A Retrospective Study of State Aid Control in the German Broadband Market

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State aid in broadband markets

- Development of **broadband infrastructure** supported by most EU Governments, along the lines of the European Digital Agenda
  - ICT as fundamental driver of future competitiveness
  - Internet access is a key element
- Broadband market prone to **market failure**:
  - Network industry with large fixed costs
  - Historically lead by national champions
- Political goal of **universal coverage**
- EU digital agenda targets:
  - 2013: Coverage basic broadband 100%
  - 2020: Coverage 30Mbit/s at 100%
  - 2020: Coverage 100Mbit/s at 50%

State aid in broadband markets

- Ambitious goals set in the digital agenda
  - To advance the speed at the frontier
  - To keep everyone as close as possible to that frontier: **reduce the digital divide**
- **How?** Policy mix of public intervention and private investments
  - Nothing new: in broadband internet access, dates back to open access policies introduced in early 2000s
- Germany (2007 –): ca. 7.9 billion EUR in a range of national & regional projects
  - Basic services in rural regions with limited coverage (our focus)
  - Investment in new generation access (NGA) networks

State aid in broadband markets

- In EU, subsidies allocated by national governments subject **to state aid control**
  - Only allowed if they are expected to effectively solve a market failure
  - **AND** do not impair competition within the European Union (EU)

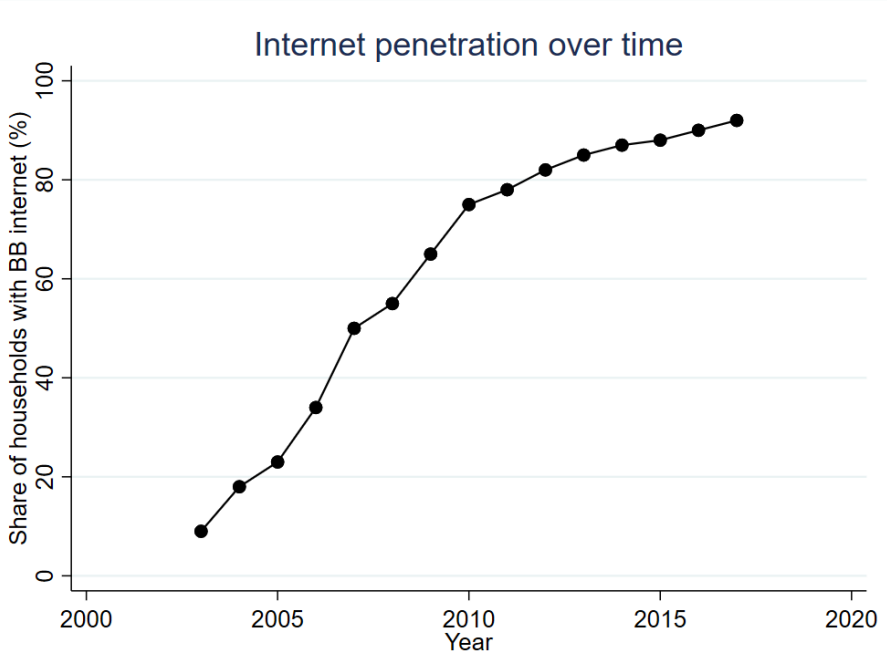
- **This paper:** Ex-post evaluation of state aid control in broadband markets
  - State aid effectiveness – Broadband availability
  - State aid competitive effects – Number of firms (by technology), prices

This paper: setting, methodology and results

- Data: panel of all West German municipalities (2010-2015)
  - Outcomes:
    - ★ Broadband availability (% covered population)
    - ★ Number of ISPs
    - ★ Average price of broadband plans
- Methodology: PS matching + Diff-in-Diff
  - Compare matched municipalities receiving state aid to similar municipalities that did not, before and after the implementation of the aid
    - ★ Robustness: To account for spatial spillovers, we also estimate a spatial autoregressive model
- **Main results:**
  - The aid significantly **increased broadband availability** in aid-receiving areas
  - **Increased number of ISPs** in aid-receiving municipalities
  - **Small effect on prices** (but still work in progress)

Broadband market – I

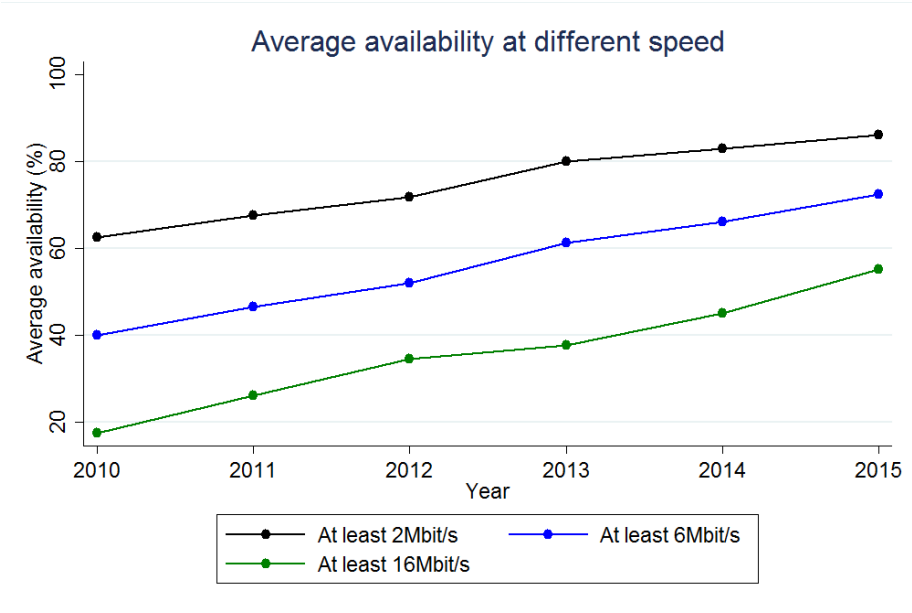
- Broadband technologies have been developed in late 1990s (DSL, conversion of Cable-TV, optic fiber etc.)
- Early 2000s: introduction of open access policies in Europe (Regulation EC 2887/2000 and Directive 2002/19/EC) to break monopoly power of national incumbents and to promote competition downstream
- Years 2000–2010: Boom of internet access

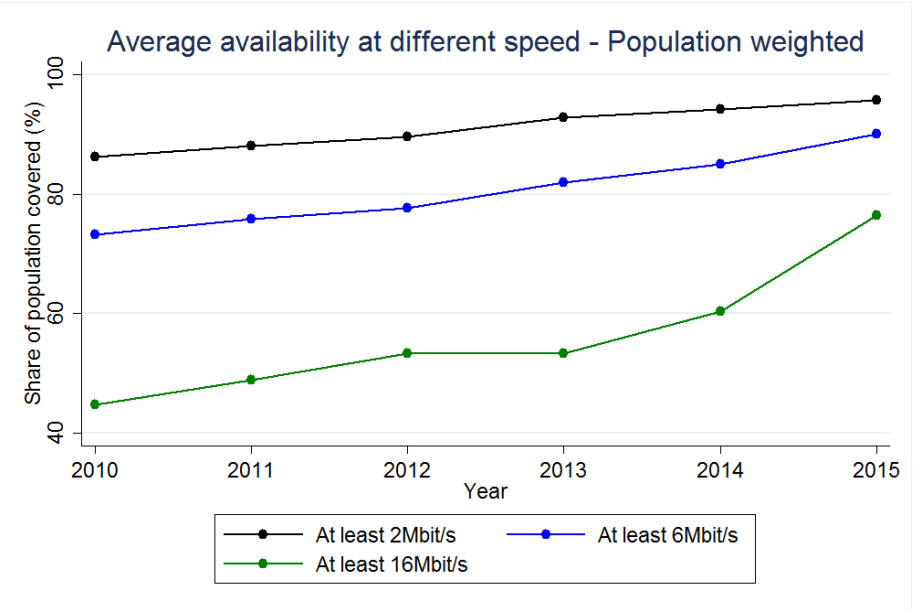


- However, broadband take-up is influenced by demand-side and supply-side factors, the latter contributing to a **sizable digital divide**. . .

Broadband market – II

- In 2010 (and 2015) we observe
  - Increase in coverage for all internet speeds
  - No full coverage, both in terms of municipalities and population



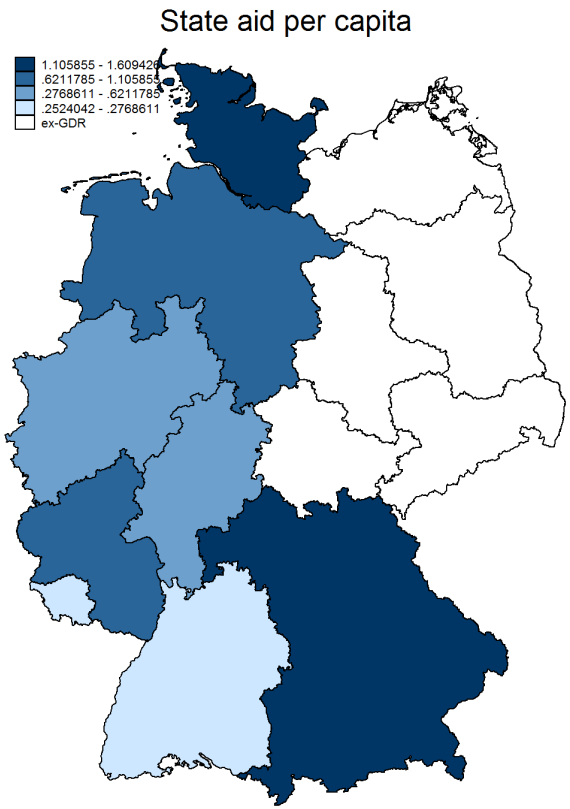


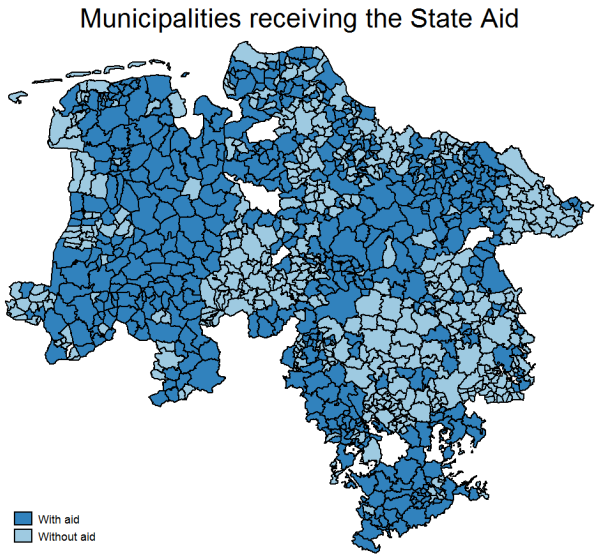
- Digital divide at the beginning of the sample period gave ground for intervention, the gap still exists at the end of the sample

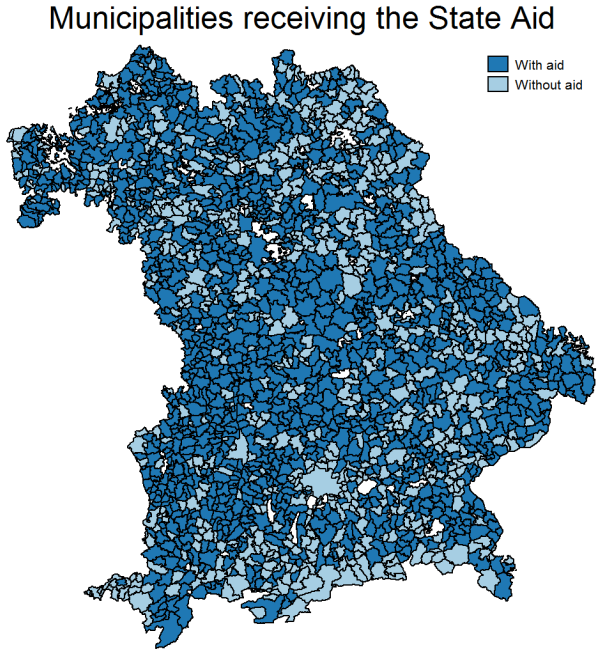
The basic broadband aid schemes – I

- Three schemes: one for entire Germany (N115/2008), additional schemes for Bavaria (N237/2008) and Lower Saxony (N266/2008)
  - Provide incentives to private operators to offer affordable broadband DSL services in rural areas of Germany to close the digital divide
  - We investigate the total effect of all of the above mentioned schemes
- How did the schemes work:
  - Regional authorities (generally municipalities) applied for the aid
  - Necessary condition was the existence of 'white areas' within the municipality
  - The schemes were supposed to be technology-neutral
    - ★ Only DSL, mobile, and to a smaller extent WMAX were effectively supported
  - Aid was allocated to the operators designated as beneficiaries via tenders
  - The aid intensity for each project was related to the so called 'profitability gap' but had to be below 200.000 EUR
- Other states did not collect digitized information on the regional subsidies, so we restrict to Bavaria and Lower Saxony
  - But we know the total (national+regional) amount, so we can compare the two states with remaining states

The basic broadband aid schemes – II







Data

- **Internet infrastructure**: Breitbandatlas collected for the Ministry for Transport and Digital Infrastructure
  - Unit of observation: municipality
  - Time: yearly data (2010-2015)
  - Variables: coverage (2Mbit/s, 6Mbit/s, 16+ Mbit/s), number of ISPs (DSL, Cable, Mobile, FTTH)
- **State aid**: Federal and State ministries
  - Unit of observation: municipality
  - Variables: indicator (received aid or not), amount received
- **Plans' Prices**: from a price-comparison website with full coverage of available plans at the phone prefix-level (re-mapping required)
- **Census data**: from National Census statistics
- **Geo-conformation**: data from the Ministry of Environment (to compute ruggedness index)
- **Internet 2005-2008**: internet coverage at 1Mbit/s from Falck et al. (2014)

Municipalities

	Mean	Std. Dev.	Min.	Max.
Total population	7,580	31,767	65	1,429,584
Average income in 2007 (1,000 EUR)	32	6.5	11.8	212.3
Unversity degree	25.9	8.3	0	70.3
Population between 24 and 65 y.o. (%)	54.4	2.7	31.7	74.7
Population density (people per km^2)	210.9	293.9	2.4	4601.2
Unemployment rate	5.6	2	1.4	18.2
Ruggedness index	38.3	32.8	0.5	289.5
Area for firms and industry (%)	0.7	1.2	0	16.4
Distance to the MDF from pop centroid (in m)	2,798	1,807	11.5	14,833
Number of MDFs within municipality	0.7	1.8	0	56
DSL Coverage 1 Mbit/s in 2005	76.3	20.6	0	100

Internet Service Providers (ISP)

- 248 different ISPs in our database
  - Entry of 144 ISPs over 2010-2015
  - 206 ISPs active in less than 200 municipalities
  - Only 14 operators are active in more than 200 municipalities (DT, Vodafone, Telefonica, Kabel Deutschland)

Table: Frequencies (%) of the number of ISPs in 2010 and 2015, by technology

	DSL		Cable		LTE		FTTH	
Num. ISPs	2010	2015	2010	2015	2010	2015	2010	2015
0	4.5	0.2	68.7	54.6	77.1	0.2	98.7	90
1	54.5	0.1	30.5	17	21.5	1.2	1.3	9.3
2	17.8	35.3	0.8	25.6	1.4	24	0	0.6
3	11.8	37.5	0	2.6	0	52.9	0	0.1
4	10.3	18.2	0	0.2	0	20	0	0
5	1	7.2	0	0	0	1.7	0	0
6	0.1	1.3	0	0	0	0	0	0
7	0	0.2	0	0	0	0	0	0

Empirical strategy

- Exploit regional variation within a common national regulatory framework: Compare aid recipients municipalities to control municipalities, before and after
  - Treated: Aid-receiving municipalities in Bavaria and Lower Saxony
  - Control: Other municipalities in Bavaria and Lower Saxony

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- Empirical analysis in two-steps:
  1. Matching on observables
     - ★ Score regression:

$$Aid_m = \alpha + \eta X_m + u_m \tag{1}$$

     - ★ Nearest neighbor matching 1:1 to select **paired municipalities**

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  2. Diff-in-diff regression on the matched sample of paired municipalities (pre: 2010, post: vs. 2015)

$$\Delta y_{pt} = \alpha + \gamma Post_{pt} + \lambda \Delta X_{pt} + \mu_p + \varepsilon_{pt}, \tag{2}$$

     where Δy_{pt} is the difference in outcome between the paired treated and control municipalities, and ΔX_{pt} is the difference in local observed characteristics between the paired treated and control municipalities

Extensions: Full sample, Spatial model

- We estimate other models and we use different samples
  1. Full sample of municipalities: we do not restrict to Bavaria and Lower Saxony
     - ★ Treated municipalities against rest of municipalities (without matching)
     - ★ Treated municipalities against rest of municipalities (with matching)
     - ★ Same using only Bavaria and Baden Wuttemberg

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  2. The network nature of the broadband industry makes spacial spillovers across municipalities likely to exist
     - ★ Spatial autoregressive model on Bavaria and Lower Saxony

$$
\begin{aligned}
y &= \rho W y + X\beta + u \\
u &= \lambda M u + \varepsilon
\end{aligned}
\tag{3}
$$

- Results consistent with our main empirical approach

Propensity score matching

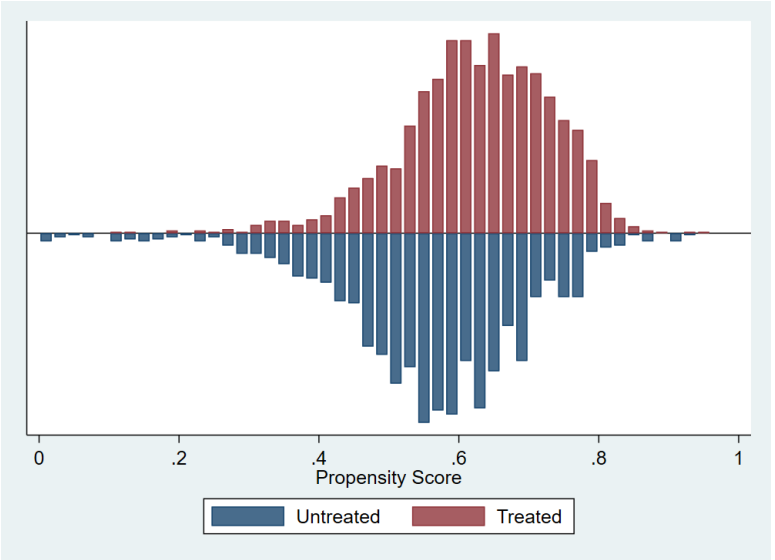
- Matching procedure:
  - Reduces bias due to potential selection on observables
  - Nearest neighbor matching 1:1 to select **paired municipalities**
  - Check common trend before state aid using Falck et al (2014) data on 1Mbit/s coverage
- Score regression:

$$Aid_m = \alpha + \eta X_m + u_m$$

  where
  - Aid_m: indicator for the municipality having received State aid
  - X_m: demographic characteristics (population, population density, income, share of people with college degree etc.)

Propensity score matching – I

Dependent variable: state aid		
	Coeff.	Std. err.
Population	0.356***	(0.059)
Population^2	-0.006***	(0.001)
Density	-0.002***	(0.000)
Income	0.003	(0.008)
College degree	-0.017***	(0.006)
Work age	0.011	(0.017)
Unemployed	-0.102***	(0.024)
Distance to LE	0.198***	(0.024)
Ruggedness	-0.002	(0.001)
Area firms and industry	0.081	(0.056)
DSL 2008	0.535	(0.362)
Constant	-0.271	(1.046)
Observations	3009	
Log-likelihood	-1927.168	
Pseudo R^2	0.049	



Propensity score matching – II

Variable	Sample	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|
Population	Unmatched	.60666	.7726	-5.0		-1.46	0.145
	Matched	.642	.58051	1.8	62.9	0.82	0.410
Pop. dens.	Unmatched	149.43	210.95	-22.6		-6.49	0.000
	Matched	166.5	160.67	2.1	90.5	0.67	0.505
Income	Unmatched	32.258	32.483	-3.5		-0.97	0.333
	Matched	32.163	32.19	-0.4	87.8	-0.10	0.919
College	Unmatched	22.148	23.886	-22.0		-5.98	0.000
	Matched	23.576	23.086	6.2	71.8	1.43	0.151
Work age	Unmatched	54.313	54.043	11.5		3.11	0.002
	Matched	54.08	54.143	-2.7	76.8	-0.62	0.536
Unemployment	Unmatched	5.2563	5.6727	-20.4		-5.52	0.000
	Matched	5.7115	5.5253	9.1	55.3	2.03	0.043
Distance MDF	Unmatched	3.0954	2.4746	34.1		9.18	0.000
	Matched	2.5571	2.6244	-3.7	89.2	-0.88	0.377
Ruggedness	Unmatched	29.867	29.792	0.2		0.07	0.946
	Matched	29.964	30.419	-1.5	-504.5	-0.33	0.739
Area firms	Unmatched	.59916	.70211	-10.3		-2.84	0.005
	Matched	.64131	.60169	4.0	61.5	1.03	0.301
Dsl 2008	Unmatched	.9175	.92334	-5.3		-1.43	0.152
	Matched	.92062	.92108	-0.4	92.0	-0.09	0.925

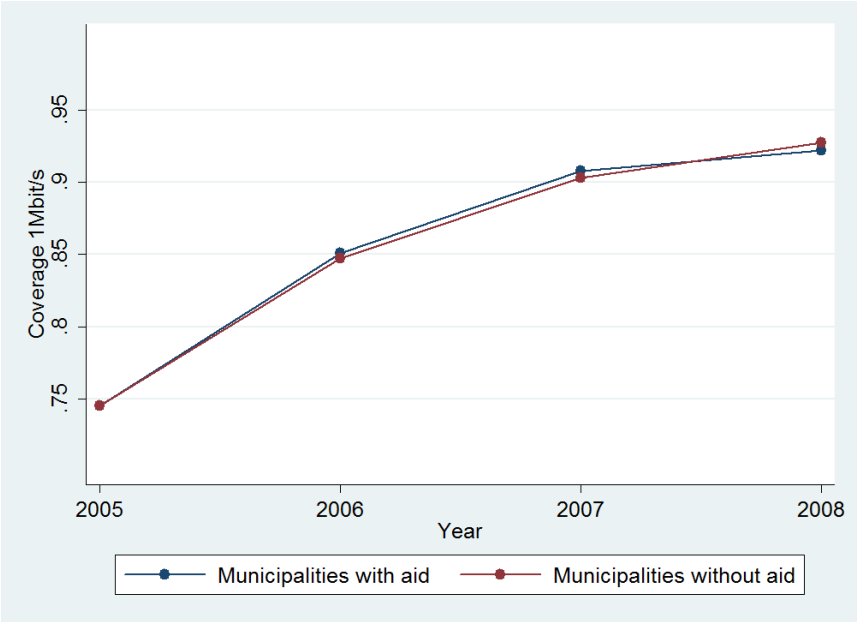
Mean Bias

- Before: 13.50
- After: 3.2

Sample	Pseudo R2	LR chi2	p>chi2
Unmatched	0.040	163.25	0.000
Matched	0.002	6.21	0.798

Propensity score matching – III

- Nearest neighbor matching 1:1
- The matching algorithm pairs 2086 municipalities out of 3009
- As shown, they are balanced in baseline characteristics (i.e., 2010) and in internet coverage in 2008



- What about the common trend?

Average Treatment Effect – Coverage and entry

$$\Delta y_{pt} = \alpha + \gamma Post_{pt} + \lambda \Delta X_{pt} + \mu_p + \varepsilon_{pt},$$

	Coverage			Entry in different tech				
	2MB/s	**6MB/s**	**16MB/s**	**All ISPs**	**DSL**	**Cable**	**LTE**	**FTTH**
$Post$	14.40***	21.14***	20.56***	0.21***	0.16***	0.06***	-0.02	0.05***
	(1.00)	(1.25)	(1.29)	(0.05)	(0.04)	(0.02)	(0.04)	(0.01)
R^2	0.167	0.216	0.196	0.017	0.016	0.011	0.000	0.013
Observations	2086	2086	2086	2086	2086	2086	2086	2086

- Receiving the grant **increases the coverage at all speeds**, not just for basic broadband
- Receiving the grant **induces more entry** in the market for DSL and Cable, and it has a positive spillover on the FTTH, although it has not be granted any aid

Average Treatment Effect – Coverage and entry

	Coverage			Entry in different tech				
	2MB/s	**6MB/s**	**16MB/s**	**All ISPs**	**DSL**	**Cable**	**LTE**	**FTTH**
$Year_{2011}$	9.78***	12.95***	11.75***	0.08**	0.04	-0.00	0.08***	0.00
	(0.81)	(0.99)	(0.98)	(0.04)	(0.02)	(0.01)	(0.03)	(0.00)
$Year_{2012}$	14.78***	20.57***	19.15***	0.12***	0.06**	0.01	0.06*	0.00
	(0.86)	(1.10)	(1.11)	(0.04)	(0.03)	(0.01)	(0.04)	(0.00)
$Year_{2013}$	15.57***	22.67***	20.33***	0.18***	0.15***	0.04***	-0.03	-0.00
	(0.89)	(1.13)	(1.15)	(0.05)	(0.03)	(0.02)	(0.03)	(0.01)
$Year_{2014}$	15.14***	22.38***	21.41***	0.23***	0.15***	0.05***	-0.02	0.02**
	(0.97)	(1.24)	(1.28)	(0.05)	(0.04)	(0.02)	(0.03)	(0.01)
$Year_{2015}$	14.40***	21.14***	20.56***	0.21***	0.16***	0.06***	-0.02	0.05***
	(1.00)	(1.25)	(1.29)	(0.05)	(0.04)	(0.02)	(0.04)	(0.01)
R^2	0.111	0.134	0.102	0.008	0.009	0.008	0.003	0.009
Observations	6258	6258	6258	6258	6258	6258	6258	6258

- If we make use of all years in the panel, we observe that:
  - Coverage reacts immediately to the arrival of the aid
  - Entry takes a while, with DSL reacting first

Average Treatment Effect – Price

Dependent variable: Average price			
	Panel FE	Panel FE	Panel IV
$Post$	-0.072**		
	(0.034)		
Δ Number of IPSs		-0.120***	-0.336**
		(0.021)	(0.164)
R^2	0.004	0.033	-0.075
F-test			17.491
Observations	2086	2086	2086

- Receiving the aid leads to a (small) reduction in average price
- Channel: Aid $\longrightarrow$ increase in entry $\longrightarrow$ lower price

Average Treatment Effect – Price

Dependent variable: Average price						
Number of firms in 2010:	Up to monopoly	Up to duopoly	Up to triopoly	Up to 4 firms	Up to 5 firms	All
$Post$	-0.248***	-0.209***	-0.234***	-0.189***	-0.084**	-0.686***
	(0.059)	(0.043)	(0.036)	(0.033)	(0.034)	(0.153)
$Post \times$ Num. of ISPs$_{2010}$						0.111***
						(0.028)
R^2	0.088	0.047	0.056	0.034	0.006	0.019
Observations	372	966	1434	1804	2040	2086

- As expected, different initial market structure lead to different reduction in price with entry of new ISPs
  - Entry in more concentrated markets leads to larger reduction in average price
- However, effects are small, likely due to national pricing and implicit assumptions (no market share data)
- Other dimension of competition? (e.g. Quality)

Heterogenous Treatment Effects

	Coverage			Entry in different tech				
	2MB/s	**6MB/s**	**16MB/s**	**All ISPs**	**DSL**	**Cable**	**LTE**	**FTTH**
Above median DSL 2008								
Year_{2015}	13.14***	20.73***	21.49***	0.01	0.13**	0.08***	0.09	0.06***
	(1.29)	(1.71)	(1.81)	(0.07)	(0.05)	(0.03)	(0.06)	(0.02)
Below median DSL 2008								
Year_{2015}	15.70***	21.56***	19.60***	0.43***	0.19***	0.04	-0.12**	0.03*
	(1.53)	(1.82)	(1.85)	(0.07)	(0.06)	(0.03)	(0.05)	(0.02)
Above median Industry								
Year_{2015}	13.80***	21.74***	20.05***	-0.05	-0.07	0.01	0.11*	0.03
	(1.44)	(1.80)	(1.90)	(0.08)	(0.06)	(0.03)	(0.06)	(0.02)
Below median industry								
Year_{2015}	14.90***	20.65***	20.97***	0.43***	0.35***	0.11***	-0.12**	0.06***
	(1.38)	(1.73)	(1.76)	(0.07)	(0.05)	(0.03)	(0.05)	(0.02)
Close to the MDF								
Year_{2015}	4.26***	9.10***	13.59***	0.28***	0.33***	0.12***	0.03	0.09***
	(0.95)	(1.34)	(1.57)	(0.07)	(0.05)	(0.03)	(0.06)	(0.02)
Far from the MDF								
Year_{2015}	24.22***	32.80***	27.29***	0.15**	-0.01	0.01	-0.06	0.01
	(1.62)	(1.96)	(1.99)	(0.07)	(0.05)	(0.03)	(0.05)	(0.02)

- Availability: larger effect in more disadvantaged areas
- Competition: larger entry in better markets

A back-of-the-envelope cost-benefit analysis

- Back-of-the-envelope cost per potentially connected household in municipality i:

$$Cost_i = \frac{TotAid_i}{\hat{\gamma} \times Population_i} \tag{4}$$

- Given $\hat{\gamma} = 14.4\%$ for 2 Mbit/s
  - On average, the aid potentially connected 729 households per municipality
  - On average, each potentially connected household cost ca. 235 €
- According to Nevo et al. (2016), US households are willing to pay 2$ per month for a 1 Mbit/s increase in connection speed $\Rightarrow$ 24$ per year
- To be cost-covering, the aid (for 2MBit/s) should bring ca. 5 years advantage in broadband development

Conclusions

- Empirical analysis of state control
- Methodology: PSM + Diff-in-Diff
- Overall, the aid program has met its targets:
  - Broadband availability has increased significantly (between 15% and 28%)
  - Entry increased in most technologies (but not in LTE which received large subsidies!)
    - ★ Evidence of technology spillovers
  - Some minor (non-lasting) effects on prices, mostly through plans of local competitors
  - The effect of the aid has been heterogeneous
- Back-of-the-envelope calculation of the cost per potentially connected household is ca. 235 €
- Further step is a more complete welfare analysis
  - Need to estimate consumers' preferences
  - Estimate an entry model for different technologies

Thank you for your attention!