The Mean Reverting Behaviour of Italian zonal energy price: An analysis of the long-term merit order effect

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GENERAL BACKGROUND

Is the merit order effect a permanent feature of high shares of renewable energy, or merely a transitory phase?

We chose this topic because while there are several studies that analyze Merit Order Effect (MoE) in the short-term, there are still few that focus on the long-term effects.

In the short-term many examples can be found in the literature. For example:

- Sensfuß et al. (2007) discuss the impact of renewable electricity generation on spot market prices in the German electricity market. The analysis is conducted considering the spot market prices calculated on hourly level for a year.
- Tselika et al. (2024) examine the asymmetric effects of renewable energy on electricity prices and transmission flows in the Nordics. The analysis use hourly electricity data from January 1, 2016 until December 31, 2019 .

This study is inspired by the work of Antweiler and Muesgens (2021), in which the attention is focused on the long-term MoE.

OBJECTIVES

This research aims to analyze the long-term effect of the MoE in Italy due to renewable energy penetration during the period from 2005 to 2020.

Acemoglu, Kakhbod, and Ozdaglar (2017), in an oligopolistic model with mixed production (both renewables and fossil fuels) suggests that the MoE is stronger when the diversification of energy portfolios is greater → by introducing investment decisions into their model, we show that:

the return on investment in renewables decreases ↓ when…. the share of renewable energy production by households (R^{NC}) increases relative to the share produced by operators (R^{C}) $\frac{R^{NC}}{R^{C}} > 1$ ↑

Table 4.8: Estimations of ψR^{NC}, ωR^{C} and $\frac{\psi}{\omega}\frac{R^{NC}}{R^{C}}$, increases and Δ plants

Period of time	ψR^{NC}	ωR^{C}	$\frac{\psi}{\omega}\frac{R^{NC}}{R^{C}}$	Δ small plants	Δ industrial plants
2021 - 2012	2,968,236	1,640,291	1.81	536,910	382
2016 - 2012	1,700,062	1,078,447	1.58	256,119	82

Source: reprocessing of ARERA data and own calculations

The objective is to see whether the long-run price of energy changes depending on the reference period, confirming the impact of the increase of production of renewables.

CONTEXT OF THE ANALYSIS

The Italian electricity market is divided in market zones ⟶ nodes are aggregated into zones with uniform prices.

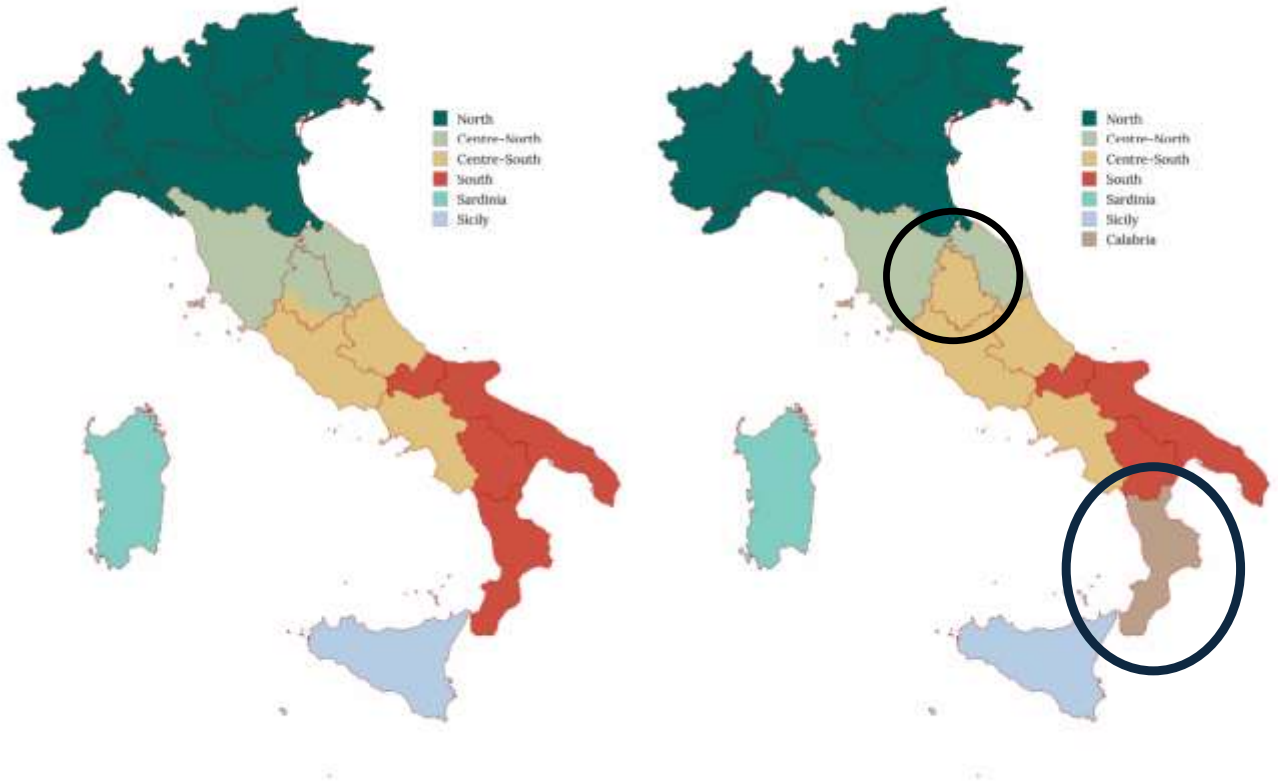
We refer to the **6 market zones**:

- North (NOR)
- Centre-North (CNOR)
- Centre-South (CSOU)
- South (SOU)
- Sicily (SIC)
- Sardinia (SAR)

As of January 2021, the geographical structure has been changed, as shown in Figure.

The Umbria region was moved from the Centre-North zone to the Centre-South zone, and Calabria became the **7th macrozone**.

Figure 5.1: On the left the zonal configuration in force until 31 December 2020, on the right the new configuration from 1 January 2021.



Before 2021
(context of the analysis)

After 2021

METHODOLOGY

We statistically analyse this phenomenon through a **mean reverting process**, which is widely used in the literature to describe the long- term trend in the price of commodities, such as energy (Schmeck and Schwerin, 2021; Pindyck, 1999).

Starting from the time series of prices of the six market zones in quarters, it is possible to model the natural logarithm of prices since it is generally assumed that raw material process are log-normally distributed $Y_t = \ln P_t$.

$$dY_t = \eta(\overline{Y} - Y_t)\, dt + \sigma\, dZ_t \quad \text{with } Y_0 \text{ at } t = 0.$$

mean reversion speed

long-term value to which Y_t converges

process volatility

standard increment of a Wiener process

$$dZ_t = \epsilon_t \sqrt{dt} \quad with \quad \epsilon_t = N(0,1)$$

From Itô's lemma:

$$\overline{Y} = \ln \overline{P} - \frac{\sigma^2}{2}$$

METHODOLOGY

Next, we apply the Ornstein-Uhlenbeck single factor process, that is, the return method of the arithmetic mean, calculating the mean of the logarithmic series, its variance and performing series regression for testing unit roots.

$$\overline{Y} = \ln \overline{P} - \frac{\sigma^2}{2}$$

$$Var(Y_t) = \frac{\sigma^2}{2\eta}(1 - e^{-2\eta t})$$

$$Y_t = a + bY_{t-\Delta t} + \epsilon_t$$

Where:

- $\bar{Y}$, the long-term value to which Y_t converges;
- η, the mean reversion speed;
- σ, the process volatility.

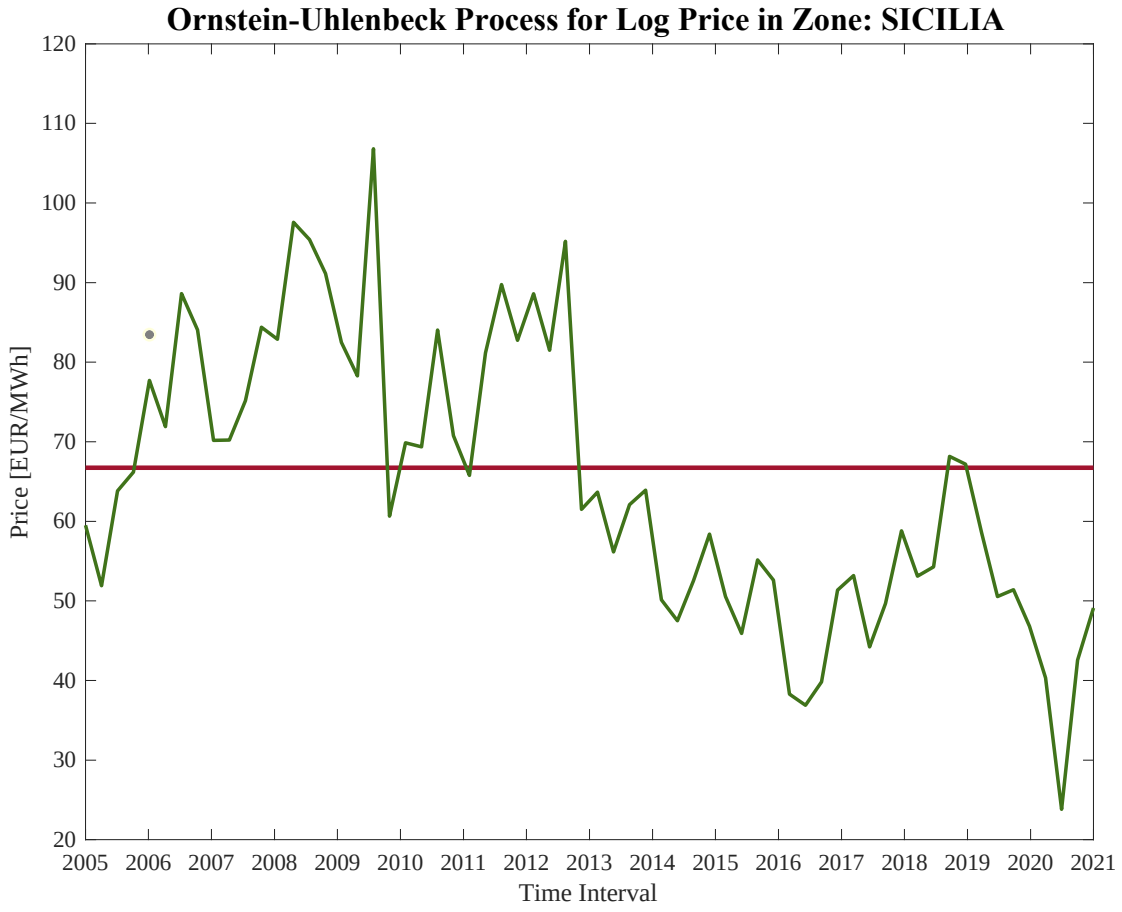
Finally, the last step is to temporally scan the data: transforming the available GME data

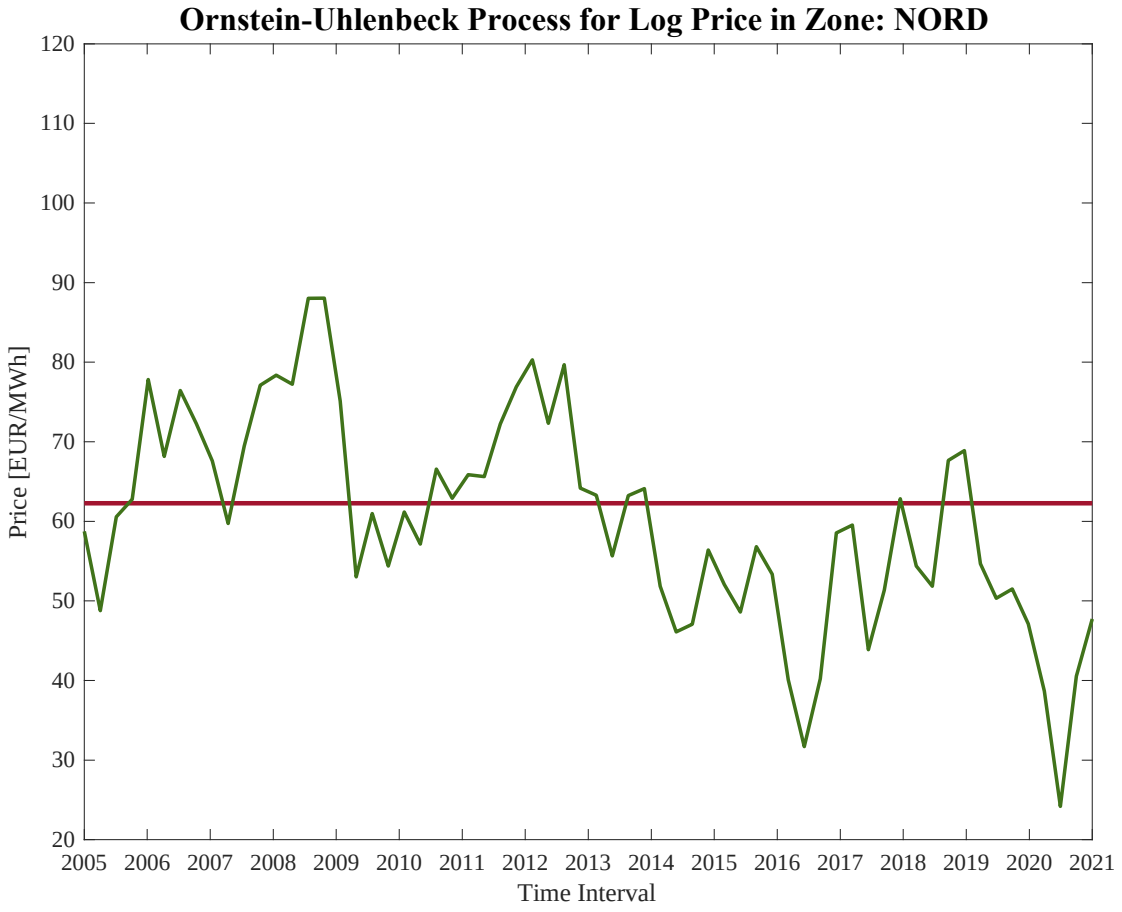
$$\bar{P} = \exp \bar{Y} \exp\left(\frac{\sigma^2}{2}\right)$$

RESULTS 1

Market zone	η mean reversion speed	$\overline{Y}$ long-term value to which Y_t converges	σ process volatility	$\overline{P}$ long-term value to which P_t converges
North	1.21	4.06	0.38	62.26
Centre-North	1.05	4.07	0.35	62.32
Centre-South	0.96	4.06	0.34	61.74
South	0.95	4.04	0.35	60.19
Sicily	0.96	4.12	0.40	66.74
Sardinia	0.90	4.23	0.39	79.39

SIMULATION OF MEAN REVERTING PROCESS



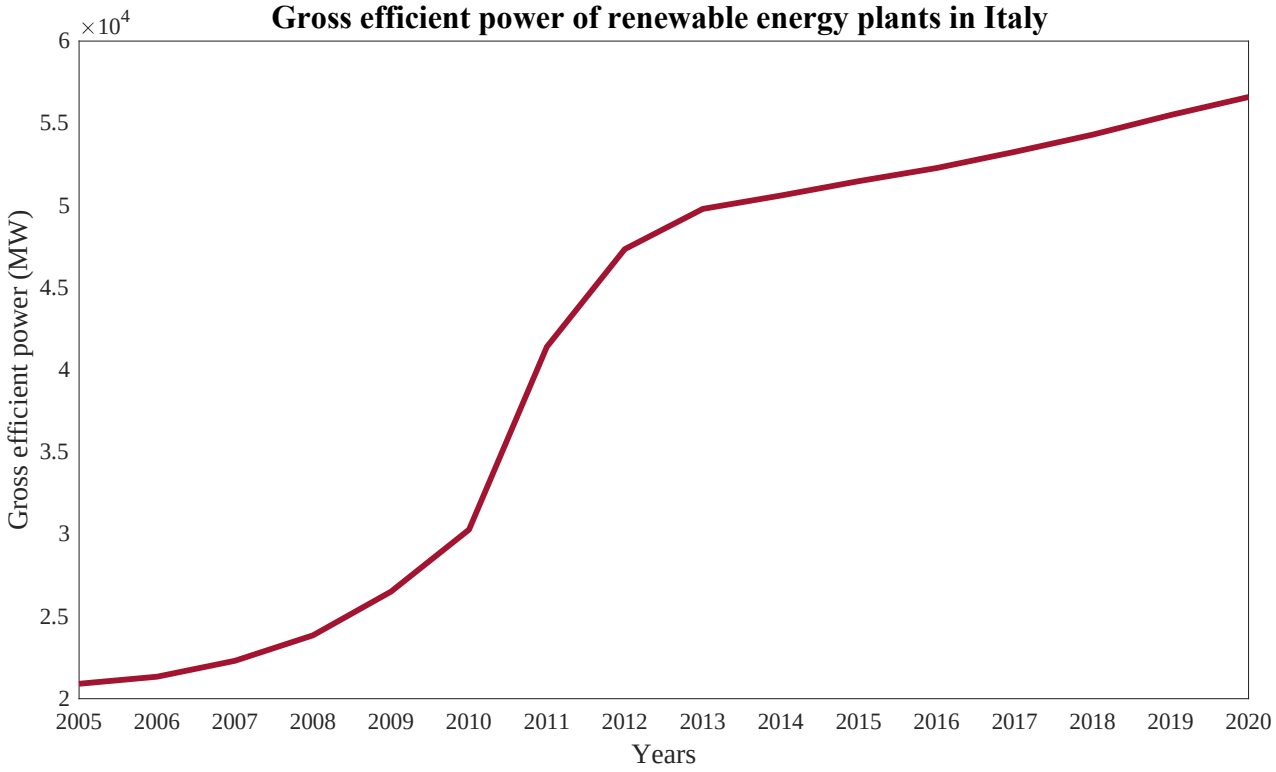


RESULTS 2

The objective of this second analysis proposes again the mean-reverting method for two **sub-periods** of the time series, **from 2005 to 2012** and **from 2013 to 2020**.

Observing the average long-term price in the two sub-periods shows whether the price of energy has decreased: analysis of MoE in the zone over time

This happens because there has been a growth of gross efficient power of renewable plants at national level between the two periods: in particular, between 2011 and 2013



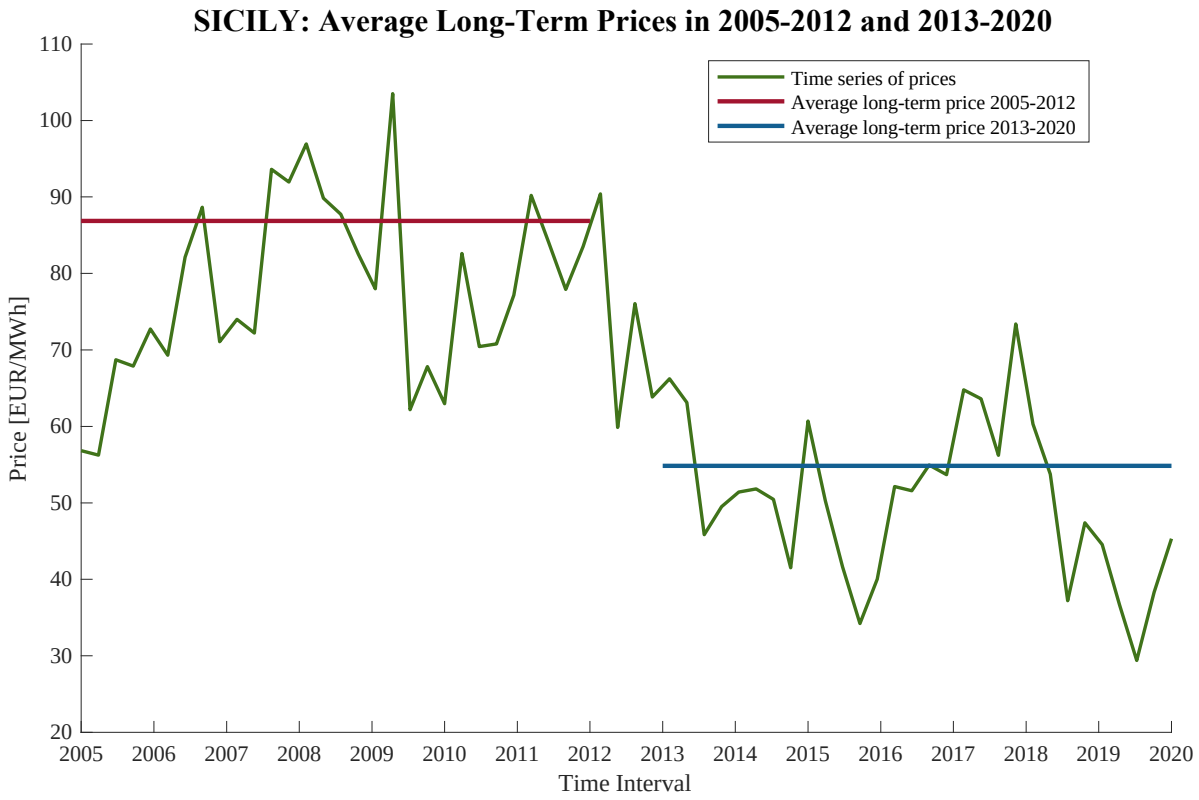
especially when the net production of renewable energy produced by **households** (R^{NC}) is higher than the production of firms (R^{C})

RESULTS 2

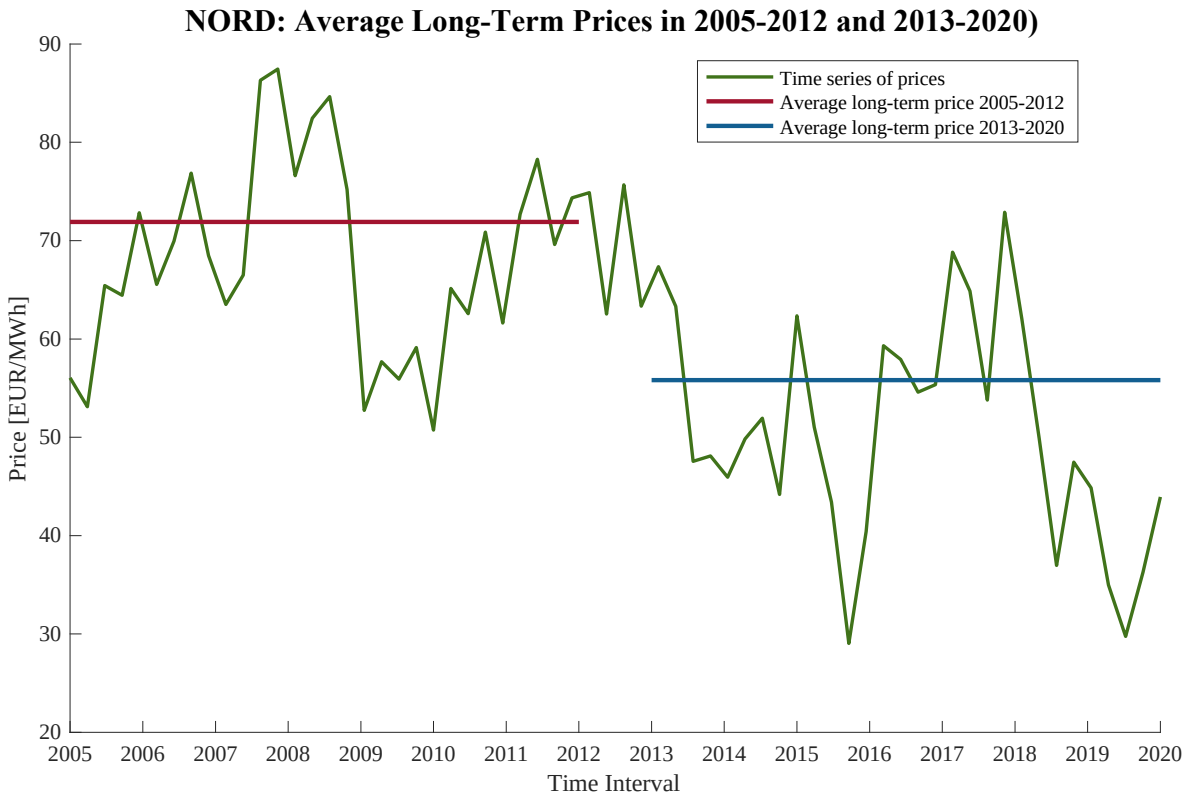
Market zone	2005-2012			2013-2020			2005-2020
	η	σ	$\overline{P}$	η	σ	$\overline{P}$	η
North	2.2614	0.3060	71.91	2.5423	0.4942	55.81	1.21
South	1.7608	0.3016	71.85	2.5151	0.4398	52.74	0.95
Sicily	4.2437	0.4702	86.86	2.5311	0.4601	54.83	0.96

MEAN REVERTING IN SICILY AND NORTH ZONES

We show significant change in the long-term average price ($\bar{P}$) in Sicily and North zones, with respect to the increase of RES produced in Italy.



$\bar{P}$ reduction in Sicily:
from 86.86 €/MWh to 54.83 €/MWh



$\bar{P}$ reduction in the North:
from 71.91 €/MWh to 55.81 €/MWh

CONCLUSIONS

- The **long-term average price is rather similar between one zone and another**, so that despite the differences in geography and production, there were no particular deviations due to increased production of renewables.

- However, there is a significant difference in the mean-reverting price between the zones of the peninsula and the two islands

$\bar{P}$ (of Sicily/Sardinia)
V
$\bar{P}$ (of North/Centre/South)

the zonal system of the Italian electricity market creates disparities in the process of investing in renewables

- The **growth of renewable energy has contributed substantially to the reduction of electricity prices** in each area of the Italian market between the two sub-periods

  In particular, the area of *Sicily* showed the greatest reduction in the long-term average price

when RES $\uparrow \Rightarrow \bar{P} \downarrow$

confirmation of long-term MoE

IMPLICATIONS OF THE ANALYSIS

The analysis can be extended until 2024, where the Italian electricity market has been characterised by an impactful and pervasive energy crisis.

NEXT STEP (1) → Studying whether the size of the MoE is reduced in situations of **exogenous shocks** (war in Ukraine and Covid-19) until it is neutralised

Study of the MoE in the long run, from 2005 to 2025:

Can the system recover from the exogenous shocks?
Can the exogenous shocks be recovered to reduce the price to pre-crisis levels?

Has the crisis triggered by the Covid pandemic and the war in Ukraine led to a structural break in which the price remains permanently higher in the long run?

IMPLICATIONS OF THE ANALYSIS

NEXT STEP (2) → Studying whether the effect that generated the structural break in 2012-13 is indeed attributable to the growth of RES produced by households (R^{NC}) compared to firms (R^{C})

Proving that:

$$\frac{R^{NC}}{R^{C}} > 1$$

would confirm the theoretical result of Acemoglu, Kakhbod, and Ozdaglar (2017).

Thank you for your kind attention