Evidence of flexibility and its economic implications on the DAM

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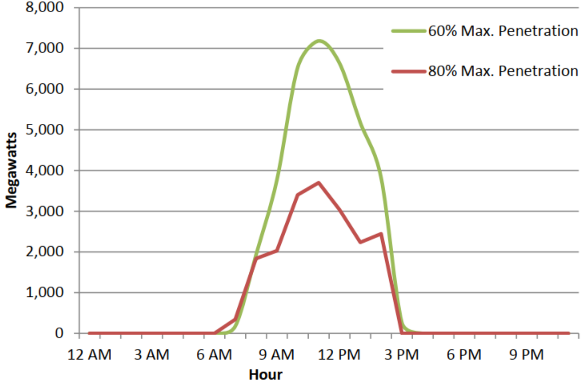
EAERE

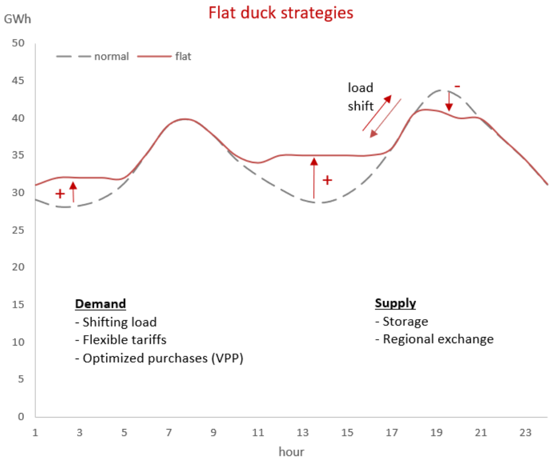
Flexibility and welfare distribution

Do flexibility solutions alter the allocative efficiency between generators and distributors in electricity systems under RPS and ETS?

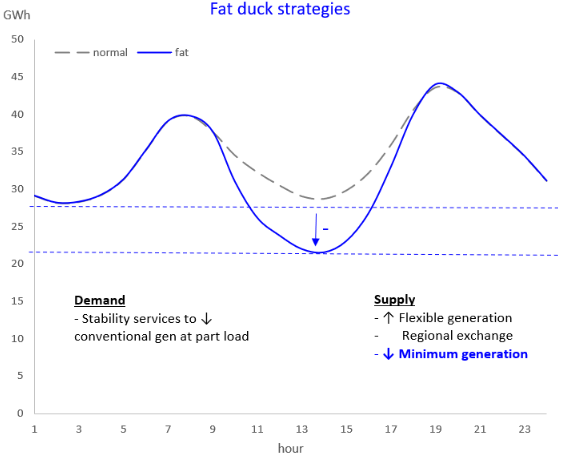
Curtailment of renewables, overgeneration. $\uparrow$ costs



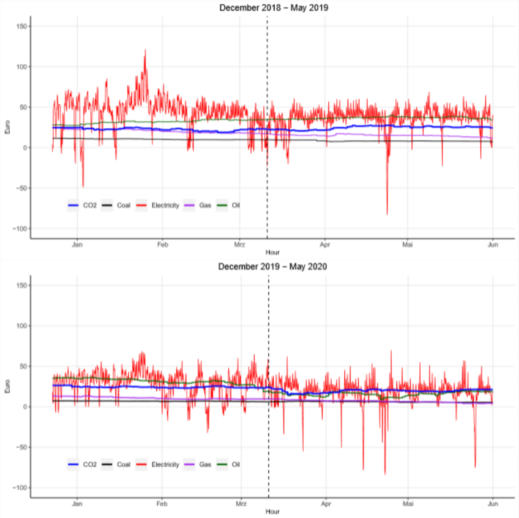
Source: NREL, 2015


Flat duck strategies
GWh
50
45
40
35
30
25
20
15
10
5
0
normal
flat
load
shift
+
+
-
Demand
- Shifting load
- Flexible tariffs
- Optimized purchases (VPP)
Supply
- Storage
- Regional exchange
1
3
5
7
9
11
13
15
17
19
21
23
hour

Fat duck strategies

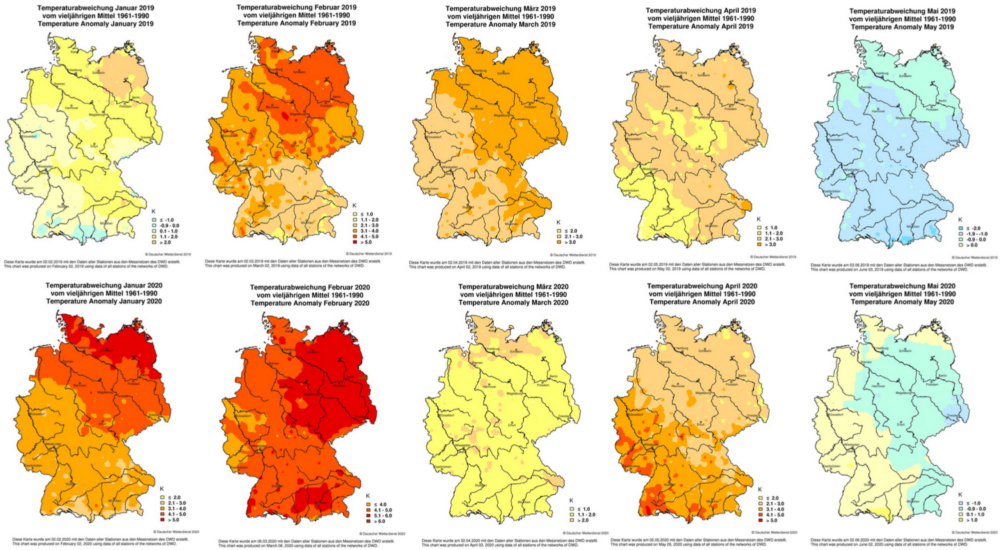


Higher frequency of negative prices

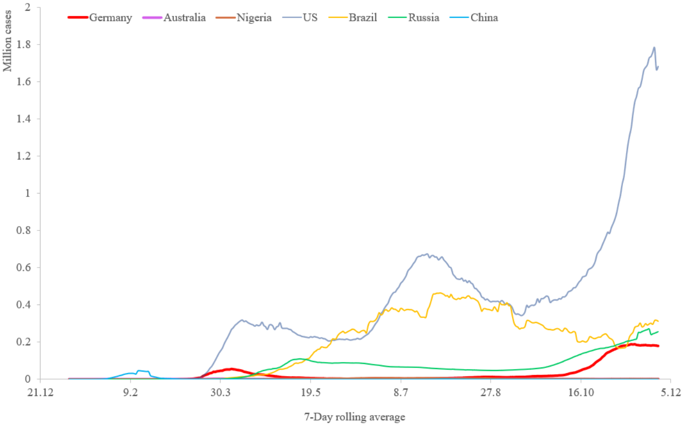


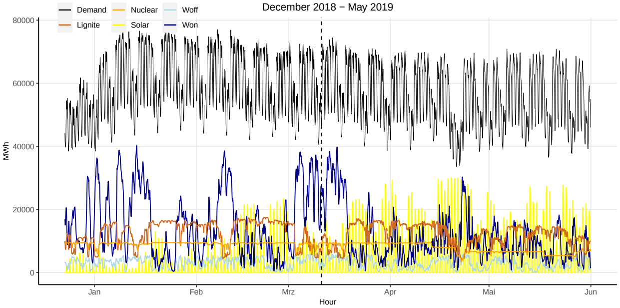
	19a	19b
Electricity	47	34
	-48/121	-83/69
CO2	10	9
Coal	5	4
Gas	10	6
Temp	3	6
	20a	**20b**
Electricity	31	21
	-32/69	-84/70
CO2	11	8
Coal	3	3
Gas	5	3
Temp	4	8

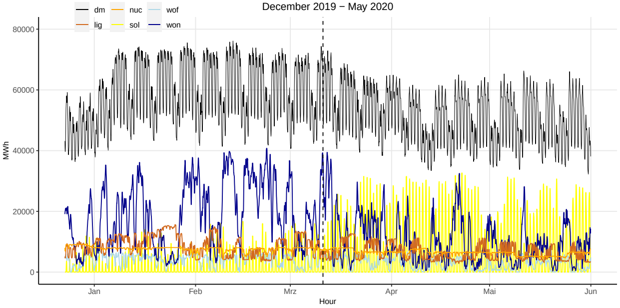
Weather anomalies + 40% renewable shares vs 32%



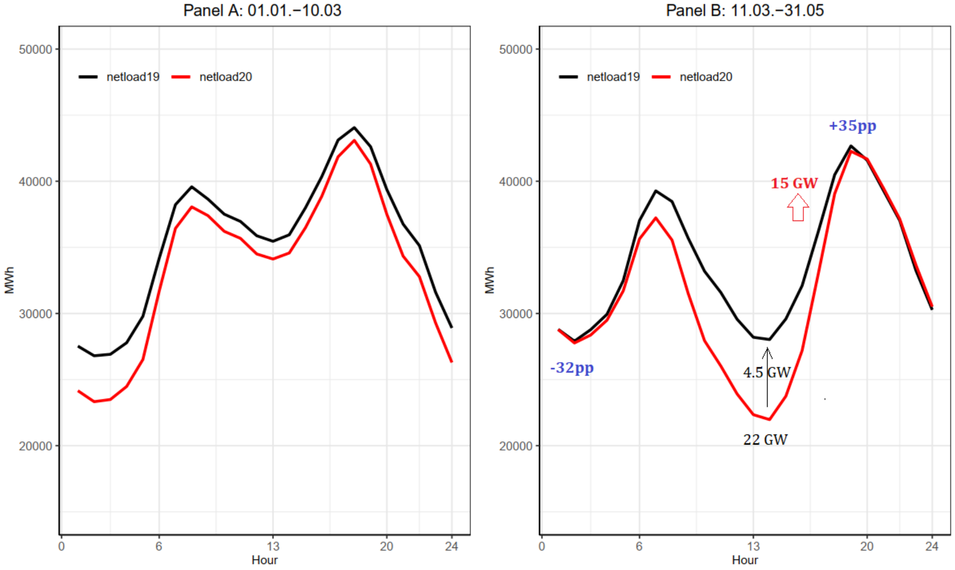
COVID-19 exogenous shock




December 2018 − May 2019
Demand
Lignite
Nuclear
Solar
Woff
Won
MWh
80000
60000
40000
20000
0
Jan
Feb
Mrz
Apr
Mai
Jun
Hour

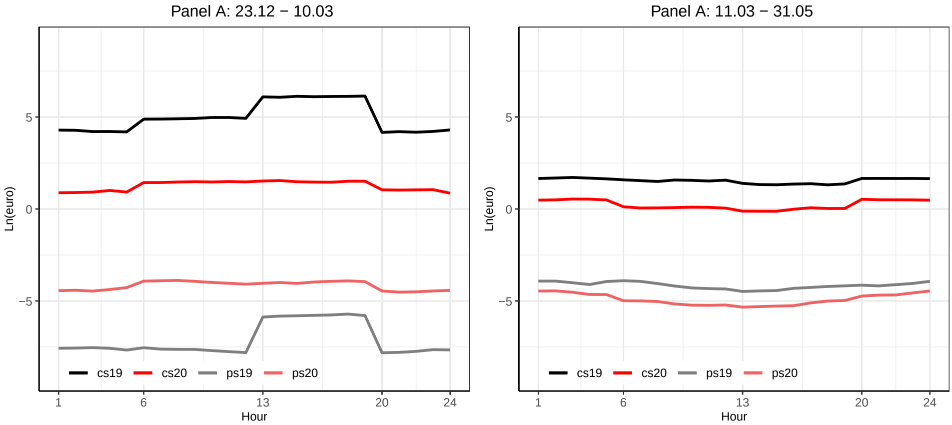

December 2019 − May 2020
dm
lig
nuc
sol
wof
won
MWh
80000
60000
40000
20000
0
Jan
Feb
Mrz
Apr
Mai
Jun
Hour

Net load

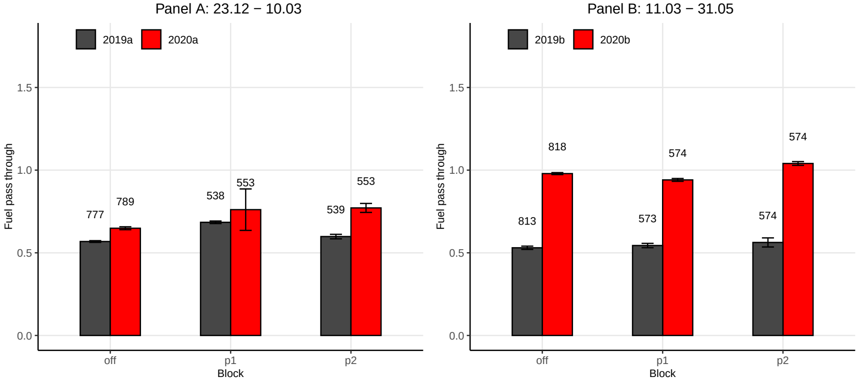


Panel A: 01.01.−10.03
Panel B: 11.03.−31.05
netload19
netload20
MWh
Hour
50000
40000
30000
20000
0
6
13
20
24
+35pp
15 GW
-32pp
4.5 GW
22 GW

↓ net load both lose
↑ both lose during the day
The gap reduced, but both ended up worst off
Positive effects overriden by negative effects

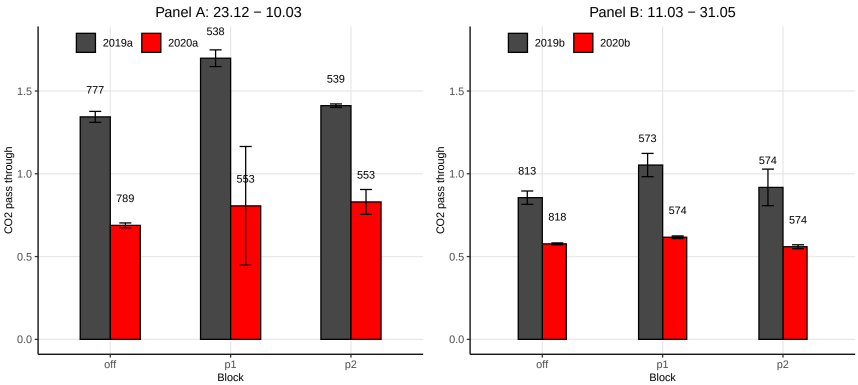


Post-COVID-19 pass-through fuel costs ≈ 1
Higher price elasticity of demand during the day



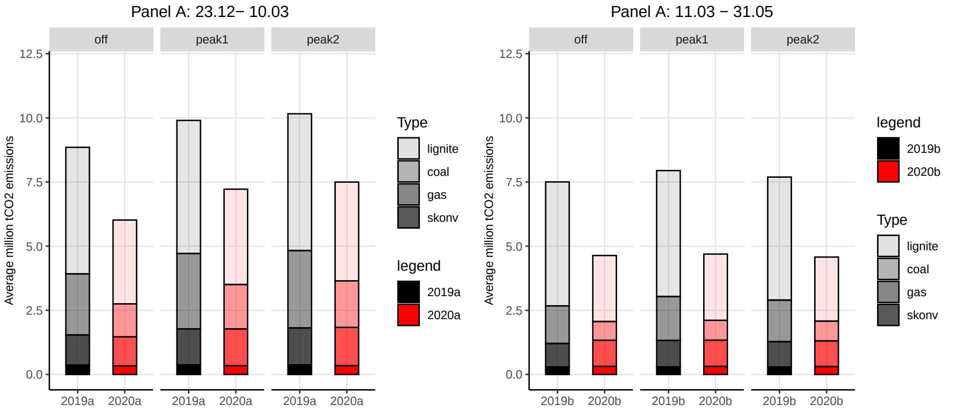
Duck

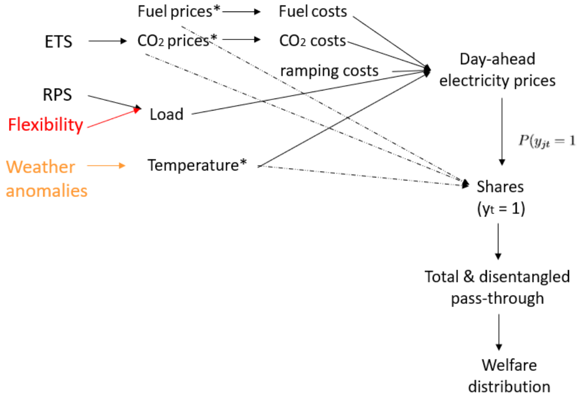
Post-COVID-19 pass-through CO_2 costs not as sensible to this type of flexibility



Duck

↓ 22% GHG emissions, lignite share lower by 8%





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

$$P(y_{jt} = 1 | \alpha p_t, \beta, X_{jt}) = \int \frac{exp(\alpha p_t + \beta X_{jt})}{1 + \sum_{j=1}^{J} exp(\alpha p_t + \beta X_{jt})} f(\epsilon_{zt}|\theta) d\epsilon_{zt}$$

$$\varpi_{jt} = p_t - \eta_{jt} - \gamma V_{jt}$$

$$\varepsilon_{jt} = \delta_{jt} - \beta X_{jt} + \alpha p_t$$

$$g(\sigma) = \begin{bmatrix} 1/N \sum_{jt} \varepsilon_{jt} Z_{jt}^{D} \\ 1/N \sum_{jt} \varpi_{jt} Z_{jt}^{S} \end{bmatrix}$$

$$\min_{\sigma} q(\sigma) \equiv N^2 g(\sigma)' W g(\sigma)$$

$$PS = \sum_{j,t} p_{jt} - c_{jt} s_{jt}$$

$$CS = \sum_{t,i} = w_i \frac{log(1 + \sum_j exp[-\beta X_{jt} + \alpha p_t + \varepsilon_{jti}])}{\alpha_i}$$

Discussion

- CO_2 pass-through rigidity to flexibility market stability reserve
- With storage, trivial marginal unit costs if off-peak = peak? Incentives for investment
- Persistent pattern?
- Daily routines changed $\uparrow$ residential consumption, $\downarrow$ industrial consumption dropped (Cicala, 2020)
- 22% of all full work days after COVID-19 at home, 2.4% higher productivity (Bloom, 2020)
- Consumption patterns in demand similar in Germany similar to the US

Duck

Thank you!

Literature

- Stochastic-discrete choices: Doraszelski et al (2018), Conlon and Gortmaker (2019)
  → COVID-19 exogenous shock affecting intermittent endogenous price formation
  → Technology as source of product differentiation
  → It does not requires bid data
  → One step supply and demand equilibrium estimation, GMM
- Pass through and welfare: Ganapati, Shapiro & Walker (2017), Cludius et al (2014), Weyl & Fabinger (2013), Hirth & Ueckerdt (2013)
  → Theory and drivers of the incidence of carbon taxes, RPS
  → Application to minimum wages, generation
- Flexibility solutions: NREL (2008, 2015), Elkasrawy & Venkatesh (2020), Wohlfarth et al (2020), Hou et al (2019)
  → Demand and supply sides

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