

ENERDAY, 12 April 2024

# Does Cross-Border Electricity Trade Stabilize the Market Value of Wind and Solar Energy? Insights from a European Panel Analysis

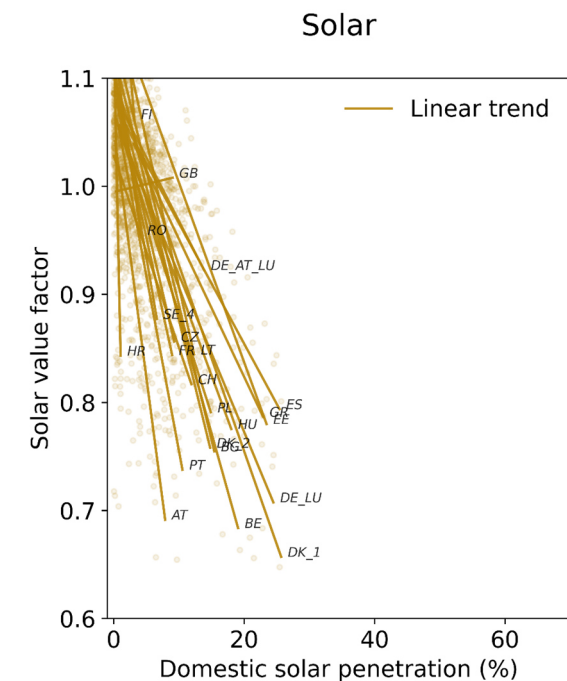
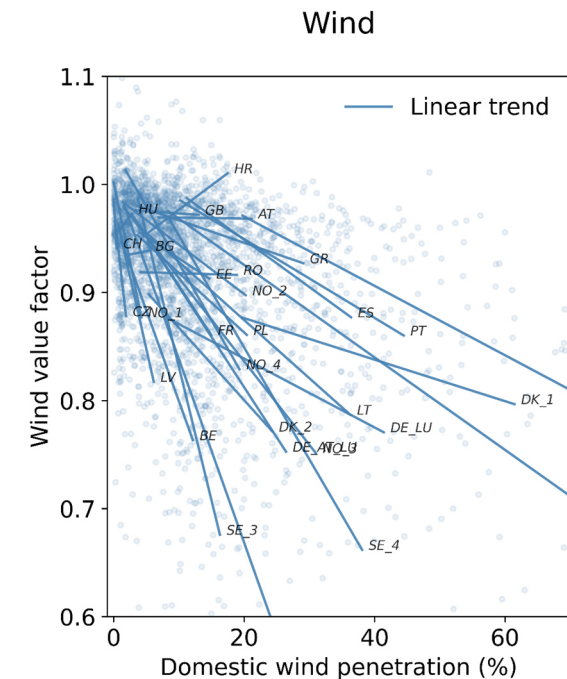
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GEFÖRDERT VOM

# Motivation

- Negative effect of domestic wind & solar market penetration on market value is well-explored
- ...but cross-border effects receive less attention
- We estimate cross-border effects on renewable market value across 30 European bidding zones
  - Jointly estimate domestic and spatial effect of wind/solar market penetration
  - Estimate moderating effect of market connectedness
  - Control for market features that determine the value drop

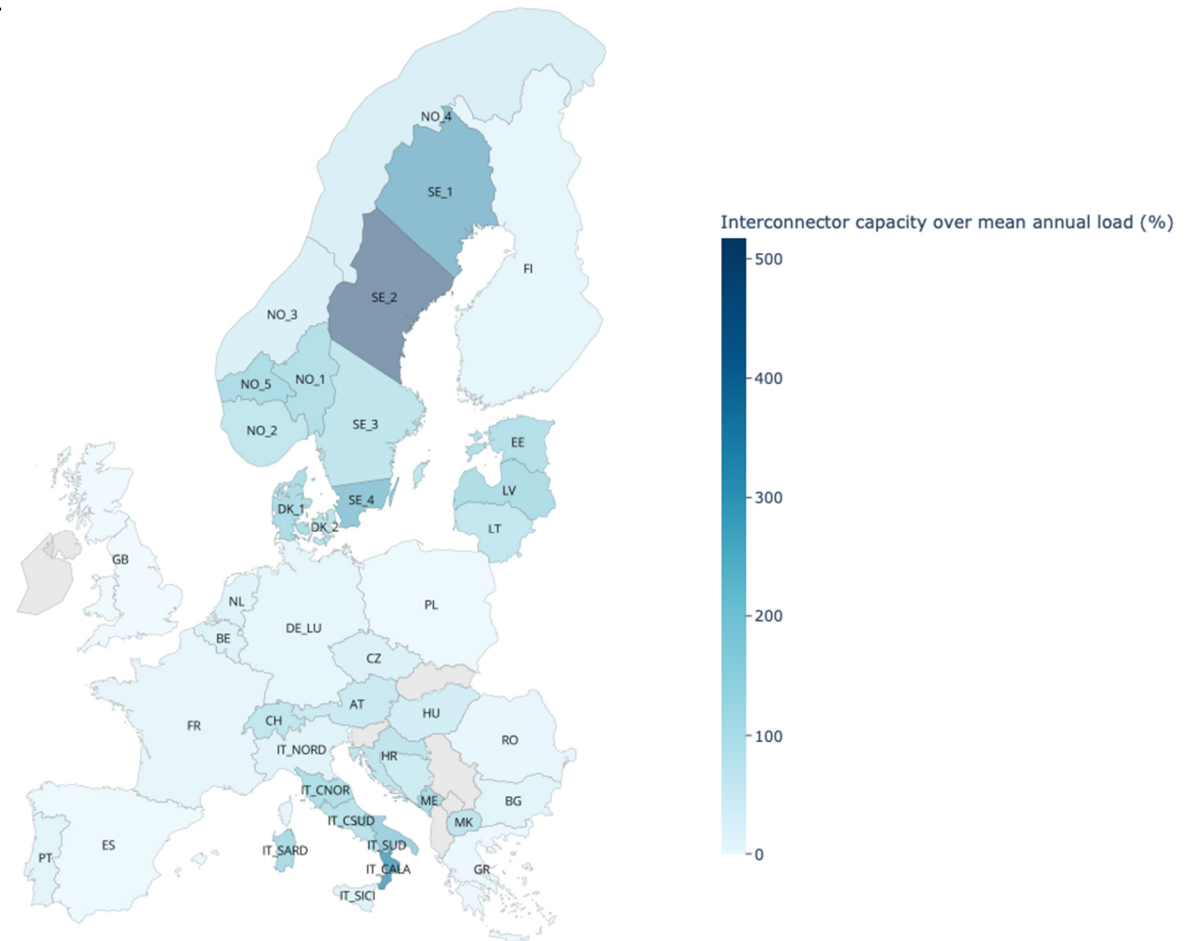


# Model variables and expected effects

	Variables	Expected effects
Dependent	Value factor of wind (solar)	
Independent	Domestic wind (solar) penetration	Negative
	Neighboring wind (solar) penetration	Negative
	Interconnector capacity	Positive / negative
	<i>Controls</i>	
	Reservoir hydro capacity	Positive
	Pumped hydro capacity	Positive
	Coefficient of variation of wind (solar) generation	Negative
	Correlation of wind (solar) generation and system load	Positive
	Clean gas-coal price ratio	Negative

# Data

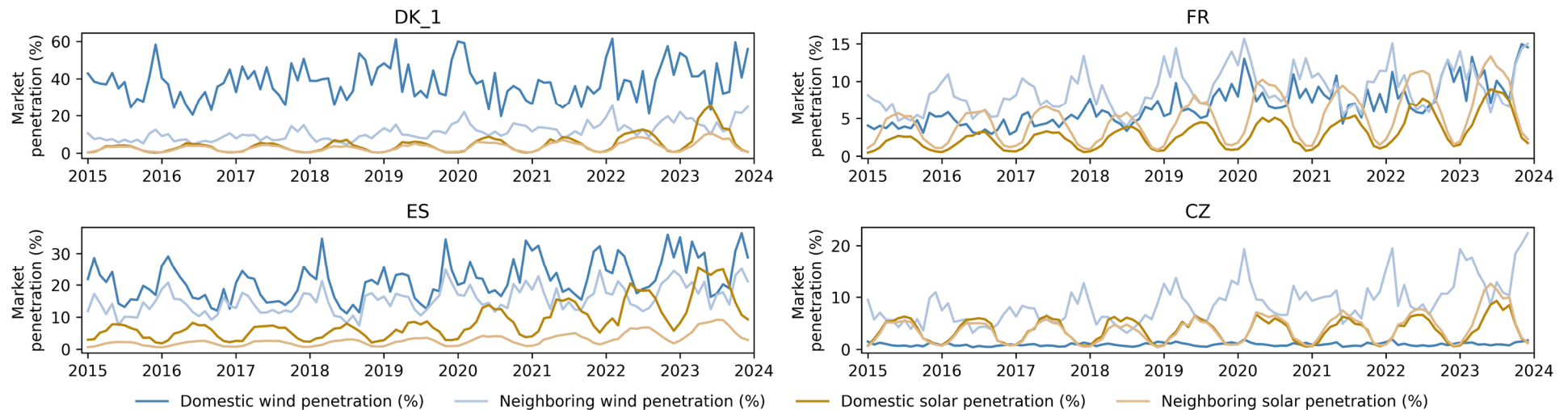
- We use electricity market data from 2015-2023 aggregated at the monthly level
- Data retrieved from ENTSO-E TP and national authorities



# Modelling spatial effects

- We model the effect of wind/solar market penetration across a bidding zone's direct neighbors on domestic market value (*spatial lag of X* approach)
- Wind/solar market penetration of bidding zone  $i$ 's neighbor  $j$  is weighted by normalized interconnector capacity between  $i$  and  $j$

Domestic and neighboring wind and solar penetration



# Identification strategy

- Renewable generation is weather-driven but cross-border flows and hydro electricity generation are endogenous to prices
- We use capacities instead of flows/generation
  - Interconnector capacity
    - Approximated by annual 95% quantile of hourly bilateral commercial exchanges
  - Hydro pumped storage and reservoir capacity
  - All capacity data normalized by mean annual zonal load

# Model specification

- Fixed effects (FE) estimation eliminates the variation we are interested in
- *Random effects within-between model* (Mundlak, 1978, Bell & Jones, 2014)
- Idea: Split up variation in  $X_{i,t}$  into two parts:
  - Variation within entities:  $X_{i,t} - \bar{X}_i$
  - Variation between entities:  $\bar{X}_i$
- *Within* effects  $\beta(X_{i,t} - \bar{X}_i)$  are equivalent to coefficients from a FE model
- *Between* effects  $\beta(\bar{X}_i)$  explicitly model heterogeneity at the zone level

# Model specification

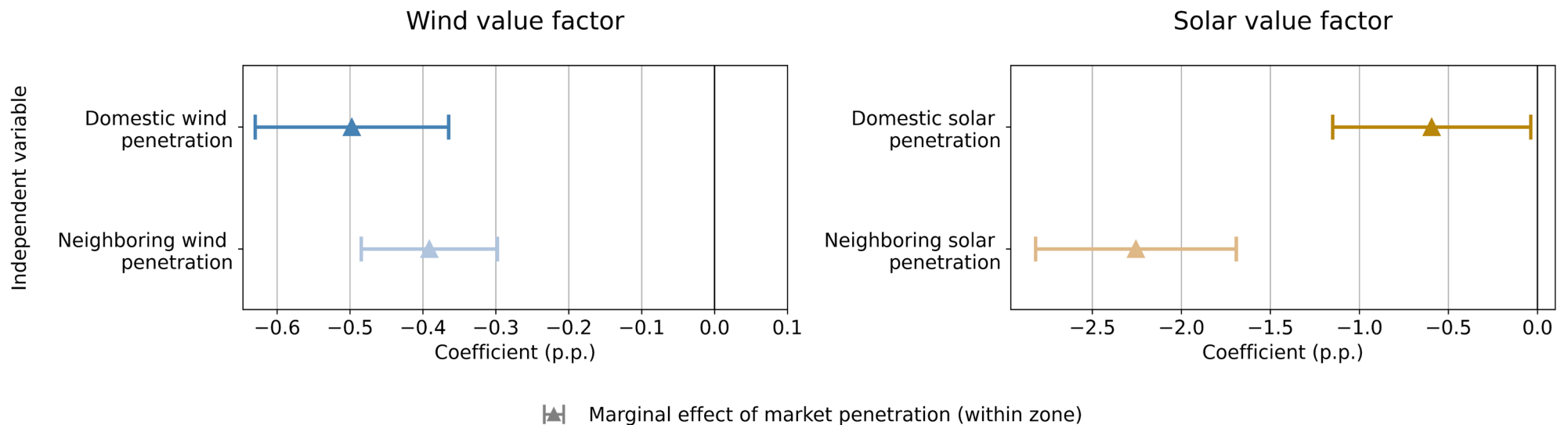
$$\begin{aligned}
 VF_{i,t}^w &= \beta_0 + \beta_1 \ddot{P}_{i,t}^w + \beta_2 \bar{P}_i^w + \beta_3 \ddot{P}_{sp,i,t}^w + \beta_4 \overline{P}_{sp,i}^w \\
 &+ \beta_5 I_i + \beta_6 \ddot{P}_{i,t}^w * I_i + \beta_7 \ddot{P}_{sp,i,t}^w * I_i + \beta_8 \ddot{P}_{i,t}^s \\
 &+ \beta_9 \bar{P}_i^s + \beta_{10} \ddot{P}_{sp,i,t}^s + \beta_{11} \overline{P}_{sp,i}^s \\
 &+ \beta' C + \beta' \ddot{P}_{i,t}^w * \ddot{C} + \beta' \ddot{P}_{i,t}^w * \bar{C} + \gamma' D_t + \varepsilon_{i,t}
 \end{aligned}$$

- $VF_{i,t}^w$  Value factor of wind
- $\ddot{P}_{i,t}^{\{w,s\}} = P_{i,t}^{\{w,s\}} - \bar{P}_i^{\{w,s\}}$  Domestic wind/solar market penetration (within zone)
- $\ddot{P}_{sp,i,t}^{\{w,s\}} = P_{sp,i,t}^{\{w,s\}} - \overline{P}_{sp,i}^{\{w,s\}}$  Neighboring wind/solar market penetration (within zone)
- $I_i$  Interconnector capacity
- $C$  Vector of controls
- $D_t$  Month and year dummies
- $\varepsilon_{i,t}$  Error term



# Results

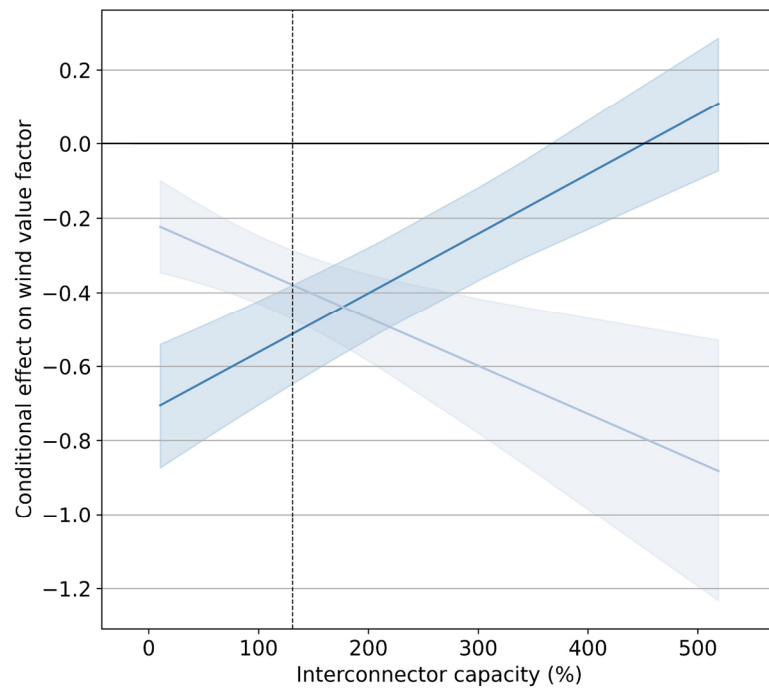
- We find substantial domestic and cross-border effects of market penetration on market value
- Domestic effect of solar is stronger (because of simultaneity)
- Cross-border effect of solar is stronger (because of geographic smoothing of wind)



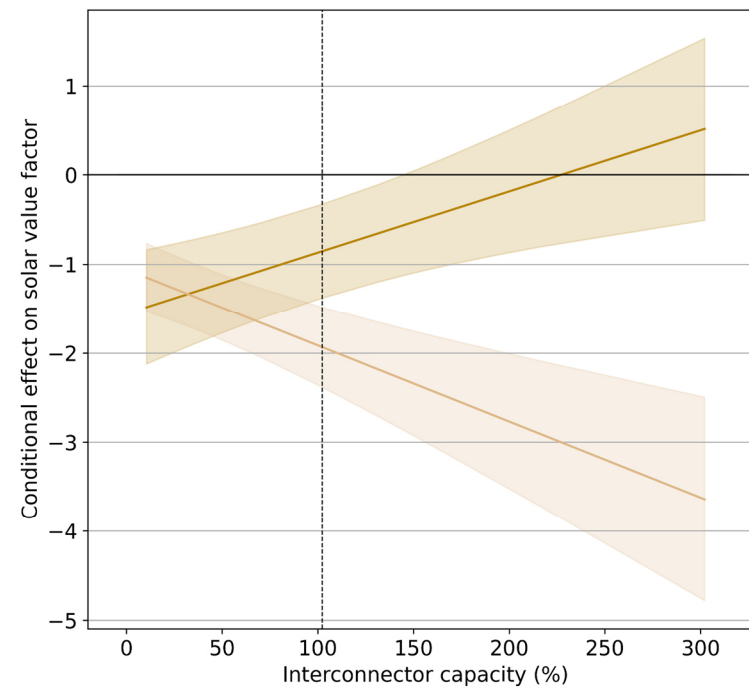
# Results

- Connectedness mitigates domestic value drop (through exports)
- ...but exacerbates cross-border spillovers (through imports)

Conditional effects of domestic and neighboring wind/solar penetration



— Conditional effect of domestic wind penetration (within zone)  
■ 95% confidence interval  
— Conditional effect of neighboring wind penetration (within zone)  
■ 95% confidence interval  
- - - Interconnector capacity sample average

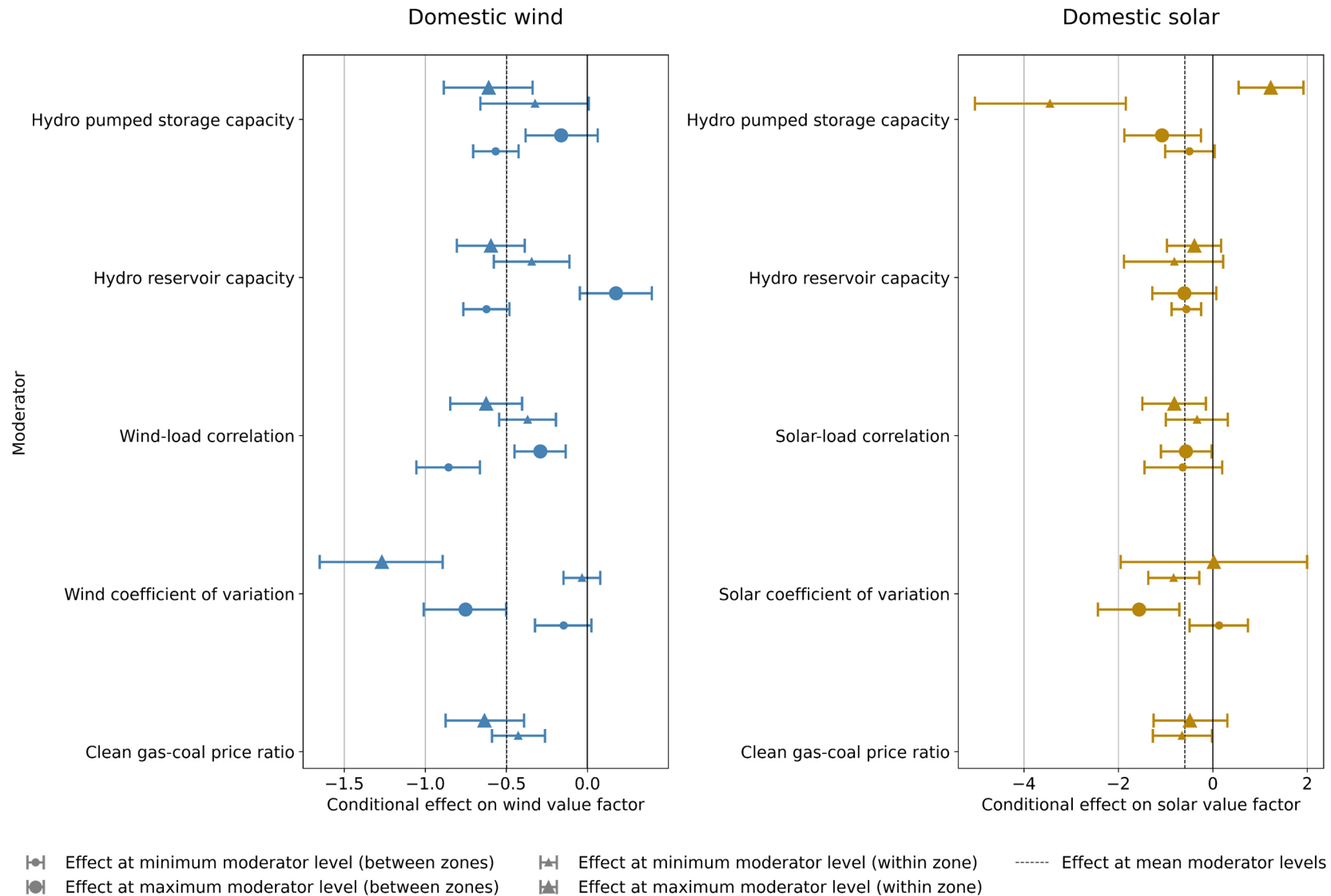


— Conditional effect of domestic solar penetration (within zone)  
■ 95% confidence interval  
— Conditional effect of neighboring solar penetration (within zone)  
■ 95% confidence interval  
- - - Interconnector capacity sample average



# Results

- We can identify more factors that mitigate the wind value drop



# Conclusion

- We confirm the negative effect of domestic wind/solar market penetration on market value
- In addition, we find substantial spatial effects which are stronger for solar
- Connectedness of price zones mitigates the domestic value drop but exacerbates spillover effects
- Hydro flexibility, load correlation and smoother generation profile can mitigate the value drop

Thank you!

