Regulation and Investment in Network Industries

Prof. Carlo Cambini - carlo.cambini@polito.it
Politecnico di Torino
Florence School of Regulation – EUI
IEFE – Bocconi University

Outline of the talk

- Fundamental to understand how to incentivize investment in sectors providing essential services to the public and creating value for the whole economic system
- General analysis:
  - Role of commitment
  - Regulatory tool
  - Interplay with privatization
  - Regulatory Institutions and politics → political economy issue
- Focus at sectoral level:
  - Telecom industry: the push for ultra-fast broadband investment in Europe but not only
  - The energy sector: from the “standard” regulatory tools to “output-based” incentives

Regulation and Investment: An Introduction

Background

- Regulation: a key driver of network utilities' investment.
- The tension between regulation goals: static efficiency and dynamic efficiency.
  - *Short term*: to promote competition and to enhance social welfare
  - *Long term*: to promote investment and dynamic efficiency
  - Laffont and Tirole (2000)
    - "*[T]here is in general a trade-off between promoting competition to increase social welfare once the infrastructure is in place and encouraging the incumbent to invest and maintain the infrastructure.*"
  - The relationship between regulation and investment has received much attention by economic theory in the last twenty years (see the survey by Guthrie, 2006), but the empirical evidence is scant and mostly focussed on US regulated utilities
- Multiple regulatory dimensions to consider

The role of commitment (1)

- **Time consistency problem**
  - Once investment is sunk, regulator has incentive to drive prices down to operating costs, forgoing recovery of investment costs (Besanko and Spulber, 1992 RAND)
  - US: legal framework gives commitment power
  - EU: repeated interactions, importance of regulatory consistency
- **Inability to commit**
  - Impossibility of complete contracts
  - Change in regulatory personnel
- **Sub-optimality of (exercising) commitment**
  - Value of flexibility in a changing environment: Learn from mistakes
- **Lack of commitment**
- *Exogenous*. Change in outside variables: Inflation, political elections
- *Endogenous*. Change in regulatory variables: Profit, investment

The role of commitment (2)

- (1) The longer the time horizon the less regulators can commit
- (2) Infrastructure investment has long lead time and long life
- (1) + (2) }→ Full regulatory commitment for time horizon of investment not possible

- (3) General result of the literature on Incentive Regulation: The less the regulator can commit to incentives (and the associated profits and losses) the weaker should incentives be

- (1) + (2) + (3) }→ Compatibility of incentive regulation and efficient investment is in doubt

Privatization and Regulation

- Extent of Privatization left to governments
  - ✓ A huge ownership transfer until mid-nineties
  - ✓ Reluctant privatization henceforth
- ✓ Extent of Delegated powers left to governments
  - ✓ Before reforms, executive-branch commissions
  - ✓ Reluctant regulation henceforth
- Implementation of privatization and regulatory reforms differs across countries → this in turn may affect firms' incentives to invest
- What is the impact of changing regulatory institutions and ownership patterns for regulated firms' decisions?

Firm Ownership and Regulation

- Within EU utilities, private ownership is the exception rather than the rule…
  - At the end of 2000s, governments were controlling more than 60% of privatized firms (either through full ownership or golden shares) (Bortolotti and Faccio, 2009 JFinEcon)
- The European Commission (as well as the OECD) recognized the potential influence of govt. ownership on regulatory decisions and outcomes

> "… concerns are reported that *the structures in place do not ensure that regulatory decisions are not influenced by State ownership considerations*"

Regulatory Institutions

- When regulators are "not independent", e.g. in executive-branch commissions, Governments can persuade them to modify their decisions in line with politicians' objectives
- Political interference may lead to time-inconsistent regulatory decisions
- The rationale behind the inception of Independent Regulatory Agencies (IRAs) is to insulate regulators from political interference and to enhance their credibility (Levy and Spiller, 1994 JLE)

Regulation and Ownership in EU15

(source: Cambini, Rondi and Spiegel, 2012; in Harrington et al. *Recent Advances in the Analysis of Competition Policy and Regulation*, Edward Elgar)

	Energy			Telecommunications	
		Electricity	Gas		
Country	**Date of establishing an IRA**	**Ownership (end 2010)**	**Ownership (end 2010)**	**Date of establishing an IRA**	**Ownership (end 2010)**
Austria	2000	State (51%)	Partially private (State 31%)	1997	Partially private (State 25%)
Belgium	1999	Partially private (State 49%)	Partially private (State 31%)	1991	State (> 50%)
Denmark	1999	--	--	2002	Private
Finland	1995	State (54%)	--	1987	State (>50%)
France	2000	State (85%)	Partially private (State 37,5%)	1996	Partially private (State 32%)
Germany	2006*	Private (State 2.5%)	Private (State 2.5%)	1996*	Partially private (State 28%)
Greece	2000	State (51%)	--	1992	Partially private (State 10%)
Ireland	1999	--	--	1997	Private
Italy	1995	Partially private (State 33%)	Partially private (State 20%)	1997	Private
Luxemburg	2000	State (100%)	State (100%)	1997	State (100%)
Netherlands	1998	--	--	1997	Private
Portugal	1995	Partially private (State 26%)	--	2001	Private (State 6%)
Spain	1998	Private	Private	1996	Private
Sweden	1998	Private	Private	1992	State (> 50%)
UK	1989	Private	Private	1984	Private

… And in new EU Member States

	Energy			Telecommunications	
		Electricity	Gas		
Country	**Date of establishing an IRA**	**Ownership (end 2010)**	**Ownership (end 2010)**	**Date of establishing an IRA**	**Ownership (end 2010)**
Bulgaria	1999	State (100%)	State (100%)	2006	Private
Czech Rep.	2001	State (67%)	Private	2005	Private
Cyprus	2003	State (100%)	State (100%)	2002	State (100%)
Estonia	2008*	Partially private	Partially private	2008*	Private
Hungary	1994	Private	Private	2003	Private
Latvia	2001**	State	Private	2001**	State (51%)
Lithuania	1997**	State (96.5%)	Partially private (State 30%)	2004	Private
Malta	2001	State	State	2001	Private
Poland	1997	State (100%)	Private	2006	Private
Romania	2000	Private	Private	2006	Partially private (State 46%)
Slovenia	2001	State	Partially private (State 31%)	2001	Partially private (State 49%)
Slovakia Rep.	2001**	State (51%)	State (51%)	2004	Partially private (State 49%)

Independent Regulation and Politicians

- Politicians ***delegate*** policy powers to bureaucrats, i.e. the regulators (Alesina and Tabellini, 2008 JPubEcon)
- IRAs are endowed with ***formal*** independence (i.e. the *right* to decide), but this does not necessarily imply ***real*** independence (i.e. the effective *control* over the decisions) (Aghion and Tirole, 1997 QJE)
- Hence, governments, even when an IRA exists, still have ***room for maneuver*** (Shleifer and Vishny, 1994 QJE)
- Politicians may pursue their partisan goals by interfering in public utilities' decisions, especially when the firm is ***state-owned*** (Zelner and Henisz, 2006)

Independent Regulation, Political Interference and Firm Investment: Evidence from EU

Cambini and Rondi (2016, *Economic Inquiry*, forthcoming)

Key Questions

- Does the presence of IRAs affect firm investment?
- Do politicians still affect investment, in spite of IRAs?
- Do private and state controlled firms respond differently to the presence of the IRA?

- The presence of an IRA is an imperfect measure of the independence of regulators
- Decision to set up an IRA is likely endogenous
- We exploit cross-country variation in social and political institutions to deal with endogeneity of IRA

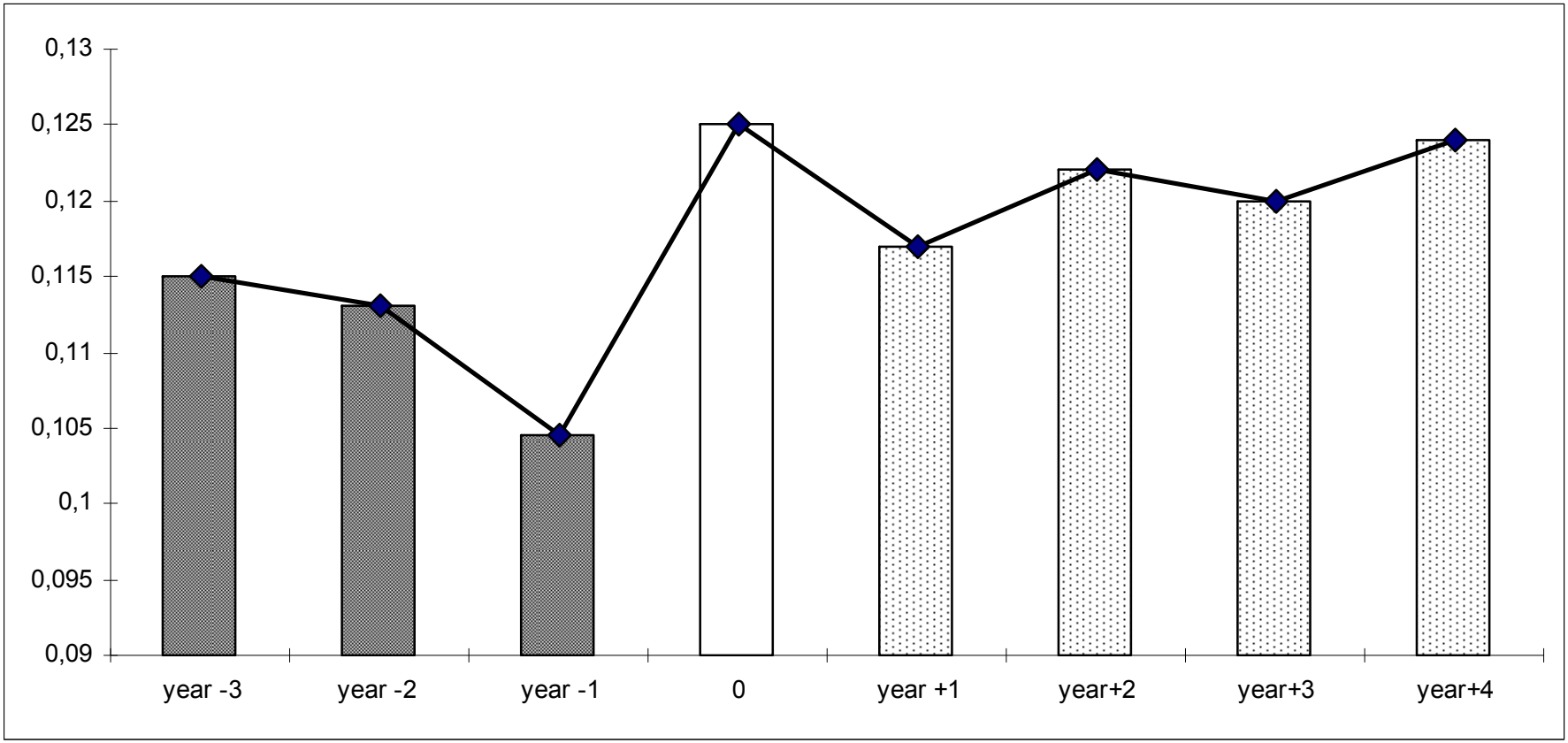
EU Context and Our Data

- In the '90s, EU Comm. spurs liberalization and privatization reforms in public utilities sector → ***Inception of IRAs***, with their own budget and independently chosen staff
  - Decisions about privatization and powers delegated to IRAs is left to Governments → **Heterogeneous reforms across Europe**
  - IRAs are in place in TLC and energy in all countries; in water supply in the UK; nowhere in transport infrastructures (up to late 2000s)
- We use a panel of 80 publicly traded utilities in 14 EU countries, 1994-2004:
  - 37 firms in electricity and gas distribution; 12 water; 15 telecoms; 6 freight roads; 10 transport infrastructure
  - 21 have been privatized during the sample period
- Sample covers 85-90% of traded utilities in EU and 12 of top 30 EU companies for Mkt. Cap.

Variables and Instruments

- **Firm level variables**
  - Investment rate, Cash flow, Sales, Debt to Capital stock (Worldscope), Government ownership stake (*Bortolotti and Faccio, 2009*)
- **Regulatory Independence** (*Gilardi, 2002*)
  - IRA dummy or Formal Regulatory Independence Index
- **Political Orientation Index** from 0 (left) to 10 (right) (*B&F, 2009*)
- **Country and industry *controls:*** **Social Capital** (Trust, WVS), ***Investor Protection, Market Openness*** *(OECD)*
- **External *Instruments*** to account for cross-country heterogeneity in political, social and law institutions
  - **Political economy variables: Rule of law, Checks and Balances, Gov't Stability** *(WB Political Institutions Dataset),* **Parliamentary fragmentation** (Disproportionality, Gallagher, 1991),

Average Investment Rate Before and After the Inception of the IRA (0)



Econometric Strategy

1. Static investment model: diff-in-diff specifications (firm-, year- country-, sector- and country*year dummies and various clustering of std. errors
2. Dynamic investment model: *GMM System Estimation*
3. Identification
    1. *Internal instruments (lags of endogenous variables and IRA)*
    2. *External instruments: Political and Social institutions*
        1. *Pseudo First-stage analysis of instruments*
4. **Robustness**:

    A) Subsamples of Firms changing the IRA status, Never with an IRA; With the IRA in place

    B) Use "placebo strategy" to test possible anticipatory effects;

    C) Use Formal Regulatory Independence Index, add Debt Finance

    D) Validity of instruments: 1) Include the suspect instruments in a) the full sample; b) sample of firms never with an IRA; 2) consider that IRA may affect investment through other channels, so control for;
5. **Social capital, Investor protection, OECD PMR index**

Investment Models

1) simple difference-in-difference specification

$$(I/K)_{it} = \beta_0 + \alpha_1 IRA_{it-1} + d_t + \eta_i + e_{it},$$

2) "accelerator"-like model

$$(I/K)_{it} = \beta_0 + \beta_1 (\Pi/K)_{it-1} + \beta_2 (Y/K)_{it-1} + \alpha_1 IRA_{it-1} + d_t + \eta_i + e_{it},$$

3) Euler equation of investment to capture the current expectations of future profitability (Bond and Meghir, 1994)

$$(I/K)_{it} = \beta_0 + \beta_1 (I/K)_{it-1} - \beta_2 (I/K)^2_{it-1} - \beta_3 (CF/K)_{it-1} + \beta_4 (Y/K)_{it-1} + \\ + \alpha_1 IRA_{it} + \alpha_2 GovernmentUCR_{it} + \alpha_3 PolOrient_{it} + \eta_i + d_t + \varepsilon_{it}$$

Independent Regulation and Investment

(Diff-in-diff and "accelerator" static models: fixed effects)

$$(I/K)_{it} = \beta_0 + \beta_1(\Pi/K)_{it-1} + \beta_2(Y/K)_{it-1} + \alpha_1 \mathrm{IRA}_{it-1} + d_t + \eta_i + e_{it},$$

Full Sample

I/K_t	(1)	(2)	(3)	(4)
IRA Dummy$_{t-1}$	0.029	0.025	0.033	0.030
	*(0.014)***	*(0.014)**	*(0.014)***	*(0.015)**
	*(0.011)***	*(0.010)***	*(0.009)****	*(0.010)***
$(\Pi/K)_{t-1}$	-	0.129	-	0.126
	-	*(0.056)***	-	*(0.055)***
	-	*(0.081)*	-	*(0.077)*
$(Y/K)_{t-1}$	-	0.029	-	0.032
	-	*(0.017)**	-	*(0.017)**
	-	*(0.012)***	-	*(0.012)***
Government UCR$_{t-1}$	-	-	0.003	0.005
	-	-	*(0.022)*	*(0.022)*
	-	-	*(0.022)*	*(0.015)*
Political Orientation $_{t-1}$	-	-	- 0.003	-0.003
	-	-	*(0.003)*	*(0.002)*
	-	-	*(0.003)*	*(0.002)*
N. Firms [N. Obs.]	80 [625]	80 [590]	80 [625]	80 [590]

Independent Regulation and Investment

Euler Equation Model-Dynamic model: FE and GMM-SYS

$$(I/K)_{it} = \beta_0 + \beta_1 (I/K)_{it-1} - \beta_2 (I/K)^2_{it-1} - \beta_3 (CF/K)_{it-1} + \beta_4 (Y/K)_{it-1} + \\ + \alpha_1 IRA_{it} + \alpha_2 GovernmentUCR_{it} + \alpha_3 PolOrient_{it} + \eta_i + d_t + \varepsilon_{it}$$

$(I/K)_t$	(1) WG	(2) GMM-SYS	(3) GMM-SYS
$(I/K)_{t-1}$	0.601	0.965***	0.939***
	*(0.095)****	*(0.136)*	*(0.133)*
	*[0.056]****		
$(I/K)^2_{t-1}$	-0.767	-1.195***	-1.160***
	*(0.181)****	*(0.196)*	*(0.190)*
	*[0.165]****		
$(\Pi/K)_{t-1}$	0.113	-0.003	-0.007
	*(0.051)***	*(0.030)*	*(0.031)*
	*[0.053]***		
$(Y/K)_{t-1}$	0.012	0.003	0.002
	(0.013)	*(0.004)*	*(0.004)*
	[0.010]		
IRA_{t-1}	0.021	0.012*	0.014**
	*(0.010)***	*(0.006)*	*(0.007)*
	*[0.008]***		
Government UCR $_{t-1}$		-	0.007
		-	*(0.008)*
Political Orientation $_{t-1}$		-	-0.002
		-	*(0.002)*

Pseudo-First stage analysis of political institutions as instruments of IRA

IRA_t	(1)	(3)
	All Firms	**All Firms**
Disproportionality $_{t-1}$	-0.051***	-0.038*
	(0.018)	*(0.019)*
Rule of Law $_{t-1}$	0.014*	0.015**
	(0.007)	*(0.007)*
Checks and Balance $_{t-1}$	-0.064**	-0.056*
	(0.032)	*(0.032)*
Stability $_{t-1}$	0.022	-
	(0.014)	-
Distrust $_{t-1}$	-	0.819
	-	*(0.540)*
Firm dummies	Yes	Yes
Year dummies	Yes	Yes
F-test joint significance	2.85	2.79
p-value	*0.029*	*0.022*
R squared within	0.205	0.222
N. Firms [N. Obs.]	80 [536]	80 [536]

IRAs, Investment and Institutions

Euler Equation Model-Dynamic model: GMM-SYS

$$(I/K)_{it} = \beta_0 + \beta_1 (I/K)_{it-1} - \beta_2 (I/K)^2_{it-1} - \beta_3 (CF/K)_{it-1} + \beta_4 (Y/K)_{it-1} +$$
$$+ \alpha_1 IRA_{it} + \alpha_2 GovernmentUCR_{it} + \alpha_3 PolOrient_{it} + \eta_i + d_t + \varepsilon_{it}$$

Political and social institutions may *directly* affect firm investment …

Or ***indirectly*** through the regulatory reforms and independence of the IRA

See below…

$(I/K)_t$	(1)	(2)	(3)	(4)	(5)	Firms never subject to an IRA
$(I/K)_{t-1}$	0.947***	0.823***	0.934***	0.942***	0.834***	0.912***
	(0.133)	*(0.122)*	*(0.131)*	*(0.135)*	*(0.126)*	*(0.109)*
$(I/K)^2_{t-1}$	-1.183***	-0.999***	-1.157***	-1.159***	-1.031***	-0.876***
	(0.197)	*(0.174)*	*(0.188)*	*(0.193)*	*(0.196)*	*(0.213)*
$(\Pi/K)_{t-1}$	-0.003	-0.004	-0.013	-0.003	-0.001	0.027
	(0.029)	*(0.038)*	*(0.032)*	*(0.031)*	*(0.039)*	*(0.055)*
$(Y/K)_{t-1}$	0.002	-0.0001	0.003	0.001	-0.001	-0.010**
	(0.004)	*(0.003)*	*(0.004)*	*(0.004)*	*(0.003)*	*(0.004)*
IRA_{t-1}	0.014**	0.020***	0.015**	0.014**	0.021***	-
	(0.006)	*(0.006)*	*(0.007)*	*(0.007)*	*(0.007)*	-
Government UCR $_{t-1}$	0.008	-0.001	0.006	0.006	-0.001	0.005
	(0.008)	*(0.010)*	*(0.008)*	*(0.008)*	*(0.013)*	*(0.011)*
Political Orientation $_{t-1}$	-0.001	-0.003	-0.002	-0.002	-0.003	-0.0001
	(0.002)	*(0.003)*	*(0.002)*	*(0.002)*	*(0.003)*	*(0.003)*
Disproportionality $_{t-1}$	0.0002	-	-	-	0.0003	0.0002
	(0.0003)	-	-	-	*(0.0004)*	*(0.0002)*
Rule of Law $_{t-1}$	-	-0.0004	-	-	-0.0005	0.0007
	-	*(0.0004)*	-	-	*(0.0005)*	*(0.0004)*
Checks & Balances $_{t-1}$	-	-	0.003	-	0.003	-0.003
	-	-	*(0.004)*	-	*(0.006)*	*(0.004)*
Stability $_{t-1}$	-	-	-	0.017	0.010	0.018
	-	-	-	*(0.014)*	*(0.012)*	*(0.019)*

IRA, Investment and Political Interference

Institutional variables as instruments

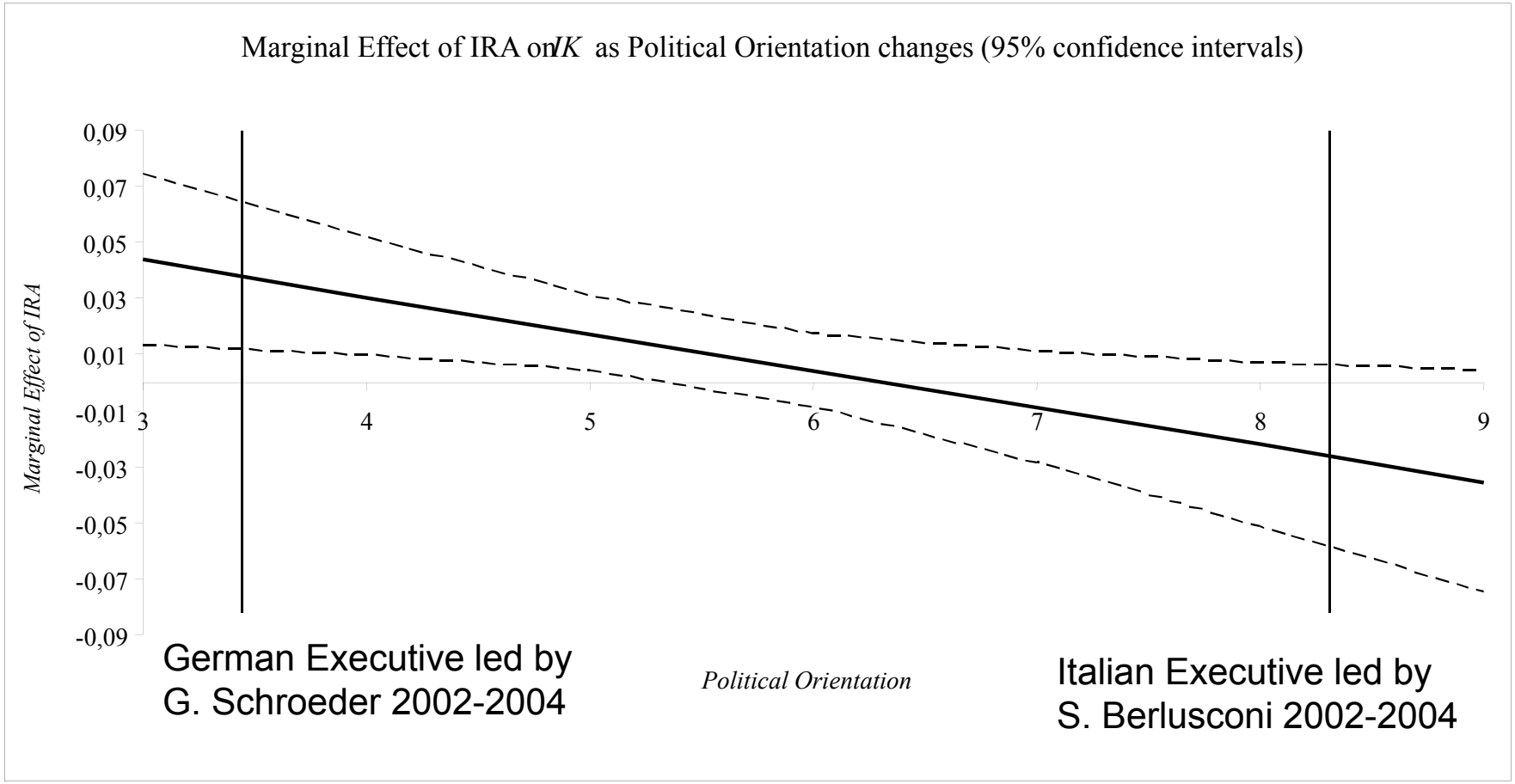
I/K_t	(1)	IRA in place (2)	(3)	(4)
$(I/K)_{t-1}$	0.882***	0.855***	0.928***	0.914***
	(0.143)	*(0.162)*	*(0.129)*	*(0.124)*
$(I/K)^2_{t-1}$	-1.122***	-1.205***	-1.267***	-1.176***
	(0.234)	*(0.233)*	*(0.186)*	*(0.206)*
$(\Pi/K)_{t-1}$	0.0001	-0.009	-0.012	-0.001
	(0.031)	*(0.059)*	*(0.075)*	*(0.031)*
$(Y/K)_{t-1}$	0.002	-0.001	-0.003	0.002
	(0.005)	*(0.003)*	*(0.006)*	*(0.005)*
IRA_{t-1} (α_1)	0.152***	-	0.143**	0.136**
	(0.059)	-	*(0.070)*	*(0.062)*
Government UCR $_{t-1}$ (α_2)	0.004	0.051**	-0.032	0.006
	(0.042)	*(0.024)*	*(0.045)*	*(0.039)*
Political Orientation$_{t-1}$ (α_3)	0.004	-0.015**	0.004	0.003
	(0.006)	*(0.007)*	*(0.010)*	*(0.006)*
Government UCR $_{t-1}$* IRA (α_4)	0.030	-	0.063	0.027
	(0.030)	-	*(0.051)*	*(0.029)*
Political Orientation $_{t-1}$* IRA (α_5)	-0.026**	-	-0.023**	-0.023**
	(0.010)	-	*(0.011)*	*(0.011)*
Distrust $_{t-1}$	0.055	0.005	-	-
	(0.054)	*(0.061)*	-	-
OECD Liberalization Index $_{t-1}$	-	-	0.004	-
	-	-	*(0.005)*	-
Investor Protection $_{t-1}$	-	-	-	-0.003
	-	-	-	(0.004)

Social capital, Inv. Protection, Liberalization as country controls

Institutions affect firm investment through the IRA

Political interference with *formally* independent regulators generates a negative spillover on investment

Marginal Effect of IRA on Investment as Political Orientation of the Executive changes from Left to Right $\alpha_1+\alpha_5$*Pol Orientation



Conclusions

- The presence of IRAs positively affects firm investment: results show that regulatory independence increases firms' investment rate by around 1.2-3.3%, on average more in Telecoms (4%) and less in water supply industry (2%)
- Cohabitation of formally independent IRAs and decidedly rightwing executives generates a negative spillover
- Potential conflicts thus arise about policy goals and generate regulatory uncertainty that hinders firms' investment decisions where the quality of institutions are not strong

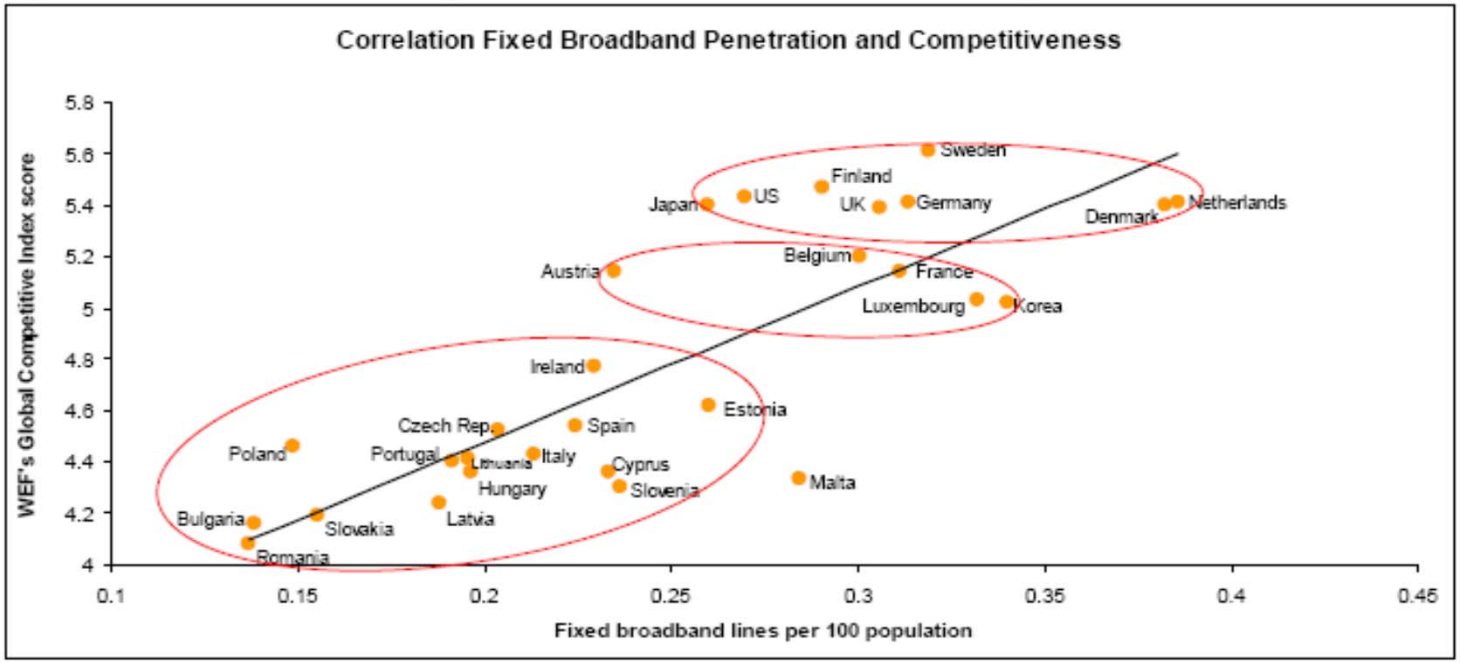
The telecom industry:
the interplay between broadband investment and regulatory interventions

Background

- Why is broadband investment important?
  - Investment in telecommunications infrastructure is believed to be a significant contributor to economic growth ever since a long time.
    - Röller and Waverman (2001 AER): An increase of 10% in the broadband penetration rate leads on average to an increase of 2.8% of GDP growth (21 OECD countries).
    - Koutroumpis (2009 TP): the average impact of broadband infrastructure on GDP is 0.63% (for the EU-15, in the period 2002–2007).
    - For the US, Greenstein and McDevitt (2009) show that the deployment of broadband infrastructure create approximately $8.3 to $10.6 billion of new GDP, that is approximately between 40% and 50% of measured total GDP in the same period

Broadband investment drives competitiveness and growth

Figure 1: Correlation between penetration of fixed broadband and competitiveness



Source: EC services based on COCOM and WEF

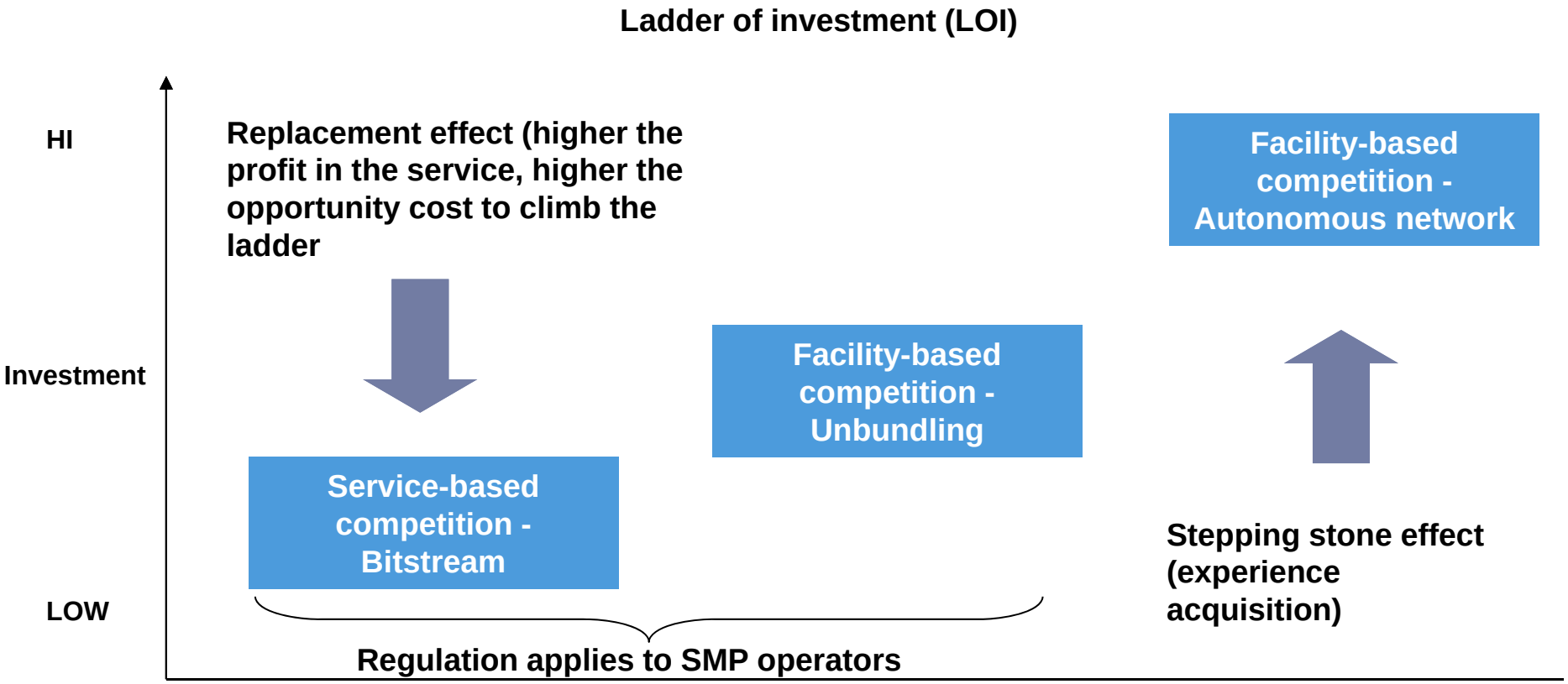
- A 10% increase in the broadband penetration rate results in 1-1.5% increase in annual GDP per-capita. Faster broadband = higher GDP growth (Czernich et al., EJ, 2011)
- Still, the EU is lagging behind in high speed broadband infrastructure investments.

A Survey (Cambini and Jiang, 2009 TP)

- The literature falls in two main categories:
  - Incentive Regulation
    - Retail level (price cap, profit sharing, revenue sharing, etc)
  - Access Regulation
    - Wholesale level (interconnection, local loop unbundling)

- Local loop unbundling is in the center of the debate.
  - Rationale
    - Incumbent: not to extend market power
    - Entrant: "stepping stone" theory

The ladder of investment theory (Cave and Vogelsang, 2003 TP)



In a nutshell: the LOI approach is a form of regulation for one-way access which ensures that service-based and facility-based competition are complements in promoting competition.

Its objective: the development of alternative infrastructures [*facility-based competition*] in the long run.

Ladder of investment: weak evidence

- The "*ladder of investment*" is an approach which provides a "transitory entry assistance" to new entrants, while giving the entrants incentives to build their own network in the medium or long term.
- Descriptive statistics, surveys and visual analysis
  - Hausman and Sidak (2005): no migration from SBC to FBC
  - Crandall and Sidak (2007): entrants stuck on the lowest rung in Mexico
  - On the opposite:
    - Distaso et al. (2009): some evidence on the effectiveness of European NRAs in applying the basic principles of LoI
    - Willig (2006) shows that 1% reduction in UNE rates correspond to approximately a 2.1% to 2.9% increase in ILEC investment
- Econometric analysis - Regulation and investment
  - Hazlett and Bazelon (2005): negative impact of UNE-P lines on current lines owned by CLECs in the US from 1999-2004

Evidence from EU/1

Supporting evidence:

- Distaso, Lupi and Manenti (2009): evidence on the effectiveness of European NRAs in applying the basic principles of LoI

Contrasting evidence:

- Waverman *et al.* (2007): -10% in LLU access pricing → -18% in subscriber share of alternative infrastructures
- Grajek and Röller (2011, JLE): negative relation between access regulation intensity and individual investment by entrants

The Effects of Regulation on Investment in Network Industries: Evidence from European Telecoms

- Recent study by M. Grajek and L.-H. Röller (2011, JLE)

- **Dataset and Main Variables**
  - Data used in the analysis covers over 70 fixed-line telecom (incumbents and entrants) operators from 20 European nations over the period 1997-2006 (yearly observations)
  - Domestic tangible fixed assets – proxy for infrastructure
  - Regulatory index (Plaut Economics)
    - Based on inputs
    - Sector-specific index: it captures regulations specific to fixed-lines
  - Control variables (costs, demand, etc.)

Regulatory performance: the Plaut Index

- The index of "*Regulatory Intensity*", the overall *Plaut Economics Regulation Index* (Zenhausern, Telser, Vaterlaus, Mahler, 2007 and 2012) captures several elements of regulation such as market entry, density and enforcement of price and quantity regulation, and other aspects that may be relevant for investment incentives.

- It ranges from 0 (low intensity) to 1 (high intensity).

- It consists in a long list of sub-indexes and sub-indicators

Regulatory performance: the Plaut Index

Table 1 Sub-indices and indicators

Sub-indices	No.	Indicators
Price regulation	1	Which interconnection regime is applied to the incumbent's fixed-line network?
	2	What interconnection regime is applied to the incumbent's mobile communications network?
	3	What mobile termination regulation is applied?
	4	Amount of weighted average cost of capital accepted by the regulator [a)]
	5	Existence of sector-specific retail price-regulation for fixed network services?
	6	Existence of sector-specific retail price-regulation for mobile communications services?
Quantity regulation	7	Existence of a USO-burden for incumbents (USO=Universal Service Obligation)?
	8	Existence of a (financial or other) USO-burden for other telecommunications companies?
	9	Existence of meet-demand clauses for specific products or services at regulated prices?
	10	Are there regulatory requirements regarding coverage of the population with 3G mobile communications technology?

Regulatory performance: the Plaut Index

Market-entry regulation	11	Existence of regulated vertical separation of the incumbent company?
	12	Accounting separation requirement to ensure non-discrimination?
	13	Is full local-loop unbundling regulated?
	14	Is line sharing regulated?
	15	Is bit-stream access regulated?
	16	Is sub-loop unbundling regulated?
	17	Number of network-based mobile communications licenses of the 2nd generation?
	18	Number of network-based mobile communications licenses of the 3rd generation?
	19	Is frequency trading regulated?
Miscellaneous regulations relevant for investment incentives	20	State's shares of the incumbent in percent?
	21	Existence of a 'golden share' (right to veto, that can be applied by the government)?
	22	Is there an asymmetric access regulation between DSL and cable network providers?
	23	Is there a sector-specific environmental regulation (e.g., regarding radiation limits)?
	24	Can fines issued by the regulator exceed 5% of turnover of activity concerned?
	25	Are there any sector-specific regulations in connection with rights of way?

a) With regard to investment incentives, it is crucial to include information on cost of capital which regulatory authorities grant companies. The returns granted directly influence the provision of capital in regulated areas.

Regulatory performance: the Plaut Index

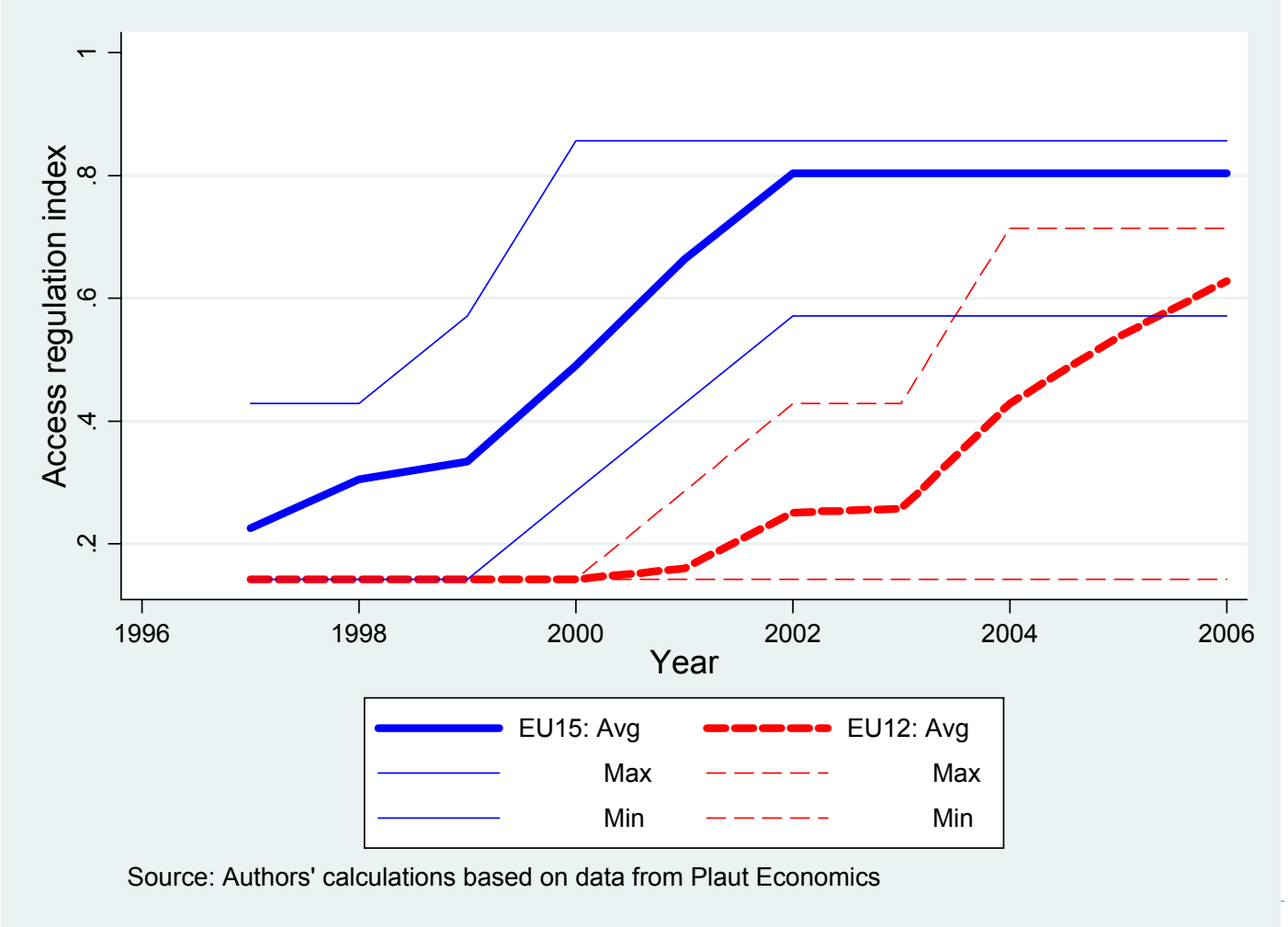
Table 2 Selection criteria and valuation of the indicators

Indicators 1, 2, and 3	Interconnection regulation		Valuation
	Regulation of the network monopoly		1
	Incremental cost accounting		1
	General cost regulation		0.8
	Combination of all regulations		0.8
	Price-cap regulation		0.5
	Rate-of-return regulation		0.5
	No regulation (competition law)		0
Indicator 4	**WACC (before tax, if available real, otherwise nominal)**		**Valuation**
	Lower threshold (>=)	Upper threshold (<)	
	0	7%	1
	7%	10%	0.8
	10%	14%	0.5
	14%		0

Regulatory performance: the Plaut Index

Indicators 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 21, 22, 23, 24, and 25	Yes or no	Valuation
	Yes	1
	No	0
Indicators 17 and 18	**No. of licenses**	**Valuation**
	1	1
	2	0.8
	3	0.5
	4	0.5
	More than 4	0
Indicator 20	**State's shares**	**Valuation**
	Lower threshold (>=) / Upper threshold (<)	
	80%	1
51%	80%	0.8
20%	51%	0.5
	20%	0

Telecoms in Old and New EU Member States: Access Regulation



Source: Authors' calculations based on data from Plaut Economics

Empirical Model of Investment in Fixed-line Telecoms

Three simultaneous equations:

i. Incumbent

$$\Delta IncInfr_{it} = \alpha^{I}_{i} + \beta^{I} IncInfr_{it-1} + \gamma^{I} \Sigma EntInfr_{it} + \delta^{I} Reg_{it} + \varepsilon_{it}$$

ii. Entrants (Competitive fringe)

$$\Delta \Sigma EntInfr_{it} = \alpha^{E}_{i} + \beta^{E} \Sigma EntInfr_{it-1} + \gamma^{E} IncInfr_{it} + \delta^{E} Reg_{it} + \zeta_{it}$$

iii. Regulation (Access to the local loop)

$$\Delta Reg_{it} = \alpha^{R}_{i} + \beta^{R} Reg_{it-1} + \gamma^{R} IncInfr_{it} + \delta^{R} \Sigma EntInfr_{it} + \eta_{it}$$

IV Estimation Results

equation:	**Incumbent**	**Entrants**	**Regulation**
dep var:	*Δln_incumb_infra*	*Δln_entra_Σinfra*	*Δentry_fix*
dynamic effects:			
lagged level	-0.695***	-0.807***	-0.671***
	(0.144)	(0.074)	(0.091)
strategic effects:			
ln_incumb_infra	-	-0.029	0.163**
		(0.180)	(0.079)
ln_entra_Σinfra	0.244**	-	-0.022***
	(0.112)		(0.007)
Regulation	-0.666*	1.181*	-
	(0.377)	(0.636)	
controls:			
no_entra_infra	1.253*	-3.001***	-
	(0.731)	(0.857)	
...	...	...	...
N	129	110	120
Hansen J	7.01 (5)	2.28 (3)	7.10 (7)
Serial correlation	0.41	-0.15	-0.06

* p<0.1, ** p<0.05, *** p<0.01; robust standard errors in brackets

Main Findings

- Access regulation discourages investment by incumbents in fixed-line telephony
- Access regulation encourages **total** investment by entrants
- Competitive pressure encourages infrastructure investment by incumbents (effect is non-linear)
- National regulators toughen access regulation in response to
  - Increased total stock of infrastructure
  - Increased infrastructure gap between incumbent and entrants

Evidences on Ladder in Europe

- Bacache, Bourreau and Gaudin (2014, RIO) propose an empirical analysis of the ladder of investment approach on a European panel-dataset (15 EU countries x 8 years)

- Their main findings:

  - No stepping stone effect from LLU to Fiber (complete ladder)
  - Stepping stone effect (though weak) from bitstream access to LLU (short ladder)

Evidences on Ladder in Europe

- **The ladder of investment approach is based on** two hypothesis **that they test:**
  - **H1**: Service-Based Competition promotes Facility-Based Competition
  - **H2**: The higher the number of levels of access, the faster new entrants deploy their own infrastructures
- They use the number of broadband lines as a proxy for investment: "New lines" (i.e., fibre + WLL + PLC), built by new entrants, and LLU lines (full- + shared-LLU)

Econometric Model: *Data*

- Main dataset is extracted from European Commission Broadband access in the EU reports
- Data from July 02 to July 10 (semi-annual), covering 15 EU European countries; 248 observations
- They also use the incumbent market share, GDP, Population, Population density and Mobile penetration rate as control variables; and they control for country fixed effects
- Other variables are used to test the robustness of our findings: Regulatory power (Plaut Eco. Regulation index, Aug. 07; availability: 2002-20010), Cable lines (EC Broadband access in the EU reports), LLU prices (EC Implementation Reports)

Estimation Results: *Lagged specification*

	Complete Ladder	Short Ladder
	GMM-Diff	GMM-Diff
	$log(Newlines)_t$	$log(LLUlines)_t$
$log(Newlines)_{t-1}$	0.552***	
	(3.78)	
$log(LLUlines)_{t-1}$		0.613***
		(4.80)
$log(LLUlines)_{t-2}$	-0.0931	
	(-0.91)	
$log(BAlines)_{t-2}$		0.0515*
		(2.10)
$incmob_t$	-0.489	1.453
	(-0.26)	(1.03)
$log(GDPpercapita)_t$	-1.802	0.220
	(-0.76)	(0.38)
$mobpenrate_t$	-0.00549	0.0126
	(-0.31)	(1.72)
$density_t$	0.0484	0.0602
	(0.63)	(1.46)
$log(Pop)_t$	8.817	-4.637
	(0.60)	(-0.58)
N	171	207

Additional results

- The result is robust to:
  - alternative number of rungs;
  - the presence of Cable (proxy of intermodal competition);
  - differences in regulatory intensity (Plaut Index).

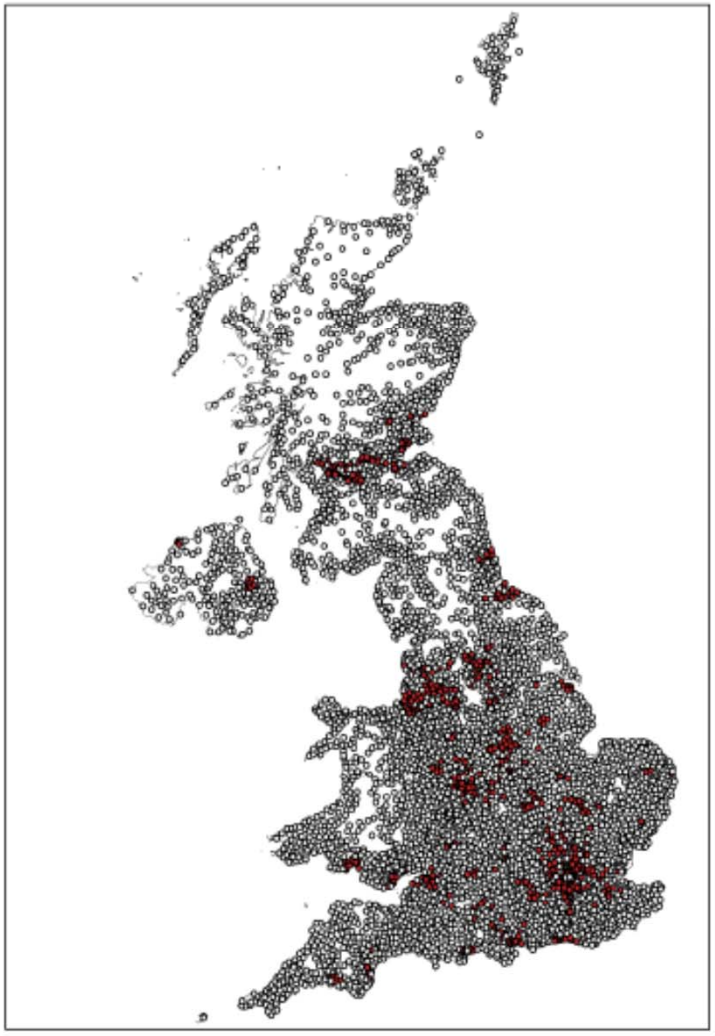
- According to the ladder of investment approach, the regulator should increase the price of LLU to incentivize the entrants to invest in their own access networks:
  - results show that there is no significant and positive impact of unbundling prices on investment in alternative infrastructures by entrants!

Micro-data: an example from Nardotto et al. (2015, JEEA)

- Quarterly panel data on investments and subscriptions in the period 2005 (Dec) 2009 (Dec) at the LE level (5,587) – Provided by Ofcom:

- For each LE they observe:
  - Total number of potential lines (households)
  - Number of lines potentially served by cable
  - Lines actually served by cable
  - Lines served by entrants through LLU (disaggregated by operator)
  - Total lines served by bit-stream
  - Total lines with broadband (LLU + cable + bit-stream)

Micro-data: an example from Nardotto et al. (2015, JEEA)



- White dots: LEs areas
- Red dots: LEs areas where cable covers at least 65% of lines

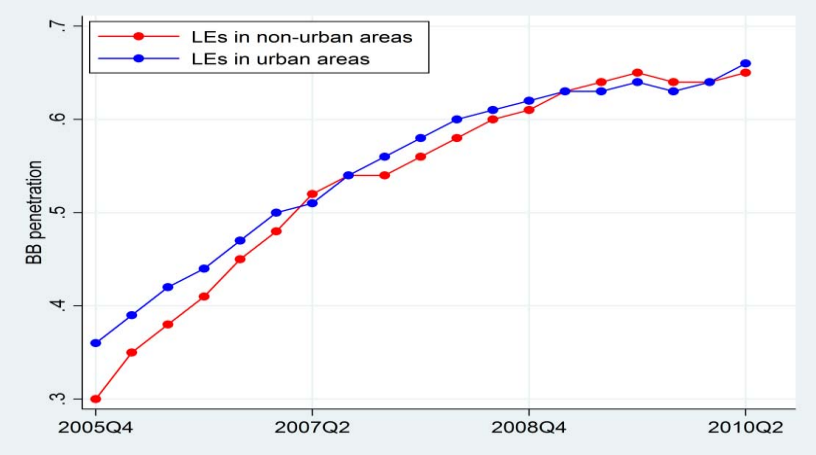
Nardotto et al. (2015, JEEA): main results

- The paper's main question:
  - Did entry through LLU induce market expansion?

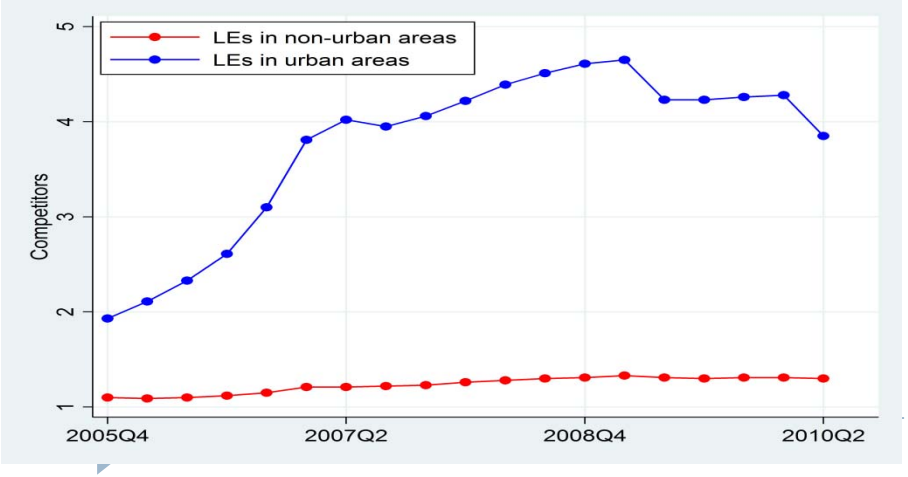
- Result 1: penetration is not improved by LLU
- Result 2: they also show that:
  - Inter-Platform competition leads to more penetration (BT lines vs. cable)
  - Quality improves with LLU (real connections speed: speedchecker.com)
    - LLU operators not only propose different quality in LLU areas (where they control the connections and they can invest), they also sell different products (Sky bundles telecom and contents!)

Nardotto et al. (2015, JEEA): main results

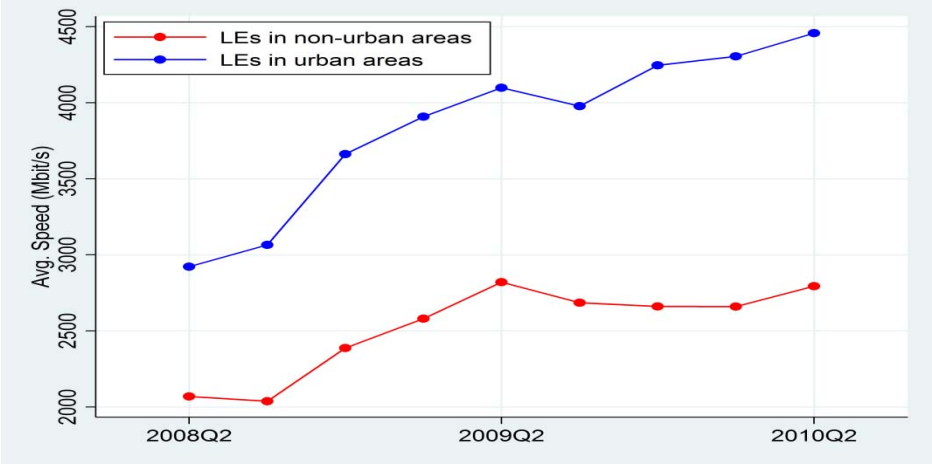
- Penetration? NO



- Entry of LLU operators? YES



Speed? YES



The transition to fiber: a gradual process

- The transition from copper to fiber infrastructures will be *gradual* due to:
  1. the large investments required to roll out fiber;
  2. uncertainties about demand and investment costs (which call for a progressive investment strategy);
  3. financial market constraints that imply that fiber investments must be phased;
  4. the regulatory constraints which rule out an immediate switch-off of copper networks in most countries.
- The regulatory framework will affect the transition to NGANs through two different channels:
  - Regulation of access to the new NGANs...
  - *but also*: regulation of access to the legacy "copper" network

Access to copper and transition to fiber

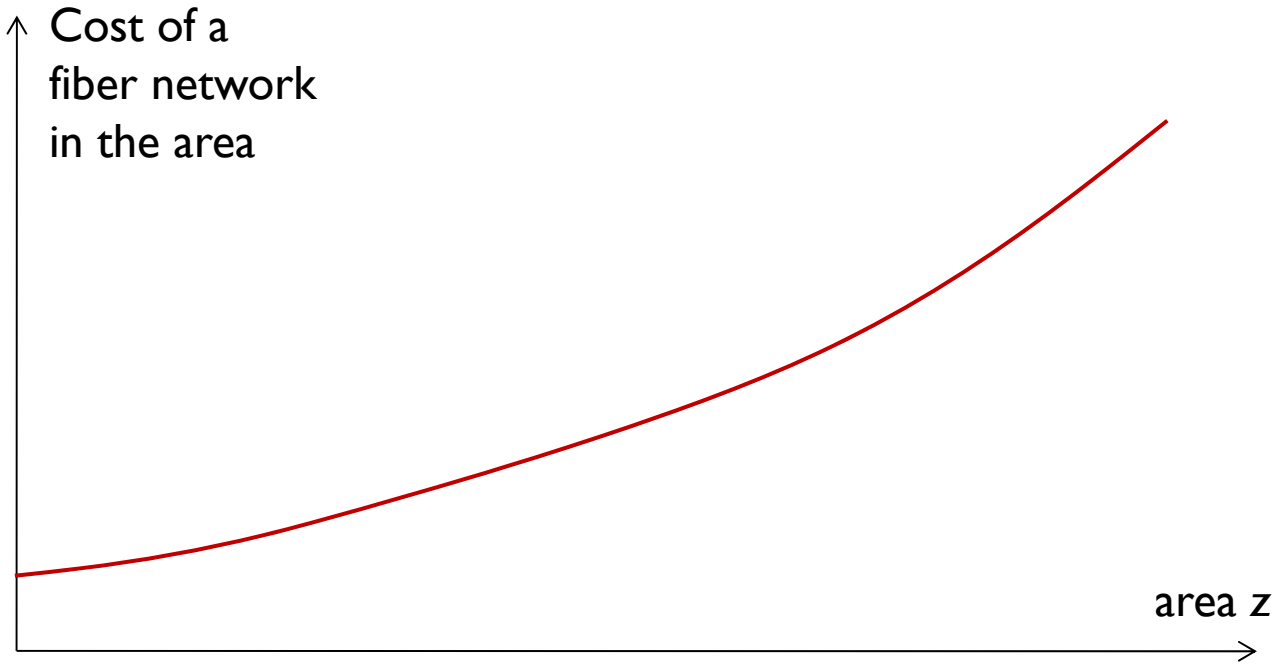
- Different contributions to this question
  - WIK (2011) model, prepared for ECTA
  - Plum (2011), prepared for ETNO
  - Charles Rivers Associates (2012), prepared for DG Information Society and Media.
  - Academic papers:
    - Bourreau, Cambini and Dogan (2012), *International Journal of Industrial Organization*.
    - Bourreau, Cambini and Dogan (2014), *Journal of Regulatory Economics*.

Bourreau-Cambini-Dogan (2012)

- Propose a general model, with one incumbent and one entrant which can both invest in fiber in a given country
- Prior to fiber roll-out, DSL is available in all the country
- Roll out of fiber in local areas
  - Copper and fiber can coexist in a given area (even if the incumbent has rolled out fiber)
- Competition in the retail market takes place at the local level, according to competitive conditions (technology of each firm)
- The regulator sets the *access price to copper*

Bourreau-Cambini-Dogan (2012)

- The country: a continuum of local areas, ranked in ascending order according to the cost of rolling out fiber



Investment in fiber = choice of fiber coverage

Bourreau-Cambini-Dogan (2012)

- The effect of a lower price of local loop unbundling on investment in fiber coverage is ambiguous, due to 3 conflicting economic effects
- Replacement effect:
  - Entrant's profits with copper = opportunity cost to invest in fiber
  - A lower access price to copper ⇨ *stronger* replacement effect (*less* investment)
- Wholesale revenue effect:
  - Incumbent face an opportunity cost of investing in fiber = loss of access revenues from copper (to the extent that the incumbent's investment stimulates the entrant's investment)
  - Lower access price to copper ⇨ *lower* wholesale revenue effect (*more* investment)

Bourreau-Cambini-Dogan (2012)

- Business migration effect:
  - When the access charge on the copper network is low, the prices for standard DSL broadband services are low.
  - Therefore, to encourage customers to switch from the copper network to the fiber network, any fiber operator also has to offer low prices.
  - This reduces the profitability of fiber networks, and hence, the incentives to invest in such networks.
  - Low access price to copper ⇨ *stronger* migration effect (*less* investment)

Bourreau-Cambini-Dogan (2012)

- To sum up:
  - *Entrant*: replacement effect + business migration effect ⇨ positive relation between price of copper and investment
  - *Incumbent*: wholesale revenue effect + business migration effect ⇨ ambiguous relation between price of copper and investment
- Therefore, in a very general setting:
  - For a LLU-based entrant, a higher LLU price implies more investment
  - For an incumbent, it can lead to either more or less investment
- Special case of a cable operator:
  - Higher LLU price leads to more investment

Regulation and Investment in European High-Speed Broadband Infrastructure

(Briglauer, Cambini and Grajek, 2016)

Our contribution

- Provide empirical evidence of the effect regulation on NGN investment
  - Use company-level data from 27 EU nations over 2004-2014
  - Use the # of fiber access lines as the investment measure
- Build theoretical model to guide empirical analysis
  - Accommodate major actors in the investment game: telecom incumbents, telecom entrants, cable companies
  - Incorporate both the regulated access to copper and fiber
  - Adjust the model to match the specificities of the EU regulatory framework
  - Guides empirical model: Estimated equations = log-linearized best response functions

A benchmark model

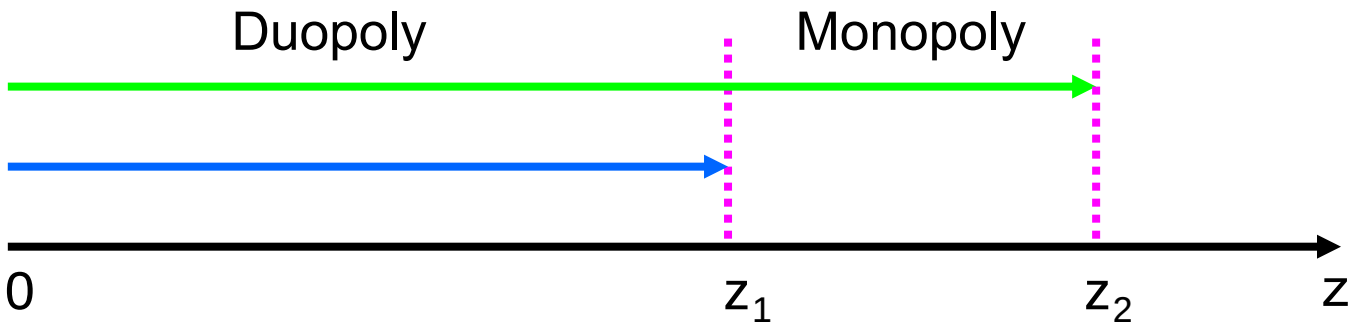
- Two firms: (telecom) incumbent and entrant (cable operator)
- The two firms compete in the broadband market
  - The market is fully covered with "basic" broadband
  - The incumbent owns the copper network
  - The entrant owns the cable TV network
  - The entrant can access the incumbent's copper network (through local loop unbundling), at regulated price a
- The two firms simultaneously decide on their investments in next generation networks (NGNs/fiber)

Profits

- In each area, the incumbent and the entrant earn profits according to the networks they use
- Four possible cases/areas
  - Incumbent with Old Network, Entrant with Old Network (O,O)
  - Incumbent with NGN , Entrant with Old Network (N,O)
  - Incumbent with Old Network, Entrant with NGN (O,N)
  - Incumbent and Entrant with NGN (N,N)
- General profit functions (net of investment cost)
  - Incumbent: $\pi_1^{O,N} \leq \pi_1^{O,O} \leq \pi_1^{N,N} \leq \pi_1^{N,O}$
  - Entrant: $\pi_2^{N,O} \leq \pi_2^{O,O} \leq \pi_2^{N,N} \leq \pi_2^{O,N}$

Profits

- The incumbent and the entrant simultaneously decide in which areas to rolled-out the NGN



- Profit (simplified): $z_i\pi - C(z_i)$, where $C(z_i)$ is convex in z_i

Profits

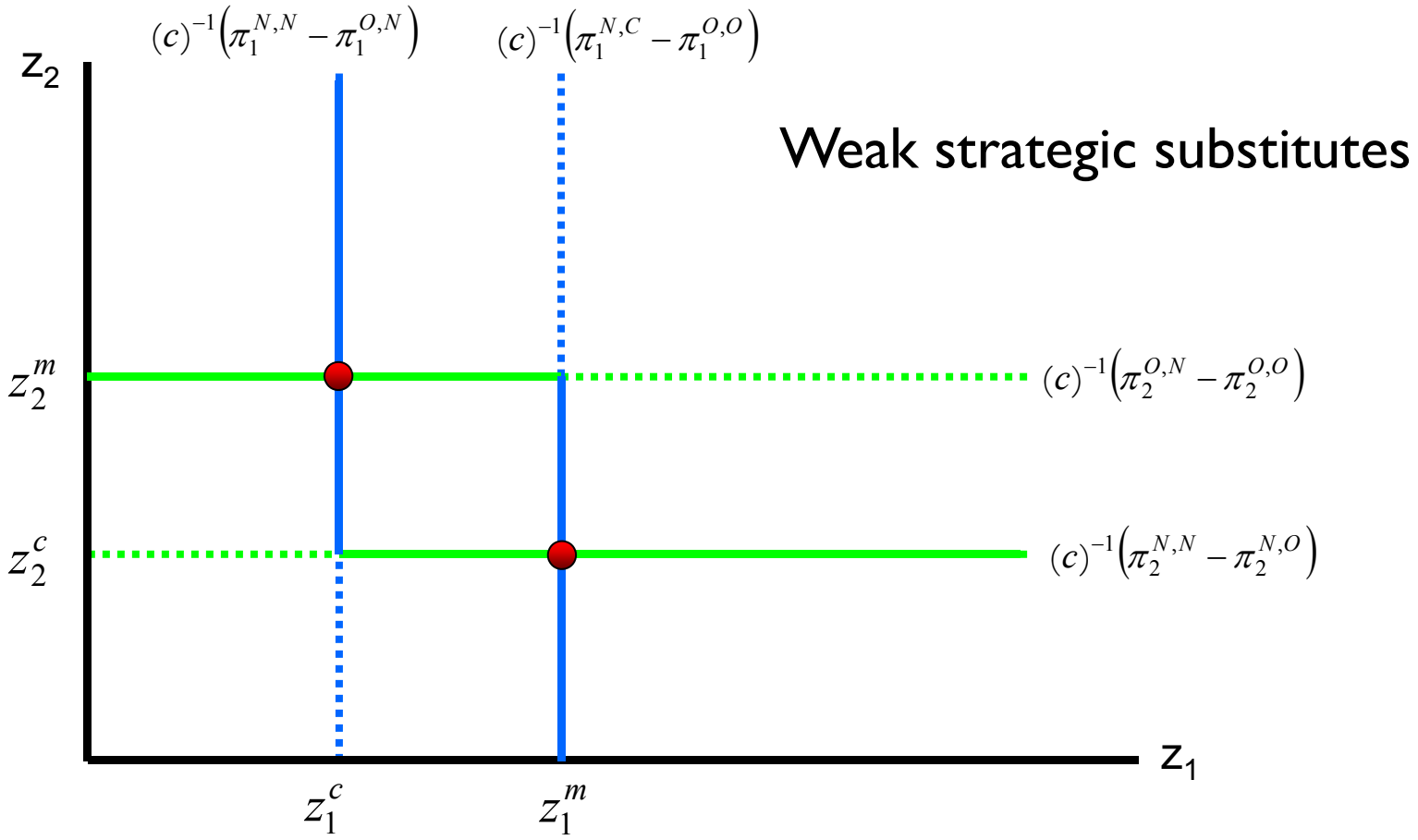
Firm 1 - Incumbent

$$\Pi_1(z_1, z_2) = -C(z_1) + \begin{cases} z_1\pi_1^{N,N} + (z_2 - z_1)\pi_1^{O,N} + (\overline{z} - z_2)\pi_1^{O,O} & \text{if } z_1 \leq z_2 \\ z_2\pi_1^{N,N} + (z_1 - z_2)\pi_1^{N,O} + (\overline{z} - z_1)\pi_1^{O,O} & \text{if } z_1 > z_2 \end{cases}.$$

Firm 2 – Entrant (telecom or cable)

$$\Pi_2 = -C(z_2) + \begin{cases} z_2\pi_2^{N,N} + (z_1 - z_2)\pi_2^{N,O} + (\overline{z} - z_1)\pi_2^{O,O} & \text{if } z_2 \leq z_1 \\ z_1\pi_2^{N,N} + (z_2 - z_1)\pi_2^{O,N} + (\overline{z} - z_2)\pi_2^{O,O} & \text{if } z_2 > z_1 \end{cases}.$$

The equilibrium



Benchmark case: Main results

- Asymmetric equilibria
  - Either the incumbent or the entrant invests more and become monopolist in high-speed broadband provision in some (intermediate) areas
- Regulated access to copper network a is irrelevant
  - Cable operator never seeks access to the copper network, because it has its own cable network

Alternative case 1: telecom entrant

- Main difference to the benchmark case
  - The entrant does not have own copper infrastructure and seeks access to incumbent's copper network
  - In all cases/areas where the entrant does not invest in NGN, the general profit functions depend on regulated access price a
- Main results
  - Entrant's NGN investment increases with a
  - The effect of a on incumbent's NGN investment is ambiguous:
    - increases with a due to **retail migration effect**
    - decreases with a due to **wholesale revenue effect**

Alternative case 2: regulated fiber access

- Main difference to the benchmark case
  - The (cable) entrant can access incumbent's fiber network at a regulated price $\tilde{a}$ (but not the other way around!)
  - In the case/area where the (cable) entrant does not invest in NGN, but the incumbent does, the general profit functions depend on regulated access price $\tilde{a}$
- Main results
  - The regulated access price $\tilde{a}$ matters only when the incumbent is the leader in NGN investments (i.e. invests more than the entrant)

Empirical model and identification

- Incumbent's investment equation (best response)

$$\ln(inc\_nga_{i,t}) = \beta^I \ln(inc\_nga_{i,t-1}) + \gamma_1^I llu\_price_{i,t} + \gamma_2^I nga\_reg_{i,t} + \\ + \delta_2^I inc\_legacy_{i,t} + \delta_3^I \ln(ent\_nga_{i,t}) + X_{i,t}\Theta^I + \lambda_i^I + \theta_t^I + \varepsilon_{i,t}^I$$

- Cable entrant investment equation (best response)

$$\ln(ent\_nga_{i,t}) = \beta^E \ln(ent\_nga_{i,t-1}) + \gamma_1^E llu\_price_{i,t} + \gamma_2^E nga\_reg_{i,t} + \\ + \delta_2^E cable\_legacy_{i,t} + \delta_3^E \ln(inc\_nga_{i,t}) + X_{i,t}\Theta^E + \lambda_i^E + \theta_t^E + \varepsilon_{i,t}^E$$

- Identification
  - Simultaneous equations: Exclusion restrictions: legacy networks
  - Dynamic panel model: Arellano-Bond intruments
  - Other endogenous variables: Anderso-Hsiao instruments
  - Additional "geographic" instruments for regulation

Main empirical results

Dep.Var.:	Incumbent infrastructure	Cable entrants infrastructure	
Lagged own infrastructure	0.55***	0.47***	Inertia in the investment process
	(0.10)	(0.12)	
Rival's infrastructure	-0.00	-0.02	No strategic substitutes: cable leads in investment
	(0.09)	(0.12)	
LLU price	0.87**	0.53	Incumbent: retail migration dominates wholesale revenue eff.
	(0.44)	(0.40)	
NGA regulation	-2.21**	1.08	Incumbent: competition from telecom entrants gives NGA regul. a bite
	(1.01)	(2.01)	
Legacy network	-17.18*	-38.87**	Wholesale/replacement effect at play for both incumbents and entrants
	(9.32)	(19.62)	
…	…	…	
# of observations	211	211	
# of countries	27	27	

Conclusion

- Access regulation on the old copper network affects incumbent's NGN investment incentives
- Stricter access regulation (both the extension to NGN and lower LLU price) discourages incumbent's incentives to invest in NGN
  - This effect is due to competition with the telecom entrants
- Cable entrants' incentives to invest in NGN are unaffected by the access regulation
  - Cable entrants don't seek regulated access to copper or fiber

The energy sector:
from the “standard” regulatory tools
to output-based incentives

Two Types of Regulatory Contracts

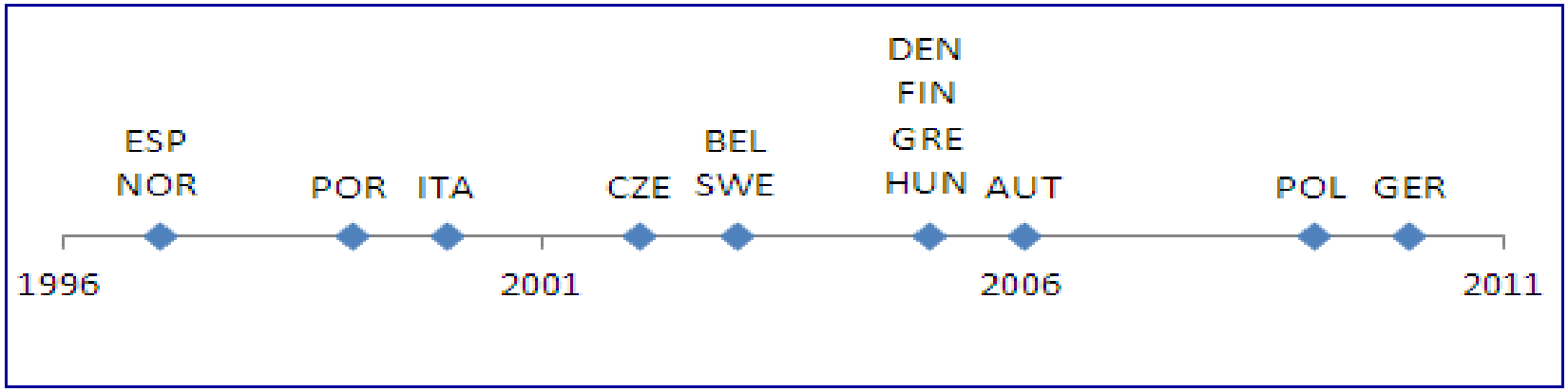
- A key policy decision (Armstrong & Sappington, 2006, 2007)

- *Cost-based regulation (e.g. rate of return)*: regulators set the price so as to cover all main operating costs and to allow firms to earn a specified rate of return.
  - Typically used in transmission services
- *Incentive regulation (e.g. price-cap)*: regulators set a limit (*cap*) on retail prices → hence managers can generate higher profits and benefit shareholders by pursuing cost savings
  - Typically used in energy distribution
- Do firms subject to *CB* or *IR* mechanisms behave differently?

- Evidence from European energy firms

Institutional Context in the EU

- Directive 96/92/EC: opens national electricity markets and prepares an integrated electricity market in Europe.
- EU Commission encourages privatization and promotes unbundling of transmission networks.
- Key novelty is the introduction of incentive regulation: most countries switched from a cost based regulation to incentive regulation



A brief literature review

- Incentive regulation increases productivity and service quality in UK electric regional distribution (Jamasb and Pollitt 2007; Domah and Pollit, 2004; Newbery and Pollit, 1998)
- Quality impact is ambiguous: Not negative impact of incentive regulation in quality provision in Norway (Growitsch *et al.* 2010); negative effect of IR on quality in the US (Ter Martirosyan and Kwoka, 2010) without MQS.
- Incentive regulation increases labour productivity in electric distribution in developing countries (Pollit, 2004; Rudnik and Zolezzi, 2001)
- Surveys on IR in Energy: Joskow (2008 RNE), Vogelsang (2006 JRE)
- **Important**: most of the focus on efficiency/productivity change

Incentive Regulation and Investment, Cambini and Rondi (2010 JRE)

- Many EU countries have reformed their energy sectors and switched from cost-based to incentive regulation
  1. Does investment differ under different regulatory contracts: cost-based vs. incentive regulation?
  2. Is investment sensitive to changes in regulatory instruments: X (Caps) and WACC
- Evidence for a panel of European energy utilities
- We control for public vs. private ownership and country, industry characteristics: underlying energy demand, existing infrastructure
- Potential endogeneity of regulation and ownership

Regulation of EU Energy Utilities

- Cost-based (Rate of Return) in Germany, France and, up to late 90s, Spain and Italy
  - A *cost-plus mechanism* where the regulator sets the rate of return the utility can earn on its asset base → The allowed rate or return through the **WACC** is the key instrument, providing incentives to invest
- Incentive regulation in UK, Italy and Spain
  - A *fixed-price contract* imposes a *cap* to tariff rates or firm revenues → **RPI – X** mechanism: The **X-factor** is the regulatory tool which prompts efficiency but is viewed as detrimental to investment
- All countries have IRAs (except Germany)
- Private control of energy utilities, mostly in the UK, Spain and, partly, in Germany

The Sample and the Data

- 23 large energy utilities in France, Germany, Italy, Spain, UK (1997-2007), small panel, but representative
  - 90% of FR and ITA markets; 60% Germany; 80% Spain; 40-50% UK
  - 6 firms (ITA & SPA) with regime switch, 13 TSO, 5 Vertically and 5 Horizontally integrated; 13 State (30%) and 10 Privately controlled
- Firm data: Investment rate, Capital stock at replacement value, Sales growth (accelerator), Cash Flow (financial factors), State Own.
- Regulatory instruments
  - WACC rates and X-factors observed at various regulatory hearings: 2-3 changes in each country
- National indicators and structural energy characteristics
  - Manufacturing share of GDP; Energy supply per GDP; OECD-PMR indexes of Market Openness and Vertical Integration

The Investment Equation

$$IK_{it} = \alpha_0 + \alpha_1 IK_{it-1} + \alpha_2 \Delta LogSales_{it} + \alpha_3 CFK_{it-1} + \alpha_4 IncentiveRegulation_{it} + \alpha_5 PrivateControl_{it} + \beta_1 ManufacturingShareGDP_{jt-1} + \beta_2 InterestRate_{jt-1} + \mu_i + \delta_t + \varepsilon_{it}$$

Endogeneity problems

- The choice of the **regulatory regime** may depend on whether the government thinks that either *larger infrastructure* or *cost reducing investment* is needed
- The choice of **privatization** may fall on firms in a healthier financial situation in order to fulfill investment programs rather than on firms under a budget constrain
- 2SLS with external instruments that capture features of the competitive, political and institutional environment
- GMM with internal instruments, lags of all RHS variables

Investment, Regulation, Ownership

	OLS	Fixed effects	2SLS Estimation	One-step difference GMM
	(1)	(2)	(3)	(4)
Investment Rate $_{t-1}$	**0.458*** (0.094)**	**0.181** (0.072)**	**0.160* (0.082)**	**0.341*** (0.106)**
ΔLog of Sales $_{t}$	**0.048*** (0.017)**	**0.066*** (0.024)**	**0.064** (0.025)**	**0.150*** (0.049)**
Cash Flow to Total Asset $_{t-1}$	**0.124* (0.066)**	**0.151* (0.075)**	**0.177** (0.083)**	**0.152 (0.166)**
LT Interest Rate $_{t-1}$	**-0.004 (0.007)**	**0.015 (0009)**	**0.022* (0.012)**	**- -**
Manufacturing Share of GDP $_{t-1}$	**-0.026 (0.053)**	**0.046 (0.304)**	**0.226 (0.312)**	**-0.329 (0.831)**
Incentive Regulation Dummy$_t$	**0.009** (0.004)**	**0.022* (0.012)**	**0.038** (0.015)**	**0.038* (0.021)**
Private Control Dummy$_t$	**0.007* (0.004)**	**0.033*** (0.004)**	**0.052 (0.136)**	**0.022 (0.015)**
Arellano-Bond test AR(1) (p-value)	-	-	-	0.015
Arellano-Bond test AR(2) (p-value)	-	-	-	0.512
Hansen χ^2 test (p-value)	-	-	-	0.999
R squared (within)	0.481	0.299	0.623	-
N. Firms [N. Obs.]	186 [23]	186 [23]	182 [23]	138 [23]

- Private firms seem to invest more, but <u>not if we account for endogeneity</u> of ownership

Investment, the X and the WACC

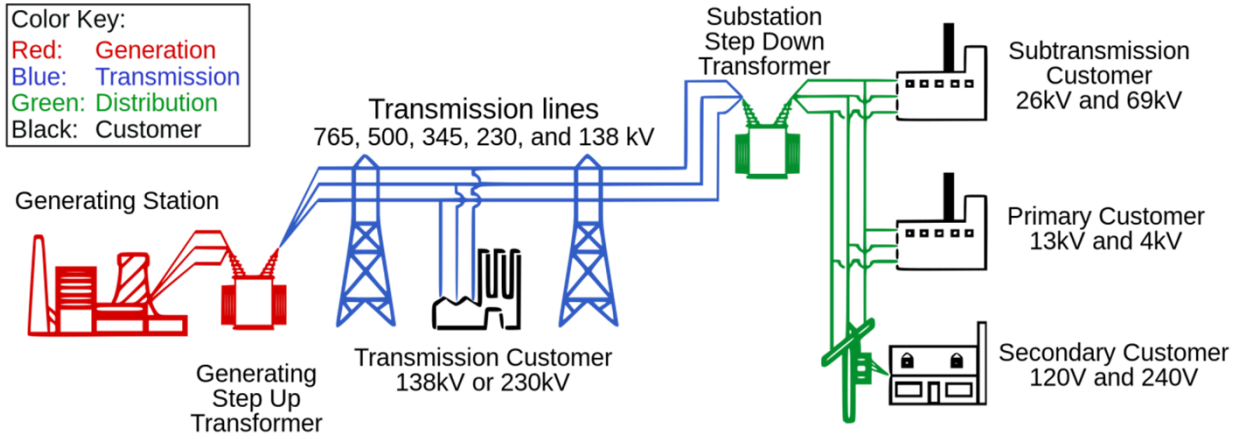
	Full sample	Firms Under Incentive Mechanisms			
		Fixed effects		2SLS	GMM
	(1)	(2)	(3)	(4)	(5)
Investment Rate $_{t-1}$	0.136	0.141	0.117	0.063	0.188***
	(0.115)	*(0.117)*	*(0.085)*	*(0.123)*	*(0.058)*
ΔLog of Sales$_t$	0.057**	0.070**	0.062***	0.067**	0.168*
	(0.024)	*(0.031)*	*(0.011)*	*(0.029)*	*(0.098)*
Cash Flow to Total Asset $_{t-1}$	0.143**	0.148*	0.166**	0.185***	-0.257
	(0.069)	*(0.082)*	*(0.067)*	*(0.071)*	*(0.246)*
Manufacturing Share of GDP $_{t-1}$	-0.187	-1.478	-1.063	-0.469	0.014
	(0.314)	*(0.939)*	*(0.964)*	*(1.141)*	*(1.602)*
Private Control Dummy$_t$	0.028***	0.031***	0.036***	0.090	0.152
	(0.004)	*(0.007)*	*(0.005)*	*(0.072)*	*(0.120)*
Incentive Regulation Dummy$_t$	0.059***	-	-	-	-
	(0.007)	-	-	-	-
WACC$_t$	0.782[a]	0.385	-	-	-
	(0.473)	*(0.448)*	-	-	-
X Factor$_t$	-	-	-0.676**	-1.280*	-2.652**
	-	-	*(0.269)*	(0.738)	(0.999)
Arellano-Bond test AR(1) (p-value)	-	-	-	-	0.036
Arellano-Bond test AR(2) (p-value)	-	-	-	-	0.285
Hansen χ^2 test (p-value)	-	-	-	-	0.999
R squared (within)	0.311	0.312	0.349	0.595	-
N. Firms [N. Obs.]	143 [20]	112 [16]	126 [19]	124 [19]	100 [19]

Large Xs reduce current revenues and expected returns, generates financial constraints, weakening incentives to invest

Summary of Results and Conclusion

- In the first decade after EU-driven privatization and liberalization reforms, investment at energy utilities under IR was higher than at firms under RoR regulation
- WACC rates positively affect investment of firms under RoR
- Investment of firms under **IR** is negatively related to the **X**
- Lack of significance of structural characteristics suggests that IR is more effective in encouraging investment aimed at reducing costs rather than at expanding infrastructure
- If regulators want to balance cost-efficiency and infrastructure investments, then increases in the X have to be compensated by including a premium in the WACC aimed at investment programs

What is the role of ownership unbundling?



a. ***Functional Unbundling:*** Organisational &decisional independence
b. ***Ownership Unbundling:*** the complete separation of ownership of generation assets from ownership of transmission assets and the separation of all network functions from the other activities of the energy supply

- European Commission passed a third energy package in September 2007 asking for the continuing vertical unbundling of transmission companies and long-distance transport in the electricity as well as the gas sector

What is the role of ownership unbundling?

- Gugler et al. (2014 En Econ) analyse the **effects of effects of ownership unbundling of the transmission grid** as well as **final consumer prices on investments**, and to corroborate the inherent trade-offs present in large sunk-cost network industries.
- The study estimates dynamic panel regression models (with GMM) for the electricity industry in 16 European countries over the period 1998–2008.
- Main results:
  - In the long run, an increase in prices by 10% increases the investment ratio by 3–4%. This indicates that higher prices, while inducing static or allocative inefficiencies, increase the rents that can be earned from investments and trigger more investments, which increase dynamic efficiency.
  - Ownership unbundling affects investment spending significantly negatively.
  - Public ownership is detrimental to investments. The X-inefficiency following from public ownership and control appears to outweigh any positive objective effects due to state involvement on investments.

New regulatory trends

- "Standard" incentive regulation: focus on productive efficiency
- Additional regulated outputs: service quality, innovation, sustainability
  - Ofgem (2010) RIIO model: Revenues, Innovation, Incentives, Outputs
  - Similar reforms in Italy (AEEGSI, 2011) and Australia (ACCC/AER, 2012)
- Service quality: example of a regulated output that requires additional expenditures
- More than a decade of quality regulation in Italy with a reward/penalty scheme
- **Our main question**:
  - How output-based incentives affects firm's investment and, in turn, service quality?
  - Are rewards and penalties both needed to spur investment?

Incentives to quality and investment (Cambini et al., 2016 JRE)

- Regulators set targets for enhancing quality over a country and introduce specific incentives in order to affect firms' operational and capital expenditures to enhance quality.
- In this paper we test the relationship between output-based regulatory incentives and firm's capital and operational expenses.
- We use a unique database for the period 2004-2009 with micro-data collected with the support of AEEGSI
- *Policy goal*:
  - a) evaluate the impact of output-based regulatory schemes on firm's investment and operational expenditures;
  - b) understand whether *rewards and penalties* are jointly needed to spur expenditures and, in turn, service quality, or if they simply push (and subtract) money towards companies for their past superior (inferior) performance.

Dataset

- Comprehensive and balanced panel for 115 Zones of *Enel Distribuzione*, tracked from 2004 to 2009. Dataset built with the support of AEEGSI (dedicated data collection)
- For each Zone and year:
  - **Technical data**
    - Number of LV consumers and Energy consumption for LV and MV load (in MWh)
    - Area served (in km^2); Network length for LV and MV feeders (in km)
  - **Accounting data** (in €)
    - Revenues from tariffs and new connections
    - Operating costs for labor, services, materials and other costs
    - Capital expenditures
  - **Quality data** (per district)
    - Number of long and short interruptions (cause and origin)
    - Duration of long interruption (cause and origin)
    - *Rewards and penalties* (RP)

Research question

- We explicitly analyze the strategy that firms pursue in order to obtain higher service quality
- We depart from previous papers (e.g Jamasb et al., 2012) in what we consider rewards *received* or penalties *paid* at the end of the year →they generate cash in-flows or out-flows and influence the decisions taken by the firm for the following year.
- Problems to consider:

1. Causality: incentives → expenditures → quality → incentives;
2. An increase in expenses can be associated with both an increase and a decrease in quality (*corrective* and *preventive* costs);
3. Measurement problems for calculating the investment rate.

Research question and Methodology

- To solve these issues, three-steps procedure:
  1. ***Analysis of the determinants of the average duration of service interruptions*** (SAIDI); we estimate the relationship between SAIDI and firms' capital and non-capital resources using both physical and economic variables → **fixed effect model;**
  2. ***Granger causality test*** to determine the relationship between capital, as well as operational, expenditures and regulatory incentives
  3. ***Dynamic accelerator model of investment*** to test the impact of output-based incentives on the investment rate.
     - we test whether incentives received still affect the investment rate after controlling for other determinants;
     - we verify whether penalties and rewards present a symmetric or asymmetric effects on the investment rate for all zones with different quality levels

Determinants of quality of supply (SAIDI)

Dep. Variable: *SAIDI*	(1) Physical Equipment	(2) Operational expenditures	(3) Physical Equipment and Operational expenditures	(4) Controlling for regulatory periods
UNDER	-519.49*	-	-406.27**	-295.05
	(219.48)	-	(201.43)	(238.59)
AUTO_LVcons	-46.55**	-	-48.42**	-51.05*
	(23.20)	-	(22.79)	(27.85)
PC_LVcons	-3.183	-	-1.290	-1.969
	(4.29)	-	(4.089)	(3.927)
OPEX_LVcons	-	1.281***	1.148***	1.125***
	-	(0.323)	(0.306)	(0.316)
PERC_NR	101.97	117.11	129.57	188.18
	(132.08)	(124.130)	(124.36)	(137.37)
UNDER*REGII	-	-	-	9.35
	-	-	-	(17.48)
AUTO_LVcons*REGII	-	-	-	13.07
	-	-	-	(22.54)
PC_LVcons*REGII	-	-	-	1.164
	-	-	-	(4.009)
OPEX_LVcons*REGII	-	-	-	-0.598**
	-	-	-	(0.267)
Constant	375.01	-110.10	186.57	70.32
	(184.70)	(95.81)	(186.60)	(220.77)
Unit dummies	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
R-squared	0.338	0.350	0.368	0.377
Observations	690	690	690	690
Number of units	115	115	115	115

Causality test/1: Investment and incentives

Investment and Incentives			
Dep. Variable: *IK*		Dep. Variable: *INC*	
α_{t-1}	-0.324	α_{t-1}^{IK}	-38.178
	(0.418)		(37.644)
α_{t-2}	-0.160*	α_{t-2}^{IK}	-8.880
	(0.086)		(8.290)
β_{t-1}^{INC}	-0.001	β_{t-1}	0.202
	(0.002)		(0.135)
β_{t-2}^{INC}	0.005**	β_{t-2}	0.348
	(0.002)		(0.221)
Constant	0.082**	Constant	3.099
	(0.035)		(3.021)
P-value test on H_0: $\beta_{t-1}^{INC} = \beta_{t-2}^{INC} = 0$	0.038	P-value test on H_0: $\alpha_{t-1}^{IK} = \alpha_{t-2}^{IK} = 0$	0.558
P-value test on H_0: $\beta_{t-1}^{INC} + \beta_{t-2}^{INC} = 0$	0.079	P-value test on H_0: $\alpha_{t-1}^{IK} + \alpha_{t-2}^{IK} = 0$	0.299
Obs. [Nr. Unit]	345 [115]	Obs. [Nr. Unit]	345 [115]
Hansen test	0.648	Hansen test	0.293
AR1	0.910	AR1	0.218

Same results hold with *Rewards* only

Causality test/2: Operational expenxes and incentives

Operational expenditures and Incentives			
Dep. Variable: *OpK*		Dep. Variable: *INC*	
α_{t-1}	0.819***	α_{t-1}^{OpK}	13.768
	(0.301)		(13.318)
α_{t-2}	0.121***	α_{t-2}^{OpK}	5.230
	(0.035)		(5.843)
β_{t-1}^{INC}	0.002*	β_{t-1}	0.259**
	(0.001)		(0.107)
β_{t-2}^{INC}	-0.003***	β_{t-2}	0.105
	(0.001)		(0.071)
Constant	0.025	Constant	-2.465
	(0.043)		(2.378)
P-value test on H_0 $\beta_{t-1}^{INC} = \beta_{t-2}^{INC} = 0$	0.007	P-value test on H_0: $\alpha_{t-1}^{OpK} = \alpha_{t-2}^{OpK} = 0$	0.582
P-value test on H_0: $\beta_{t-1}^{INC} + \beta_{t-2}^{INC} = 0$	0.597	P-value test on H_0: $\alpha_{t-1}^{OpK} + \alpha_{t-2}^{OpK} = 0$	0.301
Obs. [Nr. Unit]	345 [115]	Obs. [Nr. Unit]	345 [115]
Hansen test	0.513	Hansen test	0.027
AR1	0.100	AR1	0.014

Investment model

- We estimate the following model:

$$IK_{i,t} = \alpha_0 + \alpha_1 IK_{i,t-1} + \alpha_2 \Delta SK_{i,t} + \alpha_3 \Pi K_{i,t} + \alpha_4 INCK_{i,t-1} + I_t + \mu_i + \varepsilon_{it}$$

with *lagged investment ratio* ($IK_{i,t-1}$), *demand growth* ($\Delta SK_{i,t}$), the operating cash flow to capital stock ratio ($\Pi K_{i,t}$) to control for *financing constraints*, as well as the aggregate incentive variable (INC_t/K_{t-1}) - replaced by $REWARDK_{i,t-1}$, $PENALTYK_{i,t-1}$ - I_t and μ_i are the Zone and year dummies, while ε_{it} is the error term.

- Dynamic panel analysis (GMM-SYS) with internal *and* external instruments ($\rightarrow$ perc. non res users; population density; area covered by forest; North dummy)
- Two-step procedure (Wintoki, *et al.*, 2012) to test the weak identification of the instrument set.

Investment analysis/1

Dep. Variable: $IK_{i,t}$	(1) *Incentives*	(2) *Rewards*	(3) *Penalties*
$IK_{i,t-1}$	0.107	0.105	0.118
	(0.089)	(0.089)	(0.085)
$\Delta SK_{i,t}$	0.133***	0.133***	0.134***
	(0.024)	(0.024)	(0.022)
$\Pi K_{i,t}$	0.066***	0.068***	0.081***
	(0.018)	(0.019)	(0.015)
$INCK_{i,t-1}$	0.241	-	-
	(0.196)	-	-
$REWARDK_{i,t-1}$	-	0.233	-
	-	(0.207)	-
$PENALTYK_{i,t-1}$	-	-	-1.552**
	-	-	(0.679)
Constant	0.033***	0.033***	0.030***
	(0.006)	(0.006)	(0.006)
Unit dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
AR1 *(p-value)*	0.006	0.006	0.005
AR2 *(p-value)*	0.556	0.559	0.735
Hansen test of over-identification *(p-value)*	0.454	0.477	0.673
Diff-in-Hansen test of exogeneity *(p-value)*	0.900	0.802	0.922
Number of Instruments	25	25	27
Cragg-Donald weak identification test statistic (levels)	31.49	31.19	40.88
Cragg-Donald weak identification test statistic (first-diff)	67.50	61.36	75.89
Observations	460	460	460
Number of units	115	115	115

Investment analysis/2: subsamples

Dep. Variable: $IK_{i,t}$	(1) *High performance Units* (SAIDI ≤ 32) **I Quartile**	(2) *Average performance Units* (32 < SAIDI < 73.9) **II-III Quartile**	(3) *Average performance Units* (32 < SAIDI < 73.9) **II-III Quartile**	(4) *Poor performance Units* (SAIDI ≥ 73.9) **IV Quartile**
$IK_{i,t-1}$	0.099	0.173	0.112	0.342
	(0.072)	(0.199)	(0.152)	(0.276)
$\Delta SK_{i,t}$	0.160***	0.169***	0.168**	0.585**
	(0.021)	(0.066)	(0.085)	(0.245)
$\Pi K_{i,t}$	0.074**	0.186**	0.189***	0.074
	(0.030)	(0.080)	(0.071)	(0.077)
$REWARDK_{i,t-1}$	0.417**	-0.226	-	-
	(0.212)	(0.185)	-	-
$PENALTYK_{i,t-1}$	-	-	-0.704	-1.459*
	-	-	(1.015)	(0.767)
Constant	0.030***	0.003	0.006	0.017
	(0.008)	(0.016)	(0.017)	(0.026)
Unit dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
AR1 *(p-value)*	0.009	0.054	0.047	0.053
AR2 *(p-value)*	0.744	0.907	0.832	0.780
Hansen test *(p-value)*	0.155	0.365	0.414	0.107
Diff-in-Hansen test of exogeneity *(p-value)*	0.100	0.115	0.226	0.355
Number of Instruments	25	21	21	21
Observations	138	238	236	86
Number of units	44	83	83	36

Conclusions

- The physical assets as well as the level of operational expenditures have a significant effect on quality improvements
- Output-based incentives have a significant effect on the use of the firm's resources:
  - Areas which received a penalty responded to the output-based incentives with an increase in capital expenditures, especially so in low performance areas.
  - Rewards did not appear to play any significant role in modifying the firm's investment rate, apart for high-performance areas.
  - Asymmetric effect of incentive schemes

References / 1: Academic Papers

- Armstrong, M. and D. Sappington (2006), "Regulation, Competition and Liberalization", *Journal of Economic Literature*, **XLIV**, 325-366.
- Armstrong, M. and D. Sappington (2007) "Recent Developments in the Theory of Regulation," in M. Armstrong and R. Porter (eds.), *Handbook of Industrial Organization (Vol. III)*, Elsevier Science Publishers: Amsterdam.
- Bourreau M., C. Cambini and S. Hoernig (2012). "Ex-ante regulation and co-investment in the transition to next generation access", *Telecommunications Policy* 36, 99-406.
- Bourreau M., C. Cambini and P. Dogan (2012). "Access pricing, competition, and incentives to migrate from "old" to "new" technology", *International Journal of Industrial Organization* 36, 399-406.
- Bourreau M., C. Cambini and P. Dogan (2014). "Access regulation and the transition from copper to fiber networks in telecoms", *Journal of Regulatory Economics*, 45(3), 233-258.
- Cambini C. and Y. Jiang (2009). "Broadband investment and regulation: A literature review," *Telecommunications Policy*, Vol. 33, pp. 559-574.
- Cambini C. and L. Rondi (2010), "Incentive regulation and investment: evidence from European energy utilities", *Journal of Regulatory Economics*, 38(1), 1-26.
- Cambini C., E. Fumagalli and L. Rondi (2016), "Incentives to quality and investment: evidence from electricity distribution in Italy», *Journal of Regulatory Economics*, 49, 1-32.
- Cambini C. and L. Rondi (2016), "Independent Regulation, Investment and Political Interference: Evidence from EU", *Economic Inquiry*, forthcoming

References/2: Academic Papers

- Czernich, N., Falck, O., Kretschmer, T. and Woessmann, L., (2011). Broadband Infrastructure and Economic Growth. *The Economic Journal*, 121, 505-532.
- Grajek, M., and L.H. Röller (2011), Regulation and Investment in Network Industries: Evidence from European Telecoms, *Journal of Law and Economics* 55, 189-216.
- Guthrie G. (2006). "Regulating infrastructure: The impact of risk and investment," *Journal of Economic Literature*, Vol. 44, p. 925-972.
- Joskow, P.L. (2008), "Incentive regulation and its application to electricity networks", *Review of Network Economics*, 7(4): 547-560.
- Ofgem (2010), "Handbook for implementing the RIIO model". Available from: www.ofgem.gov.uk.
- Roller, L. H. and Waverman, L., (2001). „Telecommunications Infrastructure and Economic Development: A Simultaneous Approach". *American Economic Review,* 91(4,) 909-923
- Sappington, D.E.M. (2005), "Regulating service quality: a survey", *Journal of Regulatory Economics*, 27(2): 123-154.
- Shleifer A., Vishny R.W. (1994). "Politicians and firms", *Quarterly Journal of Economics,* 9, 995–1025.
- Vogelsang, I. (2002), "Incentive Regulation and Competition in Public Utility Markets: A 20-Year Perspective", *Journal of Regulatory Economics*, **22(1)**, 5-27.