Impact of grid innovations on electricity price volatility in Italian island markets

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Background

- The electricity market is influenced by the **infrastructures** available in the area that we are considering;
- This is coherent with the fact that **electricity markets** are sometimes divided into **separate zones** even within the same country (as is the case in Italy, our study case);
- This is especially evident in the **balancing market**, where trades take place almost in real-time and are used to address flow fluctuations, but **it also holds true for the day-ahead market**;
- This aspect highlights the **significance of infrastructure investments** in the relevant market, sometimes substantially altering its characteristics.

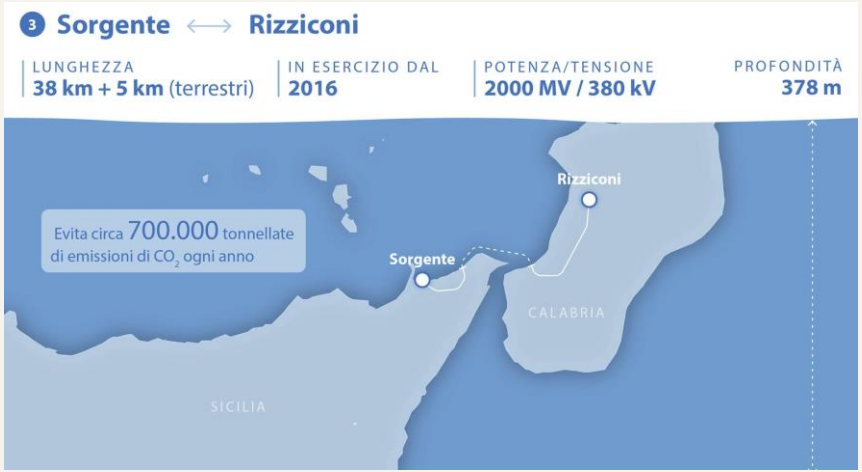
Background and scope of the work

- Islands have **fewer connection** opportunities compared to the mainland;
- For this reason, their markets often display unique patterns that make them **difficult to compare** with other areas and they are excluded from general analysis (Bertolini, D'Alpaos and Moretto, 2018; Caporin, Fontini and Santucci de Magistris, 2022);
- However, for this reason, it might be **"easier" to identify significant changes** after huge infrastructure interventions.

- The purpose of this work is to **analyze the price variance** in the **Sicily** market area to see if it has undergone changes after the **connection of the Sorgente-Rizziconi power cable.**

The Sorgente Rizziconi Cable

- **The power line links Sicily and Calabria**;
- It is a double three-phase power line (a configuration where there are two sets of three-phase conductors, meaning two separate three-phase systems running in parallel);
- It is located more than 350 meters deep;
- It helps the integration of renewables in the power system.



Source: TERNA, https://lightbox.terna.it/

Relevance of the topic and previous literature (some examples)

- **Variance analysis – spillovers and network components.** After infrastructural changes (Sapio A., Spagnolo N., 2020. "The effect of a new power cable on energy prices volatility spillovers" Energy Policy, Volume 144, September 2020, 111488) and their patterns after specific policies (Chanatásig-Niza E., Ciarreta A., Zarraga A., 2022. «Volatility spillover analysis with realized semi(co)variances in Australian electricity markets» Energy Economics, Volume 111, 2022,106076)
- **Variance and market risk** (among others, Mieth R., Kim J., Dvorkin Y., 2020. "Risk- and variance-aware electricity pricing" Electric Power Systems Research, Volume 189, 2020,106804 – on RES penetration)
- **Infrastructures and market power** in the electricity market (Sapio A., Spagnolo N., 2016. "Price regimes in an energy island: Tacit collusion vs. cost and network explanations" Energy Economics, Volume 55, March 2016, Pages 157-172)

Context – market zones

Before 2021

After 2021

Source: TERNA, https://lightbox.terna.it/it/insight/riorganizzazione-zone-mercato-elettrico

Dataset

- To perform the analysis, we build a dataset of **hourly** energy prices in the day-ahead electricity market in Italy, by zones (source: GME);
- The time frame we considered covers **4 years**, from January 2015 to December 2018;
- During the time-frame, market zones where kept stable (while later the Calabria zone was added, after 2021);
- The «event» was at the **beginning of october** 2016.

Methodology

- The model we are using is close to the one presented in Bernardi M., Lisi F. (2020), Point and Interval Forecasting of Zonal Electricity Prices and Demand Using Heteroscedastic Models: The IPEX Case, Energies, 13, 6191.
- Using a non-parametric model, we estimate prices as functions of **major features** of electricity market prices, i.e. all relevant time component (day of the week, time as day of the year, bank holidays (yes/no)) and RES production;

$$P_t = f_1(P_{t-1}) + f_2(T_t) + f_4(W_t) + f_5(B_t) + f_6(FER_t) + \cdots + \epsilon_t$$

- We do the estimate for **specific hours** during the day (4 a.m., 10 a.m. and 7 p.m.);
- We analyze the differences between real prices and estimated prices, being this difference **not explainable** with usual characteristics of day ahead electricity prices' series;
- We perform the analysis for Sicily and North.

4 a.m.

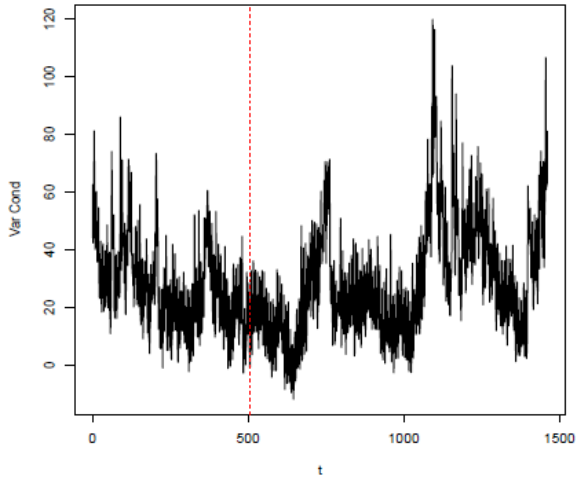


Figure 2: North LP 04: stima della varianza condizionata.

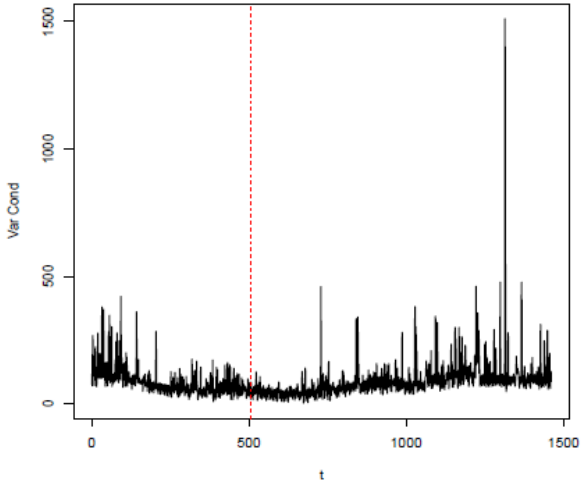


Figure 11: Sicilia LP 04: stima della varianza condizionata.

10 a.m.

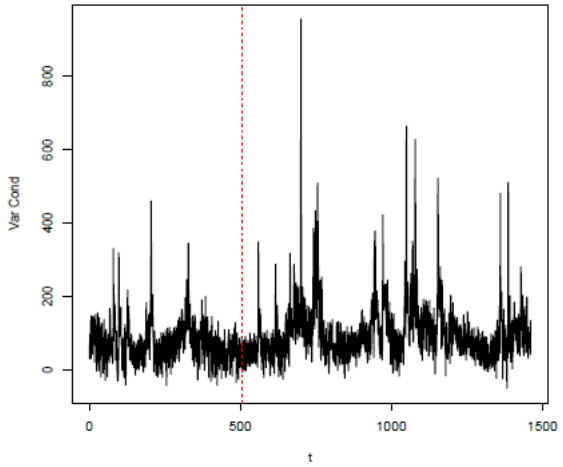


Figure 5: North LP 10: stima della varianza condizionata.

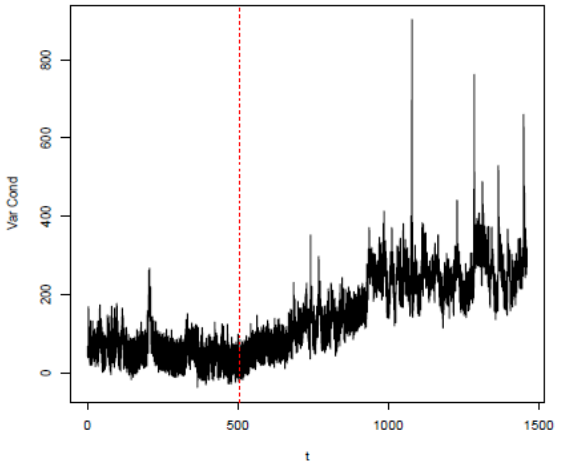


Figure 14: Sicilia LP 10: stima della varianza condizionata.

7 p.m.

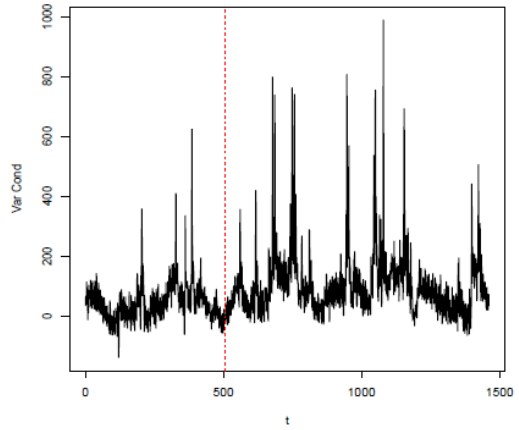


Figure 8: North LP 19: stima della varianza condizionata.

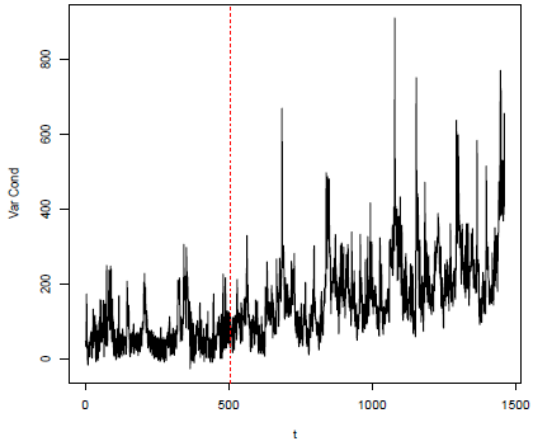
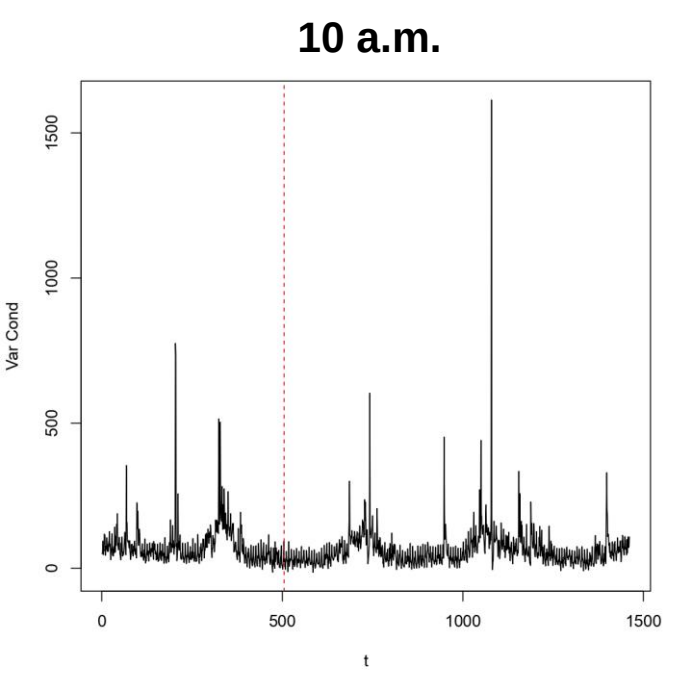


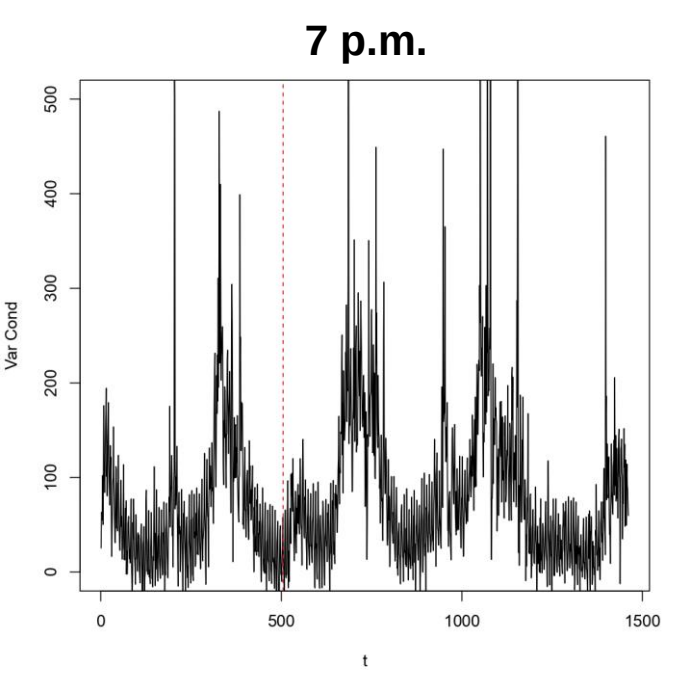
Figure 17: Sicilia LP 19: stima della varianza condizionata.

South

10 a.m.



7 p.m.



Discussion: Variance and market power

- Price variance delivers information about the market competition level

(theoretically, it also delivers information about risks and impacts investments level)

- Bertolini et al., 2020. “Competition in Smart Distribution Grids”. The *smarter* the grid (i.e. the more the grid is able to include new agents), the more volatile is the market.
- Agent based models (“Evaluating individual market power in electricity markets via Agent-based simulation” by DW Bunn, FS Oliveira, 2003): where it is harder to coordinate behavior, higher prices and *unstable* behaviour.

✓ In Sicily we had higher but more stable prices before the Sorgente Rizziconi cable

Example: random day in 2013
Price levels

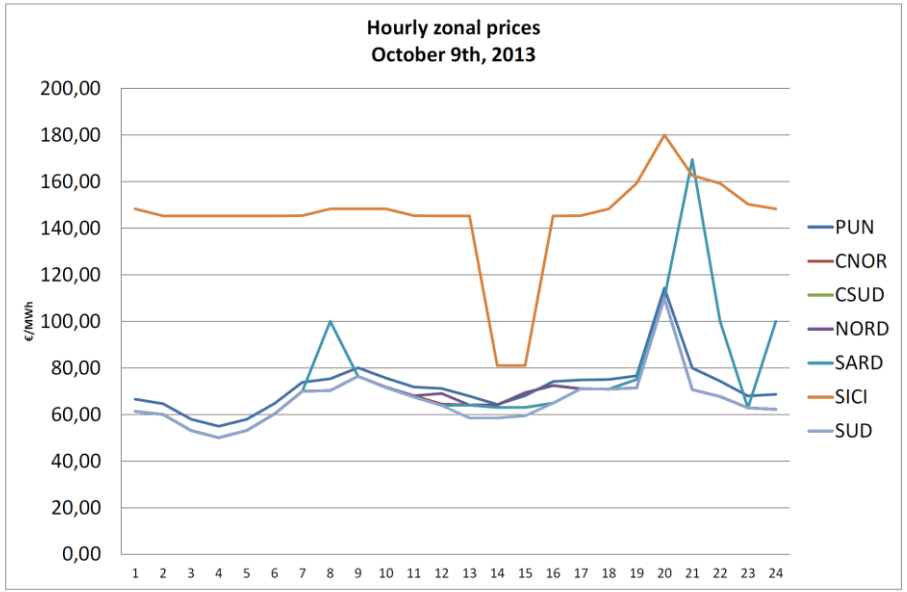


Table 15: Zonal prices on October 9th, 2013 - GME data elaboration.

Bertolini M., 2015

Conclusions and preliminary comments

- We consider evolution in time, identifying the “intervention” from data variation.

- In this context, it's difficult to **attribute** the effect to a single event;
- However, the installation of the cable conduit had a considerable impact on the market, and surely part of the variation is due to this;
- The fact that the same pattern is not observed in the northern area nor in the South supports this hypothesis;
- The variance seems to increase and then stabilize to a new level, and this effect shall be further investigated with a market and policy perspective.

Next steps

- Further model testing;
- Meaning of consistently higher variance for market risk and market power (concentration indices);
- Test the persistence of the effect;
- Possible extensions to other areas – policy?

Thank you for your attention!

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