)	Independent tel. Regulator Ministry	X	X	X	X	X	X	X	Information provided by the regulated firm and an independent audit
Luxembourg	ILT (Institut Luxembourgeois de Telecommunications)	Independent tel. Regulator				X	X	X	X	
Mexico	Cofetel (Commission Federal de Telecommunications)	Independent tel. Regulator Competition authority Ministry	X	X	X	X	X	X	X	Information provided by the regulated firm
Netherlands	OPTA(Independent Post and Telecommunications Authority)	Independent tel. Regulator Competition authority Ministry	X (fixed) X (mobile)	X	X	X	X	X	X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sector/market
New Zealand	Commerce Commission : Competion authority	Competition authority Ministry Other			X	No authorization	X	X	X	Information provided by the regulated firm
Norway	NPT (Norwegian Post and Telecommunications Authority)	Independent tel. Regulator Competition authority Ministry Other	X	X	X	No authorization	X	X	X	Information provided by the regulated firm and an independent audit
Poland	Ministry of Post and Telecommunication	Ministry	X	X	X	X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same market

Table A.2 **Regulatory setting, 1999** (continued)

	Industry regulator	Regulatory institutions	Division of regulatory responsibilities for licensing			Regulations on interconnection		Regulations on pricing	Regulations on service quality	Basis for the evaluation of the firm performance and costs
			Issuing licence	Oversight of licence requirements	Approval of Merger	Authorisation of interconnexion charges of operators with signifiant market power	Dispute resolution			
Portugal	ICP (Instituto das Comunicacoes de Portugal)	Independent tel. Regulator	X	X		X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same market
		Competition authority						X		
		Ministry			X			X		
Spain	CMT (Commision del Mercado de Telecomunicaaciones)	Independent tel. Regulator	X (fixed)	X		X	X	X		Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sector/market
		Competition authority			X					
		Ministry	X (mobile)						X	
Sweden	NPTA (National Post and Telecom agency)	Independent tel. Regulator	X	X		X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
		Competition authority			X					
Switzerland	ComCom (Communications commission) and OFCOM (Federal Office for Communications)	Independent tel. Regulator	X	X			X		X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sector/market
		Competition authority			X					
		Ministry						X		
		Other				No authorization				
Turkey	Ministry of Transport and Communications	Competition authority								Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers
		Ministry	X	X			X	X		
		Other			.	No authorization			No monitoring	
United Kingdom	OFTEL (Office of telecommunications)	Independent tel. Regulator		X	X	X	X	X	X	Information provided by the regulated firm Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sectors. Other
		Competition authority			X					
		Ministry	X	X						
United States	FCC (Federal Communications Commission)	Independent tel. Regulator	X	X	X	X	X	X	X	Information provided by the regulated firm and an independent audit Information gathered by the regulatory authority using investigative powers Information on comparative performance and costs of firms in the same sector/market Rulemaking procedures
		Competition authority			X					
		Other				X	X			

Source: OECD Secretariat.

Table A.3. **International**
Results of panel regressions, 1991-1997

Model[1]	Productivity			Prices						Quality		
Dependent variables	Outgoing minutes / employee			OECD tariff basket			International revenue / Outgoing minutes			Answer seizure ratio		
Number of periods	7			7			7			7		
Number of countries	24			22			22			24		
Number of observations	168			154			154			168		
Specification	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]
Constant	0.22	0.37	-0.03	-1.74	-1.84	-1.13	-1.12	-1.13	-0.64	62.86	62.78	61.74
	1.13	*1.34*	*-0.29*	*-2.76*	*-3.18*	*-1.72*	*-1.93*	*-2.04*	*-1.19*	*25.20*	*17.96*	*22.79*
Economic structure[4]	0.02	0.02	0.02	0.06	0.06	0.07	0.00	0.00	0.00	-0.08	-0.09	-0.10
	12.51	*18.61*	*16.53*	*2.24*	*1.21*	*2.70*	*2.61*	*1.91*	*2.82*	*-2.57*	*-3.91*	*-2.80*
Technology[5]	0.03	-0.10	-0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.20	*-0.78*	*-1.17*	*0.73*	*0.39*	*0.13*	*-1.69*	*-1.44*	*-2.33*	*1.12*	*0.84*	*1.25*
Market share of new entrants	0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.04	0.04	0.04
	2.72	*3.78*	*4.85*	*-2.13*	*-1.77*	*-2.89*	*-2.44*	*-0.85*	*-2.27*	*1.83*	*1.71*	*1.61*
Internationalisation of domestic market	-0.16	-0.17		0.30	0.30		0.21	0.20		-0.11	-0.11	
	-4.53	*-2.34*		*4.91*	*2.71*		*2.92*	*3.01*		*-0.31*	*-0.34*	
Number of years to privatisation	-0.01	0.00	0.00	-0.02	-0.01	0.05	-0.02	-0.03	-0.06	0.03	0.03	0.02
	-0.96	*-0.23*	*-0.33*	*-0.81*	*-0.15*	*1.30*	*-0.83*	*-0.46*	*-1.83*	*0.17*	*0.13*	*0.09*
State control index	0.11	0.13	0.13	-0.13	-0.19	-0.38	0.62	0.63	0.66	-0.05	-0.06	-0.06
	1.10	*2.14*	*1.77*	*-0.43*	*-0.55*	*-1.17*	*2.40*	*1.68*	*2.43*	*-0.03*	*-0.04*	*-0.04*
Number of years to liberalisation	0.05	0.05	0.06	-0.21	-0.23	-0.29	-0.07	-0.06	-0.04	1.32	1.31	1.27
	3.48	*3.48*	*5.41*	*-7.44*	*-3.33*	*-8.50*	*-2.54*	*-1.03*	*-1.49*	*9.06*	*5.97*	*6.94*
Price rebalancing indicator				0.00	0.00	0.00	0.00	0.00	0.00			
				-0.31	*0.01*	*0.59*	*-0.60*	*-0.62*	*-0.52*			
Statistics												
F			98.33			22.87			8.44			28.26
X[2].=	328.94			143.19			55.35			203.58		
Tests												
H0: Fixed-effects=0	F.=	308.99		F.=	18.27		F.=	45.24		F.=	22.58	
Hausman[6]	X2.=	0.00		X2.=	95.86		X2.=	8.85		X2.=	6.31	
Breusch-Pagan[7]	X2.=	163.46		X2.=	126.68		X2.=	244.01		X2.=	216.91	

1. See description of variables in table 6,9 and 10.
2. Correction for heteroskedasticity.
3. Only time-varying variables are included.
4. For productivity and quality : total telecommunications revenue per capita; for prices : total operating expenditure per mainline.
5. For productivity : percentage of digital lines in total mainlines; for prices : total fixed investment per mainline; for quality : capital stock (cumulative sum of investment over ten years) per mainline.
6. Ho : Random effect specification is correct.
7. Ho : Random effects = 0.

Table A.4 : **Trunk**
Results of panel regressions (1991-1997)

Model[1]	Productivity			Prices			Quality		
Dependent variables	Mainline per employee			OECD tariff basket			Service reliability		
Number of periods **Number of countries** **Number of observations**	7 24 168			7 22 154			6.96 24 167		
Specification	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]
Constant	0.39 *0.96*	0.40 *0.92*	0.00 *0.00*	0.62 *1.14*	0.69 *0.84*	1.03 *1.89*	83.58 *15.31*	83.06 *15.48*	88.72 *16.34*
Economic structure[4]	0.01 *1.40*	0.01 *1.44*	0.00 *0.73*	0.03 *1.23*	0.03 *0.69*	0.02 *1.09*	0.11 *1.77*	0.11 *2.52*	0.12 *1.94*
Technology[5]	0.19 *1.24*	0.20 *1.08*	0.26 *1.46*	0.03 *0.43*	0.00 *0.06*	-0.04 *-0.60*	0.00 *0.64*	0.00 *0.49*	0.00 *-0.07*
Market share of new entrants	0.01 *2.16*	0.01 *1.34*	0.01 *2.83*	*0.00* *-1.07*	*0.00* *-1.16*	*0.00* *-0.57*	0.00 *-0.09*	-0.01 *-0.19*	0.01 *0.17*
Internationalisation of domestic market	-0.12 *-1.66*	-0.13 *-1.41*		0.11 *1.92*	0.10 *1.67*		0.57 *0.71*	0.59 *0.95*	
Number of years to privatisation	-0.06 *-1.98*	-0.06 *-1.00*	-0.07 *-2.25*	0.04 *1.59*	0.03 *0.72*	0.02 *0.61*	0.03 *0.10*	0.04 *0.09*	0.04 *0.11*
State control index	-0.21 *-0.82*	-0.24 *-0.81*	-0.29 *-1.07*	-0.53 *-2.11*	-0.58 *-2.11*	-0.66 *-2.43*	-0.98 *-0.29*	-0.64 *-0.23*	-3.29 *-0.84*
Number of years to liberalisation	0.20 *7.53*	0.21 *3.34*	0.23 *7.66*	-0.12 *-4.79*	-0.11 *-1.64*	-0.10 *-3.47*	0.86 *3.03*	0.87 *1.99*	0.77 *2.32*
Price rebalancing indicator				-0.01 *-2.22*	-0.01 *-1.52*	-0.01 *-1.81*			
Statistics F X^2.=	 134.49	 	 26.53	 40.03		 3.29	 41.45		 28.08
Tests H0: Fixed-effects=0	F.=	44.39		F.=	26.24		F.=	30.20	
Hausman[6]	X2.=	176.60		X2.=	35.81		X2.=	3.28	
Breusch-Pagan[7]	X2.=	218.73		X2.=	155.39		X2.=	289.38	

1. See description of variables in table 6,9 and 10.
2. Correction for heteroskedasticity.
3. Only time-varying variables are included.
4. For productivity and quality : total telecommunications revenue per capita; for prices : total operating expenditure per mainline.
5. For productivity : capital stock (cumulative sum of investment over ten years) per units of revenue; for prices : total fixed investment per mainline; for quality : capital stock (cumulative sum of investment over ten years) per mainline.
6. Ho : Random effect specification is correct.
7. Ho : Random effects = 0.

Table A.5 : **Mobile**

Results of panel regressions (1993-1997)

Table A.6 : **Leasing**

Results of panel regressions
(1991-1997)

Model[1]	Productivity			Prices			Prices		
Dependent variables	Cellular subscribers per employee			Mobile revenue per cellular subscribers			National leased line charges (64Kb/s)		
Number of periods	5			5			7.0		
Number of countries	22			23			22		
Number of observations	110			115			154		
Specification	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]	Random effects	Robust[2]	Fixed effects[3]
Constant	-0.24 *-0.48*	-0.04 *-0.07*	-0.03 *-0.05*	0.04 *0.08*	0.06 *0.14*	1.35 *2.11*	-0.98 *-2.07*	-0.46 *-3.14*	-0.48 *-2.11*
Economic structure[4]	-0.01 *-0.75*	0.01 *1.97*	0.01 *1.08*	-0.03 *-1.91*	-0.03 *-10.40*	-0.03 *-1.86*	0.00 *1.66*	0.02 *1.20*	0.03 *1.72*
Technology[5]	0.54 *1.88*	0.17 *1.05*	0.18 *0.56*	-0.73 *-3.27*	-0.75 *-2.27*	-1.16 *-3.87*	0.00 *-1.56*	0.00 *1.34*	0.00 *3.78*
Market share of new entrants	-0.37 *-1.07*	-0.69 *-2.47*	-0.76 *-2.12*	-0.65 *-2.41*	-0.66 *-1.94*	-0.86 *-2.76*	0.00 *0.41*	0.00 *0.48*	0.00 *0.22*
Internationalisation of domestic market	0.05 *0.97*	0.08 *0.79*		0.15 *2.19*	0.15 *2.20*		0.10 *1.78*	0.04 *2.57*	
Number of years to privatisation	-0.06 *-1.82*	-0.09 *-0.98*	-0.18 *-1.97*	0.06 *1.72*	0.06 *1.39*	0.11 *1.33*	0.01 *0.29*	0.01 *1.55*	0.01 *0.34*
State control index	0.03 *0.09*	0.16 *0.65*	0.06 *0.13*	0.98 *2.66*	0.96 *1.97*	0.50 *1.12*	-0.40 *-0.98*	-0.03 *-0.34*	0.11 *0.06*
Number of years to liberalisation	0.36 *1.72*	1.18 *2.53*	1.38 *7.05*	-0.07 *-0.43*	-0.06 *-0.22*	0.09 *0.52*	-0.23 *-6.27*	-0.08 *-3.72*	-0.08 *-3.23*
Price local							0.00 *1.30*	0.00 *-0.40*	0.00 *-0.27*
Statistics									
F			13.57			9.46			9.92
X^2.=	13.94			54.61			48.20		
Tests									
H0: Fixed-effects=0	F.=	10.40		F.=	8.81		F.=	5.64	
Hausman[6]	X2.=	2.50		X2.=	111.22		X2.=	11.67	
Breusch-Pagan[7]	X2.=	13.42		X2.=	58.82		X2.=	12.66	

1. See description of variables in table 6,9 and 10.
2. Correction for heteroskedasticity.
3. Only time-varying variables are included
4. For productivity : total telecommunications revenue per capita; for mobile prices : GDP per capita; for leasing prices : total operating expenditure per mainline.
5. For mobile productivity and prices : percentage of digital subscribers; for leasing prices : total fixed investment per mainline.
6. Ho : Random effect specification is correct.
7. Ho : Random effects = 0.

Table A.7: **Telecommunications**

Cross-industry panel estimates (1991-1997)[1]

Industry	Trunk, international, and mobile			Trunk, international and mobile			Trunk, international, leasing and mobile			Trunk and international		
Dependent variables	Productivity			Prices[2]			Prices[2]			Quality		
Number of periods	6.2			5.6			5.9			7.0		
Number of countries	70			65			87			48		
Number of observations	446			406			557			335		
Specification	Random effects	Robust[3]	Fixed effects[4]	Random effects	Robust[3]	Fixed effects[4]	Random effects	Robust[3]	Fixed effects[4]	Random effects	Robust[3]	Fixed effects[4]
Constant	-0.33	-0.33	-0.96	-0.50	-0.49	-0.35	-0.59	-0.58	-0.57	84.87	84.85	75.09
	-0.88	*-0.91*	*-2.72*	*-0.98*	*-0.68*	*-0.59*	*-1.54*	*-1.09*	*-1.23*	*27.97*	*25.35*	*25.25*
Economic structure (income)	0.01	0.01	0.01	-0.19	-0.19	0.04	0.01	0.00	0.28	0.01	0.01	0.01
	3.42	*3.37*	*2.26*	*-0.99*	*-0.83*	*0.16*	*0.08*	*0.02*	*1.46*	*0.28*	*0.15*	*0.39*
Economic structure (cost)				0.03	0.03	0.02	0.03	0.03	0.02			
				1.58	*1.10*	*0.89*	*2.20*	*1.48*	*1.17*			
Technology (capital intensity)	0.04	0.04	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.42	*0.39*	*1.22*	*2.14*	*1.49*	*1.30*	*1.02*	*0.48*	*0.97*	*1.26*	*0.87*	*0.56*
Technology (% of digital)	0.47	0.48	0.45	-0.71	-0.70	-0.96	-0.66	-0.65	-0.90			
	3.03	*2.86*	*2.64*	*-3.71*	*-1.81*	*-4.66*	*-3.94*	*-1.73*	*-5.00*			
Market share of new entrants	0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.02	0.02	0.02
	3.24	*0.94*	*4.17*	*-3.22*	*-1.35*	*-3.27*	*-3.49*	*-1.35*	*-3.74*	*0.74*	*1.00*	*0.89*
Foreign participation in domestic projects	-0.08	-0.08		0.18	0.18		0.15	0.15		0.25	0.25	
	-1.77	*-1.81*		*4.45*	*3.07*		*4.83*	*3.27*		*0.60*	*0.71*	
Number of years to privatisation	-0.07	-0.07	-0.10	0.02	0.02	0.03	0.01	0.01	0.02	0.03	0.03	0.04
	-3.48	*-1.58*	*-3.88*	*0.98*	*0.70*	*1.11*	*0.83*	*0.59*	*0.84*	*0.19*	*0.15*	*0.20*
State control index	0.12	0.12	0.12	0.04	0.04	-0.07	0.00	0.00	-0.06	-0.44	-0.42	-1.56
	0.68	*0.59*	*0.65*	*0.21*	*0.19*	*-0.35*	*-0.02*	*0.00*	*-0.35*	*-0.24*	*-0.28*	*-0.78*
Number of years to liberalisation	0.12	0.12	0.17	-0.14	-0.14	-0.17	-0.13	-0.13	-0.15	1.08	1.09	1.01
	6.06	*3.14*	*7.19*	*-6.33*	*-3.11*	*-6.24*	*-7.73*	*-3.55*	*-7.40*	*6.83*	*4.44*	*5.26*
Price rebalancing indicator				0.00	0.00	0.00	-0.01	-0.01	0.00			
				-0.56	*-0.44*	*0.23*	*-1.41*	*-1.10*	*-0.58*			
Industry dummies : Mobil	-0.59	-0.58		1.16	1.16		1.08	1.07				
	-1.99	*-1.53*		*4.29*	*2.05*		*4.98*	*2.10*				
International	-0.01	-0.01		-0.32	-0.32		-0.01	-0.01		-23.96	-23.96	
	-0.03	*-0.03*		*-1.18*	*-1.05*		*-0.08*	*-0.07*		*-12.39*	*-12.87*	
Statistics												
F			26.18			17.16			21.25			19.13
X^2.=	167.41			171.42			209.59			295.00		
Tests												
H0: Fixed-effects=0	F.=	26.01		F.=	17.48		F.=	17.42		F.=	26.64	
Hausman[5]	X2.=	34.70		X2.=	40.84		X2.=	33.21		X2.=	10.18	
Breusch-Pagan[6]	X2.=	617.92		X2.=	512.91		X2.=	697.27		X2.=	560.36	

1. See description of variables in table 6,9 and 10.
2. For international, prices = OECD tariff basket.
3. Correction for heteroskedasticity.
4. Only time-varying variables are included.
5. Ho : Random effect specification is correct.
6. Random effects = 0.

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