The Effects of Public Ownership and Regulatory Independence on Regulatory Outcomes

A Study of Interconnect Rates in EU Telecommunications

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and

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We examine the effects of public ownership and regulatory agency independence on regulatory outcomes in EU telecommunications. We present evidence of political influence over regulatory outcomes, and demonstrate the importance of regulatory independence in ensuring unbiased regulatory policy. Specifically, we study regulated interconnect rates paid by entrant firms to incumbent firms. We find that public ownership of the incumbent positively affects these interconnect rates, suggesting an ability of governments to influence regulatory outcomes in favor of incumbents in which they are substantially invested. However, we also find that the presence of institutional features enhancing regulatory independence from the government mitigates this effect. In order to study regulatory independence, we introduce a new cross-country time-series database – the European Union Regulatory Institutions (EURI) Database. This database describes the development of institutions bearing on regulatory independence and quality in telecommunications in the 15 founding EU member states from 1997 to 2003. Beyond the current research, we expect this database will prove useful in future studies of the effects of the institutional environment of regulation on industry structure and performance.

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1 Introduction

The last two decades have witnessed worldwide trends toward the liberalization of network infrastructure industries such as electricity, gas and telecommunications, and the privatization of traditionally publicly owned incumbent monopolies. In order to ensure an effective transition to competitive markets, National Regulatory Authorities (NRAs) have been created to oversee and regulate interactions between incumbents and entrant firms typically reliant in the early stages of their development on incumbent services.[1] In many countries, liberalization has preceded privatization,[2] generating peculiar problems for regulation where the state has the dual role of regulator and owner of the regulated incumbent. For a country to benefit from the liberalization process, its government must convince entrants as new investors that the regulatory environment will provide no special favor to the publicly owned incumbent. Can governments resist influencing regulatory outcomes that bear on the financial prospects of firms in which they retain substantial ownership interests? If not, can governments solve their commitment problems by putting institutional arrangements in place around their NRAs that prevent government interference in regulatory decisions?[3]

These questions are critical, both for prospective investors in newly liberalized industries, and policy makers concerned with encouraging new investment and stimulating economic growth. Theoretical and empirical work in the economic history and development literatures concur that a government's ability to credibly commit not to interfere with private property rights is vital for countries to attract long term capital investments and experience sustained economic growth.[4] Much of this literature emphasizes the importance of institutions ensuring regulatory commitment.

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1 The number of NRAs with responsibility for telecommunications increased from just 12 in 1990 to more than 90 in 2000 (Intven, Oliver and Sepulveda 2000: 1-3).

2 Indeed, in many countries, the privatization process has stalled indefinitely.

3 These questions closely parallel questions that have long been considered in the macroeconomic policy literature as to whether governments that face elections every few years can commit to maintain a low inflation policy, and if not, whether governments can effectively tie their own hands by installing an independent central bank charged with maintaining a pre-determined inflationary target.

4 See Henisz (2000 and 2002) for good reviews of this literature.

To answer these questions, we examine institutional determinants of important regulatory outcomes in the telecommunications industry in the European Union (EU). Over the past decade, the EU has experienced substantial progress in the liberalization of markets, privatization of incumbent Public Telecommunications Operators (PTOs) and development of regulatory institutions. Specifically, we examine the regulated interconnect rates that entrants to the industry must pay PTOs to terminate calls on PTO networks. We find that public ownership of the PTO positively affects these interconnect rates, but the presence of institutional features enhancing NRA independence from the government mitigates this effect. We use OLS, instrumental variables and panel data estimation techniques and our results are robust to the inclusion of numerous additional variables and the exclusion of outliers.

In order to measure regulatory independence we take advantage of a new database – the European Union Regulatory Institutions (EURI) Database, described in Edwards (2004).[5] This database records, for each year from 1997 to 2003 and for each EU founding member state, the presence or absence of 12 important elements of the institutional environment of telecommunications regulation bearing on the independence of NRAs from government influence. We create an index of regulatory independence based on these 12 elements. Prior attempts to study the effects of regulatory independence across countries have relied on simple dummy variable measures of independence or less detailed cross-sectional indices of regulatory independence elements for a small number of countries.[6] The EURI Database allows us to use more detailed data on regulatory institutions promoting independence, and both cross-section and time-series variation, enhancing prospects for identification. Our results are robust to variations in our index measure of regulatory independence. We also conduct factor analysis on the 12 elements as an alternative to the index method, and identify common factors among the regulatory independence elements. Beyond the present study, we hope the EURI Database will prove valuable in future studies of the effects of regulatory institutions on telecommunications industry structure and performance.

Our study adds to the existing literature in two important respects. First, while some prior studies have attempted to measure and assess the (performance) effects of enhanced regulatory governance institutions, the focus of our research is on one important aspect of good regulatory governance – independence of the industry regulator from government. This focus allows us to

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5 The EURI Database is available at http://www.london.edu/ri/Research/research.html.

6 For example, see Gual and Trillas (2003), Bauer (2003) and Jones Day (2002 and 2004).

examine in greater detail than any previous study the formal institutional elements that are believed to promote regulatory independence from government influence. Second, our study presents direct evidence of government influence and the mitigating effects of institutional constraints on *regulatory outcomes*, thereby establishing a missing intermediate link in the extant cross-country empirical research in comparative institutional economics. That literature has indirectly associated the quality of a country's institutional environment with industry and overall economy *performance*. To date, there have been very few studies of the political and institutional determinants of regulatory outcomes, with most of these examining the effects of political and institutional variation within the United States.

Section 2 provides a review of the prior literature on regulatory governance in utility industries. Section 3 presents the empirical context for our research: interconnect rates in EU telecommunications. Section 4 discusses economic (cost) and non-economic determinants of interconnect rates in order to instruct our empirical design. Section 5 summarizes the data sources and measures used in the empirical analysis and section 6 presents the results. Finally, section 7 concludes with a discussion of the results and directions for future research.

2 Prior literature on regulatory governance in utility industries

Interest in cross-national institutional analysis, particularly the effects of alternative institutional environments on the performance of capital intensive regulated industries such as telecommunications, has boomed over the last decade following Levy and Spiller's (1994 and 1996) seminal work in new institutional economics. Building on work by North and Thomas (1973) and North (1990) on the importance of political institutions for economic performance, Levy and Spiller surveyed the performance of regulated telecommunications industries in different political and social environments. They argued that a country's institutional endowment at the macro-political level determines the scope for arbitrary administrative discretion, the confidence of investors that their assets will not be arbitrarily appropriated and, through this, the performance of regulated industries. The institutions that Levy and Spiller emphasized included: the existence of a strong and independent judiciary; whether governments are unified (as in parliamentary systems) or divided (as in many presidential systems); whether parties alternate in government; and the quality of the regulatory bureaucracy. Subsequent systematic empirical tests of this hypothesis, including Henisz (2000 and 2002) and Henisz and Zelner (2001), have presented evidence in support of the proposition that investment will flourish and industries and economies will perform better where policy stability is assured by a large number of robust

checks and balances constraining opportunistic behavior by governments. The independent variable in these studies is a summary measure of constraints on policy change at the macro-political level (incorporating the number of independent veto points over government policy and the distribution of preferences of the actors who inhabit those veto positions).

While the institutional structure at the macro-political level is clearly important, also important are more micro-level institutions that bear directly on the quality of regulatory governance of individual utility industries, and in particular, in the context of the current paper, institutions that enhance the degree of independence from government enjoyed by the industry regulator. Fesler (1940) provides an early consideration of important institutions for sound regulatory governance of the US state utility commissions. Outside the US, interest in regulatory governance in utility industries has grown as the movement to liberalize utility industries gathered speed in the 1990s. Drawing heavily on an already well-developed literature on central bank independence,[7] discussions of desirable institutional arrangements for effective regulation of utility industries are numerous and include: Melody (1997a); Smith (1997a, 1997b, 1997c and 2000); Green (1999); Estache (1997); Kerf, Schiffler and Torres (2001); Mustafa (2002); Smith and Wellenius (1999); Stern (1997); and Stern and Holder (1999). These authors recommend a variety of institutional arrangements to enhance the quality of regulatory governance and confidence in the regulatory system, including: clarity of roles and objectives of the regulator; independence (autonomy) of the regulator; participation in the regulatory process by interested parties; transparency of regulatory decisions; and accountability of the regulator for its decisions.

In contrast, there has been much less in the way of systematic empirical work in this area, with empirical efforts hampered by short time frames since the development of NRAs and associated institutions, and poor qualitative and quantitative data on those institutions. Most of what has been written has concerned the telecommunications industry. In this context, several authors have made efforts to estimate the effect of the quality of regulatory governance on measures of industry performance (investment and efficiency). While these studies typically report positive effects of improving regulatory governance on industry performance (either by itself or when coupled with privatization) they vary substantially in their approach to measuring the quality of

[7] There is a substantial body of theoretical and empirical work in macroeconomic policy concerning the effect of central bank independence from the executive branch of government on inflation outcomes. For example, see Alesina (1988 and 1989), Grilli, Masciandaro and Tabellini (1991), Cukierman, Webb and Neyapti (1992) and Berument (1998).

regulatory governance. Fink, Mattoo and Rathindran (2002), Wallsten (2001 and 2002), Bortolotti, D'Souza, Fantini and Megginson (2001), Gutierrez and Berg (2000) and Ros (2003) each employ a simple dummy variable – such as whether a country has a separate regulatory agency not directly under the control of the ministry – to attempt to capture regulatory independence. Guttierez (2003a and 2003b) and Gual and Trillas (2003) employ more detailed indexes of regulatory governance elements and regulatory independence elements, respectively. Many of these studies recognize the potential endogeneity of regulatory governance measures. There is a strong likelihood that these measures are correlated with unobserved variables that are also correlated with industry performance.[8] However, attempts to address the endogeneity issue have not always been sound.[9] A review of these studies is provided in Stern and Cubbin (2003). Further details of the various approaches to measuring regulatory governance and regulatory independence are provided in the Appendix.

Our current study differs from the prior empirical work on regulatory governance in two important respects. First, because our main focus is on one important component of regulatory governance – independence of the regulator from the government – we examine the formal institutions that promote regulatory independence in far greater detail than any prior study. While our regulatory independence index is closest in conception to that of Gual and Trillas (2003), we consider it offers significant improvements, both in terms of the number of included elements, and the recording of a panel data set that allows us to consider time-series as well as cross-sectional variation. Second, the dependent variable we are concerned with is distinctive. Rather than study the effects of regulatory governance on *industry performance* measures (such as

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[8] For example, Stern and Cubbin (2003: 29) note that for studies of regulatory independence and *industry performance*, "countries are more likely to adopt and encourage effective regulatory agencies the more that they have a positive attitude to the separation of powers, the commercialisation of economic activities and to private investment and market economics in general. Hence, one should not assume that independent regulators are exogenous." A different endogeneity issues arises in our study of formal institutional safeguards of regulatory independence and *regulatory outcomes*. In this context, countries with weaker informal traditions of independence are likely to compensate by developing stronger formal institutions safeguarding independence. We discuss this issue in detail in Section 6 below.

[9] For example, when studying the effect of regulatory independence on network penetration (measured by lines per 100 inhabitants), Gual and Trillas (2003) use the number of telecommunications workers per capita (staff) and Henisz and Zelner's (2001) index of (macro-political) constraints on government discretion (POLCON) as instruments for their regulatory independence index. Validity of both instruments is questionable. Each is likely to be independently associated with network penetration and therefore in violation of the exclusion restriction.

investment and efficiency) we examine the effects of government ownership and regulatory independence on *regulatory policy outcomes* (interconnect rates). We regard this research as addressing an under-researched link in the existing empirical literature in cross-national comparative institutional economics, as illustrated in Figure 1. With the focus so far on estimating indirect correlations between institutions and private (for example, investment) decisions and economic performance (see the broken arrows in Figure 1), the literature has largely ignored the important intermediate stage – the effect of institutions in constraining arbitrary government influence over the regulatory policies on which those private decisions are based (the first unbroken arrow in Figure 1).

To the best of our knowledge, only one study has previously investigated this intermediate stage outside the US context.[10] Similar in conception to our own research, Bauer (2003) examines whether the dual role of the state as owner and regulator distorts regulatory outcomes (interconnect rates) in EU telecommunications. Bauer finds that public ownership is positively associated with interconnect rates (favoring publicly owned incumbent firms and disfavouring entrants), but an index of regulatory independence features and an interaction term between public ownership and regulatory independence are both insignificant. His study therefore reports some evidence that publicly owned incumbent PTOs benefit from the dual role of the government as owner and regulator, but no evidence that enhancing regulatory independence has any mitigating effect. We suspect that the differences between Bauer's findings and the results of our current study are likely explained by differences in empirical design. Bauer's study was constrained by a small number of observations (a single cross-section of the 15 EU member states in 2000) and no attempt was made to address potential endogeneity of the regulatory independence measure. In this context, little weight can be placed on the reported results, including the finding that regulatory independence has no effect on regulatory outcomes. Our current study offers significant improvements in empirical design (including the construction of a panel data set and a robust sample size, and instrumental variables estimation to address endogeneity concerns) and, again, employs a more focused and detailed measurement of regulatory independence.

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[10] In the US, some attention has been directed to the effects on regulatory outcomes of electing rather than appointing utility commissioners. See Costello (1984) and Besley and Case (2003) for summaries of this literature. See also Besley and Coate (2002), Hoburn and Spiller (2002) and de Figueiredo and Edwards (2004) for recent evidence exploiting panel data. For investors, elected

3 Empirical context: interconnect rates in EU telecommunications

To examine the institutional drivers of regulatory outcomes, and particularly the effects of public ownership and regulatory independence, we look to the telecommunications industry in the EU in which there has been substantial activity over the past decade in liberalization of markets, privatization of incumbent PTOs and development of regulatory institutions. Unlike the situation in the United States, in most countries telecommunications liberalization has occurred in advance of full privatization, generating peculiar problems for regulation where the state has the dual role of regulator and (whole or part) owner of the regulated incumbent PTO. For empirical purposes, interesting cross-country and over-time variation has developed, permitting identification of the effects of public ownership of regulated utilities and regulatory independence on regulatory outcomes.

We have chosen to study telecommunications in the EU context as a series of EU directives liberalizing and harmonizing the legal and regulatory framework across the EU member states eliminates many of the difficulties of heterogeneity typically involved in cross-country analysis.[11] Of particular interest, the EU's regulatory framework directive requires each member state to ensure the legal and functional independence of the NRA from PTOs, and to separate the control of the PTO and the regulatory function where member states retain ownership or significant control of the incumbent PTO.[12]

We focus on the determinants of rates for interconnection to incumbent PTO networks. A practical reason for this choice is that interconnection rates are a class of regulatory outcomes that are both easy to measure and vary substantially across countries and over time. Interconnection rates are also perhaps the most important battlegrounds between incumbent PTOs and entrants in

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rather than appointed commissions merely replace the concern of arbitrary government influence with a concern of arbitrary constituency influence over regulatory policy.

[11] Telecommunications markets were fully liberalized in most of the EU on 1 January 1998 (full liberalization was delayed in Portugal and Greece until 2000 and 2001 respectively). The EU Liberalisation directives required the removal of exclusive and special rights in telecommunications services and equipment markets. A set of Harmonisation directives laid down details regarding conditions the member states were required to put in place regarding regulatory frameworks, licensing, interconnection, leased lines, universal service, tariffs, numbering, frequencies and rights of way. See Waverman and Sirel (1997) for further details.

[12] 90/387/EEC as amended by 97/51/EC, Article 5a.

telecommunications, with the potential to significantly impact on market structure, revenues and profits of entrants and incumbents in the industry.[13] If political influence and institutional variation matter, their effects are therefore likely to show up in interconnect rates outcomes. The EU's interconnection directive requires that the member states ensure PTOs with significant market power are obliged to meet all reasonable requests for interconnection and set "cost-oriented" interconnect rates.[14] As interconnection is a critical factor for the viability of competition in telecommunications, and incumbent PTOs have all the power in negotiations and little incentive to share their profits with entrants, there is consensus among telecommunications experts and policy makers that regulatory intervention (or at least the threat of regulatory intervention) is required to pave the way for effective interconnection arrangements (Cave 1997b; Melody 1997b; ITU 1998: 47; Intven, Oliver and Sepulveda 2000: 3-1). Accordingly, the interconnection directive provides that, while rates for interconnection are to be determined at first instance through negotiation between a network operator and the party seeking interconnection, the EU member states (and their NRAs) are ultimately responsible for interconnect rates, are required to ensure the adequate and efficient interconnection of networks, and are empowered to intervene in negotiations (on their own initiative or at the request of one party) or to adjust negotiated rates where they consider this appropriate.[15] We therefore assume there is significant regulatory influence over even negotiated rates. With the option of a final say over interconnect rates, we expect NRA preferences to be highly determinative of final outcomes.

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13 Interconnection allows entrants to terminate calls that they have originated on the much more extensive incumbent PTO networks, saving entrants the significant time and trouble of developing complete duplicate networks of their own. Interconnection rates are perhaps the most significant commercial issue of concern to entrants and incumbent PTOs alike. Intven, Oliver and Sepulveda (2000: 3.2) note that "[i]nterconnection-related issues are ranked by many countries as the single most important problem in the development of a competitive marketplace for telecommunications services [and] interconnection has been a highly contentious issue in Europe." Cave (1997a) has noted "a change of a few percent in interconnection charges can make the difference between profit and loss for an entrant, half of whose revenues may at the outset go to the incumbent operator."

14 Directive 97/33/EC of the European Parliament and the Council on Interconnection in Telecommunications With Regard to Ensuring Universal Service and Interoperability Through Application of the Principles of Open Network Provision (ONP), Article 7. The *Reference Paper* to the 1997 World Trade Organization (WTO) *Agreement on Basic Telecommunications* similarly prescribes cost oriented interconnect rates. While EU law does not impose the use of a specific costing model, the European Commission's *Recommendation on Interconnection Pricing* points to the use of a forward looking Long Run Average Incremental Cost (LRAIC) model which estimates the efficient (rather than historical) cost of the network.

15 Directive 97/33/EC, Articles 3, 7 and 9.

There is widespread disagreement over the appropriate cost methodology to apply in determining interconnect rates, and within any methodology there is wide discretion over the components of cost to include in the cost base, as well as the rate of return on capital to apply. There is therefore ample scope for interconnect rate outcomes to reflect political pressures without the need for explicit bias.

Table 1 lists summary information for each EU member state in 2003 including the identity of the incumbent PTO with significant market power in fixed telephony, the share of government ownership of the PTO in 2003, the responsible NRA,[16] the NRA's first year of operation, and the year in which the fixed telephony market was liberalized.

4 Determinants of interconnect rates in the European Union

4.1 Economic criteria for interconnect rates

The EU's interconnection directive requires that interconnect rates be "cost-oriented."[17] Close correspondence between interconnect rates and costs across countries and over time would support a hypothesis that rates are set mainly on this purely economic criteria. In reality, a close correspondence does not appear to exist.

Figure 2 provides circumstantial evidence that the variation in interconnect rates *between* countries reflects much more than cost considerations alone. Similar technology is used in all EU member states, and the supply of local interconnection service exhibits strong economies of density and scale.[18] Population density and average loop length are generally regarded as the

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16 In some states there is more than one body that comprises the NRA. For the purposes of this paper, we define the NRA as the body with responsibility for resolving interconnection disputes, including the determination of interconnect rates.

17 Directive 97/33/EC, Article 7. The preamble to the directive also states that rates for interconnection "should promote productivity and encourage efficient and sustainable market entry, and should not be below a limit calculated by the use of long-run incremental cost and cost allocation and attribution methods based on actual cost causation, not above a limit set by the stand-alone cost of providing the interconnection in question … charges for interconnection based on a price level closely linked to the long-run incremental cost for providing access to interconnection are appropriate for encouraging the rapid development of an open and competitive market."

18 For example, see Christensen, Cummings and Schoech (1983), Guldmann (1991), Ying and Shin (1993) and Sidak and Singer (2002).

main drivers of costs in fixed line telecommunications networks.[19] While we do not have consistent data on average loop lengths, we can proxy for the cost of fixed line networks using two alternative measures of population density: population per square kilometre (*Density*) and the percentage of the population living in urban areas (*Urbanization*). If interconnect rates reflect network costs, we would expect to see a strong negative correlation between interconnect rates and these two measures. Figure 2 suggests that the relationship between interconnect rates and network costs in 2003 is weak at best.[20] Indeed, but for one observation in each series (Finland) there is no discernible relationship between population density and interconnect rates.[21]

Further evidence of a lack of relation between interconnect rates and costs comes from an analysis of interconnect rates over time *within* the EU member states. Figure 3 reports local interconnect rates in each EU member state in 1998 and 2003 and reveals significant variation over time within countries that is unlikely to be a reflection of underlying cost conditions. Over this period, local interconnect rates have converged as rates have fallen in each EU member state, on average from 1.45 to 0.71 Eurocents per minute (an average decline of just over 51 percent). While we do not have data on actual or estimated costs, close observation of the industry over this short period does not suggest any EU wide or country specific changes in underlying cost conditions that could explain this pattern. Empirical analysis provides support for this conclusion.[22]

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19 Greater density is associated with lower costs as fixed costs (for example, of shared feeder cables) can be spread among more subscribers; longer average loop lengths are associated with higher costs, for obvious reasons. We would expect a high (negative) correlation between these cost factors in a cross-country study. Studies of the costs of interconnection typically report that population density and average loop length together explain over 80 percent of the variation in network costs. See, for example, Rosston and Wimmer (2000: 6) and the testimony of Thomas L. Spinks in *The Matter of the Pricing Proceeding for Interconnection, Unbundled Elements, Transport and Termination, and Resale*, Docket No. UT-960369, before the Washington Utilities and Transportation Commission, Exhibit (TLS-REB), p. 5.

20 The correlation coefficients between interconnect rates in 2003 and Density and Urbanization are –0.152 (p value 0.590) and –0.311 (p value 0.259) respectively (neither is significantly different from zero at conventional probability levels).

21 With the exclusion of observations for Finland, the correlations reported in the previous footnote become 0.184 (p value 0.529) and 0.048 (p value 0.871).

22 While we do not believe that the observed pattern of reductions in interconnect rates and convergence exhibited in Figure 3 has much to do with costs, for further confidence we have considered specific hypotheses that the pattern might be the result of technological catch up in some member states, country specific shifts in labor cost, or country specific labor efficiency gains. In regressions (with country and year fixed effects) of local interconnect rates on measures of

Reductions in interconnect rates have been encouraged by EU wide harmonization policies and the publication of benchmark interconnect rates (based on the three lowest rates in the EU area).[23] Yet even after six years of such policies (intended to promote more "cost-oriented" rates) the relationship between interconnect rates and important cost drivers remains weak (Figure 2). Clearly something more is going on.[24] In the remainder of this section we explore the hypothesis that much of variation in interconnect rates between and within countries can be explained by the institutional environment of regulation in the member states.

4.2 Public ownership of the PTO and regulatory independence

The dual role of the government as regulator and whole or part owner of the incumbent PTO clearly raises concerns of regulatory bias against new entrants (Noll 2000). The larger a government's ownership stake in the incumbent PTO, the greater its interest in the PTO's financial health. Preserving PTO profits and market value is particularly important for any government planning to privatize its PTO in the near future (ITU 1998: 4).[25] We therefore examine whether greater government ownership of the incumbent PTO places political pressure

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technological advance (the percent of digitalization in the fixed telephone network), labor costs and labor productivity (access channels per PTO employee), F tests provide no evidence that these variables, individually or collectively, explain within country variation in interconnect rates. The result on labor costs is consistent with Sidak and Singer (2002) who report an insignificant coefficient on a wage index in an estimation of the determinants of unbundled network element (UNE) prices. Should there be any remaining concern that unobserved cost factors could cause bias in our estimates of the effects of regulatory independence on interconnect rates, we have conducted instrumental variables analysis as a general approach to addressing endogeneity concerns.

23 See Europe Economics (2000: 2-3).

24 Sidak and Singer (2002), although discussing unbundled network element (UNE) pricing rather than interconnect pricing, provide a good example of how interconnect rates might bear little relation to underlying network costs. They describe the Irish NRA's use of averages of UNE prices in other countries (a form of benchmarking) as the basis for interim UNE prices in Ireland, and demonstrate that a significantly different outcome would have followed from the incorporation of important cost-related data (such as population density and urbanization) in the analysis. Indeed, we note that in our sample of interconnect rates the correlation between interconnect rates and Urbanization in 2003 (-0.311) is in fact smaller than the correlation in 1998 (-0.427). On this (albeit simplistic) evidence it seems there has been little progress since 1998 in making rates more cost-reflective.

25 It is well known that governments are tempted to view privatization as a valuable source of income, and to compromise the liberalization process (maintaining the potential share price at privatization) until privatization is complete. This once prompted the remark that "privatization is the enemy of liberalization," attributed to the late Professor Michael Beesley, CBE, an advisor on the UK liberalization process in the 1980s.

on NRAs and, assuming regulatory independence from the government is less than complete, is associated with higher local interconnect rates.[26]

For the government to influence a regulatory outcome, there must be a degree to which the NRA lacks independence. It has been widely observed that the degree of independence of NRAs and their susceptibility to government influence varies across even a set of well-developed countries such as the EU member states (OECD 2000: 4 and 6). While both the World Trade Organization's *Reference Paper* to the 1997 *Agreement on Basic Telecommunications* and the EU's regulatory framework directive require that NRAs be independent of telecommunications operations (PTOs), neither document explicitly requires the separation of all regulatory functions from political functions performed by the government. Where the incumbent PTO is at least partly government owned, we expect greater regulatory independence will mitigate the effect of upward pressure on interconnect rates from government influence. Greater regulatory independence should therefore be associated with lower interconnect rates in the presence of government ownership. Also, we expect the effect of greater regulatory independence will be more pronounced the larger the government's ownership stake in the incumbent PTO and the greater the incentive of the government to influence interconnect rates upwards. We will test for this effect by interacting public ownership of the PTO with regulatory independence.

5 Data and measures

We have collected panel data for the original 15 EU member states over seven years (1997-2003).[27] The unit of analysis is therefore a country-year. Data sources and measures are described in this section. Descriptive statistics of the variables included in the analysis are contained in Table 2 and a correlation matrix is presented in Table 3.

The dependent variable in this study is the per minute rate charged for call termination on incumbent fixed line networks (*Interconnect Rate*). There are in fact three methods of interconnection to fixed line networks, depending on the amount of the incumbent network the entrant wishes to utilize. These three methods are called, respectively: local; single transit; and

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[26] Bauer (2003) has previously provided some evidence from a cross-section of the EU member states in 2000 that interconnect rates are higher in the presence of government ownership of the incumbent PTO.

[27] Every effort has been made to collect information that is accurate for the end of each year.

double transit.[28] For consistency, this study uses only rates for interconnection at the local level.[29] The per minute rates we use are based on a 3 minute call duration at peak charges.[30] Data comes from a series of European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* in the member states.[31] Figure 3 presents, for illustrative purposes, the variation in local interconnect rates between and within the EU member states in and between 1998 and 2003.[32]

The cost of providing interconnection service should be an important determinant of "cost-oriented" interconnect rates. We must therefore control for cost either directly, or indirectly with country fixed effects. We use both methods in this study. First, as most variation in the cost of fixed line networks is explained by customer density and loop lengths, we include the percent of the population living in urban areas (*Urbanization*) as a control for cost variation between EU member states.[33] We expect a negative correlation between Urbanization and local interconnect

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28 Double transit interconnection allows an entrant with a single point of presence in the incumbent PTO network to terminate a call anywhere on that network. Single transit interconnection is used to terminate a call anywhere within a metropolitan area. Local interconnection is used when entrants handover calls to the incumbent PTO at the local exchange nearest the party being called. Entrants will typically need to purchase all three forms of interconnection in varying amounts, at least until they develop points of presence at each and every local exchange in the incumbent PTO's network and can then rely solely on local interconnection.

29 Sensitivity tests including data on all three sets of interconnect rates (with dummy variables to distinguish each set) report similar results to the results reported herein using just the set of local interconnect rates.

30 Unfortunately, consistently reported data from the European Commission on interconnect rates over the period of our study is limited to peak rates based on a 3 minute call duration (European Commission 1998a, 1998b, 1999, 2000, 2001, 2002 and 2003). This is a long established standardised method of comparing interconnect rates across countries. Nonetheless, to the extent that interconnect rate structures can have peak and off-peak elements and various other variations in charges, different charging structures and different calling patterns across the observations could affect our results.

31 Specifically, we gathered information from the third to ninth of these reports: European Commission (1998a, 1998b, 1999, 2000, 2001, 2002 and 2003). These reports typically contain data current at the end of each year, the exception being the third report, which contains data for January 1998. We treat the third report as containing data relevant to the end of 1997, permitting our study to cover the years 1997-2003.

32 Unfortunately, no data on the dependent variable was available for Greece before 2000 or for Luxembourg before 1998. This reduces the number of observations available for the study from 105 to 101.

33 Ideally we would like to include data on both density and loop lengths, although we suspect these are highly (negatively) correlated. Unfortunately, only data on density is currently available on a consistent basis for each of the EU member states. We tested two alternative measures of density:

rates. Total network scale[34] might also affect the costs of interconnect services, and in an alternative regression we include the total number of main telephone lines in operation in a country (*Lines*).[35] We expect that Lines will be negatively correlated with interconnect rates. In unreported analysis, we further investigated whether the degree of technological advancement in a network, labor costs and PTO efficiency affect interconnect rates (and our main results). In each case, our main results were unaffected by the inclusion of these additional variables. We found a higher percent of digitalization in a network is associated with lower interconnect rates in a regression without country fixed effects.[36] However, labor costs and each of two measures of PTO efficiency returned insignificant coefficients in regressions with and without country fixed effects.[37] Second, as an alternative to direct measurement of costs, we perform regressions with country fixed effects to control for non-time-varying cost and other country specific features.[38]

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the percent of the population living in urban areas (*Urbanization*), and the total population divided by land area (*Density*). In sensitivity tests, the *Density* measure, while significant, was not as strong a predictor of local interconnect rates as the *Urbanization* measure. There is, of course, a high correlation between these two measures (the correlation coefficient is 0.606) and to avoid multi-collinearity only the *Urbanization* measure is included in our reported regression models. Data on the percent of the population living in urban areas is from the World Bank's *World Development Indicators* (2004: Table 3.10).

34 For example, Cave (1997b) observes that equipment prices depend significantly upon the volume of purchases made.

35 Data on main lines in operation comes from the International Telecommunications Union (ITU)'s *World Telecommunications Indicators* (2003).

36 This result reflects the reality that over the period of our study many countries in the EU have not employed truly forward looking costing methodologies. If interconnect rates in the EU were set on the basis of forward looking cost estimations, the extent of digitalization in the current network would be an entirely irrelevant factor.

37 Data on the percent of digitalization in the fixed telephone network is from the OECD's *Telecommunications Database* (2003). Labor cost data was sourced from OECD (2004) No. 75, Statistical Annex, Table 43. Regarding PTO efficiency, we tested our models with the inclusion of two alternative measures – PTO access channels per employee and PTO revenues (in US dollars) per employee from the OECD's *Telecommunications Database* (2003).

38 We consider that the costs of local interconnect services will vary between EU member states, but will vary little or not at all over the short time period of our study. We therefore consider that the inclusion of country fixed effects will appropriately control for cost variation in the data. As added precaution, we have included year fixed effects in our regressions to capture any EU-wide time trend in network costs. For example, one possibility is that is that as volumes change, fixed costs can be spread over a larger number of call minutes and costs per minute will fall. To partially address remaining concerns that there might be country specific, time varying cost factors that we have not accounted for with country and year fixed effects, in footnote 22 we provide evidence that neither

Data on the government's ownership share of the incumbent PTO (*Public*) comes from various sources including the OECD's *International Regulation Database* (1998) and *Communications Outlooks* (1999, 2001 and 2003), European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* and PTO annual reports and websites. A summary of government ownership of PTOs in the EU member states in 1998 and 2003 is provided in Figure 4. A dummy variable has also been created (*Public Dummy*) coded 1 if the government share of the incumbent PTO is greater than or equal to 0.5 and 0 otherwise.

While regulatory independence is essentially a qualitative concept, it is possible to measure formal institutional features of the environment of regulation that are likely to bear on the freedom of regulators to make decisions without implicit or explicit pressure from the government of the day. Prior attempts to measure regulatory independence are discussed in Section 2 above and the Appendix. This study draws upon a newly developed database of regulatory institutions in EU telecommunications – the European Union Regulatory Institutions (EURI) Database. This database includes a seven-year panel of information on formal institutional elements in the regulation of telecommunications in the EU that bear directly on the independence of the NRA from the government. The EURI Database is available at http://www.london.edu/ri/Research/research.html.

The EURI Database measures 12 institutional elements bearing on regulatory independence and constructs from these the EURI Independence (*EURI-I*) index.[39] Full details on the rationale behind each of these elements, their measurement and data sources are in the Appendix and in Edwards (2004). Each element is measured as either a categorical or dummy variable on a 0-1 scale. The EURI-I index is a simple sum of these 12 measures; with no a-priori information on

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variation in the degree of technological advance, labor costs nor labor efficiency are responsible for within country variation in interconnect rates.

[39] The 12 elements are: 1) whether the NRA is single or multi-sector (*multi-sector*); 2) whether the NRA is single or multi-member (*multi-member*); 3) whether the NRA is funded by government appropriations or industry fees and consumer levies (*funding*); 4) whether the NRA reports only to the executive government or also to the legislature (*reporting*); 5) whether the NRA has adequate powers regarding interconnection issues (*interconnect powers*); 6) whether the NRA shares its regulatory functions with the executive (*shared roles*); 7) whether the legislature is involved in NRA member appointments (*legislative appointment*); 8) whether NRA member terms of appointment are fixed (*fixed terms*); 9) whether NRA member terms are renewable (*renewable terms*); 10) and 11) whether NRA resources are adequate (*staff* and *budget*); and 12) whether the NRA has been in operation for at least two years (*experience*).

the relative importance of the elements, we have accorded each element equal weight.[40] The index can therefore range from 0 to 12, although the minimum and maximum in our sample are 1.5 and 10.25 respectively. Tables 4 and 5 present summary statistics and a correlation matrix of the 12 measures. Table 6 presents, for each member state, the values of each element and the values of the EURI-I index in 1998 and 2003. The values of the EURI-I index in 1998 and 2003 are also summarized in Figure 5. This figure demonstrates a trend over the period of our study towards enhanced formal institutions promoting independence in most member states.

It is worth spending a moment discussing the validity of the EURI-I index as a measure of regulatory independence in EU telecommunications. The selection of elements for inclusion in the index was conditioned by the following considerations: whether the element has been identified in prior literature on regulatory governance as bearing on the independence of the regulator from government; whether the element exhibits variation between the 15 EU member states in the sample and over time; and whether the element is capable of being measured for each of the member states in each year from 1997 to 2003. The latter two considerations are necessary to allow for systematic comparative analysis. We therefore consider that the EURI-I index provides a good representation of variation in formal institutional elements bearing on regulatory independence in telecommunications in the EU member states. We note that it is positively correlated with other, less comprehensive, but similarly intentioned, measures of regulatory independence in the EU member states.[41] It is, also positively (though not highly) correlated with subjective assessments of the degree of independence of the regulator from government, as reported in various editions of the European Commission Reports on the Implementation of the Telecommunications Regulatory Package (1998 – 2003).[42] We consider it preferable to use an

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[40] This approach is consistent with previous approaches to the construction of indexes of regulatory independence (Gual and Trillas 2003; Bauer 2003) and regulatory governance more broadly (Gutierrez 2003a and 2003b). For further description of these approaches, see the Appendix. In the current study, we alternatively employ factor analysis, weighting each element so as to maximize the covariation among the elements, and report consistent results.

[41] For example, it is positively correlated (0.4017) with Gual and Trillas' (2003) measure of regulatory independence (based on a smaller set of formal institutional elements). It is also positively correlated (0.4053) with the Jones Day (2004) measure of regulatory independence in 10 EU member states (excluding from the Jones Day measure information on government ownership of the PTO, as we do not consider this to be a component of regulatory independence).

[42] This subjective data was constructed by the authors for each EU member state for each year in the study period. A single variable was created, coded one if there were no concerns of a lack of independence, 0.5 if there were some concerns raised, and zero if there appeared to be a clear lack of

objective measure of regulatory independence, such as the EURI-I index, rather than a subjective measure, due to the likelihood that regression estimates using subjective assessments of independence will suffer from simultaneity bias if subjective assessments of independence are influenced by regulatory outcomes.

6 Empirical methods and results

Our research employs variations on the following base model of local interconnect rates:

$$Interconnect\ Rate_{i,t} = \alpha + \beta_1 Urbanization_i + \beta_2 Public_{i,t} + \beta_3 EURI\text{-}I_{i,t} + \gamma_t Year_t + \varepsilon_{i,t} \qquad (1)$$

where α is a constant, $Urbanization_i$ is our most predictive measure of network cost in country i (this variable is constant over time), $Public_{i,t}$ is the government's share in the PTO in year i and country t, $EURI\text{-}I_{i,t}$ is our index of NRA independence from the government, $Year_t$ represents year fixed effects and $\varepsilon_{i,t}$ is the error term. The linear model specified here performs at least as well as, and typically much better than, any alternative functional form.

Table 7 reports pooled OLS regression results for five alternative models of local interconnect rates. Year fixed effects are included in all models to control for any EU-wide time trend in the data. All reported standard errors in this paper are consistent in the presence of heteroskedasticity using the Huber-White robust covariance estimator (White 1980).[43]

Model 1 is our base model, as described in (1) above. We find, as predicted, that public ownership of the PTO (*Public*) has a positive effect on local interconnect rates, while regulatory independence (*EURI-I*) has a negative effect.[44] Our main cost control variable (*Urbanization*) is significant and negative, also as expected.

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independence. Data is available from the authors on request. The correlation coefficient between the EURI-I index and this subjective measure is 0.1671 (p value 0.0884).

[43] Very similar standard errors resulted from use of the Newey-West covariance estimator, consistent in the presence of both heteroskedasticity and first order autocorrelation (Newey and West 1987).

[44] Alternative functional form specifications testing for exponential (increasing) and logarithmic (diminishing) relationships between EURI-I and local interconnect rates performed no better than the simple linear form. This confirmation of a linear relationship between the variables suggests that adding a further institutional element to EURI-I has a constant effect on local interconnect rates regardless of the initial value of EURI-I.

Model 2 includes an interaction between the EURI-I index and our continuous measure of public ownership (*Interaction with Public*). In this model, the main effect of regulatory independence is no longer significant, but the interaction term is significant and negative in its place. Model 3 reports a similar result using an interaction between the EURI-I index and the *Public Dummy* measure (*Interaction with Public Dummy*). We prefer Model 2 over Models 1 and 3 on the basis of a higher adjusted R-squared. Model 2 reports that, at the mean value of the EURI-I index in the sample, a fully government owned PTO will enjoy a local interconnect rate 0.464 Eurocents higher than if it were fully privatized. However, the addition of an extra formal element promoting independence of the NRA from the government will reduce this advantage by 0.199 Eurocents. A level of independence (as measured by the EURI-I index) two points above the mean should therefore come close to neutralizing the bias in favour of an entirely government owned PTO. The insignificant coefficient on the regulatory independence main effect supports our expectation that, for interconnect rate outcomes, regulatory independence matters only when the government holds an ownership stake in the PTO. When the PTO is fully privatized, and the government has no incentive to influence interconnect rates upward, enhancing regulatory independence from the government has little or no effect on interconnect rates. With public ownership, however, regulatory independence acts as a significant check on government influence over the regulatory authority, and the greater the government's share in the PTO (and incentive to influence interconnect rate decisions) the greater the effect of regulatory independence in constraining this influence.

Model 4 is based on our preferred Model 2, but includes the variable *Lines* to test for an effect of total network economies of scale on network costs and interconnect rates. We find some evidence that larger networks are associated with lower interconnect rates. Finally, Model 5 includes, as a control, the number of years since liberalization of the telecommunications industry (*Liberalization*). We find no evidence here that the number of years since liberalization has an impact on the local interconnect rate. Our results for public ownership of the PTO and regulatory independence are robust to the inclusion of each of these additional regressors.

A problem with the results of the simple OLS analyses in Table 7 is that there may be unobserved variables that simultaneously determine both our measure of regulatory independence and local interconnect rates.[45] For example, regulatory independence might not be determined

[45] Another concern often present in OLS estimates is the possibility of two-way causality (simultaneity). In the current context, we consider simultaneity between interconnect rates and our

independently of unobserved heterogeneity among the EU member states that also affects local interconnect rates. As we discuss further in section 7, we suspect that countries with weak (strong) informal institutional endowments preserving regulatory independence will be more (less) likely to put in place formal institutional safeguards against government influence over the NRA. If this is the case, OLS estimates of the effects of regulatory independence will incorporate a positive bias due to the unobserved informal environment of regulation. It is also plausible that there are other unobserved features that cause our OLS estimates of the effects of regulatory independence to incorporate a negative bias (for example, EU policies encouraging convergence among the member states might simultaneously influence both interconnect rates and regulatory independence). We employ two alternative approaches to address these concerns. First, we employ an instrumental variables procedure to address endogeneity concerns in general.[46] Second, to address specifically the concern of heterogeneity among the EU member states, we include country fixed effects to control for time invariant, country specific, omitted variables.

Due to difficulties in finding a suitable naturally occurring instrument in the current context (a problem paralleled in the literature on regulatory governance and industry performance)[47] we have chosen to follow Evans and Kessides (1993) in constructing a rank based instrument for the EURI-I index (*EURI-I Index Rank*).[48] Table 8 presents the second stage results of a set of

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measure of regulatory independence to be unlikely. Simple Granger (1969) causality tests estimating bivariate autoregressive processes for interconnect rates and regulatory independence provide evidence only of a causal effect of regulatory independence on interconnect rates. Interconnect rates fail to "Granger cause" our measure of regulatory independence:

$$\text{Interconnect Rate} = 0.949 + 0.266\ \text{Interconnect Rate}_{-1} - 0.047\ \text{EURI-I}_{-1}$$
$$(0.052)^{***} \quad (0.025)^{*}$$

$$\text{EURI-I} = 0.380 + 0.030\ \text{Interconnect Rate}_{-1} + 0.964\ \text{EURI-I}_{-1}$$
$$(0.079) \quad (0.038)^{***}$$

46 Instrumental variables estimation will also address any concern of two-way causality (simultaneity) between interconnect rates and our measure of regulatory independence.

47 See Stern and Cubbin (2003: 29-30).

48 To be valid, an instrument needs to be correlated with the suspected endogenous variable (our measure of regulatory independence) and uncorrelated with the error in (1). We sorted the observations on the EURI-I index from lowest regulatory independence to highest and assigned ranks (1, 2 and 3 respectively) to observations in the smallest, middle and largest thirds of the sample (the *EURI-I Index Rank*). By construction, the EURI-I Index Rank is correlated with the EURI-I index. This instrument will also be orthogonal to the error in (1) if relevant changes in the EURI-I index do not alter the ranks. This condition will be violated only for observations near the

regressions that mirror those in Table 7, but where the EURI-I index has been instrumented in first stage regressions using the EURI-I Index Rank.[49] The results in Table 8 are very similar to those in Table 7. All coefficients have maintained their sign and significance. The only notable difference between Tables 7 and 8 is that the coefficients on public ownership, regulatory independence and the interaction term have all become larger. Durbin-Wu-Hausman specification tests[50] of whether there are systematic differences in the coefficients in Tables 7 and 8 report weak evidence of endogeneity (for example, for Model 2 the χ^2 statistic with 2 degrees of freedom is 4.06 with a p value of 0.1315). We would reject the null hypothesis that the OLS models in Table 7 yield consistent estimates at the 15 percent confidence level. We therefore consider that, while we sacrifice some efficiency, it is prudent to prefer our instrumental variables models in Table 8 to our OLS estimates in Table 7 to ensure consistent estimates of the effects of regulatory independence. Interpreting these estimates, Model 2 in Table 8 reports that, at the mean value of the EURI-I index in the sample, a fully government owned PTO will enjoy a local interconnect rate 0.382 Eurocents higher than if it were fully privatized. The addition of an extra formal element promoting independence of the NRA from the government will reduce this advantage by 0.344 Eurocents. These results suggest that, from the sample mean, just one additional formal institutional element promoting regulatory independence could be sufficient to offset the advantage of a fully government owned PTO.

An alternative but more limited approach, to address specifically the concern of between country heterogeneity bias in the estimates in Table 7, is to include country fixed effects to control for time invariant, country specific, omitted variables. Unfortunately, with limited within country variation in our data, it is difficult to identify effects of many of our variables of interest when country fixed effects are included. Nonetheless, in Table 9 we present a set of two-way fixed effects models controlling for time-invariant country-specific effects as well as EU-wide time trends.[51] In these regressions, the effects of political and institutional variables on local

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thresholds between the ranks, so it is advisable to choose a sufficiently small number of ranks to reduce the likelihood of changes in the ranks (we have chosen just three).

[49] If the EURI-I index is endogenous, then the interaction terms in Models 2 to 6 will also be endogenous. Two endogenous variables require at least two exogenous instruments. We use an interaction between the EURI-I Index Rank and public ownership as a second exogenous instrument in our analysis of these models.

[50] Durbin (1954), Wu (1973) and Hausman (1978).

[51] F tests support the hypotheses that state and time fixed effects are significant at the 1 percent level.

interconnect rates are estimated using only within country variation.[52] Hausman (1978) tests reject the null hypothesis that unobserved country specific effects are randomly drawn and uncorrelated with the modeled independent variables.[53] We find that, when controlling for time-invariant country-specific effects and EU-wide time trends, our regulatory independence index remains significant and roughly doubles in magnitude. According to Model 1 in Table 9, an increase in the EURI-I index by one unit is associated with a fall in the local interconnect price of 0.219 Eurocents per minute. The models in Table 9 are hampered by limited available variation in the dependent and independent variables in the presence of country fixed effects and, with one exception, we do not identify a significant effect of the other explanatory variables or the interaction terms.[54]

Our results on public ownership and regulatory independence in our preferred Table 8 are not only robust to additional regressors, but also to systematic exclusion one by one of each of the 12 component elements of the EURI-I index. We are therefore confident that no single element is driving our results. In addition, these results are robust to exclusion of two notable outliers in the dependent variable (Ireland in 1997 and Portugal in 1998). We are also aware of the possibility that our annual observations may not be independent. Interconnect rates and some of the independent variables in our analysis (including the EURI-I index) do not always change every

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[52] When controlling for state fixed effects it is difficult (or impossible) to get statistically significant estimates of the effects of variables that might vary between states but vary little (or not at all) over time within states. Furthermore, including such variables reduces the degrees of freedom available to estimate the effects of other variables while adding no explanatory power to the estimation. For these reasons, our measure of cost (*Urbanization*) is not included in the models presented in Table 9.

[53] Apart from confirming that a fixed effects specification is appropriate, these Hausman test results suggest there may indeed be some bias in the coefficients on the independent variables in Table 7, and the estimates in these models should thus be treated with some caution. In any case, we prefer the results reported in Table 8, which use instrumental variables as a general method of addressing endogeneity concerns.

[54] The exception is, however, quite interesting. Whereas between countries (Tables 7 and 8) we observe a negative relationship between the number of telephone lines in operation and interconnect rates (a suggestion of network economies of scale), within countries (Table 9) the sign of this relationship is reversed. While there might be alternative explanations, one possibility is that this result reflects simultaneity resulting from an investment effect – as member states lower interconnect rates to encourage entry, incumbent PTOs respond by investing less in their networks. This is consistent with theoretical work by many authors, including Sidak and Spulber (1998) and Jorde, Sidak and Teece (2000), that forward looking costing of incumbent network elements (resulting in low interconnect rates) will adversely affect incumbent incentives to maintain and upgrade existing facilities. As our result in this regard is incidental to our study and has not been rigorously tested here, we suggest further research on this relationship is warranted in the EU context.

year, and the degrees of freedom in our analysis may consequently be overstated. As a robustness check, we performed the regressions in Table 8 using data for 1997 and 2003 alone (28 observations). Although restricted to a much more limited set of observations, we found coefficients on each of our main variables that were of similar size and direction and significant at the 10 percent level.[55]

Finally, as an alternative to the simple (equally weighted) sum of institutional elements employed by the EURI-I index, we have conducted factor analysis on the 12 elements of regulatory independence to identify a small number of important common underlying (unobserved) factors among them.[56] Table 10 presents eigenvalues for 12 factors. In accordance with standard practice, we have chosen to retain only those factors with eigenvalues greater than one. This leaves us with just three retained factors. Table 11 presents factor loadings for each of the 12 elements of regulatory independence. These factor loadings represent the correlation of each element with each of the three retained factors. The first underlying factor is associated most closely with *multi-member* NRAs, *reporting* requirements, the three elements concerning NRA member appointments and terms (*legislative appointments*, *fixed terms* and *renewable terms*) and (negatively) with NRA *funding* sources.[57] The second factor is associated most closely with the adequacy of NRA resources (*staff* and *budget*). The third factor is associated most closely with *multi-sector* NRAs, *multi-member* NRAs and *shared roles* between the NRA and the government. Table 12 presents the results of alternative regression models that substitute these three retained factors for the EURI–I index. Columns 1, 2 and 3 of Table 12 report results of regressions without country fixed effects while Columns 4, 5 and 6 report results from regressions with country fixed effects. Column 1 suggests that elements closely associated with the first two factors drive the negative relationship observed between regulatory independence and local

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55 Repeating the analysis using data for 1997, 2000 and 2003 (43 observations) we found all our main coefficients again significant at the 10 percent level, with the coefficients on public ownership and the interaction term with regulatory independence in Model 2 both significant at the 3 percent level.

56 Factor analysis is a statistical technique that attempts to identify from a large number of original variables a small number of "latent" factors that explain the maximum amount of overall covariance in the original variables. Each factor is characterised by a set of coefficients (factor loadings) that express the correlation of the factor with the original variables. The method provides an alternative method of aggregation of the institutional elements of regulatory independence as the elements are weighted to maximize the cross-country variability, rather than arbitrarily according each of them equal weight.

57 The negative relationship between NRA funding sources and the first factor is a puzzle that is left for future research.

interconnect rates in regressions without country fixed effects. The three elements concerning NRA member appointments and terms and the two NRA resources elements feature in these two factors. Columns 2 and 3 confirm our results regarding an interaction effect between public ownership of the PTO and formal elements of regulatory independence. Interaction terms between each of the first two factors and public ownership (measured either continuously or as a dummy variable) are significant and negative. Column 4 suggests that the elements associated with the third factor are the main drivers of the within country relationship between formal elements of regulatory independence and local interconnect rates. And Column 6 provides some within-country evidence of the interaction effect between public ownership of the PTO and formal elements of regulatory independence, a result that was not evident when using the EURI-I index in Table 9. Overall, the results of this factor analysis suggest that results using the simple equally weighted sum of the 12 elements (the EURI-I index) are not peculiar to that weighting scheme – similar results are found when we weight the elements so as to maximize the covariance among them in three underlying factors.

7 Discussion and conclusions

Our main results are that public ownership is associated with regulatory outcomes favoring the incumbent PTO, and formal institutions promoting regulatory independence matter, providing a check on the tendency for bias in the presence of public ownership (but otherwise have little effect).

The design of this research is novel in two respects. First, because the main focus of our research has been on the value of a regulator independent from government influence, we have examined the formal institutions that promote regulatory independence in far greater detail than any prior study. We consider that the EURI-I index of regulatory independence offers significant improvements over prior attempts to measure independence from government influence, both in terms of the number of recorded institutional elements, and the collection of panel data with variation over time as well as across countries. Second, we view this research as filling an important missing link in the mass of recent comparative cross-national studies of governance institutions and their impact on industry performance and economic growth. Some of these studies operate at a broad macro-political level, for example, linking the number of checks and balances on government power in constitutional structures to industry and economy wide *performance* measures. Others look more narrowly at the quality of regulatory systems in particular utility industries, but again, the focus has been on the effects of regulatory quality on

industry *performance* outcomes. By contrast, our research demonstrates that unchecked government influence on regulatory policy can translate into adverse *regulatory outcomes* that will affect the decisions of prospective investors, but enhancing the independence of the regulator from government influence can mitigate these effects.

We conclude that investors should be concerned not only with the number of checks and balances in a country's macro-political structure, but also with the more detailed set of institutional arrangements surrounding the regulation of the target industry – specifically, the presence of formal institutions designed to promote regulatory independence from the government of the day.[58] Even when a group of countries share similar constitutional features and sound governance at the macro-polity level – as is the case, on the whole, throughout the EU – variations in the institutional environment of regulation, such as the existence of institutions that ensure regulatory independence from the government, can have a substantial impact on regulatory outcomes that affect entry and investment decisions by the private sector. The role of institutional arrangements ensuring regulatory independence from the government is possibly even more significant for developing economies aiming to attract foreign investment to under-capitalized infrastructure industries.

Some comments regarding our novel index of regulatory independence are warranted. Each of the elements in the EURI-I index has been chosen for its amenability to objective measurement, and as such the index represents a measure of formal institutions bearing on regulatory independence. Independence is, however, much more than a set of formal institutional rules. Independence also has an important informal element that is often a function of centuries of political and legal traditions, cultural norms and individual personalities. It therefore must be stressed that the EURI-I index, while capturing independence *de jure*, does not necessarily capture independence *de facto*. For example, the UK scores only moderately on the EURI-I index, yet most industry experts regard the UK as the benchmark in independent telecommunications regulation in the EU. In fact, it is likely that there is a negative correlation

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[58] In sensitivity analysis, we found that the institutional environment of governance at the macro-polity level has no effect on interconnect rates in the EU. In particular, we find no effect of either Henisz's Political Constraints Index (PolConV) (Henisz 2000) or the World Bank's governance indicators (Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption) (Kaufmann, Kraay and Mastruzzi 2004). While appropriate for assessing macro-economic outcomes such as investment and economic growth, we suspect that the construction of these measures lacks the detail necessary to uncover important variation in the institutional environment bearing on regulatory outcomes in EU telecommunications.

between formal and informal regulatory independence: those countries with the weakest informal mechanisms for ensuring regulatory independence will compensate with stronger formal arrangements in order to allay concerns of potential investors of regulatory bias towards incumbent PTOs. Comparisons of the EURI-I index and measures of the informal environment do indeed suggest a negative correlation.[59] If this is the case, our OLS estimates of the effect of the formal institutional environment (in Table 7) are positively biased. As our OLS results report negative coefficients on the EURI-I index despite the likelihood of a positive bias, there is some evidence that, in the EU context, formal institutional safeguards do indeed overcome weaknesses in the informal endowment. A negative correlation between formal and informal independence also provides a plausible explanation for why coefficients on the EURI-I index become more negative when using instrumental variables and when we hold the informal environment fixed with country fixed effects (for Model 1, the coefficient increases in magnitude from – 0.083 to – 0.116 and – 0.219 respectively). In each case, we have controlled for a positive bias in the OLS estimate.

We expect that our results on regulatory outcomes will readily generalize to many other industries, particularly other network infrastructure industries such as electricity, gas and rail. We also expect that the importance of formal institutions promoting regulatory independence will be confirmed across a broad range of countries beyond the EU, and across both developed and developing economies. We therefore encourage future research modelled on this study and applied to different industries and geographical contexts to verify the generalizability of our results. More immediately, we hope the new database of regulatory institutions in EU telecommunications introduced in this paper will prove useful for further research on the effects

[59] The EURI-I index is negatively correlated with an index based on the results of La Porta, Lopez de Silanes, Shleifer and Vishny's (1999) analysis of legal origin. The La Porta et. al. index is constructed as follows: countries with French civil law systems are coded 1, those with German civil law systems are coded 2, those with Scandinavian law are coded 3 and those with common law systems are coded 4. A country's legal origin is thought to determine its ability to credibly commit not to expropriate private property rights and conditions a country's informal environment of regulation (with common law systems considered least interventionist). The EURI index is also negatively correlated with each of three World Bank indices purporting to measure, respectively, Regulatory Quality, Rule of Law and Control of Corruption (Kaufman, Kraay and Mastruzzi 2004). Each of these indices aggregates subjective measures of the informal institutional environment. Finally, the EURI index is negatively correlated with Henisz and Zelner's (2001) index of political constraints on government discretion (POLCONV), which we expect is itself positively correlated with the quality of the informal environment. Further support for the hypothesis of a negative correlation between formal institutional elements promoting regulatory independence and the POLCON index is provided by Gual and Trillas (2003).

of the institutional environment of regulation on the structure and performance of the EU telecommunications industry.

Appendix: Measuring regulatory independence

Prior measures of regulatory governance and regulatory independence in telecommunications

Most attempts to measure regulatory governance in the context of utility regulation have examined regulation in the telecommunications industry. In this context, several authors have made efforts to estimate the effects of regulatory quality and independence on measures of industry performance (investment and efficiency). While these studies typically report positive effects of improving regulatory governance on industry performance (either by itself or when coupled with privatization) they vary substantially in their approach to measuring regulatory governance.

Most of these studies employ a simple dummy variable – such as whether a country has a separate regulatory agency not directly under the control of the ministry – to attempt to capture regulatory *independence*. Fink, Mattoo and Rathindran (2002) are most interested in the sequencing of privatization and competition on industry performance. They interact these variables with a dummy for a separate regulatory agency. They admit themselves this is a very crude measure of the quality of regulation. Wallsten (2001 and 2002) similarly uses a dummy for whether a country has established a separate regulatory authority and observes that this variable is "better characterized as indicating a country's propensity to undertake regulatory reforms rather than the effect of a separate regulator per se." Wallsten (2002) also relies on (clearly problematic) subjective responses by regulatory authorities to the question whether they considered themselves "independent from political power." Bortolotti, D'Souza, Fantini and Megginson (2001) again use a dummy variable coded one when a regulatory agency not under direct control of a ministry and with powers to enforce regulation has been established by law. Gutierrez and Berg (2000) construct a more sophisticated dummy variable based on published accounts of whether the regulatory framework in their sample of countries afforded 1) enforcement power to the regulator and 2) neutrality/independence, but admit this also has limitations. Finally, Ros (2003) uses a dummy variable based on a classification in an ITU telecommunications regulatory database of whether a country has an independent regulator.

As Gutierrez (2003a) notes, the mere existence of a separate regulatory body does not necessarily inform as to the quality of regulatory governance in the industry. Gutierrez (2003a and 2003b) makes a much more concerted effort to explore regulatory governance in his study of

telecommunications regulation in a set of 22 Latin American and Caribbean countries from 1980 to 1997. He constructs a "regulatory framework" index that is an equally weighted sum of the presence of six institutional elements said to bear on good regulatory governance. The first element is whether there is separation between the PTO and regulatory activities. The next four elements are desirable characteristics of the regulatory body itself: independence from government; accountability (measured by the existence of mechanisms to resolve disputes between regulators and operators); clarity of the regulator's roles and objectives; and transparency and participation in the regulatory process. The final element is whether the creation of the regulatory body is backed by legislation (rather than by executive decree).

Gutierrez's research is a vast improvement on simple dummy measures of separate regulators, but his interest is on the overall quality of regulatory governance, rather than the narrower issue of whether the regulator enjoys independence from the government of the day. Gual and Trillas (2003) have constructed a more detailed index of regulatory features bearing specifically on regulatory independence from government, but at the expense of time-series variation. They look at a cross-section of 37 countries and report results on an index that equally weights information on: the degree to which the regulatory agency is responsible for each of five policy areas; the degree to which the agency's funding is independent of government discretion; the rules of appointment of the head of the agency; the length of the agency head's term of office; reporting obligations; the age of the agency; and whether the incumbent is owned by the government. An important contrast in our work is that we prefer to consider government ownership as a separate variable.

For the EU, in two separate reports commissioned by the European Competitive Telecommunications Association (ECTA), Jones Day (2002 and 2004) has attempted to measure elements of regulatory governance in the telecommunications industry and relate these to industry performance. Each of these reports sample a subset of EU member states and provide cross-sectional data not easily comparable across time. These reports are therefore limited to 9 and 10 observations respectively, precluding robust empirical analysis. Their main contribution is to provide a reasonably comprehensive cross sectional database of 66 criteria that are said to bear on "regulatory effectiveness."[60] Only six of the 66 criteria purport to relate to independence of the

[60] These criteria are divided into five sections: general powers of the NRA; effectiveness of the dispute settlement body; application of access regulations; availability of key access products; and implementation of the EU telecommunications package.

regulator from government, and one of these (whether there is government ownership of the PTO) we again consider is better addressed as a separate variable. The other five criteria are: whether intervention from political authority (other than through removal) is likely; the duration of office of NRA management; the grounds for removal of NRA management; the eligibility requirements for NRA management; and the objectives given to the NRA. Apart from the small samples, a concern with these studies is the arbitrary assignment of weights to the various criteria in arriving at overall measures of regulatory independence and regulatory effectiveness. Another concern is the use, in some cases, of apparently subjective judgment when measuring criteria, for example, whether there is a likelihood of intervention from political authority other than through removal.

Finally, in a study similar to our own research of the effects of government ownership and regulatory independence on regulatory outcomes in EU telecommunications, Bauer (2003) constructs an index to measure regulatory independence based on eight criteria recorded for 2000 in an OECD (2000) report: a regulator separate from the executive; the procedure for appointing regulators; funding sources; the ability of the government to overrule decisions; reporting obligations; and three tasks of the regulatory agency (unspecified).

Our approach to constructing an index of formal institutional features bearing on the independence of NRAs from government influence draws upon these prior attempts to measure regulatory independence. A summary of these prior measures is in Table A1. This table reveals that, apart from Gutierrez (2003a and 2003b), studies of regulatory governance in telecommunications have faced a trade-off between the quality of the measure of regulatory governance (dummy or index) and the collection of panel data. Gutierrez (2003a and 2003b) is the first to combine a detailed index measure with panel data, but his index is a measure of overall regulatory governance quality, rather than regulatory independence per se. While our index measure of regulatory independence is most similar in construction to those of Gual and Trillas (2003) and Bauer (2003), we consider that it offers significant improvements, both in terms of the number of recorded elements, and the collection of a panel data set that allows us for the first time to consider the effects of regulatory independence using time-series as well as cross-sectional variation. The construction of our index is described below.

Constructing the EURI-I index

The European Union Regulatory Institutions – Independence (EURI-I) index summarizes key formal institutional features that bear on the independence from government of the National Regulatory Authorities (NRAs) with responsibility for regulating telecommunications in the EU.

The EURI-I index is an equally weighted sum of 12 institutional elements, each measured as a dummy or categorical variable on a 0-1 scale. The elements (and, consequently, the EURI-I index) can of course vary over time, and are measured for each of the 15 founding EU member states for each year from 1997 to 2003. With no a-priori information on the relative importance of each of these elements, each element is accorded equal weight in construction of the index. The index therefore ranges from 0 to 12, although the minimum and maximum in our sample are 1.5 and 10.25 respectively. The EURI-I index values, along with data for each element, are recorded in the European Union Regulatory Independence (EURI) Database, which can be accessed at http://www.london.edu/ri/Research/research.html and is described in full detail in Edwards (2004).

The remainder of this appendix describes, for each element, theory motivating the element's inclusion in an index summarizing formal institutions bearing on regulatory independence, data sources and measurement. The elements have been divided thematically into four categories: characteristics of the NRA; NRA member appointments and terms of office; NRA resources; and NRA experience.

1. NRA Characteristics

    1.1. Does the NRA have single or multi-sector jurisdiction (*multi-sector*)? Many commentators suggest that multi-sector agencies offer greater independence than single-sector agencies (Gönenç, Maher and Nicoletti 2001; Intven, Oliver and Sepulveda 2000: 1-9; Smith 1997b; Smith 2000; Estache 1997; Smith and Wellenius 1999). First, providing an NRA with a broader constituency raises the stakes of political interference with the NRA, reducing the likelihood of such interference. Second, an agency with responsibility for more than one industry is more likely to exhibit independence from sectoral ministries. In addition, a multi-sector agency provides protection from industry capture, both by more frequently pitting interest groups against each other and by facilitating access to pooled resources to improve the agency's fact finding and information processing abilities. Data on this element comes from the European

Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003). Single-sector NRAs are coded 0 while multi-sector NRAs are coded 1.

1.2. Is the NRA a single or multi-member body (*multi-member*)? Additional NRA members provide additional checks on the exercise of power, promoting independence (ITU 1998; OECD 2000; Intven, Oliver and Sepulveda 2000: 1-8; Estache 1997). Data comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003), especially the 2002 report, NRA websites and Daβler and Parker (2004). Single-member NRAs are coded 0 while multi-member NRAs are coded 1.

1.3. Is NRA funding mainly through government appropriations, or industry fees and consumer levies (*funding*)? Where NRA funding relies on government appropriations, NRA independence can be threatened (Smith 1997a; Smith 1997c; Estache 1997; OECD 2000; Intven, Oliver and Sepulveda 2000: 1-7; Gönenç, Maher and Nicoletti 2001; Kerf, Schiffler and Torres 2001; Mustafa 2002). NRAs less reliant on government appropriations for their budgets are therefore considered to enjoy greater independence from the government in their decision-making. Data comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (2000-2003) and the OECD *International Regulation Database* (1998). This element is measured as follows. An NRA financed entirely from government appropriations, or for which industry fees and consumer levies make up less than 25% of its budget, is coded 0. An NRA funded more than 75% (50%) (25%) by industry fees is coded 0.75 (0.5) (0.25). And an NRA funded entirely by industry fees and consumer levies is coded 1.

1.4. Does the NRA report only to the executive government, or does it also have a responsibility to report to the legislature (*reporting*)? An NRA that is only required to report to a Minister is at risk of undue influence by that Minister in its operations. NRAs with additional reporting requirements (to the legislature) are better monitored and more likely to maintain independence from government influence (OECD 2000; Haskins 2000; Kerf, Schiffler and Torres 2001). This holds even in Parliamentary systems where the government and the major party in the legislature (and in the relevant legislative committee) are indistinguishable. First, legislative committees are comprised of both government and opposition members and the latter, while lacking a majority in the

committee, have the opportunity to probe the regulator's activities, raise embarrassing questions in committee hearings, and expose to the public any suspicion of inappropriate political influence over the regulatory authority. Second, even government members of legislative committees must consider not only the government's interests, but also the interests of their own constituents, on whose votes they must rely for re-election. Data on reporting requirements comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003), the OECD *International Regulation Database* (1998), NRA websites and Daβler and Parker (2004). An NRA is coded 0 if reporting is only to the relevant Minister, 0.5 if the NRA is required to report to both the Minister and the legislature and 1 if the NRA reports only to the legislature.

1.5. Does the NRA have adequate powers over interconnection issues (*interconnect powers*)? As the purpose of the current study is to examine NRA independence in the context of NRA decisions on interconnect rates, the adequacy of NRA powers over interconnect issues is relevant. Greater powers to intervene in interconnection disputes confer greater independence for the NRA (OECD 2000). This is the only element in the EURI–I index that relies on subjective assessment. Results in the current study are robust to the exclusion of this element from the EURI–I index. Data comes from a reading of comments in European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003). An NRA is coded 0 if concerns were expressed that the NRA lacked adequate powers in regard to interconnection disputes, and 1 otherwise.

1.6. Does the NRA share the regulatory role with the government or have exclusive powers (*shared roles*)? An NRA that shares regulatory functions with the govnerment is more exposed to government influence by the need to consult or communicate on a regular basis with the government (OECD 2000). Data comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003). NRAs that share roles with the government are coded 0 while NRAs with exclusive powers regarding the regulation of telecommunications are coded 1.

2. NRA Member Appointments and Terms of Office

2.1. Is the legislature involved in NRA member appointments (*legislative appointment*)? Involving the legislature in the appointment process promotes independence from the government (Smith 1997a; Smith 1997c; Estache 1997; OECD 2000; Gönenç, Maher and Nicoletti 2001; Kerf, Schiffler and Torres 2001; Mustafa 2002). Again, this holds even in Parliamentary systems. Having a legislative check on NRA appointments can help to legitimize the NRAs's authority and make the NRA aware that it has broader responsibilities to the constituency. Data comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003) and NRA websites. A code of 0 is given where NRA members are appointed by government ministers without legislative involvement, and a code of 1 where there is legislative involvement in appointments.

2.2. Are NRA members appointed for fixed terms (*fixed terms*)? Guaranteed terms of office permit NRA members to exercise regulatory power without concern for political factors that might influence their continued tenure. Fixed terms of office are therefore an important element in ensuring regulatory independence relative to appointments terminable at any time (Smith 1997a; OECD 2000; Gönenç, Maher and Nicoletti 2001; Mustafa 2002). Data comes from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003), the OECD *International Regulation Database* (1998) and NRA websites. An absence of fixed term appointments is coded 0 while the presence of fixed term appointments is coded 1.

2.3. Are NRA member terms renewable (*renewable terms*)? Literature on central bank independence has argued that non-renewable terms promote independence by eliminating the possibility that decisions will be made to maximize chances of re-appointment.[61] Data comes from European Commission *Reports on the Implementation*

[61] This is a moral hazard perspective on renewable terms. An alternative adverse selection perspective would predict the very opposite. With non-renewable terms, the ability and incentive of NRA members to develop regulatory and industry expertise will be limited. Limited expertise limits scope for independent action. Also, non-renewable terms limit the ability of regulators to build reputation and regulatory commitment power, further restricting scope for independent action. Nonetheless, as non-renewable terms are positively correlated with the other elements of the EURI-I index, we assume that the moral hazard effect dominates the adverse selection effect and overall regulatory independence is promoted by limiting NRA members to single terms.

of the Telecommunications Regulatory Package (1998-2003), the OECD *International Regulation Database* (1998) and NRA websites. Renewable terms are coded 0; non-renewable terms are coded 1.

3. NRA Resources

3.1. Are NRA staff numbers adequate (*staff*)? Adequate staff levels provide the analytic capability for NRAs to assess information and make difficult decisions with independence (Teske 1991; Domah, Pollitt and Stern 2002). Following Teske (1991), we use total NRA staff levels rather per capita figures, as a critical mass of analytical resources is required, regardless of country size.[62] Data on NRA staff is from European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1998-2003). As it is difficult to know what is "adequate" in terms of staff numbers, we use as a benchmark the average across the EU NRAs (excluding Germany which is a significant outlier). A coding of 0 was applied if the number of NRA staff was less than one standard deviation below the EU NRA average. A coding of 0.5 was applied if the number of NRA staff was greater than one standard deviation below the EU NRA average. And a coding of 1 was given if the number of NRA staff exceeded the EU NRA average.

3.2. Is the NRA's regulatory budget adequate (*budget*)? Similarly, an adequate budget is required to facilitate independence as budgets determine the resources available to assess information provided by the industry (Teske 1991; Intven, Oliver and Sepulveda 2000: 1-7; Domah, Pollitt and Stern 2002). Again, following Teske (1991), we use total NRA budget levels rather per capita figures, as a critical mass of resources is required, regardless of country size.[63] Data on NRA budgets is from European Commission

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62 Domah, Pollitt and Stern (2002) empirically demonstrate high fixed costs in utility regulation. This is particularly the case for assessments of interconnect rates. These are typically set on a national rather than regional basis, and in the EU, Reference Interconnection Offers (RIOs) are established that all entrants can accept without the need for individual negotiations with the incumbent PTO. An informal test on the validity of this choice is to examine the correlations between the absolute and per capita staff measures, and the other elements in the EURI-I index. We find a positive correlation for the absolute measure, but a negative correlation for the per capita measure. As we expect to see positive correlations among the formal elements of regulatory independence, this provides some support for our preference for absolute figures.

63 Again, examining correlations between the absolute and per capita budget measures and the other elements in the EURI-I index, we find a positive correlation for the absolute measure, but a negative

Reports on the Implementation of the Telecommunications Regulatory Package (1998-2003). Again, as it is difficult to know what is "adequate" in terms of NRA budgets, we use as a benchmark the average across the EU NRAs (excluding Germany which is again a significant outlier). A coding of 0 was applied if the NRA budget was less than one standard deviation below the EU NRA average. A coding of 0.5 was applied if the NRA budget was greater than one standard deviation below the EU NRA average. And a coding of 1 was given if the NRA budget exceeded the EU NRA average.

4. NRA Experience: Has the NRA been in existence for at least two years (*experience*)? Newly created NRAs often lack experience and can be overwhelmed with their responsibilities, compromising their independence from the government (Smith and Wellenius 1999). For example, it took several years for Italy's NRA to develop sufficient experience and skills to cease reliance on the government in the fulfilment of its functions.[64] To capture this effect, an NRA is coded 0 if it is in the first two years of its operation and 1 if it is at least two years old. NRAs did not become operational in Austria, France, Ireland, Luxembourg and the Netherlands until 1997, while Germany and Italy's NRAs commenced operation as late as 1998.

Two final points should be made. First, the EURI-I index only includes elements bearing on NRA independence that are not standard across the EU member states and over the study period (1997-2003). For example, most NRAs in the EU were formed by legislation rather than executive decree, and in all cases appeals from NRA decisions are possible to a non-executive judicial body (a right of appeal only to the executive would undermine the independence of the NRA). While these features likely promote regulatory independence, they have not been recorded in the EURI Database as they do not vary between or within EU member states over the study period. Researchers interested in comparing institutions bearing on regulatory independence across a broader set of countries would need to include a range of additional institutional features that are taken as given in the EU context.

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correlation for the per capita measure. Again, this provides support for our preference for absolute figures.

64 See the European Commission *Reports on the Implementation of the Telecommunications Regulatory Package* (1999-2000).

Second, there are several data limitations of the EURI-I index. The index includes only elements on which data can be compiled for all 15 of the founding EU member states for each year from 1997 to 2003 inclusive. Upon further development of the EURI Database we hope to include data on a number of additional institutional elements that are likely to bear on regulatory independence from the government.

Table A1: Summary of Prior Measures of Regulatory Governance in Telecommunications

Study	Independent Variable	Measure	Dataset: Cross-Section or Panel
Gutierrez and Berg (2000)	Regulatory Independence	Dummy	Panel (19 Latin American countries in three years)
Bortolotti, D'Souza, Fantini and Megginson (2001)	Regulatory Independence	Dummy (for separate regulator)	Panel (25 countries: 1981-1998)
Wallsten (2001)	Regulatory Independence	Dummy (for separate regulator)	Panel (30 African and Latin American countries: 1984-1997)
Wallsten (2002)	Regulatory Independence	Dummy (if agency claims independence)	Panel (197 countries: 1985-1999)
Fink, Mattoo and Rathindran (2002)	Regulatory Independence	Dummy (for separate regulator)	Panel (86 developing countries: 1985-1999)
Ros (2003)	Regulatory Independence	Dummy (for separate regulator)	Panel (20 Latin American countries: 1990-1998)
Gual and Trillas (2003)	Regulatory Independence	Index (eleven elements including responsibility for five policy areas)	Cross-section (37 countries in 1998)
Jones Day (2002 and 2004)	Regulatory Independence	Index (six criteria with arbitrary weights)	Cross-section (9 and 10 EU countries in 2002 and 2004)
Bauer (2003)	Regulatory Independence	Index (eight criteria including responsibility for three policy areas)	Cross-section (15 EU countries in 2000)
Gutierrez (2003a and 2003b)	Regulatory Governance Quality	Index (six elements of regulatory governance quality)	Panel (22 Latin and Caribbean countries: 1980-1997)

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Figure 1: The Effects of the Institutional Environment

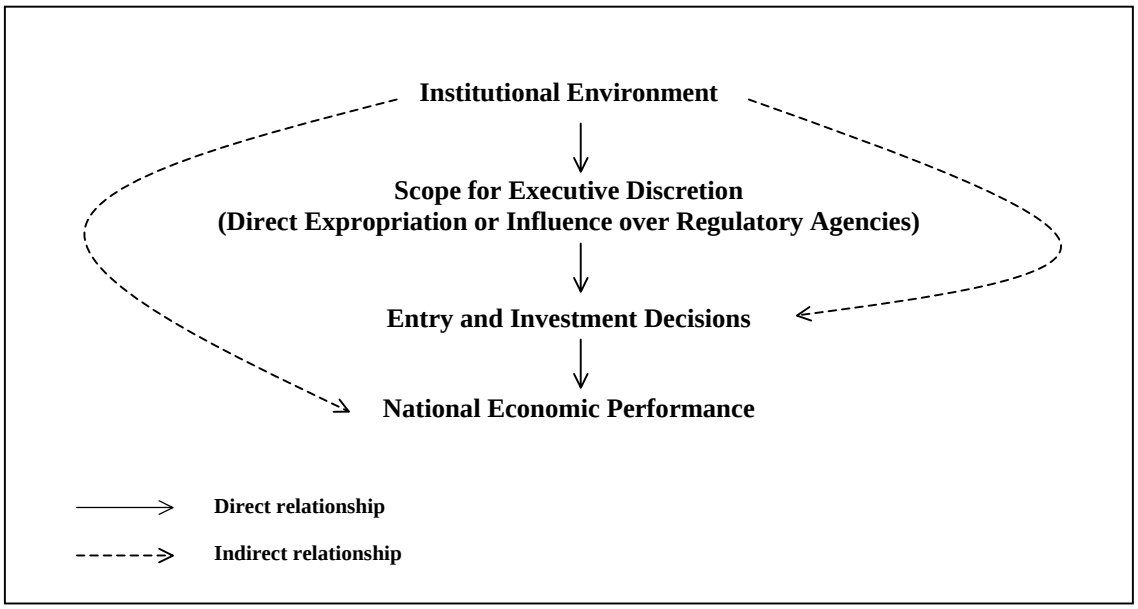


Figure 2: Absence of Close Correspondence Between Local Interconnect Rates and Costs (2003)

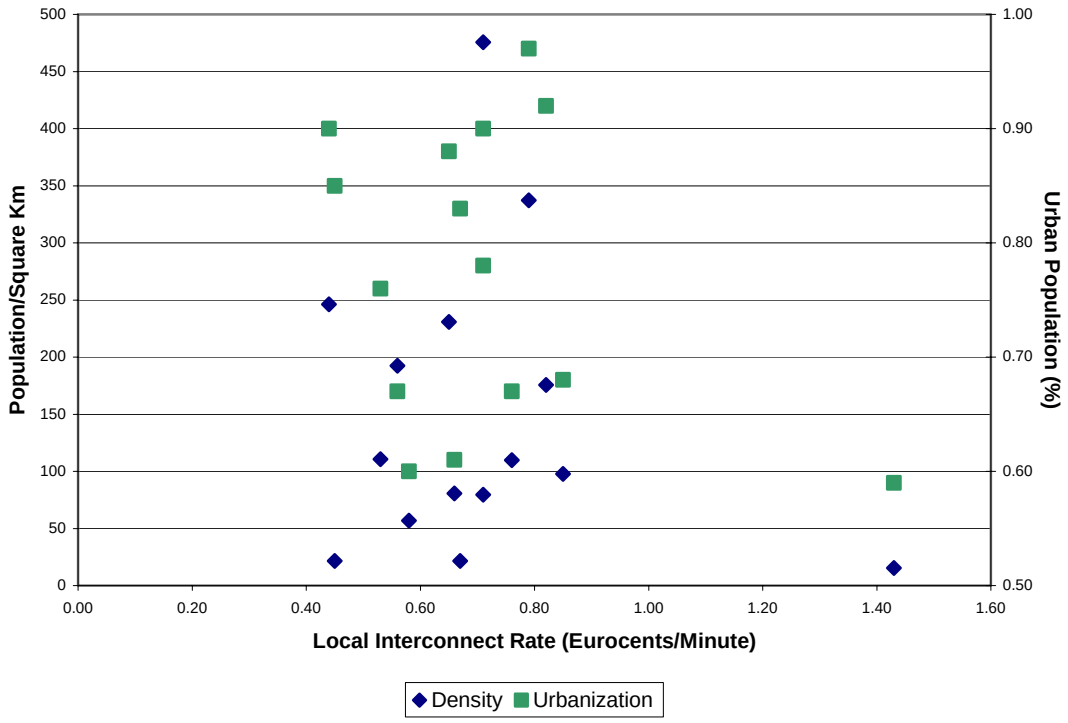
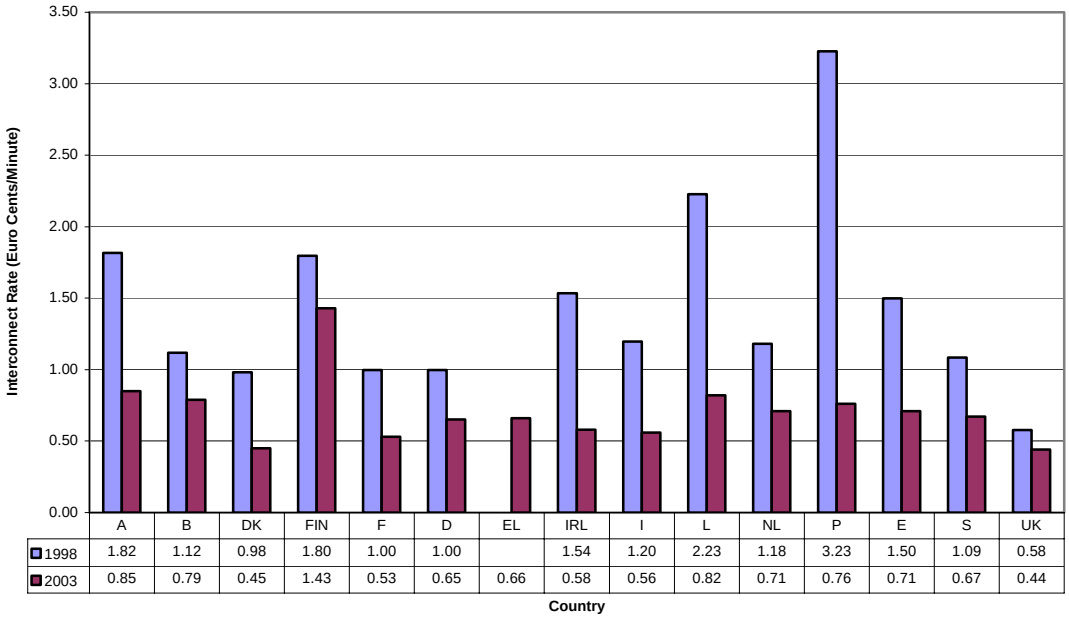
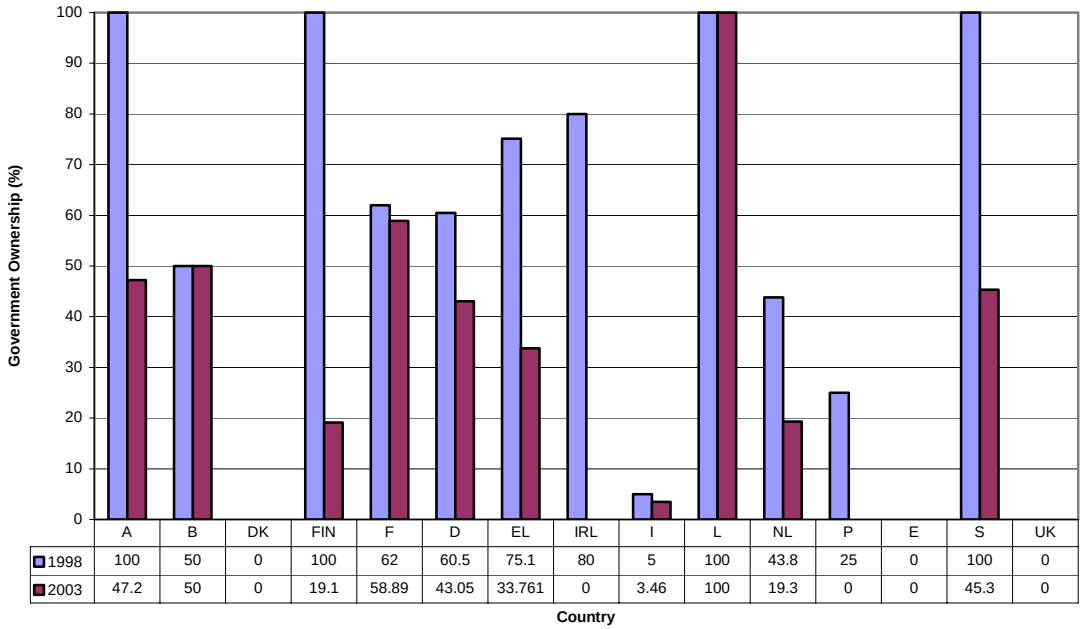


Figure 3: Local Interconnect Rates in the European Union (1998 and 2003)



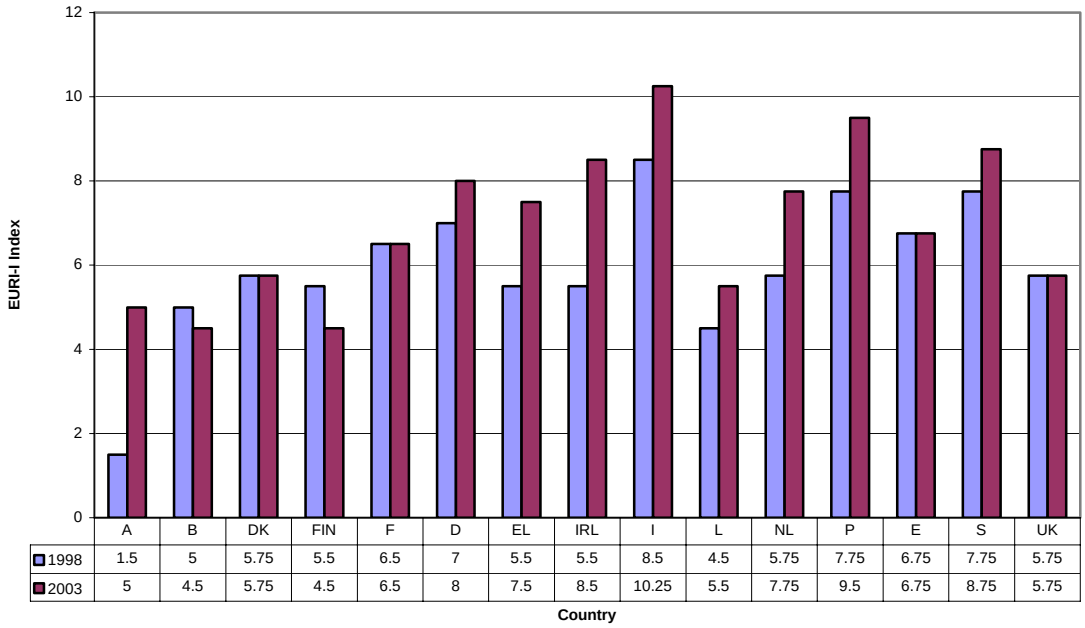
	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK
1998	1.82	1.12	0.98	1.80	1.00	1.00		1.54	1.20	2.23	1.18	3.23	1.50	1.09	0.58
2003	0.85	0.79	0.45	1.43	0.53	0.65	0.66	0.58	0.56	0.82	0.71	0.76	0.71	0.67	0.44

Figure 4: Government Ownership (%) (1998 and 2003)



	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK
1998	100	50	0	100	62	60.5	75.1	80	5	100	43.8	25	0	100	0
2003	47.2	50	0	19.1	58.89	43.05	33.761	0	3.46	100	19.3	0	0	45.3	0

Figure 5: European Union Regulatory Institutions – Independence (EURI-I) Index (1998 and 2003)



	A	B	DK	FIN	F	D	EL	IRL	I	L	NL	P	E	S	UK
1998	1.5	5	5.75	5.5	6.5	7	5.5	5.5	8.5	4.5	5.75	7.75	6.75	7.75	5.75
2003	5	4.5	5.75	4.5	6.5	8	7.5	8.5	10.25	5.5	7.75	9.5	6.75	8.75	5.75

Table 1: Country Summaries of PTOs and NRAs

Country	Country Code	Public Telecommunications Operator (PTO)	Government Ownership in 2003 (%)	National Regulatory Authority (NRA)	First Year of NRA Operation[1]	Year of Liberalization
Austria	A	Telekom Austria	47.2	Rundfunk und Telekom Regulierungs-GmbH (RTR)	1997	1998
Belgium	B	Belgacom	50	Institut Belge des services Postaux et de Télécommunications (BIPT)	1993	1998
Denmark	DK	Tele Danmark (TDC)	0	Telestyrelsen - National Telecom Agency (NTA)	1991	1996
Finland	FIN	Sonera[2]	19.1	Viestintävirasto Kommunikationsverket (FICORA)	1988	1993
France	F	France Telecom	58.9	Autorité de Régulation des Télécommunications (ART)	1997	1998
Germany	D	Deutsche Telekom	43.1	Regulierungsbehoerde für Telekommunikation und Post (Reg TP)	1998	1998
Greece	EL	Greek Telecom Organization (OTE)	33.8	National Telecommunications and Post Commission (EETT)	1992	2001
Ireland	IRL	Eircom	0	Commission for Communications Regulation (ComReg)	1997	1998
Italy	I	Telecom Italia	3.5	Autorità per le Garanzie nelle Comunicazioni (AGC)	1998	1998
Luxembourg	L	P&T Luxembourg (EPT)	100	Institut Luxembourgeois de Régulation (ILR)	1997	1998
The Netherlands	NL	KPN	19.3	Onafhankelijke Post en Telecommunicatie Autoriteit (OPTA)	1997	1997
Portugal	P	Portugal Telecom (PT)	0	Autoridade Nacional de Comunicações (ANACOM)	1981	2000
Spain	E	Telefonica de Espana S.A.	0	Comisión del Mercado de las Telecomunicaciones (CMT)	1996	1998
Sweden	S	Telia	45.3	Post & Telestyrelsen (PTS)	1992	1994
United Kingdom	UK	British Telecom (BT)	0	Office of Communications (OFCOM)	1984	1985

[1] Including any predecessor NRA.

[2] Sonera is the largest of numerous incumbent fixed local PTOs in Finland. Its market share in 1996 was 32% (46 other PTOs held a combined share of 68%).

Table 2: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Interconnect Rate	101	1.065	.742	.44	6.58
Density	105	148.095	124.060	15	476
Urbanization	105	.774	.125	.59	.97
Public	105	.412	.351	0	1
Public Dummy	105	.467	.501	0	1
EURI-I	105	6.452	1.666	1.5	10.25
Lines (000,000)	88	13.895	14.816	.28	53.72
Liberalization	105	3.333	4.194	– 4	18

Table 3: Correlation Matrix

	I/C Rate	Density	Urban	Public	Public Dummy	EURI-I	Lines	Lib
Interconnect Rate	1							
Density	-0.1595	1						
Urbanization	-0.2716	0.6088	1					
Public	0.3704	-0.0921	0.0554	1				
Public Dummy	0.2574	-0.2021	0.0352	0.8491	1			
EURI-I	-0.2991	0.0300	-0.1094	-0.3562	-0.3573	1		
Lines (000,000)	-0.3129	0.2648	0.2536	-0.1757	-0.1134	0.3273	1	
Liberalization	-0.3395	0.0282	0.2113	-0.2117	-0.1647	-0.0768	0.2154	1

Table 4: Descriptive Statistics of EURI-I Index Elements

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Multi-sector	105	0.438	0.499	0	1
Multi-member	105	0.610	0.490	0	1
Funding	105	0.719	0.358	0	1
Reporting	105	0.310	0.356	0	1
Interconnect Powers	105	0.543	0.501	0	1
Shared Roles	105	0.457	0.501	0	1
Legislative Appointment	105	0.333	0.474	0	1
Fixed Terms	105	0.733	0.444	0	1
Renewable Terms	105	0.133	0.342	0	1
Staff	105	0.671	0.366	0	1
Budget	105	0.667	0.351	0	1
Experience	105	0.838	0.370	0	1

Table 5: Correlation Matrix of EURI-I Index Elements

	M-S	M-M	Funding	Report	I/C Powers	Shared Roles	Leg Appt	Fixed	Renew	Staff	Budget	Exp
Multi-sector	1											
Multi-member	0.313	1										
Funding	0.144	-0.439	1									
Reporting	-0.121	0.148	-0.622	1								
Interconnect Powers	-0.192	-0.225	0.054	0.046	1							
Shared Roles	0.153	0.108	0.026	-0.181	0.113	1						
Legislative Appointment	-0.339	0.566	-0.676	0.380	0.000	-0.243	1					
Fixed Terms	0.098	0.753	-0.370	0.314	0.009	0.121	0.426	1				
Renewable Terms	0.049	0.314	-0.713	0.488	0.135	-0.360	0.555	0.237	1			
Staff	-0.020	-0.293	-0.216	0.161	0.091	0.172	-0.222	-0.249	-0.031	1		
Budget	0.073	-0.009	-0.284	0.160	0.055	0.246	0.067	-0.144	0.094	0.786	1	
Experience	0.023	-0.140	0.288	-0.273	0.064	0.040	-0.183	-0.148	-0.208	0.172	0.136	1

Table 6: European Union Regulatory Institutions – Independence (EURI-I) Index Elements (1998 and 2003)

Country	A		B		DK		FIN		F		D		EL		IRL		I		L		NL		P		E		S		UK	
Year	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03	98	03
EURI-I	1.5	5	5	4.5	5.75	5.75	5.5	4.5	6.5	6.5	7	8	5.5	7.5	5.5	8.5	8.5	10.25	4.5	5.5	5.75	7.75	7.75	9.5	6.75	6.75	7.75	8.75	5.75	5.75
EURI-I (0-1 Scale)	0.125	0.417	0.417	0.375	0.479	0.479	0.458	0.375	0.542	0.542	0.583	0.667	0.458	0.625	0.458	0.708	0.708	0.854	0.375	0.458	0.479	0.646	0.646	0.792	0.563	0.563	0.646	0.729	0.479	0.479
multi-sector	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0
multi-member	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
funding	1	1	1	1	0.75	0.75	1	1	0	0	0	0	1	1	1	1	0	0.25	1	1	0.75	0.75	0.75	1	0.75	0.75	0.75	0.75	0.75	0.75
reporting	0	0	0	0	0	0	0.5	0.5	0.5	0.5	1	1	0	0	0.5	0.5	1	1	0.5	0.5	0	0	0	0.5	0	0	0	0	0.5	0.5
interconnect powers	0	1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	0	1	1	1
shared roles	0	1	0	0	1	1	0	0	0	0	1	1	0	1	1	1	0	0	0	0	1	1	1	1	0	0	1	1	0	0
legislative appointment	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
fixed terms	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
renewable terms	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
staff	0.5	0	1	0.5	1	1	1	1	0.5	0.5	1	1	0	0	0.5	0.5	0.5	1	0	0	0.5	0.5	1	1	0.5	0.5	1	1	1	1
budget	0	0	1	1	1	1	1	1	0.5	0.5	1	1	0.5	0.5	0.5	0.5	1	1	0	0	0.5	0.5	1	1	0.5	0.5	1	1	0.5	0.5
experience	0	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1

Table 7: Regression Results for Local Interconnect Rates (One-Way Fixed Effects)

	(1)	(2)	(3)	(4)	(5)
	Base Regression	Interaction with Public	Interaction with Public Dummy	Lines (000,000)	Liberalization
Urbanization	-1.827***	-1.446*	-1.495**	-1.238	-1.391*
	(0.646)	(0.732)	(0.683)	(0.840)	(0.721)
Public	0.515***	1.757***		1.816***	1.568***
	(0.168)	(0.531)		(0.594)	(0.576)
Public Dummy			1.324***		
			(0.328)		
EURI-I	-0.083***	0.004	-0.012	0.041	-0.014
	(0.026)	(0.036)	(0.027)	(0.043)	(0.039)
Interaction with Public		-0.199**		-0.209**	-0.175*
		(0.086)		(0.098)	(0.092)
Interaction with Public Dummy			-0.176***		
			(0.052)		
Lines (000,000)				-0.008**	
				(0.004)	
Liberalization					-0.014
					(0.010)
Constant	2.858***	1.657**	1.880***	2.214*	1.840**
	(0.538)	(0.756)	(0.651)	(1.197)	(0.810)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	No
Observations	101	101	101	84	101
Adjusted R-squared	0.34	0.35	0.33	0.34	0.35

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Regression Results for Local Interconnect Rates (Instrumental Variables)

	(1)	(2)	(3)	(4)	(5)
	Base Regression	Interaction with Public	Interaction with Public Dummy	Lines (000,000)	Liberalization
Urbanization	-1.877***	-1.211*	-1.410**	-0.893	-1.166*
	(0.682)	(0.647)	(0.650)	(0.761)	(0.640)
Public	0.464***	2.618***		2.988***	2.520***
	(0.135)	(0.594)		(0.613)	(0.605)
Public Dummy			1.772***		
			(0.485)		
EURI-I (†)	-0.116**	0.039	-0.003	0.106	0.030
	(0.047)	(0.046)	(0.043)	(0.065)	(0.047)
Interaction with Public (†)		-0.344***		-0.400***	-0.332***
		(0.082)		(0.085)	(0.084)
Interaction with Public Dummy (†)			-0.252***		
			(0.072)		
Lines (000,000)				-0.007**	
				(0.004)	
Liberalization					-0.009
					(0.009)
Constant	3.629***	2.063**	2.613***	1.486	2.107**
	(1.057)	(0.988)	(0.943)	(1.153)	(1.006)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	No
Observations	101	101	101	84	101
Adjusted R-squared	0.33	0.34	0.32	0.31	0.33

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
(†) Predicted values from first-stage regressions using EURI Index Rank and an interaction of EURI Index Rank and Public (Public Dummy in Model 3) as instruments

Table 9: Regression Results for Local Interconnect Rates (Two-Way Fixed Effects)

	(1)	(2)	(3)	(4)	(5)
	Base Regression	Interaction with Public	Interaction with Public Dummy	Lines (000,000)	Liberalization
Public	1.517 (1.175)	1.336 (1.141)		1.925 (1.484)	1.517 (1.175)
Public Dummy			0.840 (0.650)		
EURI-I	-0.219*** (0.079)	-0.237 (0.150)	-0.184* (0.110)	-0.203** (0.096)	-0.219*** (0.079)
Interaction with Public		0.033 (0.226)			
Interaction with Public Dummy			-0.074 (0.089)		
Lines (000,000)				0.093** (0.038)	
Liberalization					0.047 (0.066)
Constant	1.189 (0.921)	1.265 (0.785)	1.587*** (0.578)	0.359 (1.196)	0.905 (1.078)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	101	101	101	84	101
Adjusted R-squared	0.43	0.42	0.37	0.43	0.43

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 10: Eigenvalues from Factor Analysis: Three Factors Retained

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	3.29554	1.33232	0.4045	0.4045
2	1.96321	0.58251	0.241	0.6455
3	1.3807	0.63564	0.1695	0.815
4	0.74506	0.23969	0.0915	0.9064
5	0.50537	0.10204	0.062	0.9684
6	0.40333	0.15726	0.0495	1.0179
7	0.24607	0.18811	0.0302	1.0481
8	0.05796	0.11891	0.0071	1.0553
9	-0.06095	0.03771	-0.0075	1.0478
10	-0.09867	0.03544	-0.0121	1.0357
11	-0.13411	0.02237	-0.0165	1.0192
12	-0.15648	.	-0.0192	1

Table 11: Factor Loadings on the Three Retained Factors

Element	F1	F2	F3	Uniqueness
multi-sector	-0.0695	-0.11814	0.59056	0.63245
multi-member	0.68468	-0.32727	0.55262	0.11872
funding	-0.85967	-0.3501	0.02914	0.13755
reporting	0.58496	0.25964	-0.16356	0.56366
interconnect powers	-0.03525	0.16224	-0.17503	0.9418
shared roles	-0.1768	0.14259	0.56277	0.6317
legislative appointment	0.82613	-0.05117	-0.19628	0.27636
fixed terms	0.61347	-0.30024	0.37628	0.39192
renewable terms	0.73519	0.14204	-0.23201	0.38549
staff	-0.1255	0.89945	0.14988	0.15277
budget	0.07135	0.8207	0.2979	0.23262
experience	-0.29669	0.10004	0.08027	0.89552

Table 12: Regression Results Using the Three Retained Factors

	(1)	(2)	(3)	(4)	(5)	(6)
	- - - - Without Country Fixed Effects - - - -			- - - - With Country Fixed Effects - - - -		
	Base Regression	Interactions with Public	Interactions with Public Dummy	Base Regression	Interactions with Public	Interactions with Public Dummy
Urbanization	-1.624**	-1.657**	-1.606**			
	(0.622)	(0.682)	(0.647)			
Public	0.510***	0.460***		1.587	1.334	
	(0.168)	(0.159)		(1.172)	(1.087)	
Public Dummy			0.290**			0.362
			(0.120)			(0.342)
F1	-0.139***	0.009	-0.026	0.436		
	(0.046)	(0.057)	(0.045)	(0.578)		
F2	-0.109**	0.097	-0.016	-0.069		
	(0.045)	(0.067)	(0.053)	(0.414)		
F3	-0.009			-0.507**	-0.268	-0.288
	(0.062)			(0.241)	(0.213)	(0.260)
F1*Public		-0.361***				
		(0.123)				
F2*Public		-0.359***				
		(0.123)				
F3*Public					-0.494	
					(0.384)	
F1*Public Dummy			-0.249***			
			(0.068)			
F2*Public Dummy			-0.268**			
			(0.107)			
F3*Public Dummy						-0.429**
						(0.215)
Constant	2.187***	2.184***	1.871***	0.155	-0.195	0.351
	(0.457)	(0.491)	(0.487)	(1.643)	(1.075)	(0.479)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	Yes	Yes	Yes
Observations	101	101	101	101	101	101
Adjusted R-squared	0.34	0.39	0.38	0.40	0.42	0.38

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%