Expansion of Intermittent Renewables: Strategies, Pass-through, and Welfare

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Abstract

We investigate technology as a source of product differentiation and its impact on strategic behavior and wealth distribution in the German day-ahead market. We compare the performance of our model to a benchmark, using elasticity-adjusted markups and without bid data. We represent uncertainty on the demand side as an intermittency of renewables or a flexible demand response. In a system with 33% renewable shares, both model estimates converge at off-peak hours, being robust to ramping cost and renewable forecast assumptions. Producers pass on fuel and CO_2 costs differently with implications for reinforced regulations by the European Emissions Trading Scheme. Implications for counterfactuals with carbon prices up to €100/tCO_2 are also discussed.

Introduction

Intermittent renewables decrease significantly the operational reliability of the grid, creating a quality differentiation between conventional, such as coal or gas, and non-conventional technologies.
But the traditional SFE model based on Cournot competition does not include this quality differentiation.
We compare the traditional model to a Bertrand with production differentiation and calculate random joint probabilities of conventional and non-conventional technologies to analyze consequences in strategies, pass-through of input costs, and welfare.
These heterogeneous effects of technologies might affect conventional plant, which were facing prices below marginal costs more frequently between 2017-2018.
EU ETS prices were between €25 per tCO_2 and a plan to introduce a carbon price floor of €35 per tCO_2 and a carbon price ceiling of €60 per tCO_2 by 2026 was in place.

Method

We represent heterogeneous technologies (θ) as random loads and shares s per plant j every hour t on the demand side:

$$s_{jt} = \int \frac{exp(\alpha p_t + \beta X_{jt} + \mu_{jt})}{1 + \sum_{j=1}^{J} exp(\alpha p_t + \beta X_{kt} + \mu_{kt})} f(\mu_{jt}; \theta) d\mu_{jt},$$

the supply side as linear cost functions:

$$c_{jt} = \gamma V_{jt} + \varpi_{jt},$$

and solve simultaneously the profit maximization condition:

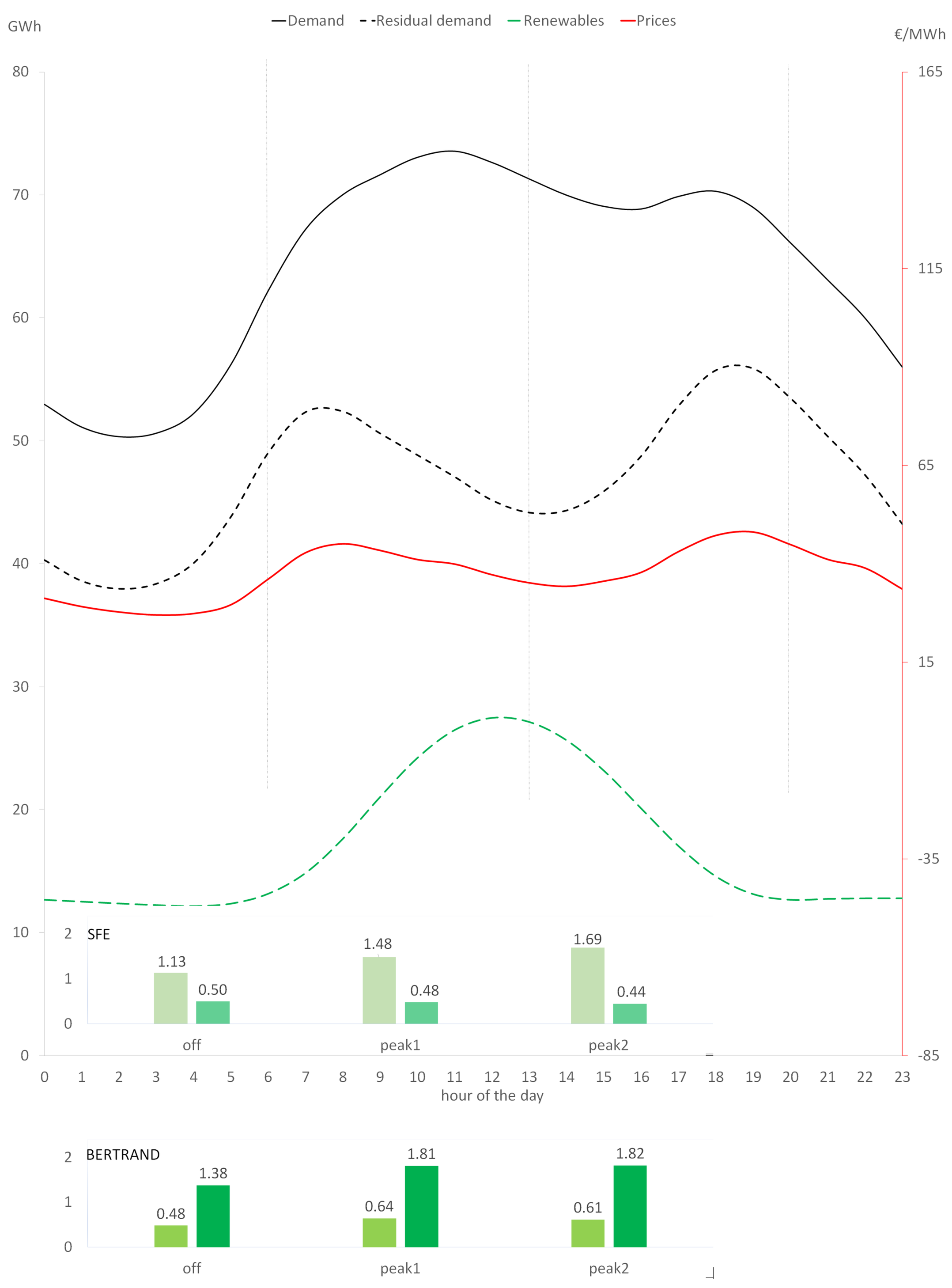
$$\max_{P_t} \prod_{it} = (p_t - c_{jt}) M_t s_{jt}(p_t, X_{jt}, \epsilon_{jt}; \theta)$$

We also compare it to the SFE model using elasticity-adjusted markups:

$$\psi_t = (\frac{p_t - c'_{jt}}{p_t})\phi_t$$

where p_t: hourly prices; X_{jt}: control variables; V_{jt}: costs; M: exogenous market size

Results



Block	SFE	Bertrand
off-peak (night)	0.019	0.029
	(0.018)	(0.020)
peak 1 (morning)	0.033	0.106
	(0.030)	(0.016)
peak 2 (afternoon)	0.030	0.099
	(0.030)	(0.015)

Strategies.- They converge at off-peak hours and diverge at peak hours. The competition seems to be higher at off-peak hours and lower at peak hours when there are more renewables in the grid.

Pass-through costs.- $Fuel$ and CO_2 estimates show an inverse relation in magnitudes depending on the strategy. Moreover, CO_2 estimates show the exact opposite trend, but with diminished price-sensitivity along the day when we use the SFE model. Thus, applying different strategies impacts differently the pass-through estimates of input costs.

Welfare distribution.- We treat the model as a minimum bound study, and find that $welfare$ is higher for retailers than producers, particularly at off-peak hours when there are less renewables in the grid.

Overall, more competition results in lower price-sensitivity for $fuel$ costs, higher price-sensitivity of CO_2 costs and higher $welfare$ for retailers.

Counterfactuals changing EU ETS prices

Counterfactuals using data up to €25/tCO_2 (1)

We separate the existing data to simulate EU ETS maximum price controls of €10/tCO_2, €20/tCO_2, and compare them to carbon prices up to €25/tCO_2

At these levels we find that retailers would be better off without a maximum EU ETS price control. One reason might be that as the EU ETS (and electricity) price increased in 2018, there was a reduction in shares of electricity production, when free EU ETS allowances were also reduced.

Producers were worse off than retailers, particularly at peak hours (when there were more renewables in the system) and the merit order effect dominated over EU ETS prices.

Synthetic counterfactuals up to €100/tCO_2 (2)

We replace EU ETS with fixed prices of €25/tCO_2, €60/tCO_2, and €100/tCO_2

With ceteris paribus fuel costs, **we find that retailers are better off with higher EU ETS fixed prices and that this might be due to the hypothetical replacement of almost all conventional fuels with must-run and renewable technologies**. As the EU ETS price increases, the pass-though of fuel costs decreases while the pass-through of CO_2 also increases.

As the EU ETS fixed price goes up, producers were worse off than retailers, particularly at off-peak hours.

Conclusions

We assumed that under the transition to a low-carbon economy and beyond with more flexible demand loads, electricity is better represented as a heterogeneous good.

We reject Bertrand competition at peak hours more strongly than at off-peak hours. Higher renewable levels in the morning peak seem to be consistent with the ability to exercise market power profitably under the SFE method. Although price elasticity of demand was low, we observe a difference in the pass-through of fuel and CO_2 costs, which in turn highlights the differentiated impact of input costs on electricity prices.

Taking this model as a minimum-bound study, all our counterfactuals with ceteris paribus fuel costs show that producers are worse off than retailers, confirm the central role of must-run technologies, and the importance of increasing the levels of flexibility. This could be achieved by upgrading or replacing less flexible technologies, with more flexible and cleaner ones. Another option from the consumer side would be that regulations for utilities allow more flexible demand responses and pricing schemes, which highlights the importance of the role of utilities in the transition to a low-carbon electricity system.

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