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CENTRE ON REGULATION IN EUROPE

Evaluating market consolidation in mobile communications

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Introduction

- Europe is experiencing a merger wave in telecoms
- Focus typically on short run effects (ex. prices); impact on efficiencies (ex. investments) have received less attention
- Telecoms industry is an interesting working environment:
  - Regulation (entry, termination rates)
  - Competition among operators
  - Significant technological change
- Theory ambiguous on the effect of concentration on prices and investment
- No empirical work on the dual relationship between market structure and prices & investment in the mobile telecoms industry

Overview of results

- Data intensive analysis aimed at evaluating the impact of **market structure** 1) on **prices** and 2) **investments**:
  - Most comprehensive data effort so far: quarterly observations for 2002-2014 covering 33 countries (EU plus selected OECD countries): 8k obs
  - Analysing the impact of market structure over and above historical trends (e.g. decline in prices due to technological progress)
- We find a significant trade-off: concentration drives prices and investments up
- Hypothetical symmetric 4 to 3 merger:
  - Prices go up by 16.3% (with 90% confidence interval of 8% – 24%)
  - Capex by operator increases by 19.3% (confidence interval 5% – 35%)

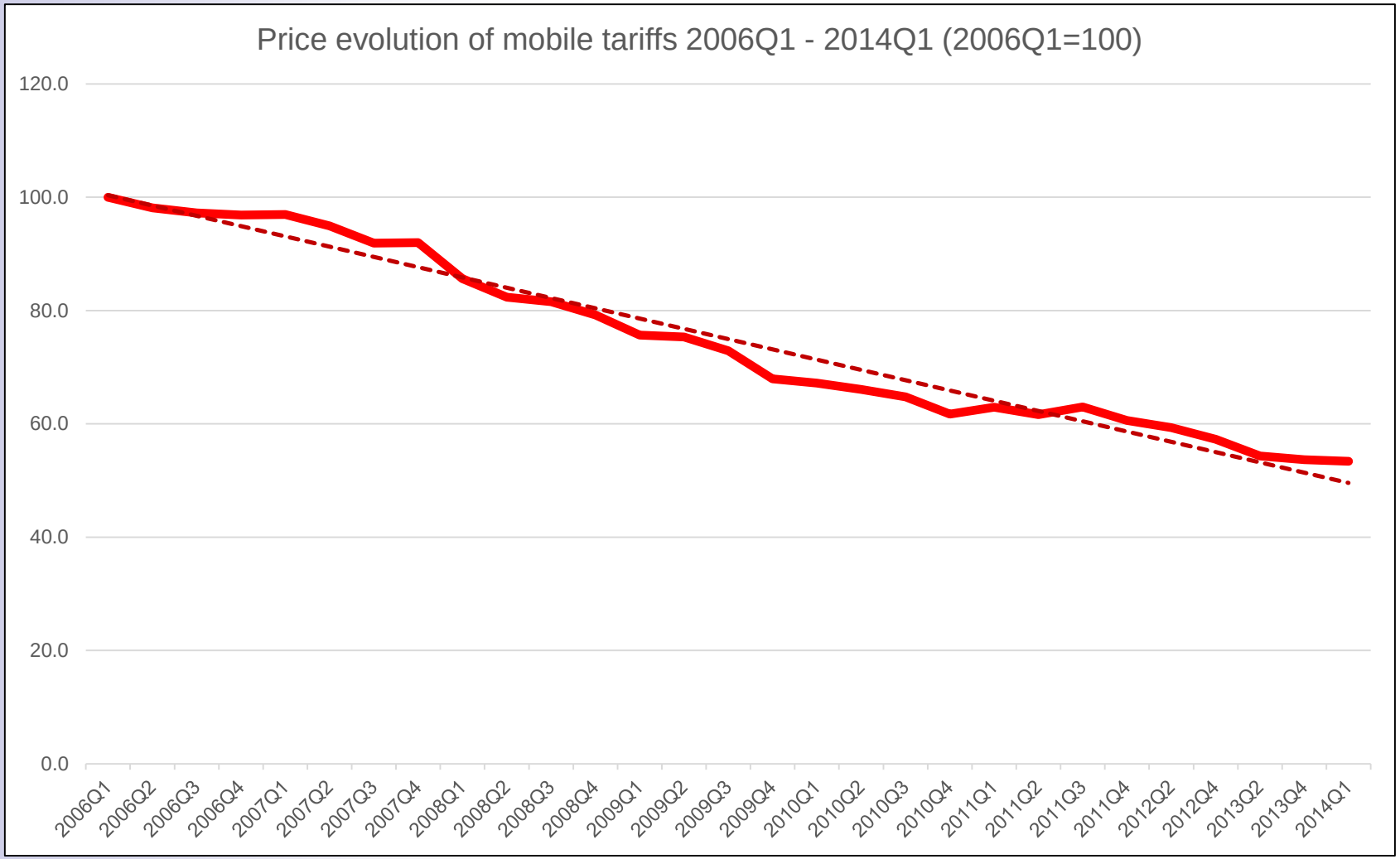
Data (1)

- To our knowledge, the most comprehensive data effort collection exercise so far
  - Period: 2002-2014 (quarterly data)
  - Countries: 33 countries (Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, UK) with gaps
- Sources:
  - Teligen for bills
  - Bank of America/Merrill Lynch for market structure and investments
  - Cullen International and OECD for mobile termination rates
- Key for data collection: sources must be comparable across countries and over time
- We obtained a dataset with almost 8,000 observations, although earlier observations more noisy: our preferred dataset is post-2005 (when Teligen revised basket definition): 5,000+ observations

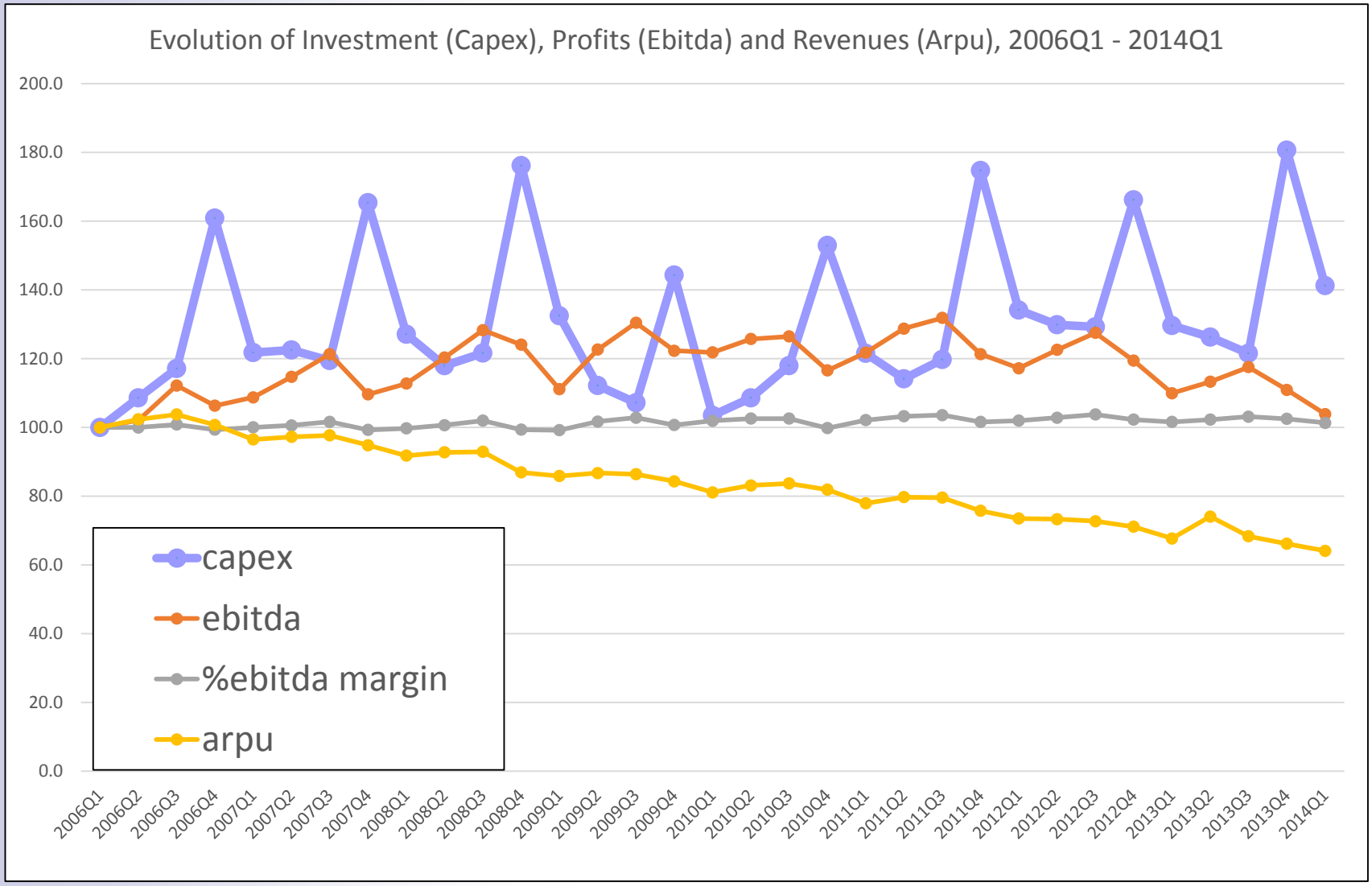
Data (2)

- Price = bill:
  - Total bill paid by consumers with a given usage profile. Fixed weights: 2002, 2006, 2010 and 2012 basket (2012 with data)
  - High/medium/low user
  - Pre-paid and post-paid contracts
- Other key variables:
  - Number of competitors
  - Herfindahl index (HHI)
  - Mobile termination rates (MTRs) and their difference
  - Entry/Exit indicators
  - Time since year of operator entry
  - GDP, etc.
- Empirical strategy is to exploit the panel dimension

Descriptive Statistics



Descriptive Statistics



Descriptive Statistics

Period	2002Q2	2006Q1	2010Q1	2014Q1
	Number of countries	Number of countries	Number of countries	Number of countries
2 competitors	3	3		
3 competitors	14	14	16	18
4 competitors	7	7	10	13
5 competitors	3	3	1	1
6 competitors	1	1	1	1
TOTAL	28	28	28	33

Key descriptive statistics

- Prices have been declining
- Generally, new firms have entered but there has been both entry and exit
- Capex has been going up, while EBITDA up and down
- ARPU has been declining, EBITDA margins stable
- Good news: lots of variation, it's meaningful to conduct a proper empirical test
- We are interested in the impact of market structure over and above any historical trend

Empirical strategy (prices)

- Our baseline specification in levels is

$$\ln P_{uoct} = \alpha_{uoc} + \alpha_t + \beta_1 Mkt\_Str_{ct} + \beta_2 Char_{uoct} + \varepsilon_{uoct}$$

where

  - *P* = consumer total bill, *Mkt_Str* = market structure
  - *u* = usage profile, *o* = operator, *c* = country, *t* = time.

- In estimation we use First Differences (FD) of the above equation to:
  - Control for usage-country-operator unobserved characteristics
  - Control for serial correlation in bills over time
  - Cluster standard errors (s.e.) by usage-country-operator
- $Char_{uoct}$ include pre-paid dummy, GDP, MTR level
- **Mkt_Str**: we use different indicators
  - **Number of licenced operators**: a bit crude, but likely to be exogenous
  - **HHI**: varies smoothly and better reflects market shares, but endogenous => IV: index of **MTR *differences*** and dummies for number of licensed operators

Main results on prices: varying basket & post 2005

Estimation method	(1) FD	(2) FD	(3) FD	(4) IV-FD	(5) IV-FD
Dependent variable	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}
Teligen basket	varying basket	varying basket	varying basket	varying basket	varying basket
Time Period	2006-2014	2006-2014	2006-2014	2006-2014	2006-2014
Number of mobile operators	-0.0855*** (0.0290)				
Four competitors		-0.159*** (0.0425)			
Five+ competitors		-0.0785 (0.0629)			
Cumulative entry			-0.0934* (0.0488)		
Cumulative exit			0.0432* (0.0248)		
HHI				2.037*** (0.637)	2.529** (1.148)
Instrumental Variables				Diff MTR index, Binary indicators for n. of competitors	Diff MTR index, Cumulative entry and cumulative exit
First stage partial R^2 of excl. IVs				0.450	0.302
First stage F-test				33.25 [0.000]	51.49 [0.000]
Observations	4,550	4,682	4,550	4,550	4,550
R^2	0.788	0.787	0.788	0.788	0.787
Clusters	192	192	192	192	192

Interpretation of main results on prices

- Column 1: more firms reduce prices
- Base case is markets with 2-3 operators
  - Column 2: 4th operator reduces prices by 15.9%, 5th + operator does not make additional difference
  - Column 3: asymmetric effect (entry brings prices down by 9.3%, exit pushes prices up by 4.3%)
- HHI:
  - Column 4: 10% increase in HHI causes prices to increase by 20.37%
  - Hypothetical symmetric merger => merger from 4 to 3 in symmetric industry causes price to increase by 16.3% (90% confidence interval of 8% - 24%)
  - Put in perspective: general price drop of 47% over 8 years
  - Quarterly price drop is 2.2%, then it takes roughly 8-9 quarters to reach a 20% price drop, so a merger increasing HHI by 10% is “equivalent” to “going back in time” about two years

Robustness: time period and Europe only

Estimation method	(1) IV-FD	(2) IV-FD	(3) IV-FD	(4) IV-FD
Dependent variable	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}
Teligen basket	Varying basket	Varying basket	Varying basket	Varying basket
Countries	All	All	Europe only	Europe only
Time Period	2006-2014	2002-2014	2006-2014	2002-2014
HHI	2.037*** (0.637)	1.399*** (0.465)	1.028* (0.528)	0.827** (0.375)
Instrumental Variables	Diff MTR index, Binary indicators for competitors	Diff MTR index, Binary indicators for competitors	Diff MTR index, Binary indicators for competitors	Diff MTR index, Binary indicators for competitors
First stage partial R2 of excl. IVs	0.450	0.194	0.585	0.2306
First stage F-test	33.25 [0.000]	42.03 [0.000]	15927.21 [0.000]	951.12 [0.000]
Observations	4,550	6,044	3,632	4,886
R2	0.788	0.782	0.895	0.888
Clusters	192	201	150	156

Robustness: Teligen basket composition

Estimation method	(1) IV-FD	(2) IV-FD	(3) IV-FD	(4) IV-FD	(5) IV-FD
Dependent variable	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}
Teligen basket	Varying basket	Varying basket	2002 basket	2002 basket	2006 basket
Time Period	2006-2014	2002-2014	2006-2014	2002-2014	2006-2014
HHI	2.037*** (0.637)	1.399*** (0.465)	1.293*** (0.375)	1.048*** (0.351)	1.628*** (0.450)
Instrumental Variables	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.450	0.194	0.453	0.194	0.455
First stage F-test	33.25 [0.000]	42.03 [0.000]	33.44 [0.000]	41.94 [0.000]	58.58 [0.000]
Observations	4,550	6,044	4,533	6,027	4,590
R^2	0.788	0.782	0.094	0.088	0.021
Clusters	192	201	192	201	192

Robustness: Teligen usage types

Estimation method	(1) IV-FD	(2) IV-FD	(3) IV-FD
Dependent variable	lnP_{uoct}	lnP_{uoct}	lnP_{uoct}
Teligen basket	Varying basket	Varying basket	Varying basket
Usage profile	Low	Medium	High
Time Period	2006-2014	2006-2014	2006-2014
HHI	1.751* (0.904)	2.142* (1.172)	2.246* (1.182)
Instrumental Variables	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.450	0.450	0.450
First stage F-test	10.35 [0.000]	10.96 [0.000]	11.01 [0.000]
Observations	1,520	1,516	1,514
R^2	0.916	0.791	0.741
Clusters	64	64	64

Empirical strategy (investment)

- Our baseline specification (operator level) in levels is:

$$\ln CAPEX_{oct} = \alpha_c + \alpha_t + \beta_1 Mkt\_Str_{oct} + \beta_2 Op\_Char_{oct} + \varepsilon_{oct}$$

where

  - o = operator, c = country, t = time
  - *CAPEX* = capital expenditures
  - We also present results for alternative measures: EBITDA, EBITDA margin, ARPU

- **Also run the equation at country level** (adjusted by market share):

$$\ln TOTCAPEX_{ct} = \alpha_c + \alpha_t + \beta_1 Mkt\_Str_{ct} + \beta_2 Mkt\_Char_{ct} + \varepsilon_{ct}$$

- We use Fixed Effects (FE) of the above equation to:
  - Control for country (and operator) unobserved characteristics
  - Capex is most often lumpy and not serially correlated
  - Cluster s.e. by country-operator

Main results on CAPEX: post 2005/operator level

Estimation method	(1) FE	(2) FE	(3) FE	(4) IV-FE	(5) IV-FE
Dependent variable	$lnCAPEX_{oct}$	$lnCAPEX_{oct}$	$lnCAPEX_{oct}$	$lnCAPEX_{oct}$	$lnCAPEX_{oct}$
Time Period	2006-2014	2006-2014	2006-2014	2006-2014	2006-2014
Number of mobile operators	-0.107** (0.0416)				
Four competitors		-0.183*** (0.0612)			
Five+ competitors		-0.253** (0.120)			
Cumulative entry			-0.110 (0.0695)		
Cumulative exit			0.0560 (0.0541)		
HHI				2.410** (1.164)	2.786** (1.204)
Instrumental Variables				Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Cumulative entry and cumulative exit
First stage partial R^2 of excl. IVs				0.586	0.476
First stage F-test				252.24 [0.000]	65.38 [0.000]
Observations	2,202	2,202	2,202	2,073	2,073
R^2	0.173	0.174	0.173	0.139	0.137
Clusters	78	78	78	75	75

Interpretation of main results on CAPEX

- Column 1: Capex per operator goes down by 10.7% with additional operator
- Base case is markets with 2-3 operators
  - Column 2:
    - 4th operator reduces Capex by 18%
    - 5th + operator reduces Capex by an additional 7%
  - Column 3: asymmetric effect of cumulative entry and cumulative exit increases Capex by more (but not significant)
- HHI:
  - Column 4 : 10% increase in HHI causes Capex to increase by 24.1%
  - Hypothetical symmetric merger -> merger from 4 to 3 in symmetric industry causes Capex to increase by 19.3% (90% confidence interval 4 – 34%)
- Note: being early in the market increases Capex, but the order of entry does not matter
- Note: these are results on Capex per operator

Robustness: alternative samples

Estimation method	(1) FE	(2) FE	(3) FE	(4) FE
Dependent variable	$\ln CAPEX_{oct}$	$\ln CAPEX_{oct}$	$\ln CAPEX_{oct}$	$\ln CAPEX_{oct}$
Countries	All	All	Europe only	Europe only
Time Period	2006-2014	2002-2014	2006-2014	2002-2014
HHI	2.410** (1.164)	1.400* (0.796)	2.075* (1.149)	1.119 (0.786)
Instrumental Variables	Diff MTR index$_{ct}$, Binary indicators for the number of competitors	Diff MTR index$_{ct}$, Binary indicators for the number of competitors	Diff MTR index$_{ct}$, Binary indicators for the number of competitors	Diff MTR index$_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.586	0.640	0.614	0.672
First stage F-test	252.24 [0.000]	168.70 [0.000]	534.62 [0.000]	500.43 [0.000]
Observations	2,073	2,269	1,612	1,789
R^2	0.139	0.143	0.161	0.162
Clusters	75	75	59	59

Main results on CAPEX: post 2005/country level

Estimation method	(1) FE	(2) FE	(3) FE	(4) IV-FE	(5) IV-FE
Dependent variable	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$
Time Period	2006-2014	2006-2014	2006-2014	2006-2014	2006-2014
Number of mobile operators	-0.0358 (0.0439)				
Four competitors		-0.0594 (0.0672)			
Five+ competitors		-0.0877 (0.0872)			
Cumulative entry			-0.0558 (0.0950)		
Cumulative exit			0.0179 (0.0525)		
HHI				1.196 (1.592)	1.457 (1.240)
Instrumental Variables				Diff MTR $index_{ct}$, Binary indicators for the n. of competitors	Diff MTR $index_{ct}$, Cumulative entry and cumulative exit
First stage partial R^2 of excl. IVs				0.542	0.408
First stage F-test				70.81 [0.000]	11.82 [0.000]
Observations	720	720	720	618	618
R^2	0.030	0.030	0.031	0.022	0.018
Clusters	27	27	27	24	24

Robustness (country level): alternative samples

Estimation method	(1) FE	(2) FE	(3) FE	(4) FE
Dependent variable	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$	$lnCAPEX_{ct}$
Countries	All	All	Europe only	Europe only
Time Period	2006-2014	2002-2014	2006-2014	2002-2014
HHI	1.196 (1.592)	0.354 (0.956)	-1.362 (1.425)	-1.029* (0.554)
Instrumental Variables	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.542	0.621	0.523	0.652
First stage F-test	70.81 [0.000]	38.38 [0.000]	330.54 [0.000]	125.00 [0.000]
Observations	618	671	467	514
R^2	0.022	0.032	0.140	0.130
Clusters	24	24	18	18

Results on alternative measures (operator level)

Estimation method	(1) FE	(2) FE	(3) FE	(4) FE
Dependent variable	$lnCAPEX_{oct}$	$lnEBITDA_{oct}$	EBITDA $Margin_{oct}$	$lnARPU_{oct}$
Countries	All	All	All	All
Time Period	2006-2014	2006-2014	2006-2014	2006-2014
HHI	2.410** (1.164)	4.809*** (1.531)	0.537** (0.267)	0.115 (0.627)
Instrumental Variables	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.586	0.613	0.614	0.612
First stage F-test	252.24 [0.000]	309.02 [0.000]	307.69 [0.000]	311.34 [0.000]
Observations	2,073	2,231	2,221	2,338
R^2	0.139	0.596	0.371	0.051
Clusters	75	80	79	81

Additional results at operator level

- EBITDA: Interpretation in line with results on Capex
- EBITDA margins: Interpretation in line with results on prices (but weaker)
- ARPU: Basically… nothing!
- Not an interesting variable to look at in any case: revenues/subscribers
  - It is an average price and not a true index
  - It mixes true price effects from changing basket of goods
- Note: Since ARPU does not change while EBITDA margins go up… and EBITDA margin can be rewritten as 1 – ACPU/ARPU … suggests that average costs per user decrease in more concentrated markets
- We also analysed the impact of market structure on market penetration: we found no effect. Possibly because many markets already saturated, though some still growing over the period.

Asymmetric merger effects

Country	Austria		Netherlands		UK	
Time of merger	2013Q1		2007Q4		2010Q2	
Type of merger	4 to 3		4 to 3		5 to 4	
Buyer	3 (Hutchison)		T-Mobile		T-Mobile	
Market share buyer	11%		15%		21%	
Seller	Orange		Orange		Orange	
Market share seller	19%		12%		20%	
HHI before	0.291		0.347		0.221	
HHI after	0.355		0.383		0.288	
Change in HHI	0.064		0.036		0.067	
Predicted change in price	**6.6%**		**3.7%**		**6.9%**	
90% confidence interval	1.0%	12.2%	0.6%	6.8%	1.1%	12.7%
Predicted change in investment	**13.3%**		**7.5%**		**13.9%**	
90% confidence interval	1.2%	25.5%	0.7%	14.3%	1.2%	26.5%

Summary and caveats

- First systematic empirical analysis on average effects across markets over time
- We establish the presence of a trade-off:
  - Concentration drives prices up (relative to a declining trend)
  - Concentration drives Capex up (relative to an increasing trend)
- To assess overall welfare changes, one would need to assess impact on demand of Capex (not possible in our data)
- Caveats
  - MVNOs missing from analysis
  - Teligen prices refer to the two largest companies
  - Country case studies would be valuable

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Descriptive Statistics

Variable	Obs	Mean	SD	Obs	Mean	SD
	Teligen dataset (2002 – 2014)			Teligen dataset (2006-2014)		
Mobile price (P_{uoct})	7789	559.7	2760.7	5329	564.7	3328.2
Num. of comp. (N_{ct})	7378	3.556	0.925	5002	3.558	0.830
Four competitors dummy (0/1)	7789	0.293	0.455	5329	0.343	0.475
Five+ competitors dummy (0/1)	7789	0.113	0.317	5329	0.078	0.268
Cumulative entry	7378	0.382	0.536	5002	0.419	0.548
Cumulative exit	7378	0.298	0.607	5002	0.383	0.686
HHI	7330	0.371	0.078	5002	0.359	0.065
Pre-paid dummy (0/1)	7789	0.349	0.477	5329	0.360	0.480
GDP per capita	7510	37,803	20,813	5134	41,181	21,964
MTR	6679	0.105	0.068	4930	0.087	0.058
MTR_Diff_{ct}	6760	0.502	2.595	4930	0.301	1.436

Descriptive Statistics

	Bank of America Merrill Lynch dataset (2002 – 2014)			Bank of America Merrill Lynch dataset (2006 – 2014)		
$CAPEX_{oct}$	2573	159.6	257.6	2345	164.9	267.0
$EBITDA_{oct}$	3004	376.5	545.1	2715	386.1	560.2
$EBITDA\ margin_{oct}$	4666	0.321	0.237	2704	0.349	0.221
$ARPU_{oct}$	4994	35.205	62.213	2875	32.793	81.086
Num. of comp. (N_{ct})	5049	3.805	1.013	2903	3.725	0.866
Four competitors dummy (0/1)	5049	0.361	0.480	2903	0.429	0.495
Five+ competitors dummy (0/1)	5049	0.188	0.391	2903	0.118	0.323
Cumulative entry	5049	0.317	0.481	2903	0.372	0.483
Cumulative exit	5049	0.297	0.597	2903	0.454	0.711
HHI	5049	0.361	0.077	2903	0.349	0.069
GDP per capita	4793	33,782	16,886	2761	39,335	17,791
MTR	3922	0.123	0.089	2495	0.084	0.064
MTR_Diff_{ct}	3957	0.444	2.325	2495	0.317	1.443

Results on alternative measures (country level)

Estimation method	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE
Dependent variable	$lnCAPEX_{ct}$ - adjusted	$lnCAPEX_{ct}$ - unadjusted	$lnEBITDA_{ct}$ - adjusted	$lnEBITDA_{ct}$ - unadjusted	$lnSubscribers_{ct}$
Countries	All	All	All	All	All
Time Period	2006-2014	2006-2014	2006-2014	2006-2014	2006-2014
HHI	1.196 (1.592)	3.088* (1.859)	0.537 (0.787)	2.519*** (0.680)	0.441 (0.485)
Instrumental Variables	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors	Diff MTR $index_{ct}$, Binary indicators for the number of competitors
First stage partial R^2 of excl. IVs	0.542	0.542	0.542	0.559	0.559
First stage F-test	70.81 [0.000]	70.81 [0.000]	70.81 [0.000]	72.14 [0.000]	72.14 [0.000]
Observations	618	618	618	624	624
R^2	0.022	0.023	0.010	0.042	0.065
Clusters	24	24	24	24	24