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Good volatility, bad volatility: What drives the asymmetric connectedness of Australian electricity markets?

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ABSTRACT

Efficient delivery of network services and the electricity infrastructure to meet the long-term consumer's interests are the main objectives and the strategies of a national electricity market, while the main interests of generators are to maximize their profit through pricing strategies. Therefore, the objective of this study is to explore whether electricity prices across the four Australian States display symmetric price volatility connectedness. The study is the first attempt in the literature to make use of intraday 5-min Australian dispatch electricity prices, spanning the period December 8th, 1998 to May 5th, 2016 to quantify asymmetries in volatility connectedness emerging from good, and bad volatility. The results provide supportive evidence that the Australian electricity markets are connected asymmetrically implying the presence of some degree of market power that is exercised by generators across regional electricity markets.

1. Introduction

The literature has extensively explored volatility spillovers across energy (or energy commodity) markets. According to Sattary et al. (2014), there is a rapidly growing literature which addresses linkages across oil and stock markets in terms of volatility spillovers. Certain studies focus on such spillovers across regions like Asia, the U.S. and the U.K. Their findings provide supportive evidence of the presence of volatility spillover linkages, mostly over the post-crisis period (In, 2007; Alsubaie and Najand, 2009; Moon and Yu, 2010; Arifin and Syahruddin, 2011; Gebka, 2012; Zheng and Zuo, 2013; among others). There is also a strand of literature that corroborates the significance of volatility spillovers across European stock markets in the light of oil prices (Giannellis et al., 2010; Arouri et al., 2012; Antonakakis, 2012; Tamakoshi and Hamori, 2013; Reboredo, 2014), while a third strand explores extensive volatility spillover comparisons among different countries (Serra, 2011; Korkmaz et al., 2012; Krause and Tse, 2013; Salisu and Mobolaji, 2013). A number of recent studies investigate the behavior of U.S. stock markets and sector indices depending on oil behavior, while they provide positive evidence of the presence of transmissions of volatility and shocks across oil markets and relevant sectors (Malik and Ewing, 2009; Du et al., 2011; Diebold and Yilmaz, 2012; Liu et al., 2013). Finally, there is a methodological strand of the literature that focuses on the comparison of econometric methodologies used to measure volatility spillovers, along with the presence of asymmetric effects across and within energy, such as oil and natural gas, markets (Chang et al., 2010; Sadorsky, 2012; Ewing and Malik, 2013).

It is important to examine the dynamics of volatility spillovers across electricity markets to add knowledge of the information transmission channels on Australian national electricity markets. According to Higgs (2009), the Australian electricity markets are characterized by the limitations of the interconnectors across the member states, indicating that the Australian regional electricity markets are relatively isolated. The absence of convergence has been also confirmed by the study of Apergis et al. (2017). It is generally accepted that in electricity markets, supply or demand shocks, say due to the presence of unexpected outages of generation units or transmission constraints cannot be fully compensated in the short run. As a result, sudden jumps in prices (i.e., spikes) usually occur, especially in the cases when reserve capacity is limited, which is the case for electricity markets across Australia (Apergis et al., 2017). Given that the electricity market is perceived to have a high level of exposure to external shocks, such market contains significant market risk level. Therefore, accurately measuring the

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downside market risk exposure represents a pivotally important and difficult practical problem for suppliers and consumers in the electricity market and, hence, electricity prices are expected to be very volatile and pose a huge risk for those market participants. In addition, such findings will allow further the study of the differences in volatility across the Australian electricity markets and to provide evidence on whether price volatility across those markets is high and/or persistent either in the real time market or in the day-ahead market. Furthermore, the findings will allow a more consistent manner in further forecasting electricity price volatility, while will also allow to measure the market risk level and to analyze the risk evolution which is expected not only to efficiently analyze the heterogeneous market structure, but also to improve the risk measurement accuracy (Deng and Oren, 2006; Pineda and Conejo, 2012). Therefore, it is expected that the documentation of volatility spillovers will shed further light on the understanding of the dynamics of electricity pricing, and further on the efficiency of pricing, given that the Australian state electricity markets are identified as centralized markets which still are primarily composed of commercialized and corporatized public sector entities. The findings in relevance to the presence of such spillovers will also benefit the proper evaluation as a step towards higher levels of regional electricity markets integration.

The Australian National Electricity Market (NEM) is currently operating as a nationally interconnected grid and interconnecting five state-based regional markets (i.e., Queensland, New South Wales, Victoria, South Australia and Tasmania), while NEM covers about 40,000 km of transmission lines. The main domestic network is the *National Electricity Market* (NEM), which was established in 1998 and links regional markets in Queensland, New South Wales, Victoria and, more recently, Tasmania and South Australia. Both producers and retailers trade through a spot market operated by the Australian Energy Market Operator. Our study does not cover Western Australia (WA). WA's main wholesale market is the South West Interconnected System (SWIS), which covers the area of Perth and surroundings and is operated by WA's Independent Market Operator (IMO). In WA, there is no existing interconnection with any other power system outside the state. The lack of interconnection capacity between the SWIS and the rest of Australia does not allow for arbitrage of electricity prices, at least in the short run.

The goal of the paper is to extend Higgs' (2009) work and undertake a research effort for the first time, to the best of the authors' knowledge, the presence of asymmetries in volatility spillovers across Australian electricity markets. This is also the first study that uses 5-min high frequency data to capture more information in relevance to the dispatched price data. Investigation towards the presence of asymmetric volatility spillovers seems to be substantially important because spillovers that are asymmetric tend to be a source of contagion, which could have important implications towards the implementation of energy and electricity policies. It is highly possible that in certain conditions, especially in the phase of expanding electricity demand, the electricity market in a certain region looks as if it is not related to the market of another region, which could be more advanced. The concept of asymmetric volatility spillovers comes from the financial literature. In particular, there have been two competing hypotheses that provide the theoretical background for the presence of such asymmetric volatility spillovers: the leverage hypothesis effect, according to which negative returns increase financial leverage, causing volatility to rise (Christie, 1982; Schewert, 1989), and the volatility feedback effect, according to which if the market risk premium is an increasing function of market volatility, anticipated increases in volatility raise the required returns on equity, leading to immediate declines of stock prices (Campbell and Hentschel, 1992). The findings in the case of electricity prices are expected to be very helpful in designing efficient electricity trading rules, leading to an efficient, as well as integrated electricity market.

Whereas asymmetric volatility in financial markets has long been recognized as a stylized fact (Black, 1976; Christie, 1982; Pindyck, 1984; French et al., 1987), question if these asymmetries propagate to other assets, or markets, have not yet received the same attention. Since large literature documents how volatility transfers across different assets and markets, it is worth assuming that volatility spillovers exhibit asymmetries as well and such asymmetries might stem from qualitative differences due to bad and good uncertainty. Segal et al. (2015) provide precise definitions, and coin bad uncertainty as the volatility that is associated with negative innovations to quantities (e.g., output, returns) and good uncertainty as the volatility that is associated with positive shocks to these variables. Baruník et al. (2015, 2016) hypothesize that volatility spillovers might substantially differ depending on nature of these shocks. They suggest how to quantify the asymmetries in volatility spillovers originating due to bad and good uncertainty as defined by associated with negative and positive shocks to volatility (as defined by Segal et al., 2015). In addition, Baruník et al. (2015, 2016) document asymmetries in volatility spillovers in financial assets as well as petroleum markets.

The remaining of the paper is organized as follows. Section 2 describes the data set used in the empirical analysis, and provides the description of the methodologies used. Section 3 reports the empirical results, and finally, Section 4 concludes the paper.

2. Data and methodology

The paper employs high frequency data on electricity dispatched price obtained from the Electricity Market Management Company, and the prices are in Australian dollars per megawatt hour (MWh). The time resolution of the data is 5 min basis, representing 288 trading intervals in each 24-h period. The spot price is where market generators are paid for the electricity they sell to the pool and market customers pay for their electricity consumption from the pool. All electricity is traded through the pool at the spot price. The pool is defined into a number of pre-defined regions. A dispatch price for each region is determined every 5 min, and the 6 dispatch prices in a half-hour period are averaged to determine the regional spot price for that half-hour trading interval.

AEMO uses the spot price to settle all energy traded in the NEM. In other words, the wholesale market of the NEM is operated as a real-time energy market through the centrally coordinated dispatch system to match demand and supply instantaneously in real time. The dispatch price for each 5 min interval is the one of the last bid that matches demand at time period t. The dispatch electricity prices, spanning the period from December 8th, 1998 to May 5th, 2016[1], are obtained and the asymmetric spillover effects between electricity markets across four Australian regions, i.e. Queensland, New South Wales, Victoria and South Australia, are examined using the squared realized variance (i.e. RV) time series in a logarithm form.

2.1. Measuring asymmetric volatility spillovers

This sub-section aims at defining a measure of asymmetries in volatility spillovers. In their seminal works, Diebold and Yilmaz (2009, 2012) developed a volatility spillover index based on forecast error variance decompositions from vector autoregressions (VAR) to measure extend of transfers among markets. Consecutive large strand of literature extended this approach in various ways incorporating covariances, or frequency dependent shocks to the analysis (among many see for example McMillan and Speight, 2010; Kumar, 2013; Fengler and Gisler, 2015; Barunik and Krehlik, 2016; and Křehlík and Baruník, 2017). Despite its versatility, the spillover measures do not distinguish the potential asymmetry in originating due to bad and good uncertainty associated with negative and positive shocks to volatility. An important extension has been proposed in this direction by Baruník et al. (2016), who showed how to quantify asymmetries due to negative and positive

[1] Data can be downloaded from http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data-dashboard.