Welfare Cost of Mobile Spectrum (Mis)Allocation

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Any opinions expressed here are not those of Orange

Motivation

- Spectrum = scarce resource & valuable asset
- Allocation or reallocation (by auctions)

➢ Impact on market structure

- Trade-off quality – price
- More concentration versus more competition

This policy paper

Evaluation of German 5G allocation of frequencies in two phases

1. To operators (March 2019)
2. To private firms (November 2019)

Literature (relatively scarce)

- **Differentiated-products oligopoly models**
  - Berry & Haile (2021)
- **Spectrum allocation, cost efficiency & welfare**
  - Kuroda & Forero (2017), Peha (2017), Woroch (2020)
- **Market structure, investment and consumer surplus**
  - Genakos, Valletti & Verboven (2018)
  - Houngbonon & Jeanjean (2016)
  - Ershov and Salant (2022)

Own research

- **Horizontal cooperation on investment: Evidence from Mobile network sharing**
  - ➢ Cojoc, Ivaldi, Maier-Rigaud, März (2020, unpublished)

- **Market Structure, Investment and Technical Efficiencies in Mobile Telecommunications**
  - ➢ Elliott, Houngbonon, Ivaldi, Scott (JPE, 2025)

Content

- **Database**
  - 23 MNOs in 5 major European countries (GSMA)
  - Quality index = coverage and spectrum data
  - Average price = ARPU
- **Estimation of demand for mobile telecom services**
  - Recovering marginal costs of German operators assuming Bertrand competition
- **Simulation**
  - Impact of spectrum allocation on consumer surplus in Germany

Main results

- **Allocation to 3 instead of 4 operators**
  - ➢ ∆CS = +3.8%
- **Reallocating local assignement to operators**
  - ➢ ∆CS = +4% (4 operators)
  - ➢ ∆CS = +7% (3 operators)

Main limit

- **Static analysis**
  - ➢ No dynamic efficiency

Data

- Scope
  - Europe Big 5 (France, Germany, Italy, Spain, UK)
  - 70 quarters (2004Q3 – 2021Q4)
  - 1241 obs on 23 MNOs

- Variables
  - ARPU, OPEX, # subscribers / operator (Strategy Analytics)
  - Population coverage for 3G, 4G & 5G technologies (GSMA)
  - Spectrum allocation

Variable	Mean	Std. Dev.	Min	Max
Intra-MNO market share	27%	10%	3%	47%
ARPU (Euros/month)	19	7	7	43
Coverage3G (population)	83%	23%	8%	100%
Coverage4G (population)	44%	44%	0%	100%
Coverage5G (population)	4%	12%	0%	95%
Band_3G (MHz)	52	14	10	114
Band_4G (MHz)	46	51	0	210
Band_5G (MHz)	15	32	0	120
OPEXuser(Euros/month)	16	6	5	41

Figure 2: Temporal pattern of market shares per MNO

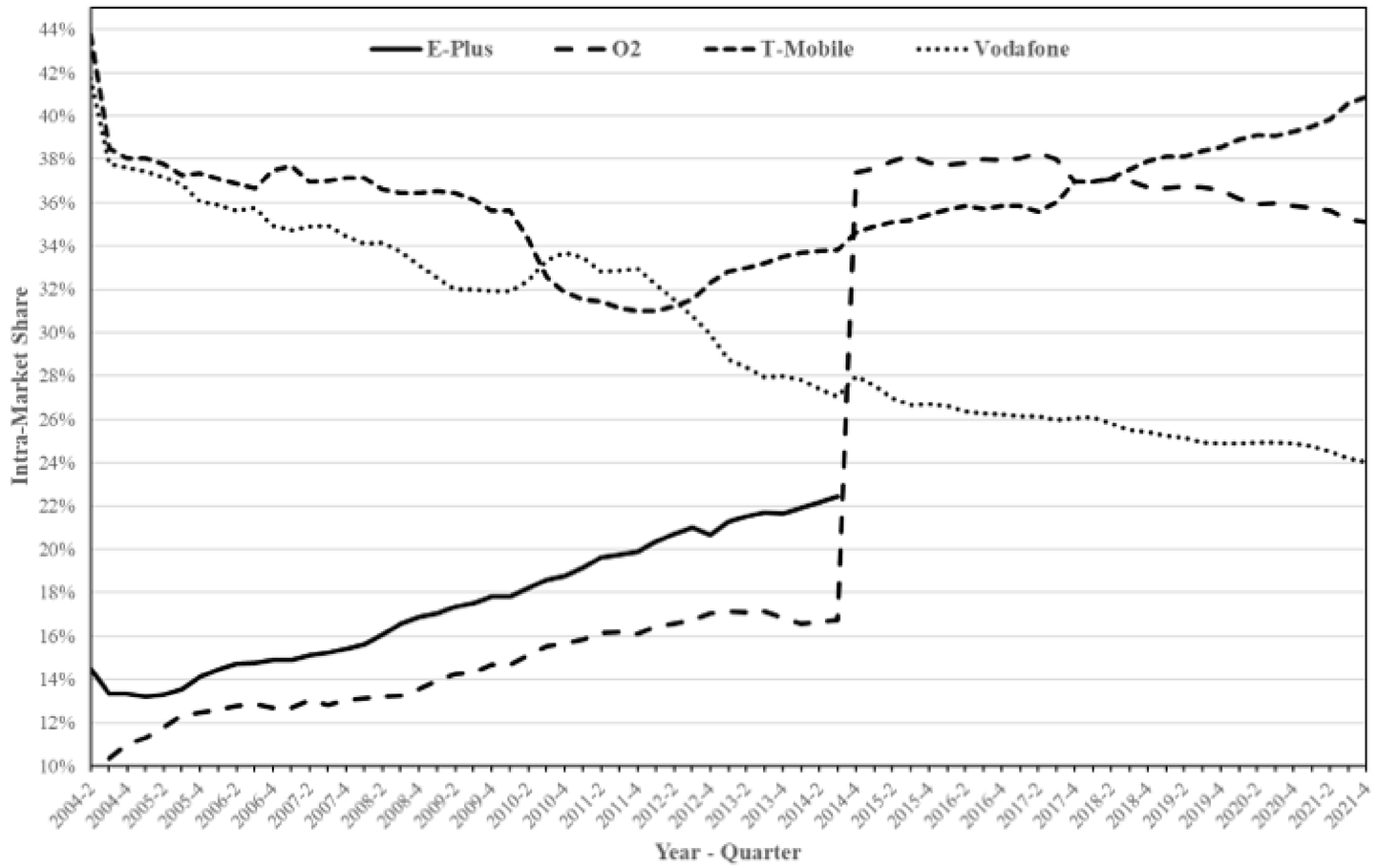
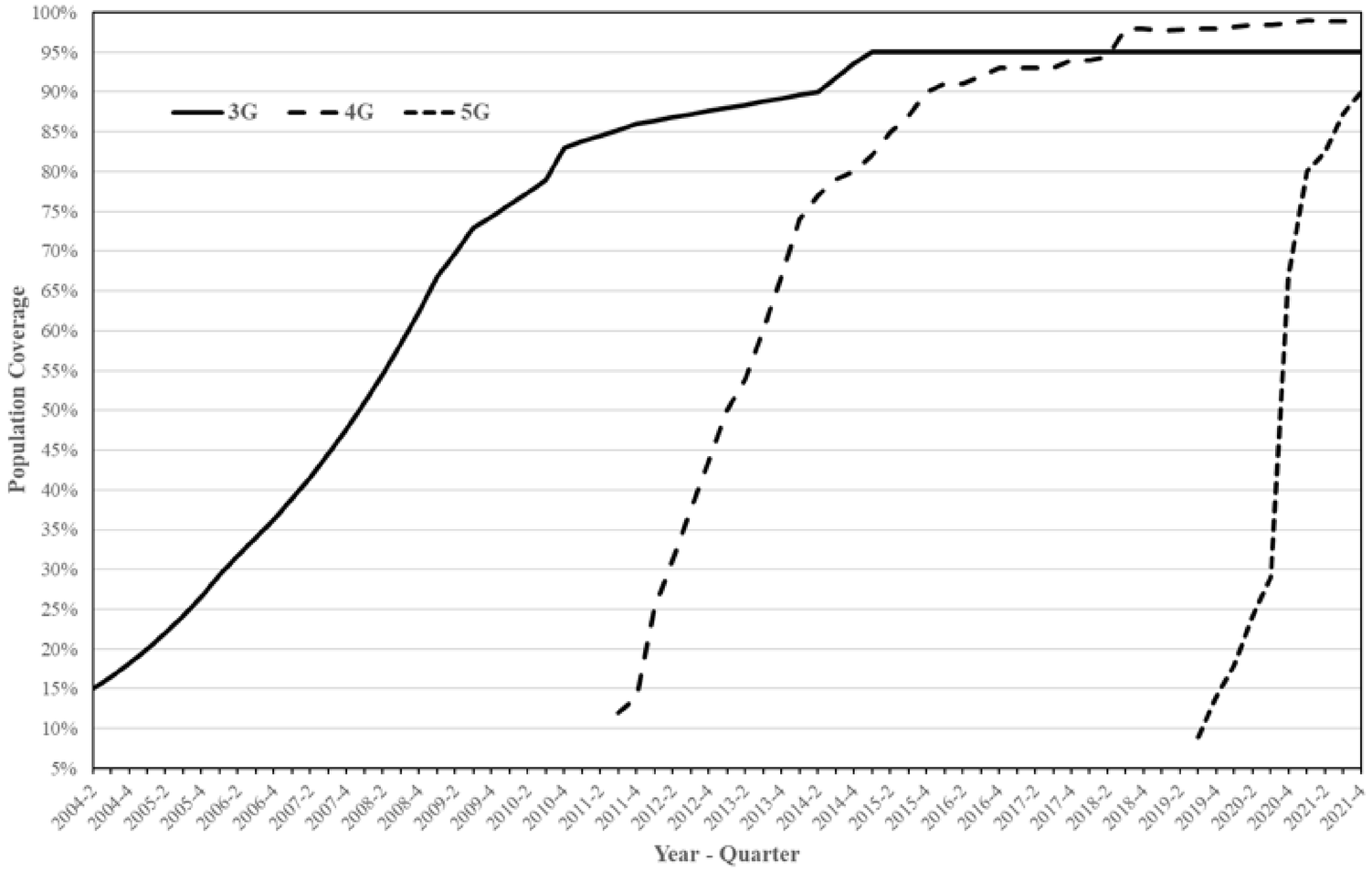


Figure 3: Temporal adoption of mobile technologies



Model

Consumer's nested logit demand

$$ln\left(\frac{s_{jt}}{s_{0t}}\right) = \mu_0 + \beta q_{jt} - \alpha p_{jt} + \sigma ln(s_{j|gt}) + \xi_j + \xi_{jt}$$

$$\beta_3 cov3G_{jt}$$

$$\beta_4 cov4G_{jt} * band4G_{jt}$$

$$\beta_5 cov5G_{jt} * band5G_{jt}$$

Note on quality index

- Usual index = Speed
  - Download or upload speed
  - Available for Ookla
- Speed depends on band * spectrum efficiency
  - Spectrum efficiency
    - 3G ~ 0.8 bit/Hz
    - 4G ~ 1.9 bits/Hz
    - 5G ~ 4.8 bits/Hz (roughly 3 times more efficient than 4G)
- Our index = band * coverage
  - Strongly correlated with speed
  - Tested on Ookla data

Estimation

- Endogeneity

- Instruments
  - OPEX per user
  - BLP type instruments
    - OPEX of competitors
    - Mean ARPU of competitors

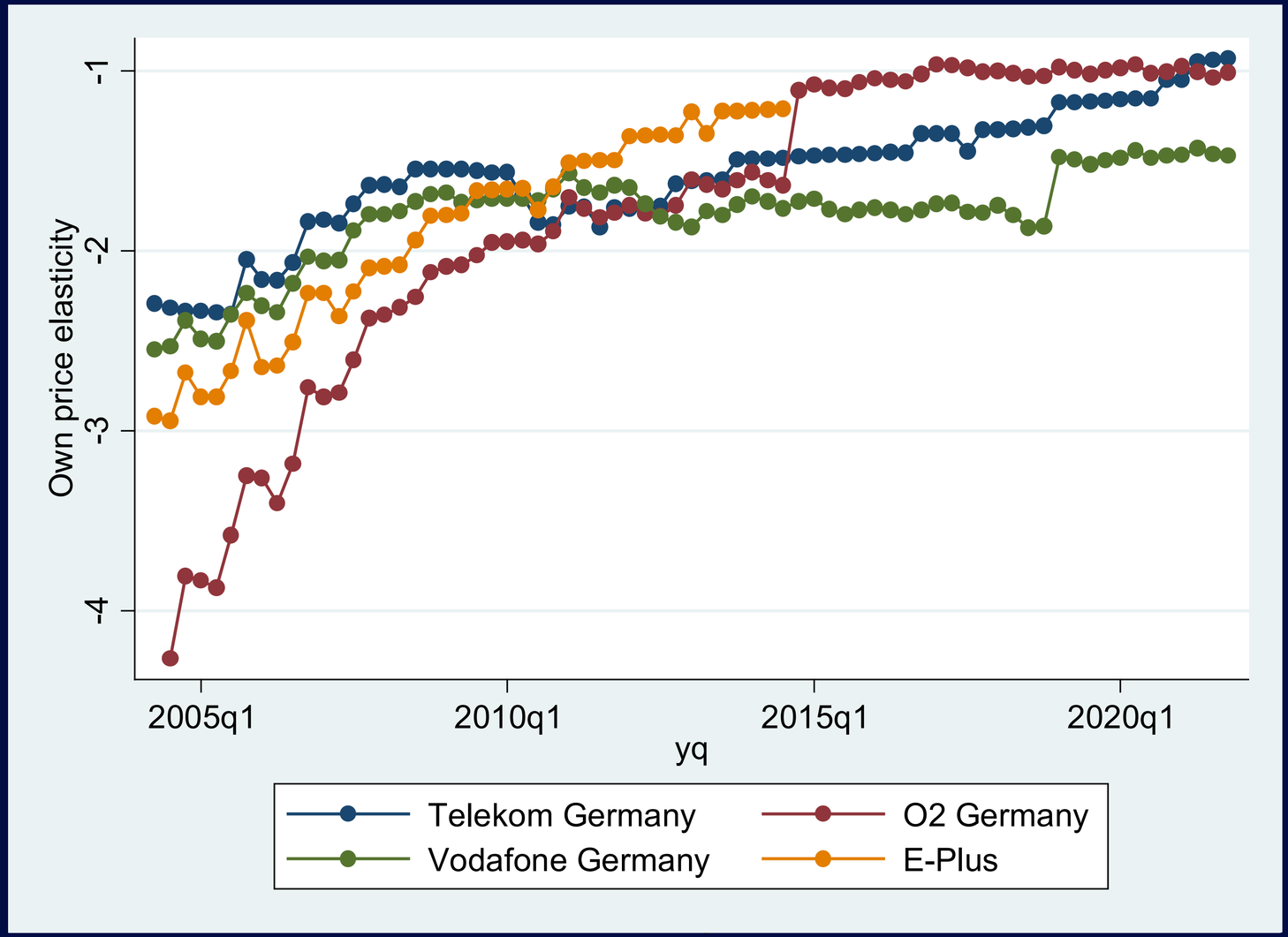
Estimates

VARIABLES	all MNOs' FE included ln(market share)	German MNO FE=0 ln(market share)
Price (-α)	-0.0551***	-0.0566***
	(0.003)	(0.003)
intra-MNO market share (σ)	0.6356***	0.6936***
	(0.047)	(0.041)
coverage3Gpop	0.9707***	1.0127***
	(0.111)	(0.109)
band4Gcov	0.0014***	0.0016***
band5Gcov_2021Q4	0.0045**	**0.0052****
	(0.002)	(0.002)

The German Market

- Main operators
  - E-Plus (merged with O2 in 2015)
  - O2 (Telefonica)
  - Deutsche Telekom
  - Vodafone

Own-price elasticities



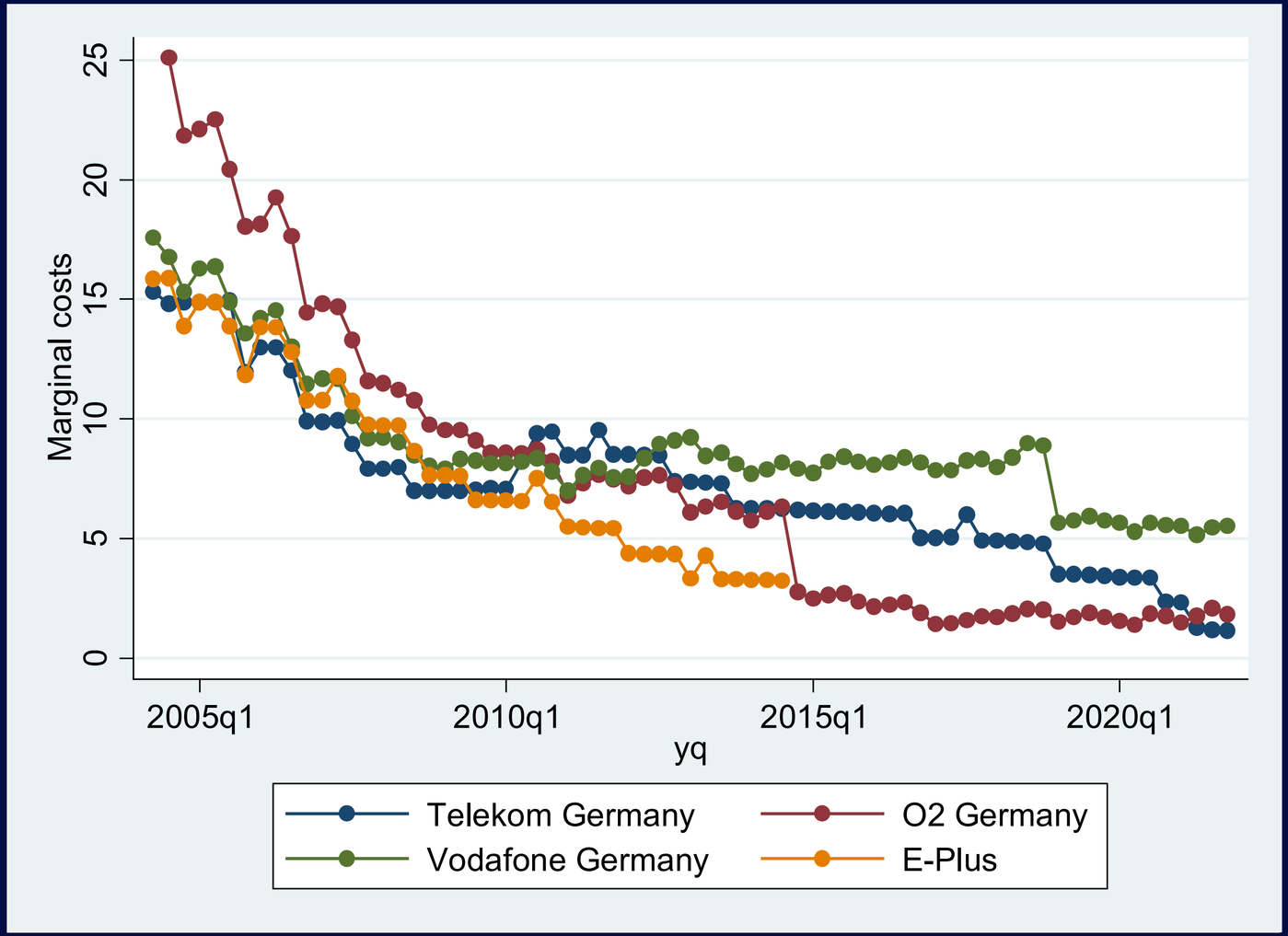
Model

Competition in prices among operators

$$\frac{p_{jt} - c_{jt}}{p_{jt}} = \left|\frac{1}{\eta_{jj,t}}\right|$$

$$c_{jt} = p_{jt} - \frac{1 - \hat{\sigma}}{\hat{\alpha}(1 - \hat{\sigma}\, s_{j|gt} - (1 - \hat{\sigma})s_{jt})}$$

Marginal costs



Simulation of alternative allocations

- Allocating
  50MHz to 3 existing MNOs instead to the entrant (Drillish)
- Assigning
  100 MHz to 3 or 4 MNOs instead to local assignement

Simulation results

Change in CS	3-MNOs	4-MNOs
Spectrum before 2019 auction	3651	
50MHz more (Drillisch)	+3.8%	+0.5%
100MHz more (Local assignment)	+7.4%	+6.5%

Change in quality	3-MNOs	4-MNOs
Spectrum before 2019 auction	24.5	
50MHz more (Drillisch)	+2.9%	+0.8%
100MHz more (Local assignment)	+9.0%	+4.9%

Change in prices	3-MNOs	4-MNOs
Spectrum before 2019 auction	11.1 €	
50MHz more (Drillisch)	+2.0%	-1.0%
100MHz more (Local assignment)	+6.0%	+2.0%

Concluding remarks

- In this static analysis, 3 seems to be better than 4 based on CS

Thank you for your attention!