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Regulation and Investment in Network Industries: Evidence from European Telecoms

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Regulation and Investment in Network Industries: Evidence from European Telecoms*

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Abstract

We provide evidence of an inherent trade-off between access regulation and investment incentives in telecommunications by using a comprehensive data set covering 70+ fixed-line operators in 20 countries over 10 years. Our econometric model accommodates: different investment incentives for incumbents and entrants; a strategic interaction of entrants' and incumbents' investments; and endogenous regulation. We find access regulation to negatively affect both total industry and individual carrier investment. Thus promoting market entry by means of regulated access undermines incentives to invest in facilities-based competition. Moreover, we find evidence of a regulatory commitment problem: higher incumbents' investments encourage provision of regulated access.

Keywords: Telecommunications, Access Regulation, Unbundling, Investment

JEL Codes: C51, L59, L96

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I.

The rationale for access regulation in network industries is to intensify competition in order to promote efficiency and thereby enhance social welfare. In a static environment, opening access to competitors increases competition, which lowers margins and prices and results in a higher consumer surplus. In dynamic settings, the relationship between access regulation and welfare is more complicated. Lower access prices might increase competition short term but undermine incumbents' incentives to invest in the network, higher access prices provide stronger incentives to invest but impede entrants' use of incumbents' infrastructure and thereby reduce competition (see, for instance, Jean-Jacques Laffont and Jean Tirole, 2000, or David M. Newbery, 2002).

The regulation-investment trade-off is further complicated by entrants' investment incentives. The role of access regulation with respect to infrastructure investment by entrants is inherently ambivalent (Martin Hellwig, 2008); it reduces barriers to entry, as entrants do not need to duplicate the existing network, but also reduces, because infrastructure can be rented from incumbents at mandated prices, incentives to build new infrastructure. This trade-off is reflected in what is termed facilities-based (i.e., entrants invest in their own infrastructure) vs. service-based (i.e., entrants rely on regulated access to incumbents' infrastructure) competition.[1] Permitting relatively "easy" access to incumbents' infrastructure might thus undermine not only incumbents', but also entrants', incentives to invest in infrastructure.[2]

Although it is suggested that "easy" access limits entrants' incentives to invest in facilities-based competition, this might not be the case for entrants' investment in *upgrading* incumbents' infrastructure. For example, to enable broadband access to the Internet via an unbundled local loop an entrant needs to upgrade the local loop, as well as invest in the backbone network. Every entry other than simple reselling of incumbent services thus requires further investment. But these two types of investment differ fundamentally with respect to easy access in that incentives to invest in upgrades might grow out of, and thus be aligned, in contrast to investments in facilities-based competition (as in cable), which are not aligned, with easy access provisions (see Glenn A. Woroch, 1998).

[1] Although infrastructure leasing is not needed, interconnection issues among competing networks and bilateral access prices might exist, under facility-based competition. For an analysis of regulatory issues in such two-way networks, as opposed to one-way networks in which entrants have access to incumbents' essential facilities, see Tommaso Valletti (2003).

[2] A variant of this trade-off is emphasized by the so-called ladder hypothesis of investment (Martin Cave and Ingo Vogelsang, 2003; Martin Cave, 2004, 2006), also referred to as the stepping stone hypothesis (Gregory L. Rosston and Roger G. Noll, 2002), which suggests that easy access is needed to promote entry and greater infrastructure investment long term.

These inherent trade-offs have important implications for policy. Many policy makers argue that facilities-based competition affords advantages of variety, low price, and innovation, whereas service-based competition provides only price benefits resulting from regulator-promoted access (Cave, 2004). Empirical evidence from broadband suggests that infrastructure competition between DSL and cable TV providers had a significant positive impact on broadband deployment (see Felix Höffler, 2007). If facilities-based competition is regulators' ultimate objective, then incentives for infrastructure investments become a key policy concern.[3]

Empirical assessments need to take into account that incumbents' and entrants' investment incentives are fundamentally different and might not be aligned. This paper establishes an empirical framework for identifying the effect of access regulation on investment by treating incumbents' and entrants' investment decisions as interdependent. Estimating via separate equations the impact of regulation on entrants and incumbents enables us to identify the differential effects on investment incentives between the two as well as the *strategic effect* of infrastructure investments; it enables us to identify incumbents' and entrants' investments as strategic substitutes or complements.

We further allow for regulation to be endogenous, regulatory commitment being highly relevant to long-term investment decisions in regulated (or potentially regulated) industries. That regulatory outcomes such as unbundling policies and mandated access prices are subject to political and administrative processes gives rise to a fundamental *endogeneity* problem.[4] For example, when regulator's objective is to promote competition to the benefit of the consumer, higher infrastructure investment by incumbents may cause national regulators to provide cheaper access. This, however, will undermine the incumbent's incentives to invest in infrastructure in the first place giving rise to a regulatory *commitment problem*. Consequently, regulation needs to be treated as endogenous.

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[3] Facilities-based competition might ultimately provide greater benefits in terms of variety, long-term pricing, and innovation. According to the European Commission: "Empirical evidence shows that investment and innovation are strongest where there is effective competition between infrastructures. However, there is still no infrastructure-based competition on around 80 percent of the EU's local loops. This means that, ex-ante, regulation continues to play a crucial role in maintaining competition and protecting consumers by setting conditions for access to the incumbent's infrastructure" (European Commission, 2007).

[4] J. Gregory Sidak and Daniel F. Spulber (1996) discuss circumstances under which mandatory unbundling can lead to "deregulatory takings" by opportunistic regulatory agencies taking a legal perspective. See also Newbery (2002) for an extensive discussion of the problem of regulatory commitment. Robert W. Crandall (2005, p. 71) shows that US access prices in 2002 were negatively correlated with 1996-1999 capital spending of incumbent telecoms companies, suggesting that regulators exploit investment ex post ("regulatory takings") by reducing the rate at which the investing company is obliged to lease its network to competitors. Tomaso Duso and Lars-Hendrik Röller (2003) show that the degree of deregulation in the mobile telecommunications industry is explained largely by political variables.

We estimate our econometric model using a comprehensive new data set that covers more than 70 fixed-line operators in 20 EU member states over a 10-year period.[5] Among the advantages of this data set for purposes of studying investment incentives in regulated industries is that it enables us to differentiate between the impact of regulation on incumbents and entrants, and to abstract from cable competition to focus on telecoms operators, competition from cable being much less developed in Europe than in, for example, the United States (according to OECD Communication Outlook 2007, EU member states typically have low cable penetration rates—Czech Republic, 24 percent, Hungary, 8 percent, Poland, 34 percent, Spain, 57 percent, Sweden, 50 percent, United Kingdom, 50 percent—compared to the United States' nearly 100 percent penetration[6]).

Finally, our data set makes use of a new regulatory index based on the number of existing legal measures that facilitate one-way access to incumbents' networks. Other studies use as the regulatory variable a mandated access price such as the unbundled local loop rental rate used by Robert W. Crandall, Allan T. Ingraham, and Hall J. Singer, 2004. Two important advantages of our indicator of access regulation over access price are (1) that it reflects access at different levels of infrastructure (e.g., local loop unbundling, line sharing, and bitstream access), whereas available access price reflects only local loop unbundling, and (2) it is better suited to the context of international comparisons, being independent of country-specific costs of building infrastructure. Moreover, our index, being based exclusively on regulatory measures and not entry or market shares, is a significant improvement over the existing OECD index used in other studies (e.g., Alberto Alesina et al. 2005), which, being based in part on number of entrants, does not distinguish regulation from competition.

The principal empirical findings of our study of the impact of access regulation on investment are as follow.

(i) We find considerable support for our approach, in particular, as it accounts for the differential impact of access regulation on the investment decisions of incumbents and entrants. Access regulation discourages investment by incumbents and *individual* entrants even as entrants' *total* investment increases. Moreover, incumbents' investment reacts to entrants' investments, that is, incumbents invest more as entrants' total investment increases.

[5] The data set were assembled by ESMT Competition Analysis (see Hans Friederiszick, Michał Grajek, and Lars-Hendrik Röller, 2008) with the support of Deutsche Telekom.

[6] We have included as a robustness check in the following empirical analysis the percentage of cable households. The results, as expected, not being affected, are not reported below.

(ii) We also find that endogeneity of regulation matters empirically. Specifically, absent controlling for endogenous regulation, we do not find any significant impact of regulation on investment, but do identify a significant effect when regulation is permitted to be endogenously determined by level of infrastructure investment.

(iii) In terms of magnitude, we estimate the overall effect of access regulation on total industry investment in Europe to be a loss of some €16.8 billion over the past 10 years.

(iv) In terms of regulatory determinants, we find regulatory responses to infrastructure investments to differ between incumbents and entrants. Whereas access regulation is not affected by entrants' investment, regulators toughen access regulation in response to increased investment by incumbents.

We emphasize that our focus in this paper is on investment, not welfare. Although the two are related, we do not examine the effect of investment on consumer prices.

The rest of the paper is organized as follows. In the next section, we review the literature on investment and regulation in network industries, with a focus on telecommunications. Our econometric model is introduced in section 3. Data, descriptive results and instruments are discussed in section 4. In section 5, we present our empirical results. Section 6 concludes.

II. Literature Review

Competition in retail markets can be significantly affected by elements of infrastructure that have natural monopoly properties, a prominent example in the telecommunication infrastructure being the local loop that connects individual households to the local switch. Duplicating the copper lines in local loops is expensive, at least for purposes of providing an alternate path for traditional telecommunications service.[7]

In both Europe and the United States, the infrastructure bottleneck was typically resolved by mandating unbundling and sharing of the local loop to provide access to the incumbent

[7] The natural monopoly features of traditional fixed-line networks are diminishing in importance (Hellwig, 2008) as technological progress facilitates development of alternative networks that deliver similar services and mobile telecommunications and cable networks that offer services that, albeit imperfect substitutes, nevertheless exert competitive pressure on incumbents.

telephone network.[8] Such provisions increase the likelihood of successful entry, but reduce the rent that can be earned on infrastructure investments. Because basing access regulation on a simple cost recovery rule encourages efficient utilization of infrastructure, but has the potential to discourage investment (Valletti, 2003), the literature has emphasized a regulatory trade-off between static and dynamic incentives.

Although evidence that access regulation has enhanced static efficiencies abounds, debate persists regarding the impact of access regulation on investments in telecommunications.[9] The Federal Communications Commission (FCC) has recently moved away from access regulation applied to broadband entry (see Jonathan E. Nuechterlein and Philip J. Weiser, 2005), but access regulation and local loop unbundling continue to be the dominant regulatory paradigms in Europe.[10]

We have divided the literature review into two parts. The first reviews theoretical contributions, the second empirical results.

A. Impact of access regulation on investment: Theoretical perspectives

Access regulation has been demonstrated to have a negative impact on investment in a number of theoretical settings including (i) lowering the Net Present Value (NPV) of incumbents' investments, (ii) shifting risk from entrants to incumbents, and (iii) increasing incumbents' risk exposure and, thereby, cost of capital.

The first line of argument emphasizes that rents earned from leasing infrastructure at cost-based prices are lower than monopoly rents realized from owning and selling the infrastructure directly to consumers (Valletti, 2003). Under NPV calculations, investments are thus less likely (to be profitable) when access is regulated (Robert S. Pindyck, 2007).

In the context of the considerable uncertainty regarding whether telecommunication infrastructure investment will be adequately reflected in cost-based access charges (see, for instance, Jerry A. Hausman, 1997; Thomas M. Jorde, J. Gregory Sidak, and David J. Teece, 2000; John Haring and Jeffrey H. Rohlfs, 2002; Valletti, 2003; Pio Baake, Ulrich Kamecke, and Christian Wey, 2005; Pindyck, 2007), under mandated access incumbents bear all the

[8] See Robert W. Crandall and Leonard Waverman (2006) for a recent overview of the industry and regulatory trends on both sides of the Atlantic.
[9] A large body of literature examines the question of how to set access charges so as to allocate resources efficiently (see, for example, Mark Armstrong, 2002).
[10] See Paul De Bijl and Martin Peitz (2005) for a recent overview of telecommunications market developments in Europe.

investment risk while entrants enjoy a risk-free option to lease infrastructure and exploit the regulatory arbitrage between wholesale and retail prices when demand uncertainty is resolved. Cost-based access charges that do not accommodate this risk reduce to sub-optimal levels (as defined by the NPV) incumbents' incentives to invest. The risk-free option also adversely affects entrants' ex ante incentives to invest in their own infrastructure.

Finally, shifting the risk from entrants to incumbents through cost-based access regulation, if it increases the latter's cost of capital (Jorde, Sidak, and Teece, 2000), will reduce their ability to invest. The argument is as follows. When uncertainty plays out unfavorably, that is, when demand for telecommunications services turns out to be weak, entrants are more likely to lease local loops. When it plays out favorably and demand is strong, entrants will be able to afford, owing to higher prices for services, to roll out their own networks. Because cost-based access charges under-compensate their investment, incumbents' returns will suffer in times of recession and improve during expansion. Investors must be compensated for volatility in incumbents' returns on assets relative to the market with higher returns on their stocks, which increases the cost of equity.[11]

A number of theoretical contributions, on the other hand, suggest a positive effect of access regulation on investment. As has been pointed out in the literature, a vertically integrated incumbent may not raise retail competitor's costs if the competitor is more efficient (see, for instance, Patrick Rey and Jean Tirole, 2007; David S. Sibley and Dennis L. Weisman, 1998). Taking this theory a step further, Oystein Foros (2004) and Kaisa Kotakorpi (2006) show that service-based competition, if it increases variety and innovation and, concomitantly, demand, might encourage investment by incumbents. It is crucial, though, that incumbents be able to appropriate profits from increased demand through sufficiently high (possibly unregulated) access charges. The cost-based access charges set by US and EU regulators have been criticized for being too low (see, for instance, Pindyck, 2007).[12]

According to the so-called "investment ladder" theory (Cave and Vogelsang, 2003; Cave 2006), entrants enabled by low access fees to build up an installed base and learn about demand and cost conditions will subsequently be encouraged by rising access charges, together with technological progress and falling costs, to roll out their own networks and

[11] Using US data, Allan T. Ingraham and J. Gregory Sidak (2003) present econometric evidence that supports this hypothesis.
[12] See Valletti (2003) and Ingo Vogelsang (2003) for a general overview of access pricing and its possible effect on innovation and investment.

commence facilities-based competition.[13] This has been formalized by Marc Bourreau and Pinar Dogan (2005, 2006), who show that optimal from incumbent's viewpoint access charges rendered prohibitively high when there is no effective threat of facilities-based entry will decrease over time as technological progress renders entry less expensive. Following this strategy would enable an incumbent to forestall facilities-based entry while extracting the maximum rent from entrants.

Finally, access regulation can precipitate a "race" to provide infrastructure that plays out as increased investment by incumbents and entrants alike (Joshua Gans and Philip L. Williams, 1999; Valletti, 2003). This race is particularly relevant to investment in upgrades, as to broadband Internet provision via digital subscriber line (DSL). Incumbents reluctant, due to the well known "replacement effect," to upgrade prior to access regulation will, under access regulation, recognize that the opportunity cost of not upgrading is that an entrant will upgrade.

B. Impact of access regulation on investment: Empirical evidence

Robust empirical analyses of the role of access regulation in investment in rapidly developing telecommunications markets are few. Jerry A. Hausman and Gregory Sidak (2005) concluded from their descriptive, case-based analyses of telecoms markets in Canada, Germany, New Zealand, the United Kingdom, and the United States that mandatory unbundling failed to spur infrastructure investments by incumbents or entrants.

Crandall, Ingraham, and Sidak (2004) conclude, from their finding that low local loop rental rates reduce entrants' facilities-based lines, that unbundling decreases facilities-based competition, and Hsihui Chang, Heli Koski, and Sumit K. Majumdar (2003), from estimating the relationship between access price and incumbents' infrastructure investment, that low access prices spur investment. Our study estimates incumbents' and entrants' investments simultaneously as well as accommodates strategic interaction.

Studies of the impact of regulation on telecommunications investment that aggregate the fixed-line and mobile segments (e.g., Wei Li and Lixin C. Xu, 2004; Alesina et al., 2005) find a positive impact of entry liberalization and competition on total investment, but cannot draw

[13] David E. Sappington (2006) argues, however, that entrants' rent-or-make decision might be largely insensitive to access charges, that entrants might be willing to pay higher than cost rental charges to constrain retail competition.

a conclusion about individual segments having quite different competitive landscapes.[14] Studies of broadband penetration (see Scott Wallsten 2005, 2006)—which, in capturing both supply and demand side factors, is an important indicator of a telecommunications market's degree of development—report a negative impact of local loop unbundling on broadband. Because it examines investments of individual telecoms operators, our study enables us to derive policy conclusions and test in more detail a number of predictions.

Finally, most of these studies acknowledge the problem of endogeneity with respect to regulation, but few tackle it econometrically.[15] Our data enable us to employ a set of unique instruments, including political and geographic variables, to accommodate endogeneity in regulation.

III. Econometric Model

To analyze the effect of regulation on investment by incumbents and entrants, we need to consider as well the regulator. Our specification enables us to determine simultaneously with the level of regulation, entrants' and incumbents' respective levels of infrastructure. In other words, regulation has an effect on incumbents' and entrants' investment decisions, which, in turn, affect regulation. Firms decide how much capacity to add to the existing infrastructure in order to offer an additional service to customers.[16]

We specify the regulation equation as follows:

$$\Delta Reg_{it} = \alpha^R_i + \lambda^R_t + \beta^R Reg_{it-1} + \gamma^R IncInf_{it} + \delta^R \Sigma EntInf_{it} + \boldsymbol{X}^R_{it}\boldsymbol{\theta}^R + \eta_{it}, \qquad (1)$$

where Reg_{it} denotes the intensity of regulation in a given national market i in year t, $IncInf_{it}$ the infrastructure stock of the incumbent, $\Sigma EntInf_{it}$ the sum of the stock of entrants' infrastructure, and Δ the change from year $t-1$ to year t. $\boldsymbol{X}^R_{it}$ is a set of control variables. The superscript R denotes variables and coefficients specific to the regulation equation.

Equation (1), our policy equation, endogenizes access regulation, the intensity of regulation (Reg_{it}) depending on the stock of infrastructure of both incumbents ($IncInf_{it}$) and entrants ($\Sigma EntInf_{it}$). We can thus investigate empirically whether a regulator is responding differently

[14] The most important difference is the economic viability of pure facilities-based competition which is viable in mobile telecommunications with two and more parallel network infrastructures in many geographic markets, but questionable in fixed-line telecommunications.
[15] Li and Xu's (2004) study, which applies instrumental variable (IV) techniques, is an exception.
[16] An upgrade of the existing PSTN lines to offer broadband Internet service based on DSL technology, for example.

to investments by incumbents and entrants. If a regulator is more responsive to incumbents' infrastructure, $\gamma^R > \delta^R$.

The second building block of our empirical model is incumbents' investment, which is specified as follows:

$$\Delta IncInf_{it} = \alpha^I_i + \lambda^I_t + \beta^I IncInf_{it-1} + \gamma^I \Sigma EntInf_{it} + \delta^I Reg_{it} + \boldsymbol{X}^I_{it}\boldsymbol{\theta}^I + \varepsilon_{it}, \qquad (2)$$

where $\boldsymbol{X}^I_{it}$ is a set of control variables. The superscript I denotes variables and coefficients specific to Equation (2), which stipulates that incumbents' investment ($\Delta IncInf_{it}$) depends on the intensity of regulation (Reg_{it}) and sum of the stock of entrants' infrastructure ($\Sigma EntInf_{it}$). Parameter δ^I denotes the impact of regulation on incumbents' investments, parameter γ^I the *strategic effect* of entrants' investment on incumbents' investment. Note that a $\gamma^I > 0$ is evidence that incumbents' and entrants' investments are strategic complements, $\gamma^I < 0$ that their investment decisions are substitutes.

We model the sum of entrants' investment as follows:

$$\Delta \Sigma EntInf_{it} = \alpha^E_i + \lambda^E_t + \beta^E \Sigma EntInf_{it-1} + \gamma^E IncInf_{it} + \delta^E Reg_{it} + \boldsymbol{X}^E_{it}\boldsymbol{\theta}^E + \zeta_{it}, \qquad (3)$$

where, analogously, $\boldsymbol{X}^E_{it}$ is a set of control variables and the superscript E denotes variables and coefficients specific to Equation (3), which permits entrants' investment decisions ($\Delta \Sigma EntInf_{it}$) to depend on the intensity of regulation (R_{it}) and stock of incumbents' infrastructure ($IncInf_{it}$). Parameter δ^E measures the impact of regulation on entrants' investment decisions. When $\delta^E < \delta^I$, the impact of regulation on investment decisions is greater for incumbents than for entrants. Analogous to equation (2), when $\gamma^E > 0$ ($\gamma^E < 0$), incumbents' and entrants' investments are strategic complements (substitutes).

Note that by summing over all entrants in (1)-(3), we assume that regulators and incumbents react to aggregate investment by entrants. In other words, we treat *de novo* entry and investment by existing entrants analogously. In particular, we assume no strategic interaction between entrants, as entrants' investments do not depend on each other in equation (3). This set of assumptions is consistent with the regional-based entry pattern often observed in fixed-line telecommunications. When each entrant chooses a different region of operations to avoid competing with other entrants, all entrants can be treated as one player that reacts strategically to regulation and incumbents' investments and not to other entrants' investments. Below, we

estimate a variant of (3) at the individual entrant level. Examining individual investments sheds more light on facilities-based vs. service-based entry; as facilities-based entry is likely to involve substantially greater investment, less investment per entrant would be expected in the case of service-based entry. Moreover, estimating (3) at the individual entrant level enables us to test the assumption of no strategic interaction between entrants.

Note also that equations (1)-(3) include country dummies, year dummies, and lagged dependent variables.[17] Accordingly, α_i's capture country-specific effects such as the cost of rolling out infrastructure, λ_t's control for common time trends such as possible stock-market bubbles, and β's the dynamic adjustment process of infrastructure investment and regulation. For instance, the long-term effect of an increase in regulation on incumbents' infrastructure stock can be calculated from (2) as $-\delta^I/\beta^I$. Because we use the logarithm of infrastructure stock, the results of the estimates are interpreted as percentage changes. Finally, we assume the errors η_{it}, ε_{it} and ζ_{it} to be i.i.d.[18]

Note that we include both lagged dependent variable and country-specific effects. Consistent estimation of our equations requires panel data with a sufficiently long time dimension. Because Monte Carlo simulations of a dynamic panel data model such as ours indicate that our sample size might not be sufficiently large (Ruth A. Judson and Ann L. Owen, 1999), we investigate the potential bias by applying a corrected estimator (Jan F. Kiviet, 1995; Giovanni S. F. Bruno, 2005).

We now describe our data and provide descriptive statistics.

IV. Data, Descriptive Results, and Instruments

The data used in our estimations cover more than 70 fixed-line telecoms operators in 20 EU member states during the period 1997-2006.[19] The Amadeus database is the main source of firm-level accounting data used to calculate the stock of infrastructure, Plaut Economics (Patrick Zehnhäusern, Harry Telser, Stephan Vaterlaus, and Philippe Mahler, 2007) the source of the regulation index. Additional data sources include the Osiris database, World Bank's WDI, and the political manifesto database (Hans-Dieter Klingemann, Andrea Volkens, Judith

[17] That all dependent variables are in differences enables us to interpret the infrastructure equations as investment equations. This specification is equivalent to the one with levels (or stocks) as the dependent variable.
[18] We report standard errors, which are robust to heteroskedasticity.
[19] The following countries (EU 15) are in our dataset: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Portugal, Sweden, and the United Kingdom. The dataset also includes the following EU 12 countries (new member states after the 2004 and 2007 accession): Bulgaria, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, and Slovenia.

L. Bara, Ian Budge, and Michael D. McDonald, 2006). Table 1 summarizes the variable definitions and identifies the sources. Descriptive statistics are reported in Table 2.

Using in our estimation as the infrastructure stock variables firms' tangible fixed assets deflated by the Producer Price Index (PPI) for telecoms equipment enables us to calculate infrastructure investments as the year-to-year change in stocks.[20] The stock of telecoms infrastructure in the five major European countries is shown in Figure 1.

The regulation variables in our analysis are from Plaut Economics (Zehnhäusern et al., 2007). The Plaut regulatory index provides detailed, comprehensive information on different regulatory measures in the telecoms sector for all 27 EU countries during the period 1997-2006. We use seven sub-indices related to access to incumbents' infrastructure, specifically, the existence of regulated vertical separation and an accounting separation obligation, of regulation regarding full unbundling, line sharing, bitstream access, and subloop unbundling of fixed-line incumbents' local loops, and of regulation asymmetry between DSL and cable network providers.[21] Our measure of access regulation intensity is thus an average of these binary sub-indices that reflects the extent of mandated sharing of incumbents' infrastructure.

Figure 2 reports the evolution of regulation in the European telecoms sector, as represented in our analysis, over the past 10 years. Whereas the "old" EU members (EU 15) experienced growing regulatory intensity in the fixed-line segment, which leveled off in 2002, in the new member states (EU 12) no substantial measures to promote entry into fixed-line telephony were introduced until the eve of the 2004 EU accession.

Tables 1 and 2 also present the control variables used in equations (1)-(3). GDP per capita is included in our estimations to control for changes in demand for telecommunication services. The no-entry indicator (*NoEnt*) equals one when there is no entrant infrastructure in a given market, and zero otherwise. *NoEnt* picks up any special effects when infrastructure stock equals zero.[22]

The other control variables characterize aspects of national access regulation. *RegNeighbor* is a geographical instrument that captures the average level of entry regulation in neighboring markets. In defining neighboring markets, we distinguish between "old" EU (EU 15) and

[20] One issue is mergers and acquisitions (M&A), which represent a change in asset ownership rather than new infrastructure investment. To check robustness, we include in our estimation data on firms' M&A activity from the SDC Platinum M&A database. The M&A variable not being significant in these estimations, we do not report the results, but they are available upon request.

[21] The indicators that enter our regulatory index for the fixed-line segment correspond to the keys 11 through 16 and 22 of the Plaut index.

[22] It also helps us to estimate equations (1)-(3) in logs, as we do not have to drop observations. When entrants' infrastructure stock equals zero, we set entrants' infrastructure at the smallest positive value in the sample.

"new" EU members (EU 12), as regulation of telecoms sectors depends crucially on EU accession as illustrated in Figure 2. For instance, neighboring markets for Germany are other EU 15, for Poland other EU 12, member states. Variables based on party manifestos to measure political positions of governments include overall policy positions of governments in terms of right versus left (*Rile*), favoring market regulation and government presence in markets (*Gov*), and attitude towards European integration (*Europe*).[23] We expect right-wing governments and governments that favor regulation and European integration to be more inclined to implement mandated sharing of telecom infrastructure as prescribed in the EU regulatory framework. We also expect regulation to be spurred by developments in neighboring markets that exert pressure on national regulators. In other words, we expect to see a regulatory catching-up effect among the member states.

V. Empirical Results

We estimate equations (1)-(3) using first OLS and then instrumental variables (IV). In each equation, all explanatory variables of the model are used as instruments. The OLS results are reported in Table 3, the IV results in Table 4. Country dummies (α_i's) and year dummies (λ_t's) are not reported for brevity.

We perform a number of specification tests including testing exogeneity and the strength of our instruments in the IV regressions. As reported in Table 4, Hansen J statistics are insignificant, which suggests that the over-identifying orthogonality restrictions are valid.[24] The regressions-based tests (Jeffrey M. Wooldridge, 2002, p. 176) accept no serial correlation in the error term, which is important for the consistency of our estimates, as we have lagged dependent variables in the model and use as instruments, among others, lagged values of endogenous variables. Finally, F-tests for our instruments in the first-stage regressions (not reported) are significant at the one percent level for all endogenized variables except incumbent infrastructure, for which the test is significant at the 14 percent level. These test results support our instruments, albeit somewhat more weakly for the incumbent infrastructure variable.[25]

[23] The position of government is defined as the weighted average score of parties in the government, the weights being determined by the proportion of parliamentary seats held by each party. In election years, the government position is taken as the average position of two consecutive governments weighted by number of months in office.
[24] The regulation equation (1) is exactly identified, so the Hansen J statistic cannot be computed.
[25] Results of the first-stage regressions are available from the authors upon request.

We also test for endogeneity of regulation and investment decisions, a crucial part of the analysis often absent from previous studies. Comparing the OLS to the IV estimates reveals significant differences in the coefficient estimates (see Tables 3 and 4). A Hausman specification test rejects that the difference in coefficients is not systematic at the one percent confidence level for each of our three equations (1)-(3), confirming that endogeneity matters empirically. As can be seen in Table 3, if we do not account for endogeneity of regulation we find no significant impact of regulation on investment, whereas if we allow regulation to be endogenously determined by level of infrastructure investment we find a significant effect (see Table 4). In sum, investment in regulated network industries is subject to significant endogeneity bias that must be accounted for to understand the relationship between access regulation and investment.[26]

A number of interesting insights emerge from a review of the estimates in Table 4. One is the importance of dynamic adjustment effects, as the lagged infrastructure and regulation variables are statistically significant and economically relevant, suggesting that there are both short-term and long-term effects: a short-term adjustment of infrastructure levels will be followed by future adjustments until the desired level of infrastructure is reached. Interestingly, there is also evidence of a dynamic regulatory process, that is, of regulatory changes as a gradual process rather than a one shot affair.

We now discuss each equation in turn, starting with equation (1). The estimates in Table 4 imply that regulators do respond to investment by firms, as regulation is increasing in the stock of incumbents' infrastructure (γ^R is positive). This finding suggests that regulators are subject to a commitment problem: when the level of incumbents' infrastructure stock is high, national regulators tend to grant easier access, which is a disincentive for incumbents to invest in the first place. Regulatory intensity is not affected, however, by entrants' infrastructure stock (δ^R is insignificant). We thus find evidence in our data that regulators respond quite differently to incumbents' and entrants' infrastructure investments.[27]

The results of equations (2) and (3) presented in Table 4 indicate that the effect of regulation on the investment decisions of incumbents and entrants is quite different. Controlling for

[26] We also tested, using OLS, the bias of estimating the dynamic paned data model with fixed effects (also referred to as the Least Square Dummy Variable, or LSDV). Applying a corrected LSDV estimation (Kiviet, 1995; Bruno, 2005), we found little difference from our estimates; coefficients on the lagged dependent variable were slightly lower in magnitude, the other coefficients virtually unchanged (these results are available upon request). We therefore conclude that the endogeneity bias is much more important, and ignore the other bias. In doing so, we might underestimate the long-term effects of explanatory variables in our model.

[27] Moreover, we test whether regulation depends positively on the *gap* between incumbents' and entrants' infrastructure levels. This hypothesis can be formulated as $(\gamma^R - \delta^R)/2>0$. Using the estimates on standard errors in Table 4, we do not reject the "gap hypothesis" at the 10 percent level.

endogeneity, an increase in regulatory intensity decreases incumbents' investment but increases total investment across entrants. Specifically, our estimate suggests that increasing regulatory intensity by 0.5, which corresponds roughly to the average change in the regulatory regime in EU 15 between 1997 and 2002, reduces incumbents' infrastructure stock by approximately 49 percent, and long-term by as much as 72 percent.[28,29] The same change in regulation increases entrants' total infrastructure stock by approximately 60 percent, and long-term by as much as 73 percent. These results suggest that the impact of regulatory intensity on investment is significantly different for incumbents and entrants, which confirms the validity of our empirical approach of treating incumbents and entrants differently.

Taking this a step further, we note that in Table 4 the impact of entrants' on incumbents' infrastructure investments is positive (γ^I is estimated at 0.179 and significant at the 10 percent level), indicating that the respective investments are *strategic complements*. In other words, when entrants invest more, so do incumbents. This strategic effect reduces the negative impact of regulation on investment incentives. The estimates in Table 4 further suggest that although tighter regulation has a direct negative effect on incumbents' investment incentives, it also increases entrants' infrastructure investment, which, in turn, has a positive impact on incumbents' investment through strategic complementarity.[30] Taking this into account, we find that increasing the regulation index by 0.5 reduces incumbents' infrastructure stock by approximately 47 percent over the long term. In other words, the negative impact of regulation on incumbent's investment incentives is only partially compensated by strategic complementarity. On the other hand, the strategic effect boosts investment by entrants. Although not statistically significant, the strategic effect increases entrants' infrastructure investment to 96 percent over the long term. In terms of monetary impact, the additional 96 percent of entrants' infrastructure stock and 47 percent loss of incumbents' infrastructure stock correspond to €444 million and €1.1 billion, per EU member state, respectively.[31] This adds up to some €16.4 billion lost infrastructure investment for the European Union as a whole, which corresponds to almost 23 percent of the infrastructure stock.

The impact of the control variables is generally as expected. In Table 4, regulation in neighboring markets, *RegNeighbor*, has a significant impact on national regulation, which reflects regulatory catching-up in the European Union. A positive attitude of government

[28] The dependent variable being in logarithms, the effect is in percentages.
[29] Recall that the long-term effect of an increase in regulation on incumbents' infrastructure stock can be calculated from (2) as $-\delta^I/\beta^I$, which is -.4875/.676 ≈ 0.72.
[30] Note that strategic complementarity does not work the other way around, that is, from incumbents to entrants (γ^E is negative and not significant).
[31] This is calculated at the sample mean, assuming that regulation is exogenous.

towards European integration, *Europe*, increases regulatory intensity in a given national market, whereas government attitude towards regulation, *Gov*, has, somewhat surprisingly, a significant negative impact. One explanation for the latter finding is that *Gov* measures attitude towards "old-style" regulation of monopoly markets. Governments' attitude towards access regulation in telecommunications markets might be quite different, even opposite, as it emphasizes generating competition within the market. Government's ideological position, *Rile*, and GDP are significant in the OLS (Table 3), but not in the IV, estimation. Finally, the negative coefficient on *NoEnt* in the entrants' equation (3) controls for zero infrastructure levels.

Note that thus far, we have investigated only the impact of access regulation on *total* investment summed over entrants, not to what extent regulation affects entrants' *individual* investments. An increase in total infrastructure investment could obviously be due either to greater numbers of entrants or larger investments by individual entrants, or both. Examining individual investments sheds light on facilities-based vs. service-based entry. As facilities-based entry is likely to involve substantially more investment, lesser investment per entrant would be expected in the case of service-based entry. To test for this in our data, we estimate equation (3) at the firm level as follows:[32]

$$\Delta EntInf_{jit} = \alpha^E_i + \lambda^E_t + \beta^E EntInf_{jit-1} + \gamma^E IncInf_{it} + \delta^E Reg_{it} + \boldsymbol{X}^E_{it}\boldsymbol{\theta}^E + \xi_{jit}, \qquad (3')$$

where $\Delta EntInf_{jit}$ denotes infrastructure investment by individual entrants j in market i at time t. The results of re-estimating equation (3') using OLS and IV are reported in Table 5. As can be seen, Hansen J does not reject exogeneity of the instruments, and the Hausman specification test (not reported) suggests that the difference in coefficients is systematic.

Comparing the coefficients' estimates of (3) and (3'), we see that most results remain unchanged.[33] The estimated coefficient on the lagged dependent variable is negative and highly significant as well as much smaller than in Table 4, suggesting that the dynamics are more persistent at the individual entrant than at the market level. As before, incumbent infrastructure has a negative impact on entrants, although it is now significant in the IV

[32] Unfortunately, no data broken down by facilities-based vs. service-based infrastructure investment are available.

[33] We also tested the strategic interactions between entrants by including total entrants' stock of infrastructure in the disaggregated equation (3'). That this variable turned out never to be significant corroborates our assumptions. The results are available upon request.

estimation (γ^E is estimated at -1.492 and significant at the 10 percent level). More important, however, the impact of regulation on individual entrant's investment is negative (although statistically significant only at the 10 percent level), suggesting that entrants' total investment increases even as investment by *individual* entrants declines with regulation that eases access. In other words, easier access pushes entrants towards service-based competition.[34] This finding is consistent with the view that the EU regulatory framework is not providing effective incentives to move towards facilities-based competition.

VI. Conclusion

This paper investigates the trade-off regulators face between promoting market entry and "static" efficiency by means of regulated access and not undermining incentives to invest in infrastructure. It provides empirical evidence of this inherent trade-off between access regulation and investment incentives in network industries by differentiating between incumbents and entrants and permitting regulation to be endogenous.

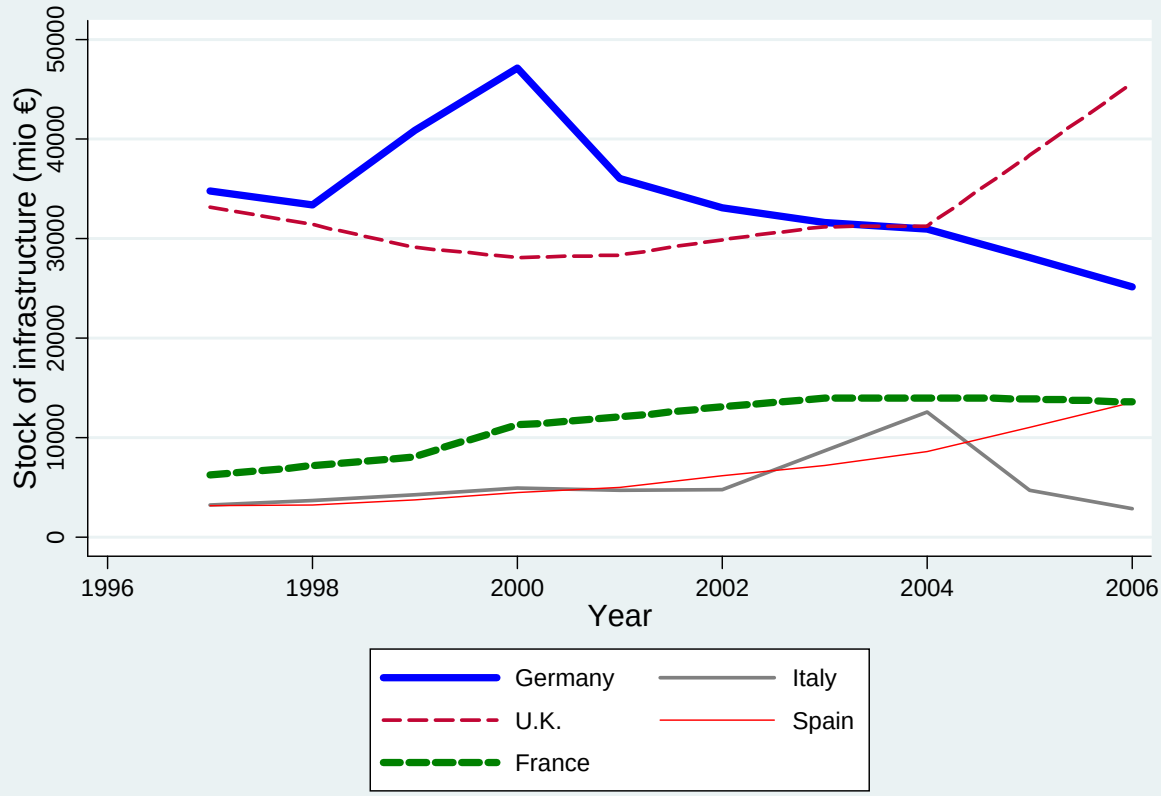
We find considerable support for our approach. In particular, regulation has a quite different impact on the investment decisions of incumbents and entrants, discouraging investment by incumbents and *individual* entrants even as entrants' *total* investment increases. We find that an endogenous treatment of regulation drives these results.

These findings cast doubt on the EU regulatory environment with respect to moving towards facilities-based competition in telecommunications. Our results suggest that regulation discourages entrants' *individual* investment even as entry and total investment by entrants increases. Because facilities-based entry is likely to require substantial firm-level investment, our results are consistent with the view that the regulatory framework in Europe fails to deliver effective incentives to move towards facilities-based competition.

Finally, we find regulatory responses to infrastructure investments to differ between incumbents and entrants. Whereas access regulation is not affected by entrants' investment, we find that regulators respond to higher infrastructure investment by incumbents by providing easier access, thereby undermining incumbents' incentives to invest in infrastructure in the first place. This finding suggests that the regulatory environment in Europe is subject to a regulatory commitment problem.

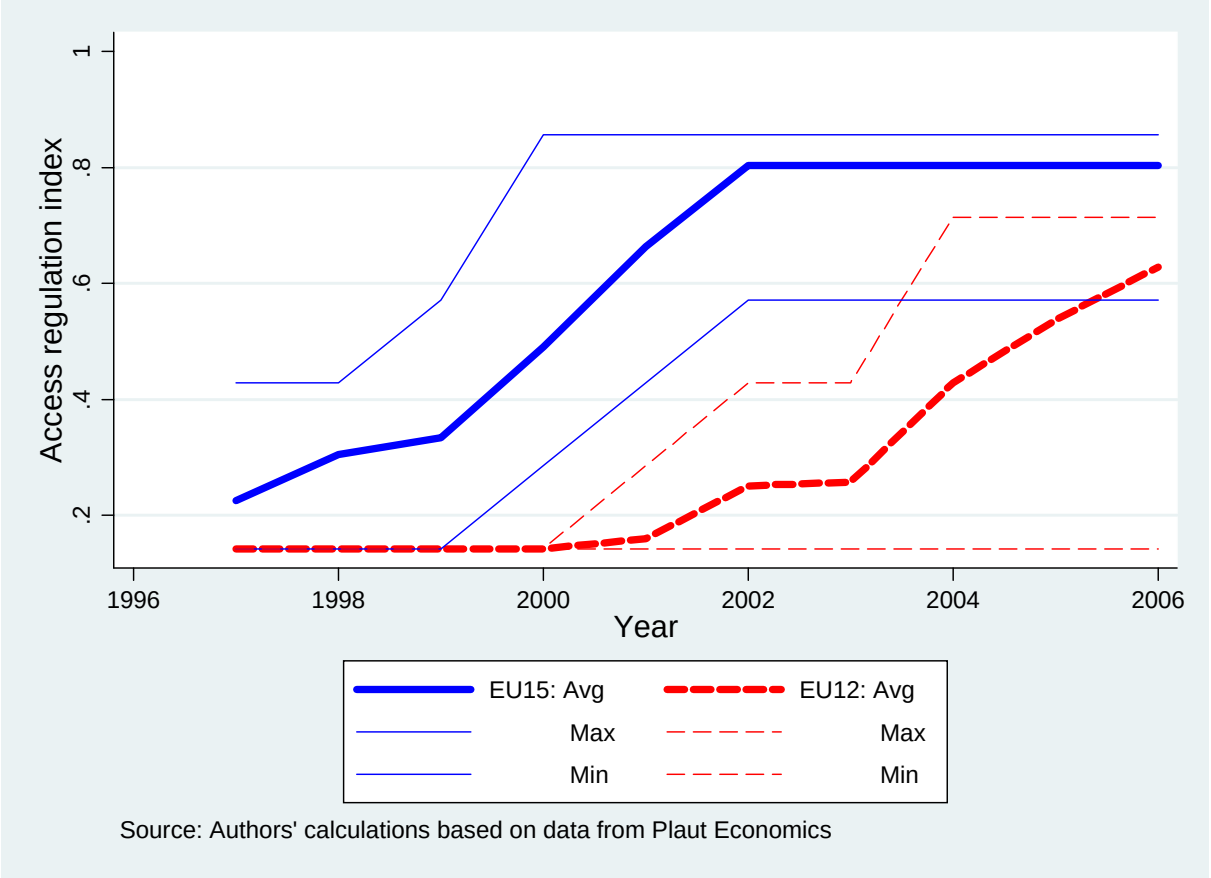
[34] This result is consistent with Friederiszick, Grajek, and Röller (2008), who estimate a similar model without the strategic effects.

Figure 1. Stock of fixed-line telecoms infrastructure in the major EU economies



Source: Authors' calculations based on data from Amadeus and Osiris

Figure 2. Index of access regulation in EU fixed-line telecoms markets



Source: Authors' calculations based on data from Plaut Economics

Table 1. Description of variables

Variable	*Description*	*Source*
Main variables:		
IncInf	Incumbent's infrastructure stock (measured as tangible fixed assets; million €, 2000 prices)	Amadeus, Osiris
EntInf	Entrant's infrastructure stock (measured as tangible fixed assets; million €, 2000 prices)	Amadeus, Osiris
ΣEntInf	Total (aggregated at the national level) entrants' infrastructure stock (measured as tangible fixed assets; million €, 2000 prices)	Amadeus, Osiris
Reg	Index of access regulation intensity (higher values indicate higher intensity of regulation)	Plaut Economics
Controls:		
NoEnt	Dummy variable set equal to 1 if there are no entrants in the market, and zero otherwise	Amadeus, Osiris
GDP	Per capita GDP (€, 2000 prices)	World Bank's WDI
RegNeighbor	Average index of access regulation intensity in neighboring markets	Plaut Economics
Gov	Government's attitude towards regulation (higher values indicate more favorable position)	Manifesto Project
Rile	Government's ideological position on the right-left scale (higher values indicate more right-wing position)	Manifesto Project
Europe	Government's attitude towards European integration (higher values indicate more favorable position)	Manifesto Project

Table 2. Descriptive statistics

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Main variables:				
IncInf	2350.1	3597.1	.051	19787.3
EntInf	140.0	250.8	.010	1563.9
ΣEntInf	462.6	1020.0	0	7008.4
Reg	.45	.29	.14	.86
Controls:				
NoEnt	.24	.43	0	1
GDP	12425.4	8379.9	1415.2	29067.0
RegNeighbor	.44	.26	.14	.78
Gov	1.50	1.14	0	4.47
Rile	3.94	9.19	-12.65	28.47
Europe	1.98	1.56	-.78	6.25

Table 3. OLS estimation results

Equation:	**Regulation**	**Incumbent**	**Entrants**
Dep var:	ΔReg_t	$\Delta log(IncInf_t)$	$\Delta log(\Sigma EntInf_t)$
Dynamic effects:			
Reg_{t-1}	-0.689***		
	(0.090)		
$log(IncInf_{t-1})$		-0.716***	
		(0.132)	
$log(\Sigma EntInf_{t-1})$			-0.794***
			(0.081)
Simultaneity:			
Reg_t		-0.094	0.479
		(0.192)	(0.342)
$log(IncInf_t)$	0.033***		-0.186**
	(0.013)		(0.082)
$log(\Sigma EntInf_t)$	-0.004	0.034	
	(0.009)	(0.036)	
Controls:			
$NoEnt_t$	0.031	-0.068	-7.088***
	(0.075)	(0.325)	(0.914)
$log(GDP_t)$	-0.208**	0.068	-0.581
	(0.099)	(0.404)	(0.541)
$RegNeighbor_t$	0.669***		
	(0.111)		
Gov_t	-0.073***		
	(0.023)		
$Rile_t$	0.004***		
	(0.001)		
$Europe_t$	0.019		
	(0.012)		
N	120	129	139
Serial correlation	0.04	0.33	-0.03

* p<0.1, ** p<0.05, *** p<0.01
Robust standard errors in parentheses
Coefficients on country and year dummies not reported

Table 4. IV estimation results

Equation:	**Regulation**	**Incumbent**	**Entrants**
Dep var:	ΔReg_t	$\Delta \log(IncInf_t)$	$\Delta \log(\Sigma EntInf_t)$
Dynamic effects:			
Reg_{t-1}	-0.685***		
	(0.094)		
$\log(IncInf_{t-1})$		-0.676***	
		(0.149)	
$\log(\Sigma EntInf_{t-1})$			-0.817***
			(0.080)
Simultaneity:			
Reg_t		-0.975**	1.195*
		(0.458)	(0.634)
$\log(IncInf_t)$	0.157**		-0.407
	(0.076)		(0.433)
$\log(\Sigma EntInf_t)$	-0.002	0.179*	
	(0.021)	(0.098)	
Controls:			
$NoEnt_t$	0.084	1.172	-7.351***
	(0.165)	(0.798)	(1.024)
$\log(GDP_t)$	-0.182	-0.360	-0.300
	(0.148)	(0.650)	(0.743)
$RegNeighbor_t$	0.661***		
	(0.125)		
Gov_t	-0.080***		
	(0.024)		
$Rile_t$	0.002		
	(0.002)		
$Europe_t$	0.032**		
	(0.015)		
N	110	110	110
Hansen J	-	3.42 (3)	4.26 (3)
Serial correlation	-0.03	0.12	-0.18

* p<0.1, ** p<0.05, *** p<0.01
Robust standard errors in parentheses
Coefficients on country and year dummies not reported

Table 5. Estimation results for individual entrants

Estimation method:	**OLS**	**IV**
Dep var:	$\Delta\log(EntInf_t)$	$\Delta\log(EntInf_t)$
Dynamic effects:		
Reg_{t-1}		
$\log(IncInf_{t-1})$		
$\log(\Sigma EntInf_{t-1})$	-0.075**	-0.078**
	(0.030)	(0.032)
Simultaneity:		
Reg_t	-0.935*	-1.942*
	(0.556)	(1.103)
$\log(IncInf_t)$	-0.115	-1.492*
	(0.230)	(0.883)
$\log(\Sigma EntInf_t)$		
Controls:		
$NoEnt_t$		
$\log(GDP_t)$	0.672	0.699
	(0.799)	(1.252)
$RegNeighbor_t$		
Gov_t		
$Rile_t$		
$Europe_t$		
N	237	192
Hansen J	-	4.97 (4)
Serial correlation	0.01	0.05

* p<0.1, ** p<0.05, *** p<0.01
Robust standard errors in parentheses
Coefficients on country and year dummies not reported

References

Alesina, Alberto, Silvia Ardagana, Giorgio Nicoletti, and Fabio Schiantarelli. 2005. "Regulation and Investment." *Journal of the European Economic Association*, 3(4): 791–825.

Armstrong, Mark. 2002. "The Theory of Access Pricing and Interconnection." In *Handbook of Telecommunications Economics. Vol. 1*, ed. Martin Cave, Sumit K. Majumdar, and Ingo Vogelsang. London and New York: Elsevier.

Baake, Pio, Ulrich Kamecke, and Christian Wey. 2005. "A Regulatory Framework for New and Emerging Markets." *Communications & Strategies*, 60: 123–136.

Bourreau, Marc, and Pinar Dogan. 2005. "Unbundling the Local Loop." *European Economic Review*, 49(1): 173–199.

Bourreau, Marc, and Pinar Dogan. 2006. "'Build-or-Buy' Strategies in the Local Loop." *American Economic Review*, 96(2): 72–76.

Bruno, Giovanni S. F. 2005. "Approximating the Bias of the LSDV Estimator for Dynamic Unbalanced Panel Data Models." *Economic Letters*, 87(3): 361–366.

Cave, Martin. 2004. "Making the Ladder of Investment Operational." http://www.ictregulationtoolkit.org/en/Publication.2916.html.

Cave, Martin. 2006. "Encouraging Infrastructure Investment via the Ladder of Investment." *Telecommunications Policy*, 30(3-4): 223–237.

Cave, Martin, and Ingo Vogelsang. 2003. "How Access Pricing and Entry Interact." *Telecommunications Policy*, 27(10-11): 717–727.

Chang, Hsihui, Heli Koski, and Sumit K. Majumdar. 2003. "Regulation and Investment Behaviour in the Telecommunications Sector: Policies and Patterns in US and Europe." *Telecommunications Policy*, 27(10-11): 677–699.

Crandall, Robert W. 2005. "Competition and Chaos." Washington D.C.: Brookings Institution Press.

Crandall, Robert W., Allan T. Ingraham, and Hal J. Singer. 2004. "Do Unbundling Policies Discourage CLEC Facilities-Based Investment." *Topics in Economic Analysis & Policy*, 4(1): 1–23.

Crandall, Robert W., and Leonard Waverman. 2006. "The Failure of Competitive Entry into Fixed-Line Telecommunications: Who Is at Fault?" *Journal of Competition Law and Economics*, 2(1): 113–148.

De Bijl, Paul, and Martin Peitz. 2005. "Local Loop Unbundling in Europe: Experience, Prospects and Policy Challenges." *Communications and Strategies*, 57: 33–57.

Duso, Tomaso, and Lars-Hendrik Röller. 2003. "Endogenous Deregulation: Evidence from OECD Countries." *Economic Letters*, 81(1): 67–71.

European Commission. 2007. "Summary of the Impact Assessment." Commission Staff Working Document SEC 1473.

Foros, Oystein. 2004. "Strategic Investments with Spillovers, Vertical Integration and Foreclosure in the Broadband Access Market." *International Journal of Industrial Organization*, 22(1): 1–24.

Friederiszick, Hans, Michał Grajek, and Lars-Hendrik Röller. 2008. "Analyzing the Relationship between Regulation and Investment in the Telecom Sector." ESMT White Paper WP-108-01.

Gans, Joshua, and Philip L. Williams. 1999. "Access Regulation and the Timing of Infrastructure Investment." *Economic Record*, 75(229): 127–138.

Haring, John, and Jeffrey H. Rohlfs. 2002. "The Disincentives for ILEC Broadband Investment Afforded by Unbundling Requirements." Strategic Policy Research Paper.

Hausman, Jerry A. 1997. "Valuing the Effect of Regulation on New Services in Telecommunications." *Brookings Papers on Economic Activity: Microeconomics*, 1-38.

Hausman, Jerry A., and J. Gregory Sidak. 2005. "Did Mandatory Unbundling Achieve its Purpose? Empirical Evidence from Five countries." *Journal of Competition Law and Economics*, 1(1): 173–245.

Hellwig, Martin. 2008. "Competition Policy and Sector-Specific Regulation for Network Industries." *MPI Collective Goods Preprint*, No. 2008/29.

Höffler, Felix. 2007. "Costs and Benefits from Infrastructural Competition: Estimating Welfare Effects from Broadband Access Competition." *Telecommunications Policy*, 31(6-7): 401–418.

Ingraham, Allan T., and J. Gregory Sidak. 2003. "Mandatory Unbundling, UNE-P, and Cost of Equity: Does TELRIC Pricing Increase Risk for Incumbent Local Exchange Carriers?" *Yale Journal of Regulation*, 20: 389-406.

Jorde, Thomas M., J. Gregory Sidak, and David J. Teece. 2000. "Innovation, Investments, and Unbundling." *Yale Journal of Regulation*, 17: 1–37.

Judson, Ruth A., and Ann L. Owen. 1999. "Estimating Dynamic Panel Data Models: A Guide for Macroeconomists." *Economics Letters*, 65(1): 9–15.

Kiviet, Jan F. 1995. "On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Data Models." *Journal of Econometrics*, 68(1): 53–78.

Klingemann, Hand-Dieter, Andrea Volkens, Judith L. Bara, Ian Budge, and Michael D. McDonald. 2006. *Mapping Policy Preferences II: Estimates for Parties, Electors and Governments in Central and Eastern Europe, European Union and OECD 1990-2003*. Oxford: Oxford University Press.

Kotakorpi, Kaisa. 2006. "Access Price Regulation, Investment and Entry in Telecommunications." *International Journal of Industrial Organization*, 24(5): 1013–1020.

Laffont, Jean-Jacques, and Jean Tirole. 2000. *Competition in Telecommunications*. Cambridge, MA: MIT Press.

Li, Wei, and Lixin C. Xu. 2004. "The Impact of Privatization and Competition in the Telecommunications Sector around the World." *Journal of Law and Economics*, 47(2): 395-430.

Newbery, David M. 2002. *Privatization, Restructuring, and Regulation of Network Utilities*. Cambridge, MA: MIT Press.

Nuechterlein, Jonathan E., and Philip J. Weiser. 2005. *Digital Crossroads: American Telecommunications Policy in the Internet Age*. Cambridge, MA: MIT Press.

Pindyck, Robert S. 2007. "Mandatory Unbundling and Irreversible Investment in Telecom Networks." *Review of Network Economics*, 6(3): 274–298.

Rey, Patrick, and Jean Tirole. 2007. "A Primer on Foreclosure." In *Handbook of Industrial Organization, Vol. 3*, ed. Mark Armstrong and Robert H. Porter, 2145–2220. Amsterdam: North-Holland.

Rosston, Gregory L., and Roger G. Noll. 2002. "The Economics of the Supreme Court's Decision on Forward Looking Costs." *Review of Network Economics*, 1(2): 81–89.

Sappington, David E. 2006. "Regulation in Vertically-Related Industries: Myths, Facts, and Policy." *Review of Industrial Organization*, 28(1): 3-16.

Sibley, David S., and Dennis L. Weismann. 1998. "Raising Rivals' Costs: The Entry of an Upstream Monopolist into Downstream Markets." *Information Economics and Policy*, 10(4): 451–470.

Sidak, J. Gregory, and Daniel F. Spulber. 1996. "Deregulatory Takings and Breach of the Regulatory Contract." *New York University Law Review*, 71(4): 851–923.

Valletti, Tommaso. 2003. "The Theory of Access Pricing and Its Linkage with Investment Incentives." *Telecommunications Policy*, 27(10-11): 659–675.

Vogelsang, Ingo. 2003. "Price Regulation of Access to Telecommunications Networks." *Journal of Economic Literature*, 41(3): 830–862.

Wallsten, Scott. 2005. “Broadband Penetration: An Empirical Analysis of State and Federal Policies.” AEI Brookings Joint Center for Regulatory Studies Working Paper 05-12.

Wallsten, Scott. 2006. “Broadband and Unbundling Regulations in OECD Countries.” AEI Brookings Joint Center for Regulatory Studies Working Paper 06-16.

Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

Woroch, Glenn A. 1998. “Facilities Competition and Local Network Investment: Theory, Evidence and Policy Implications.” *Industrial and Corporate Change*, 7(4): 601–614.

Zenhäusern, Patrick, Harry Telser, Stephan Vaterlaus, and Philippe Mahler. 2007. “Plaut Economics Regulierungsindex: Regulierungsindex in der Telekommunikation unter besonderer Berücksichtigung der Investitionsanreize.” Unpublished.

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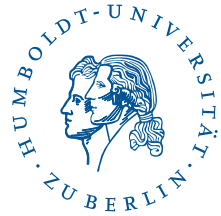

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