

Radioinactive: Are nuclear power plants outages contagious to the German electricity price?



Sonja Rinne
University of Münster

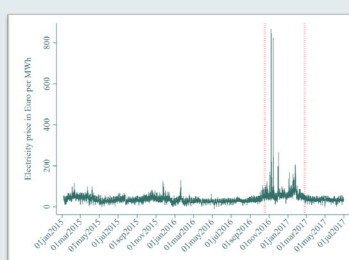
Introduction

From October 2016 to February 2017 the French electricity market was subject to an exogenous shock. Due to security concerns, 20% of the French nuclear power plant capacity was unavailable at short notice, and under extensive inspection until February 2017. The research question is twofold: First, to identify the effect on prices on the French electricity market. Second, to investigate whether this exogenous shock was passed on to the German market through cross-border trade.

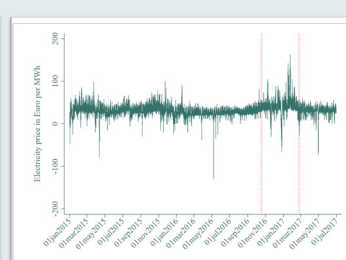
- Hypothesis 1: The inspection period increased the French electricity spot market price.
- Hypothesis 2: The inspection period increased the German-Austrian electricity spot market price through the cross-border trade with France.



Nuclear power plants in France (red affected by the inspections).



French (middle) and German-Austrian (right) electricity spot market price in Euros per MWh (red lines indicate the inspection period).

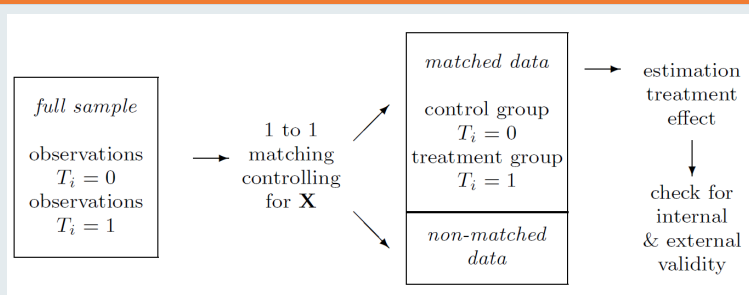


Cross-border electricity trade is a possible mechanism to ensure the security of the supply at times of a demand or supply shock. The integration of national electricity markets in Europe is an ongoing process (Jamansb, Pollitt 2005). Although the market integration is being continuously intensified, a "European supergrid" and a "law of one European electricity price"

is far from a reality. In 2016, the average electricity day-ahead spot market price was 28.98 Euros per MWh in Germany and Austria and 36.75 Euros per MWh in France. Hence, the considerable difference in prices came to, on average, 7.77 Euros per MWh (ACER, CEER 2017).

The challenge to estimate the price effects is to identify the counterfactual situation. Thereby, a thorough identification strategy is necessary to disentangle the various simultaneous influences such as the overall load and renewable electricity generation on the electricity prices. Hence, the answer to the following question needs to be found: "If there were no inspection, what would have been the electricity prices during that period?" With an answer to that, the price effect of the inspection is simply the price difference between the treated observations within the inspection period and their untreated doppelgänger.

Methods



Quasi-experimental identification strategy to estimate causal effects



Analogy to matched observations which differ only by the treatment

Matching is a nonparametric method to control for the influence of the control variables. To identify causal effects, coarsened exact matching is applied, as suggested by Ho et al. (2007) and Iacus et al. (2011, 2012). Thereby, continuous variables are "coarsened" into categories. Then, by matching pairwise observations with control variables within the same categories, a treatment and control group are created.

To ensure that the treatment and control group differ only in respect to the treatment, t-tests and the Kolmogorov-Smirnov tests for equality of distribution are applied to test for differences for the control variables.

Coarsened exact matching is preferable to other matching methods, such as propensity score matching, on several grounds, of which the most important is that coarsened exact matching is nonparametric and considers the higher moments of the control variables, and thus does not rely only on the means. Moreover, the counterfactuals are not extrapolated beyond the scope of the actual observational data.

Radioinactive: Are nuclear power plants outages contagious to the German electricity price?



Sonja Rinne
University of Münster

Results

The binary variable T_i informs about the treatment. The effects of the controls X are estimated in the vector δ while ε is an error term. The standard errors are clustered at the hour of the observation.

Hypothesis 1: Average treatment effect on the French electricity spot market price. The average treatment effect is captured by β_1 .

$$\text{electricity price} = \beta_0 + \beta_1 \times T_i + \delta \times X + \varepsilon$$

Hypothesis 2: Average treatment effect on the German-Austrian electricity spot market price through cross-border trade with France. The average treatment effect of electricity exports from Germany to France Ex is captured by γ_1 . The average treatment effect of electricity imports to Germany from France Im is captured by γ_2 .

$$\text{electricity price} = \gamma_0 + \gamma_1 \times T_i \times Ex + \gamma_2 \times T_i \times Im + \delta \times X + \varepsilon$$

The strategy to address outliers in this analysis is twofold. First, a matched sample is created by the matching algorithm. Outliers with a rare combination in terms of the control variables are less likely to be matched. Second, an adjusted dataset without outliers based on the 3 σ -rule is also used in the analysis, as a robustness check.

Electricity price in € per MWh # of observations	France 2,366	Germany-Austria 2,366
Inspection period		
$T_i = 1$	14.146*** (1.213)	
Inspection period \times exports in GWh (to France from Germany)		
$T_i = 0$		2.851* (1.073)
$T_i = 1$		3.949*** (0.495)
Inspection period \times imports in GWh (from France to Germany)		
$T_i = 0$		-0.602 (0.369)
$T_i = 1$		-2.459*** (0.462)
Controls (Load in France and Germany, solar and wind electricity generation Germany, CO ₂ , coal and gas price, hour of the day)	\times	\times

Average treatment effects Hypothesis 1 and 2.

Electricity price in € per MWh	Germany-Austria	average cross-border trade	absolute effect Ex/Im: \times average effect
Exports in GWh (from Germany to France)			
$T_i = 0$		0.106	0.303
$T_i = 1$		0.400	2.018
Δ		0.294	1.715
Imports in GWh (to Germany from France)			
$T_i = 0$		1.179	-0.710
$T_i = 1$		0.524	-1.289
Δ		-0.655	-0.379

Absolute treatment effects Hypothesis 2.

Are nuclear power plant outages in France contagious to the German electricity price? Yes, they are if the outages are of a magnitude and an extent such as the ones caused by the extensive inspections from October 2016 to February 2017. The security concerns in the 12 nuclear power plants affected not only the French but also the German-Austrian electricity price. The French day-ahead electricity price increased on average by 14.15 Euros per MWh due to the extensive inspections. The effect on the German-Austrian day-ahead electricity price relates to the cross-border trade. Due to the increased electricity exports from Germany to France, the German-Austrian electricity price increased on average by 1.72 Euros per MWh.

Conclusions

Although nuclear electricity generation is dispatchable, in contrast to solar and wind electricity generation, the reliability of nuclear power plants can be interfered with. The security concerns regarding one specific component affected at once 20% of the French nuclear power plants. As shown in this analysis, this capacity shock increased the French electricity price substantially. Hence, a stronger diversification of the electricity mix in France might have reduced the price effect.

In addition, the analysis of the cross-border trade between France and Germany during the inspection period sheds light on the potential and current limitations of an integrated European electricity market. During the inspection period, the capacity loss on the French market was partly compensated for by electricity imports from the German market.

Nevertheless, the French day-ahead electricity price increased considerably due to the extensive inspection to achieve a security of supply during winter. Hence, European electricity markets are likely to profit from an extension of the cross-border trade to maintain the security of supply at lower costs.

References

- ACER, CEER, 2017. Annual Report on the Results of Monitoring the Internal Electricity and Gas Markets in 2016.
- Ho, D. E., Imai, K., King, G., Stuart, E. A., 2007. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis* 15 (3), 199-236.
- Iacus, S. M., King, G., Porro, G., 2011. Multivariate matching methods that are monotonic imbalance bounding. *Journal of the American Statistical Association* 106 (493), 345-361.
- Iacus, S. M., King, G., Porro, G., 2012. Causal inference without balance checking: Coarsened exact matching. *Political Analysis*, 1-24.
- Jamasb, T., Pollitt, M., 2005. Electricity market reform in the European Union: review of progress toward liberalization & integration. *The Energy Journal*, 11-41.
- Full discussion paper available at: <https://www.wiwi.uni-muenster.de/ciw/de/forschung/ciw-diskussionspapiere>