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Price regimes in an energy island: Tacit collusion vs. cost and network explanations

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ABSTRACT

In this paper, we explore the determinants of wholesale electricity prices in an energy island such as Sicily, by estimating regime switching models with fixed and time-varying transition probabilities on daily data in the 2012–2014 period. Explanatory variables used alternatively in the price equation and in the switching equation include power demand, the supply of intermittent renewables, the residual supply index, and a congestion indicator. Four competing hypotheses on the determinants of price regimes are tested (arbitrary market power, cost profile, tacit collusion, congestion) in order to understand why, despite the general trend of declining prices induced by renewables in southern Italy, Sicilian prices stood high. The pattern of estimated coefficients is consistent with a tacit collusion story.

1. Introduction

The integration of electricity markets in Europe is among the main goals of the 2030 Climate-Energy Package, approved by the European Council in October 2014. The existence of *energy islands* is identified as one of the main impediments towards the single electricity market. Understandably, the investment targets outlined in the package are influenced by geopolitical considerations, motivating the focus on the Baltic States, that are integrated with the Russian grid but not sufficiently with the EU partners. Not less relevant in economic and geopolitical terms are the bottlenecks that separate the Iberian peninsula from France, Ireland from Great Britain, and Sicily from the Italian mainland. Ten years after market liberalization, in 2014 Sicily was separated for about 80% of the hours from the rest of Italy. From a purely geographical viewpoint, the Sicilian interconnection problem is rather similar to the Irish one and Sicily is a potential bridge towards Northern Africa just like the Iberian countries (see Cambini and Rubino, 2014). Yet, Sicily faces less workable southward interconnection opportunities, due to the Libyan civil war and Tunisia's slow post-revolutionary recovery, than those facing Spain and Portugal (Morocco, a rather stable and favorable destination for FDIs).

The energy isolation of Sicily may lie behind its less than satisfactory price performance. Following the subsidized boom in new renewable energy investments, the annual reports of the Italian Power Exchange (IPEx) have shed light on the declining trend in the wholesale price in the renewable-rich southern regions, leading prices south of Rome to undercut the historically lower northern ones (see GME, 2012, 2013). Sicily strikingly departs from this trend, despite its large wind and solar penetration rates. Between 2011 and 2012, the price in Sicily increased by 2.2%, in line with Sardinia (+2.2%) and the South zone (+1.9%) and below the other market zones (GME, 2012). Yet, the pronounced price plunges observed between 2012 and 2013 (from −16.8% in the North zone to −24.7%

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in Sardinia) were not replicated in Sicily (−3.4%) (GME, 2013). While the average national price fell below 50 Eur/MWh in the summer of 2014, Sicilian prices reached 95 Eur/MWh on average in July and 108 Eur/MWh in August, roughly twice the price in the neighboring South zone. Therefore the win–win outcome of renewables support (stable revenues for subsidized producers, lower prices for wholesale purchasers) is not available in Sicily, causing an equity issue that needs to be solved by providing policy-makers with sound information about the roots of such price dynamics.

In this paper, we explore the determinants of wholesale electricity prices in Sicily by estimating regime switching models, using daily data in the 2012–2014 period. Explanatory variables included in the price equation and in the switching equation are power demand, the supply of renewable energy, a measure of market power, and a congestion indicator. Testing theoretical hypotheses on price regimes is rife with potentially fruitful insights, in view of the high policy-making returns from appropriate modeling of the price process. Indeed, the regime switching model has been successfully applied to the electricity market (e.g. in Huisman and Mahieu, 2003; Weron et al., 2004; Mari, 2008; Karakatsani and Bunn, 2008; Janczura and Weron, 2010 among others), thanks to its fit performance and its possible consistency with multiple equilibria and tacit collusion rooted in repeated interaction among oligopolistic power generating companies (since Green and Newbery, 1992; von der Fehr and Harbord, 1993).

Finding price regimes in Sicily could testify to the role of tacit collusion in the observed upward trend. Yet, while persistence in a high-price regime would be consistent with a collusive focal point, it may alternatively occur because of congestion, which may keep the price in a high regime even if generators fail to collude. The high frequency of congestion episodes is a powerful limit to competition on the island, in line with the pioneering theoretical analysis performed by Liu and Hobbs (2013), showing how strategic (de)congestion and the generators' ability to anticipate the moves by the transmission system operator sustain collusion. Joint ownership at both sides of the transmission line can also exacerbate the collusive temptations (Boffa and Scarpa, 2009).[1] Consistently, one may interpret sky-rocketing prices in the summer of 2014 as the attempt of generating companies to reap large profits before the expected upgrade of the Sorgente-Rizziconi cable linking Sicily with the Italian mainland, that was scheduled to be completed in 2015. At the same time, generators in Sicily face highly volatile residual demands, as renewable supply is growing and the paucity of hydropower resources implies limited flexibility and storage. Coupled with a contractionary demand trend after the financial crisis, volatility defies the otherwise clear expectation that Sicilian generators would easily sustain a tacit collusion agreement.[2]

The tacit collusion hypothesis, empirically assessed e.g. by Fabra and Toro (2005) and Sweeting (2007), needs to be tested against alternative hypotheses, grounded in the existing empirical literature. Besides congestion, previously mentioned (Haldrup and Nielsen, 2006a,b; Sapio, 2015a,b), regime transitions may result from electricity demand fluctuations spanning a kinked market-wide cost function, even in the absence of market power (Kanamura and Ohashi, 2008). In a quite popular class of models (Huisman and Mahieu, 2003; Janczura and Weron, 2010), the price in the "high" regime is a random draw from a probability distribution, as if generating companies exercised an *arbitrary* market power, as Karakatsani and Bunn (2008) put it.

[1] The former monopolist, Enel, operates thermal power and hydropower plants in both Sicily and Calabria.

[2] Collusive incentives are pro-cyclical according to Green and Porter (1984). Renewable energy producers receive a regulated tariff, hence they have no incentive to join in the collusion game.

The regime-switching model that we build is able to encompass the abovementioned four hypotheses. Depending on the signs of the parameters in the price equation and in the switching equation, one can obtain four different models, nested in the general one, that correspond to the competing hypotheses. Unlike Fabra and Toro (2005), we allow all coefficients in the mean price equation to vary across regimes, not just the constant, and consider the possible effects of intermittent renewables and network congestion. In our analysis, persistence in a high-price regime will be attributed to sustained tacit collusion only if the whole set of estimated parameters rules out alternative interpretations.

We empirically identify two regimes – high and low – and find that in each regime, the electricity price in Sicily can be explained by positive drivers (demand, market power, congestion) but its level is mitigated by the supply of renewables, confirming the merit order effect shown by a number of works (Sensfuss et al., 2008; Guerci and Sapio, 2012; Ketterer, 2014; Paraschiv et al., 2014; Veraart, 2015 and references therein). Market power, thus, does not translate into occasional random spikes, ruling out the arbitrary market power hypothesis. The cost profile hypothesis, too, is discredited, as price levels reflect something more than cost information. Both the high and low regimes are strongly persistent, consistent with both the congestion and tacit collusion hypotheses. The congestion indicator helps predicting the regime transitions, but it displays statistically significant variation within each regime, suggesting that it is not the main explanation for price regimes. Supporting the tacit collusion hypothesis, the transition probability from the high to the low regime increases when demand, market power, and congestion are relatively low, and when RE supply is relatively high. This is consistent with the theoretical conditions triggering price wars (see Ivaldi et al., 2003).

The paper is structured as follows. After a literature review, Section 2 outlines the competing hypotheses to be tested through the model described in Section 3. Section 4 presents the dataset and the empirical results, discussed in the concluding Section 5.

2. Literature review and hypotheses

Regime switching models are built for a variety of goals, from improving the forecast performance of power price models, to the valuation of electricity-based contracts, to the detection of price wars in repeated games. Accordingly, those different approaches put the stress on different underlying drivers of the regime dynamics, such as strategic behavior, distribution of marginal costs, tacit collusion, and network congestion. We shall organize the following literature review on regime switching models along these lines.

2.1. Strategic behavior and market power

A first class of models defines a *base regime*, wherein the electricity price is driven by a mean-reverting autoregressive process and/or by fundamentals, a *spike regime*, corresponding to a random draw from a given probability distribution, and sometimes a *drop regime*, in which the price drops in a similarly random fashion. A three-regime model has been estimated by Huisman and Mahieu (2003) and Janczura and Weron (2010). Karakatsani and Bunn (2008) found it to be a superior representation of the price process in peak periods, whereas Huisman and Kiliç (2013) employed a two-regime model. The switching process is usually Markovian; the fit is usually improved by assuming transition probabilities that depend on time-varying variables, i.e. load and the reserve margin (see Mount et al., 2006; Mari, 2008) or by positing self-exciting dynamics (Lucheroni, 2012).