Is there a level of competition intensity that maximizes investment in the mobile telecommunications industry?

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Introduction

- A fierce debate between the telecom industry and EU regulators about the existence of an optimal level of competition.

- *“Competition is the most important single driver of innovation, competitiveness and therefore growth.”* Joaquim Almunia (2012)

- “*EU regulatory policies have resulted in a fragmented market structure which prevents carriers from capturing beneficial economies of scale and scope and retards the growth of the mobile wireless ecosystem. ”* GSMA (2013)

- The current state of the literature does not help to settle this debate.
- Research question : How much competition is optimal for investment in new technologies ?

Related literature (Theory)

- At the micro-economic level, any kind of relationship between competition and investment is possible : Schmutzler (2010)
- At the macro level, Aghion et al. (2005) design a growth model that yields an inverted-U relationship
- The impact of competition on investment depends on how far a firm is from the technological frontier : Boone (2000), Aghion et al. (2005)

Related literature (Empiric)

- Cross-industry studies are plagued with an unobserved difference in technological opportunities across industries, (Kamien & Schwartz, 1975)

- Cross-firms studies are plagued with the unobserved difference in efficiency across firms.

- Reverse causality running from investment to competition :
  - Aghion et al. (2005) use EU's common market policies as instruments and find an inverted-U relationship.
  - Darai et al. (2010) use experimental method to identify a U-shaped relationship.

- Lack of data does not help the existing literature to provide a robust empirical evidence.

Main results

- **There is actually an inverted-U relationship** between competition and investment in the wireless communications industry.

- Based on the Lerner index, the average optimal level of competition stands at 62% which means at a **38% rate of margin** with a 95% confidence interval (58%-66%)

- **Technological progress** tends to shift the optimal level of competition toward lower intensity.

Dataset

- Accounting data on investment (capex), operational profit (ebitda), revenue and market share : WCIS (Informa Telecom)

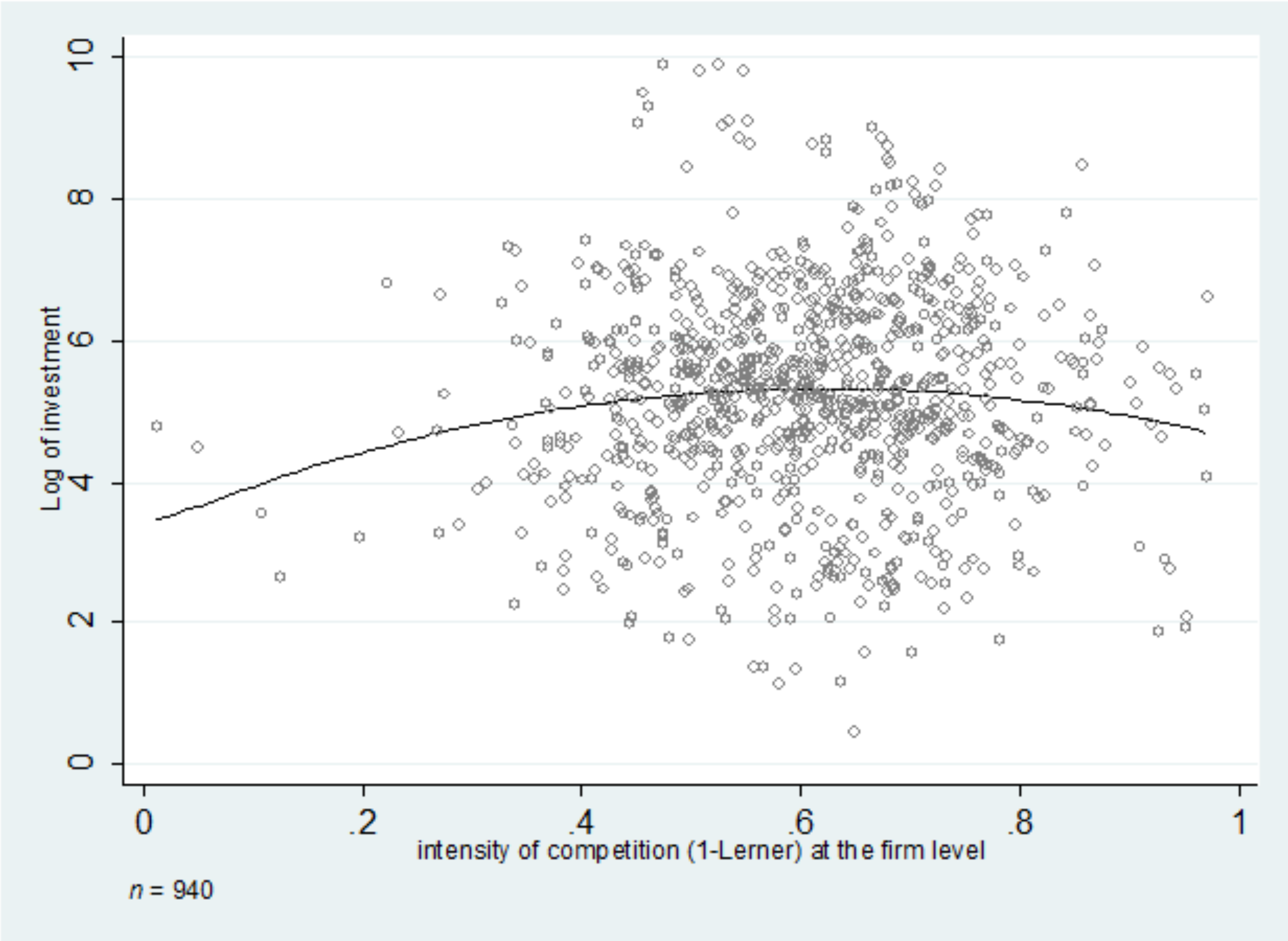
- Date of entry, radio spectrum release, entry, merger and exit : Wireless Intelligence (GSMA)

- Population size, population density and GDP per capita : World Development indicator (World Bank)

- Unbalanced panel of 187 mobile network operators worldwide (77 countries), from 2003 to 2012 : 1075 observations

- 135 observations corresponding to the licenses buying are released to have only investment in improving quality. Remains 940 observations.

Scatter plot



Variables

- Variables of interest:
  - Investment as the annual expenditures in durable assets (more than one year)
  - Competition as $1 - Lerner$, i.e. $1 - ebitda/revenue$
- Instruments:
  - Number of radio spectrum bands released before 2005 (excluded)
  - Year of entry into the market
- Control variables:
  - Cost and demand shifters : GDP per capita, Population density
  - Market maturity : rate of penetration of mobile communications
  - Firms characteristics : Rank according to market share, Fixed incumbent operator
  - Market dynamics : Entry, Merger, Exit in/from a market

Econometric model

- Generic model:

$$Investment = f(C, D, \theta)$$

C: Cost shifter; D: demand shifter; θ: Competition index

- Model:

$$Ln(Capex) = \alpha + \beta_1\theta + \beta_2\theta^2 + \sum_i \lambda_i X_i + \varepsilon$$

$$\theta = 1 - L; L = Ebitda/Revenue$$

X_i control variables: GDP per Capita; Population density; rate of penetration; rank of the firm, incumbent, entry, merger

Optimal level of competition

- There is an inverted U relationship if $\beta_1 > 0 \; and \; \beta_2 < 0$
- The optimal level of competition is:

$$\hat{\theta} = \frac{-\beta_1}{2\beta_2}$$

- The confidence interval of $\hat{\theta}$ is estimated using the Delta method.
- Instrumental variable estimation using the Generalized Method of Moments (dealing with heteroskedascity and serial correlation)
- Two instruments: Number of Radio spectrum bands released before 2005, and the year of entry into the market

The role of radio spectrum policies

- A key input for the provision of wireless communications services.
- Pro-competitive governments release more radio spectrum and earlier to promote entry.
- The number of radio spectrum released before a given year determines the intensity of competition afterwards.
- The year of entry of a mobile network operator is exogenously determined by government’s regulation.

Estimation Results (Selection of the model)

	Log of investment					
	(1)	(2)	(3)	(4)	(5)	(6)
Competition	0.302	5.883*	6.520***	53.67***	82.76***	67.41***
	(0.837)	(3.061)	(1.560)	(10.43)	(16.56)	(13.51)
Squared of competition		-4.780**	-5.727***	-44.84***	-69.94***	-53.64***
		(2.273)	(1.217)	(9.163)	(14.71)	(11.87)
Log of population density			0.015	-0.061	-0.005	-0.056
			(0.056)	(0.039)	(0.045)	(0.038)
Log of active pop.			0.744***	0.783***	0.738***	0.838***
			(0.050)	(0.051)	(0.058)	(0.044)
Incumbent			0.226*	0.287	-0.132	0.104
			(0.119)	(0.200)	(0.192)	(0.190)
Entry						-0.197*
						(0.107)
Merger						0.133
						(0.208)
Exit						-0.183
						(0.244)
Regional effects	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes	Yes	Yes
Constant	5.053***	3.142***	-8.647***	-22.34***	-30.05***	-28.37***
	(0.522)	(0.962)	(0.999)	(3.021)	(4.443)	(3.840)
Observations	940	940	940	937	894	815
R-squared	0.001	0.028	0.698			
Optimal level of competition:						
Lower bound		0.45	0.51	0.55	0.56	0.58
Mean		**0.62**	**0.57**	**0.60**	**0.59**	**0.63**
Upper bound		0.78	0.63	0.64	0.63	0.68

Significant at 1% (***), 5% (**) and 10% (*). OLS estimation in specifications (1), (2) and (3). Instrumental variable estimation using the Generalized Method of Moment in specifications (4), (5) and (6). Robust standard errors are in parentheses, clustered at the country level for the OLS estimation.
Specifications (1) to (4) rely on the full sample. Specification (5) drops extreme values from the original sample. Specification (6) drops extreme values and restricts the sample to firms that enter into the market before 2003.
Competition is measured as the complement to one of the Lerner index of monopoly power. This latter is measured as the ratio of profit over revenue.
The endogenous variables "Competition" and the "squared of competition" have been instrumented by i) the number of radio spectrum allocated to mobile telecommunications services before 2005 (excluded) in a given country and by ii) the date of entry of a given firm into the mobile telecommunications market.
The optimal level of competition and its confidence interval are estimated using the "delta method".

Results and statistical tests

	Log (invest) IV-GMM (1)	Log(revenue) IV-GMM (2)	Log(revenue) OLS	Invest./Revenue IV-GMM (3)
Competition	71.00***	114.5***		-7.837***
	(14.57)	(19.07)		(2.023)
Squared of competition	-57.04***	-90.93***		6.273***
	(11.88)	(15.53)		(1.612)
Log of investment			0.874***	
			(0.037)	
Log active pop.	0.822***	0.752***	-0.008	0.015**
	(0.045)	(0.063)	(0.037)	(0.007)
Region fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	No
Observations	815	815	815	815
R-squared			0.881	
Optimal level of competition:				
Lower bound	0.58	0.59		0.57
Mean	**0.62**	**0.63**		**0.62**
Upper bound	0.66	0.67		0.68
Underidentification test (H0: model is underidentified)				
Kleibergen-Paap rk LM statistic (Chi2)	14.11***	14.12***		14.12***
Weak identification test (H0: weak instrument)				
Kleibergen-Paap Wald rk F-stat	8.14	8.14		8.14
Weak-instrument-robust inference (H0: Endogenous regressors are not jointly significant)				
Anderson-Rubin Wald test F-stat	18.20***	49.93***		12.67***
Endogeneity test (H0: comp and comp2 are exogenous)				
Chi-squared statistics	25.51***	57.19***		18.27***

Significant at 1% (***), 5% (**) and 10% (*). Standard errors in parenthesis are robust to heteroskedasticity and auto-correlation of order 1. Auto-correlation is corrected for by using the Newey-West kernel function.
The sample includes all firms that enter into the market before 2003, excluding outliers.

Exogeneity of the instruments

- Two endogenous regressors, two instruments : No over identification test

- Number of frequency bands allocated to mobile communications before 2005
  - Not determined by the firms, but by the government
  - Determined by government before investment and competition took place (results are robust to constraining the data to 2005-2012)
  - Different from the number of spectrum licenses allocated to mobile operators : only capture government pro-competitive behavior

- The year of entry into the market
  - The entry decision is made by the firm but the timing is determined by government's regulation.
  - The year of entry for firms that enter before 2003 : before investment and competition take place.

The role of technical progress

- by the firms Escape competition effect: The more intense the competition, the higher the incentives to invest.

- Shumpeterian effect: Investment in new technologies increase profits but the more intense is the competition, the faster is the reaction of the competitors and the shorter is the benefit from investment.

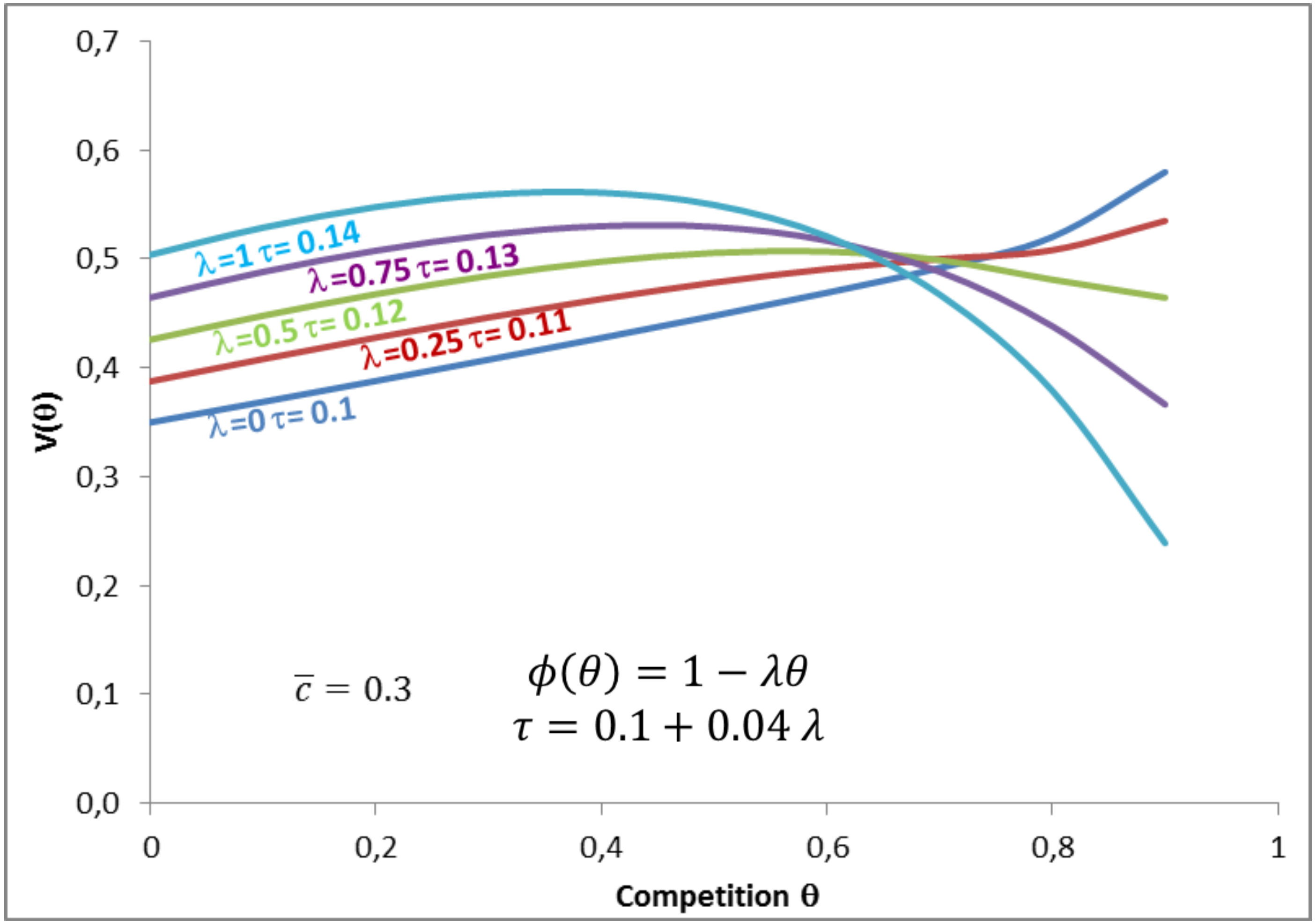
- The combination of those two effects may result in an inverted U relationship

- Technical progress increases the probability that the inversion of the curve occurs and tends to shift the optimal level toward lower intensity of competition.

The role of technical progress

- $V(\theta) = \int_0^T e^{-rt} f(\theta)dt + \int_T^\infty e^{-rt} g(\theta)dt$
- $V = \frac{1}{r}\big(\phi(\theta)f(\theta) + (1-\phi)g(\theta)\big)$ with $\phi(\theta) = 1 - e^{-rt}$
- $f(\theta) = \pi^1(\underline{c},\theta) - \pi^d(\overline{c},\theta)$ and g$(\theta) = \pi^d(\underline{c},\theta) - \pi^d(\overline{c},\theta)$
- $\frac{\partial V}{\partial \theta} = \frac{1}{r}\left(\underbrace{\frac{\partial \phi}{\partial \theta}(f-g)}_{-} + \underbrace{\phi\frac{\partial f}{\partial \theta}}_{+} + \underbrace{(1-\phi)\frac{\partial g}{\partial \theta}}_{-}\right)$; $\frac{\partial f}{\partial \theta} > 0$; $\frac{\partial g}{\partial \theta} < 0$ and $\frac{\partial \phi}{\partial \theta} < 0$
- When $\theta = 0$ (monopoly case); $f = g$; $\phi = 1$ then $\frac{\partial V}{\partial \theta} = \frac{1}{r}\frac{\partial f}{\partial \theta} > 0$
- When $\theta = 1$ (perfect competition), if $\phi(1)$is sufficiently small, then $\frac{\partial V}{\partial \theta} < 0$
- Technical progress increases negative terms and decreases positive term. As a result, it decreases $\frac{\partial V}{\partial \theta}$ and then the maximum is shifted leftward.

Example with Singh & Vives demand function



Technological progress and Investment

- Significant Technological progress
  - The average rate of technological progress for data transmission was 34.7 % between 1940 and 2006 (Koh & Magee, 2006)
  - Every year, several equipment based on new technologies are released by equipment providers.

- Significant and yearly investment in new technologies
  - Equipment are available to all network operators
  - Between 2003 and 2012, the yearly average investment per operator is 636.1 millions of current US dollars

Potential bias Number

- Omitted variables:
  - Market size : overestimate the optimal level or obtain a linear relationship
  - Unobserved efficiency : underestimate the optimal level or obtain a linear relationship
  - Unobserved collusion : overestimate the optimal level or obtain an increasing and linear relationship
- Reverse causality : More investment triggers price competition (overestimate the optimal level of competition)
- Extreme values : in this case, they could drive the inverted-U