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Renewables diffusion and contagion effect in Italian regional electricity markets: Assessment and policy implications

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ABSTRACT

In the electricity market, sudden price jumps occur more frequently than in other markets due to the peculiarity of electricity. Furthermore, the structural spot characteristics of the electricity market determine high price variability. All these characteristics have been accentuated by the dramatic increase of renewable energy supply in Italy starting in 2010. These features suggest the possibility of contagion effects across Italian regional electricity markets, considering contagion such as a sudden and significant increase in cross-market links arising from a shock to a specific market.

In this paper we investigate whether such a renewable energy increase has affected the contagion behavior in the Italian electricity spot market taking into account both the difference between interdependence and contagion and the direction of the shock. We find empirical evidence, with significant tests, that no changes have occurred in interdependence mechanism, nor in contagion effects due to renewable energy sources development in Italy.

1. Introduction

The deployment of electricity from renewable energy sources (RES) is considered to be important to reduce pollutant emissions and to preserve fossil fuel. Consequently, its public promotion has become a priority on the European Union (EU) agenda, although with some difficulties related to the acceptance[1] of the extra-charges needed to support the high cost of RES supply and to the technical implications such as the merit order effect [9–11] and the intermittency issue in electricity generation. This latter is a crucial point contributing to increasing market volatility and the frequency of sudden price jumps. When these extreme movements become more frequent it is interesting to analyze if they pass though other interconnected markets. Of course, this propagation requires markets interdependence but when linkages across markets became stronger after a shock, contagion could invest these markets.

However, contagion in electricity markets is a phenomenon that has rarely been analyzed in the empirical literature[2] [15] even if the very high frequency of electric market data, which is constituted by hourly, or half-hourly, equilibrium outcomes, lends itself to the investigation of the existence of contagion. In this context, to the best of our knowledge, there is not an explicit analysis of the RES impact on electricity market structure in term of markets interdependence or contagion. Consequently, we want to ascertain whether the rapid penetration of RES in the Italian electricity market, which started around the end 2010, led to an increase of the phenomenon of contagion across Italian regional markets.

In particular the aim of this paper is to investigate the contagion effect in the Italian day-ahead electricity market, considering its peculiar structure, consisting of six regional markets [16] [3] using for the first time an appropriate method that allows us to distinguish between interdependence and contagion and, if differences exist among markets and according to price change direction [17].

The paper is organized as follows. Section 2 provides a brief review of the literature in order to define contagion. We also describe the Italian Power Exchange (IPEX) and set forth the hypothesis to be

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[1] There is vast literature investigating the economic convenience of RES support mechanisms in several countries [1–6], also appraising how much market forces can support RES development [7] while del Rio and Mir-Artigues [8] have compared RES supportive instruments for several European countries.

[2] A macroeconomic investigation of the links between energy prices and economic growth is provided by Egger et al. [12]. An analysis of contagion between oil prices and stock market prices is provided by Wen et al. [13]. An analysis in the electric utility industry is provided by Mama and Bassen [14].

[3] We want to underline that our analysis can also shed light on outcomes of other electric markets, such as the German EEX, which is often split in two regions (North and South) due to massive wind generation. More generally, our analysis is relevant for the new EU market coupling design, which is aimed at integrating several European markets.

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tested. Section 3 describes the methodology to identify contagion in a multi-market context. Section 4 describes the data used for estimation. Section 5 discusses the econometric results. Section 6 concludes and presents policy implications.

2. Whither contagion? RES development in the Italian electricity market

2.1. The Italian energy system

For many years oil and oil products, these latter especially for road transportation, have dominated the Italian energy mix. Since 1995, the fuel mix has showed a continuous decrease in consumption of oil, and oil products, both replaced by the increasing use of gas and, recently, by the substantial growth of renewables. Compared with other European countries, Italy is characterized by a high share of gas and hydro, a limited use of coal and the absence of nuclear power. Italy has limited high temperature geothermal resources, which cannot contribute to satisfy Italian energy demand. Recently, oil resources have been found in the South of Italy; the production is estimated to cover about 10% of domestic needs. Domestic gas production covers only about 10–12% of gas consumption, the remainder is imported, mainly through pipelines, from Russia (45%), Algeria (20%), the rest coming mostly from EU and Africa countries. Due to its high dependence rates in the energy sector Italy has tried to diversify its sources of energy also investing in renewables; since 2005, green electricity has increased steadily due to photovoltaic plants whose capacity has increased by 275% from 2010 to 2011. The overall Italian energy market is constituted by a consumption of 180 million of tonnes of oil equivalent (Mtoe), of which 85% is imported. The final consumption is about 140 Mtoe, of which 50% for transportation and the remaining for industrial, commercial and residential use. Total electricity consumption (equal to generation) represents about 50% of the total, or 70 Mtoe, equivalent to 290 GWh.

2.2. The Italian electricity system

The generation capacity in Italy is quite concentrated and over two-thirds of this capacity is fueled by oil and natural gas (CCGT plants). The RES contribution to total electricity generation is about 15% from hydro and the contribution from other RES, such as photovoltaic, wind, biomass and geothermal has increased recently by 7%. In particular photovoltaic installed capacity reached 18,000 MW and 591,000 plants in 2013. Consequently, the operation hours of CCGTs decrease from the historical level of 6,000 h a year to less than 2000 h in 2013. The total electricity consumption is divided into 50% industry, 24% residential and the remaining percentage commercial and others. Electricity is exchanged in an organized wholesale market managed on hourly frequency by a centralized operator, which collects the supply and demand bids in the day ahead market, determining an equilibrium market price, based on the merit order of the bids. The RES National Operator (a government agency) is responsible for bidding the RES supply, with dispatching priority. The Transmission System Operator is responsible for acquiring reserves in an auxiliary market for the network security management. In case of transmission line congestion, market splitting occurs resulting in different zonal prices. There are three types of zones in the IPEX. Foreign virtual zones, that is a point of interconnection with neighboring countries, the physical national zones that represent a portion of the national grid and the national virtual zones or constrained zones, that are points or poles of limited production. Our analysis focuses on the physical national zones (Fig. 1), which are North Italy (North), Center-North Italy (C-North), Center-South Italy (C-South), South Italy (South), Calabria, Sicily and Sardinia..

2.3. Prices dynamic in the electricity markets

In the electricity market, sudden price jumps can occur more frequently than in other markets [18], due to the peculiarity of electricity, which is a non-storable commodity. The absence of storage buffers yields a high variability in the equilibrium price, which is very sensitive to supply and demand shocks. The supply technology is also another determinant of such price variability. In fact, it is possible that the market supply function shows kinks that correspond to the entrance of a high cost plant in the market. Moreover, continuous adjustments in demand functions add to the equilibrium price variability. In addition, the small number of players, especially in the supply side of the market, i.e. large companies controlling many generation units, can generate sudden spikes in the equilibrium price. Furthermore, the analysis of electric market structure has shown the existence of a substantial departure from competitive equilibrium, with a variable degree of the exercise of market power depending on the time of the day, due to the existence of transmission line congestion [16,19]. Typically, during daily peak hours it is more likely that congestion occurs resulting in a higher degree of oligopolistic market power, while during other periods, typically nightly off-peak hours, the electricity market is characterized by a higher degree of competition among generators. In the literature, the focus of the analysis of electricity price characteristics has been on high volatility, heteroscedasticity and large, or extreme, price changes (see among others [20–25]).

As far as market integration is concerned, many authors find evidence of weak integration among European markets, [26–32]. More recently, Dias and Ramos [33] have analyzed the US electric markets, finding: *"evidence of synchronization of price dynamics in the mean-reverting and highest volatility regimes between East and West coast"*. Australian electricity regional markets have also been deeply analyzed in terms of: price dependence [34], prices transmission and volatility [35]. Finally, Lindström and Regland [36] have analyzed co-movements among six European markets (except IPEX) finding that the frequency of extreme events is positively related to the amount of RES.

2.4. Contagion effect

The possibility of sudden spreads of shocks originating in one

Fig. 1. Italian regional markets and foreign virtual zones.