Universität zu Köln

ewi Energiewirtschaftliches Institut an der Universität zu Köln

The impact of network tariffs on PV investment

An Empirical Analysis on Regionally Different Network Tariffs in Germany

1st IAEE Online Conference | 7th – 9th June 2021

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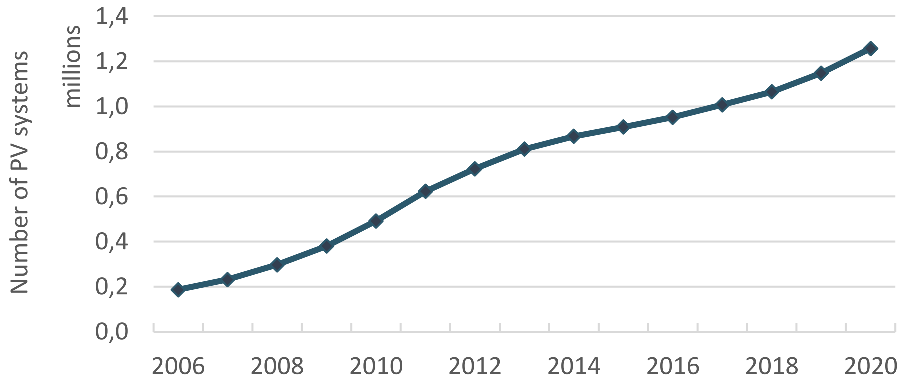
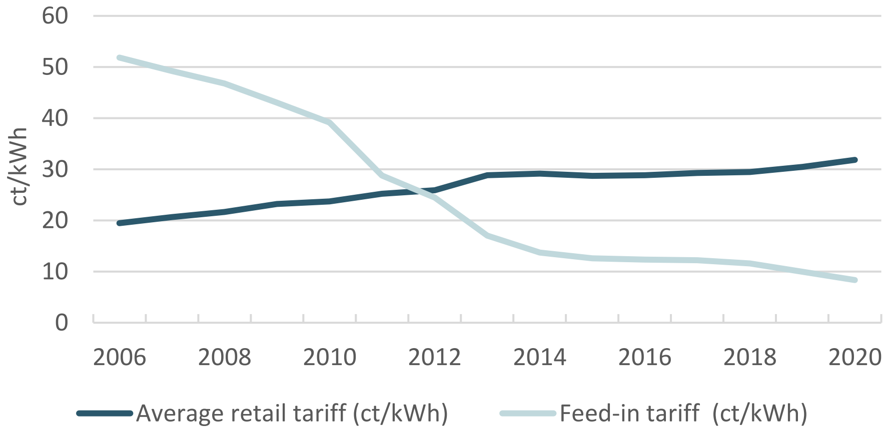
Motivation



Cumulative number of PV systems < 10 kW in Germany, 2006-20

Source: Own illustration based on data from BNetzA (2021b).



Residential feed-in and average retail tariffs in Germany, 2006-20

Source: Own illustration based on data from BNetzA (2021a) and BDEW (2021).

- Decentral, residential PV installations will have a substantial share in the future electricity mix and the importance of spatial coordination of investments increases
- In Germany, incentives for PV investments should be increasingly influenced by self-consumption, and, thereby, retail tariffs
- Network tariffs are a major part of retail tariffs in Germany and the only price component that varies regionally
- Knowing whether and how consumers respond to price signals is important for discussions regarding policy reforms to increase the share of the fixed network tariff and to decrease the volumetric network tariff

Research Questions

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Do price signals impact German households‘ decision to invest in PV systems?

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Do households differentiate between fixed and variable price components?

Literature

Main drivers of PV investments

- **Socio- and techno-economic factors:**
  - Schaffer & Brun (2015), Dharshing (2017)
- **Behavioural factors:**
  - Bollinger & Gillingham (2012), Rode & Weber (2016)
- **Economic factors:**
  - Jacksohn et al. (2019) for feed-in tariffs
  - Gautier & Jacqmin (2020) for network tariffs under net-metering

Perception of electricity price components

- Mixed findings how consumers respond to nonlinear prices
  - Ito (2014), Ito & Zhang (2020), Shaffer (2020)

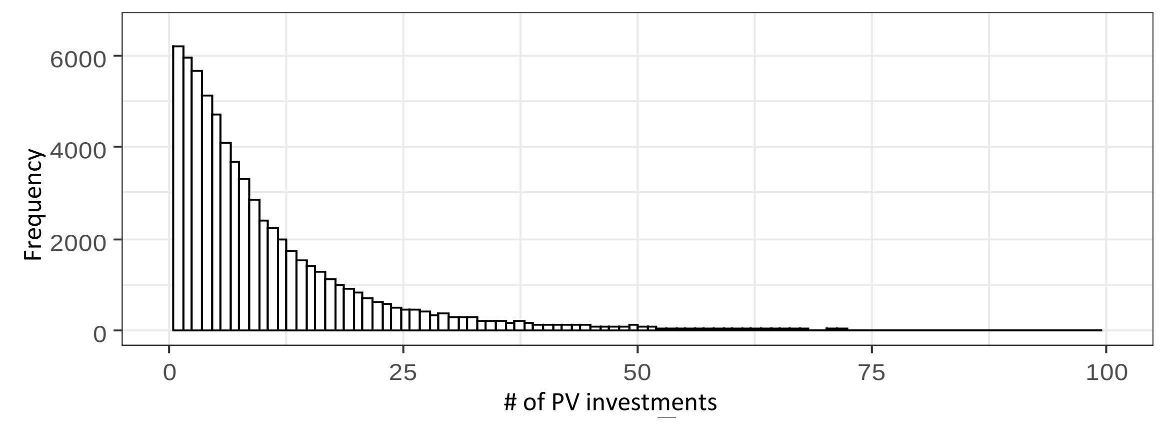
➢ No research on the impact of price signals on PV installations in Germany (and under net purchasing)
➢ No analysis on the impact of electricity price components on investment decisions

Data (1/2)

- Unique panel data set from 2009 to 2017 with 8,148 postcode areas, resulting in 64,531 observations
- Our data consists of 708,555 PV systems commissioned between 2009 and 2017
  - The number of PV installations follows an over-dispersed Poisson distribution
- Data on network tariffs includes volumetric and fixed component
- Socioeconomic factors are included to control for other potential drivers

Variable	Mean	Median	SD	Min	Max	Source
Dependent variables						
# of PV	9.66	6	11.57	0	184	MaStR
capacity (kWp)	62.70	38.83	76.77	0	1272.56	MaStR
Independent variables						
tariff (ct/kWh)	5.29	5.08	1.04	2.38	9.90	ene't
fixed_tariff (Euro/year)	21.56	18.00	17.72	0	95.00	ene't
average_tariff (ct/kWh)	5.90	5.65	1.24	2.67	11.55	ene't
income (log of)	9.95	9.95	0.19	9.30	11.01	RWI
housetype (% of 1- and 2-family homes)	58.32	63.64	20.69	0.30	100	RWI
average age	43.74	43.58	2.35	35.11	58.48	RWI
buildings (log of)	7.40	7.46	0.92	0.69	9.80	RWI

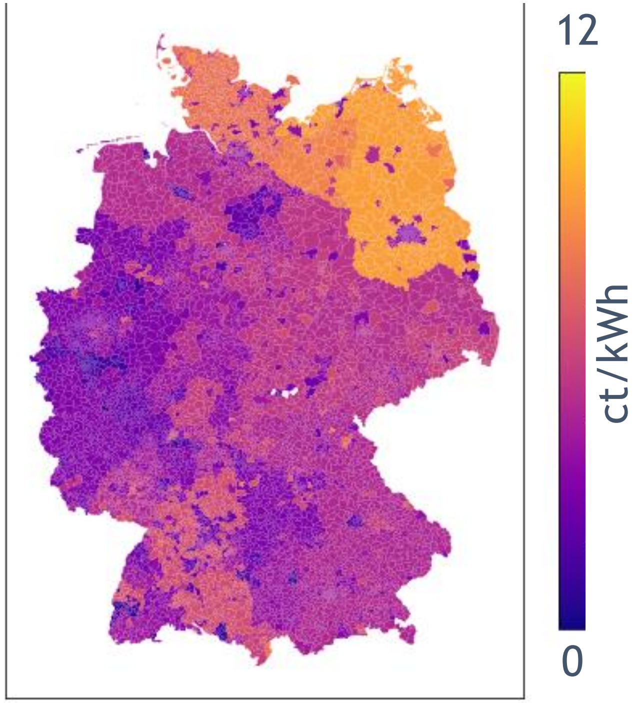
Descriptive statistics, 2009-2017



Histogram of PV systems < 10 kW per year and postcode, 2004-20
Source: Own illustration based on data from BNetzA (2021b).

Data (2/2)

- Retail tariffs in Germany comprise of three elements:
  - Procurement and sales costs of the retailing firm (24%)
  - Network tariffs (24%)
  - Administratively determined taxes, charges, and levies (52%)
- Retail tariffs vary regionally, which is mainly due to the heterogeneity of network tariffs
- The regional variation has increased over time



Regional variation of volumetric network tariffs, 2017
Source: Own illustration based on data from ene't (2021).

Empirical strategy

$$Y_{i,t} = \exp(\beta * tariff_{i,t-1} + \gamma * \boldsymbol{X} + \phi_t + \mu_i + \alpha_i * t)\epsilon_{i,t}$$

- We use a Quasi-Poisson maximum likelihood estimator with multiple fixed effects
  - Accounts for overdispersion
  - Includes clustering of standard errors (robust standard errors) to accommodate for arbitrary correlation across clusters
- Our main explanatory variable is the lagged network tariff
  - Time lag represents price perception and ex-post billing for households
  - Ensures exogeneity

Symbol	Description
$i \in N$	PLZ-Areas
$t \in T$	Time
$tariff$	Network tariff
$\boldsymbol{X}$	Vector of socio-economic var.
ϕ_t	Time-specific fixed effect
μ_i	PLZ-specific fixed effect
α_i	PLZ-specific time trend

Results (1/2)

- Volume-based network tariffs have a positive and significant impact on the number of PV installations.
  - The result is robust against the specification of the distribution
- The impact of network tariffs is higher for the period 2012-2017 than for the earlier years
- The results indicate that the importance of network tariffs has increased, as feed-in tariffs for PV systems in households declined, while incentives for self-consumption increased

Model:	(1)	(3)
Dependent Variable:		
tariff_{t-1}	0.0578***	
	(0.0061)	
$\text{dummy}_{<2012} \times \text{tariff}_{t-1}$		0.0112
		(0.0083)
$\text{dummy}_{\geq 2012} \times \text{tariff}_{t-1}$		0.0707***
		(0.0064)
income (log of)	-0.0334	0.0230
	(0.1497)	(0.1488)
housetype	0.0041	0.0050
	(0.0042)	(0.0042)
average_age	0.0168	0.0184
	(0.0136)	(0.0136)
buildings (log of)	-0.1225	-0.1363
	(0.1688)	(0.1688)
Fit statistics		
observations	64,531	64,531
AIC	330,230	330,094
BIC	476,772	476,644
Log-Likelihood	-148,967	-148,898

Robust standard errors clustered at the postcode level.
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Results (2/2)

- Consumers react to lagged rather than contemporary tariffs
- Our results confirm the theoretical expectation, that households react to marginal prices rather than average prices
- The result could indicate that consumers are able to understand two-part tariffs (the simplest form of non-linear pricing)

Model:	(1)	(4)	(5)
Dependent Variable:		# of PV	
tariff_t		0.0351***	
		(0.0056)	
tariff_{t-1}	0.0578***		0.0914***
	(0.0061)		(0.0208)
$\text{average\_tariff}_{t-1}$			-0.0386*
			(0.0224)
income (log of)	-0.0334	-0.1770	-0.0332
	(0.1497)	(0.1468)	(0.1495)
housetype	0.0041	0.0152***	0.0042
	(0.0042)	(0.0038)	(0.0042)
average_age	0.0168	-0.0043	0.0171
	(0.0136)	(0.0131)	(0.0136)
buildings (log of)	-0.1225	-0.1371	-0.1287
	(0.1688)	(0.1543)	(0.1689)
Fit statistics			
observations	64,531	72,672	64,531
AIC	330,230	375,142	330,225
BIC	476,772	523,758	476,776
Log-Likelihood	-148,967	-171,406	-148,963

Robust standard errors clustered at the postcode level.
Models include year- and postcode-specific fixed effects, and postcode-specific time trends.
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Concluding remarks

- All else equal, an increase in network tariffs by 1 ct/kWh is estimated to increase PV installations by around 6%
- The impact of network tariffs has increased over time indicating that the economic incentives for self-consumption have become more important in recent years
- Consumers respond to marginal rather than average prices which suggests that they can differentiate between the price components of nonlinear tariffs

⇒ Price signals seem to be effective, even on the household level. The incentive effects of prices should, therefore, be considered regarding the regional allocation of electricity demand and supply across Germany

⇒ A reform of price components, that shifts from volumetric to fixed prices, is likely to affect the adoption of PV systems which should be considered in the discussion on the effectiveness of reforming electricity price components, e.g., with regards to the network tariff system

Do you have any comments, thoughts or further ideas?

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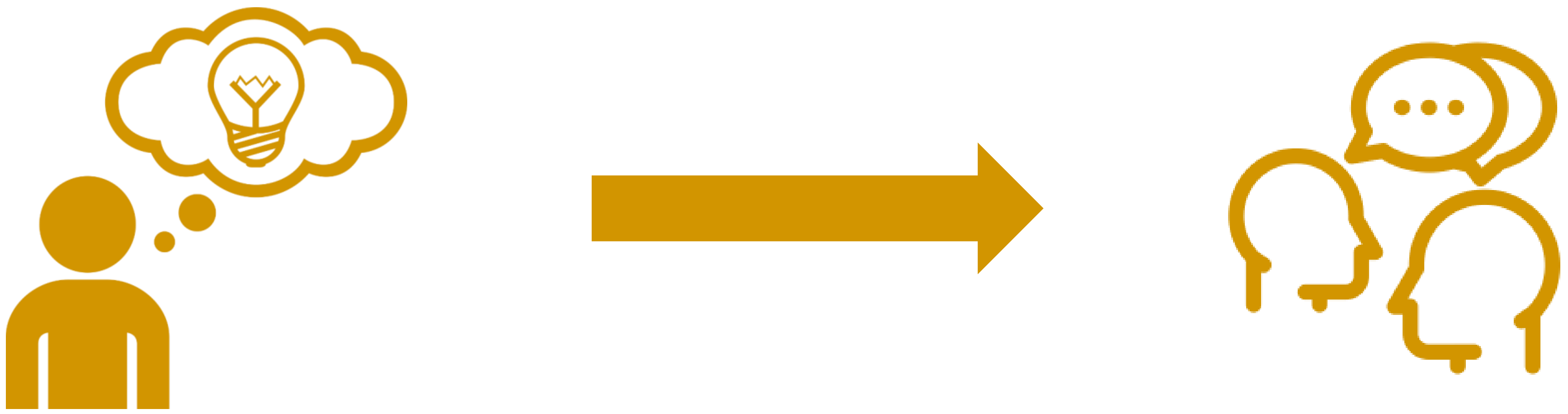

Thank you for your attention!

Questions? Recommendations? Ideas?

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Acknowledgements

The authors gratefully acknowledge the financial support of the Kopernikus-project ENSURE by the Federal Ministry of Education and Research (BMBF) and the project supervision by the project management organization Projektträger Jülich (PtJ).