DIRECTIONAL SPILLOVERS BETWEEN ELECTRICITY AND FOSSIL FUEL PRICES IN A HYDROTHERMAL POWER GENERATION MARKET: THE CASE OF BRAZIL AND CANADA

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Overview

The electricity markets of Brazil and Canada are based on a hydrothermal power generation system, characterizable by significant differences in the marginal costs of the generation sector, heavy dependence on weather factors and fossil fuel prices, and small renewable generation capacity [1,2]. The Brazilian electricity market is one of the largest in Latin America and has an installed capacity greater than 174GW, of which 65% correspond to hydro, 20% to renewable sources, and 13% to thermal generation [3].

Similarly, Alberta's electricity market is the only open market in Canada. Alberta generated 81TWh of electricity in 2018, and about 91% is produced by fossil fuels such as natural gas (49%) and coal (43%). The renewable sources, including water, have a weight of 8% in the electricity matrix. Besides, the electricity market is based on a pool market like the Nord-Pool market of Norway, in which electricity is generated and sold through a wholesale market, and the transmission and distribution costs pass-through to final consumers [4–6].

According to authors of [7], fuel prices are a key driver of electricity prices and a relevant factor for expansion decisions in the generation sector. Besides, fossil fuel prices impact the operational cost of power plants and the opportunity costs of hydropower plants. This leads us to ask whether there is a relationship between electricity price and fossil fuel prices due to the economies of Brazil and Canada having a strong dependence on mining-energy activity. For this reason, the main objective of this research is to evaluate the directional spillovers between the electricity spot prices of Brazil and Canada and gas, coal, and crude oil prices.

Methods

The methodology applied was proposed by [8–10], and it allows the volatility connectedness for the sample to be assessed. The method is based on the variance decomposition of the forecast error of the vector autoregression model (VAR) with N-dimensions. Besides, this approach ensures the volatility measurement of spillovers through assets, prices, markets, and companies over time [11]. The study used data from the southeast region of Brazil, characterized by a high industrial level and a heavy dependence on hydropower plants, and Alberta's pool market, which is structured by thermal power plants to compare the electricity price response between countries.

The database is a balanced time-series panel with monthly frequency from January 2010 to December 2019. The sample period was selected due to the data availability with no methodological changes, and monthly frequency was determined to avoid possible problems of high frequency (daily or weekly observations) in the VAR models. Besides, the electricity markets indicators take time to respond to exogenous shocks. Therefore, the variables were transformed to monthly frequency through their average. Finally, to estimate the spillovers and directional connectedness between the electricity spot prices and fossil fuel prices, the variables were transformed through the logarithmic returns to observe possible changes in electricity price distribution, which are associated with changes in terms of unexpected fossil fuel shocks.

Results

The method allowed energy prices in shock transmitters of volatility or shock receivers of volatility to be classified. Thus, the Brazilian and Canadian electricity spot prices are pure shock transmitters. On the one hand, 10.4% and 7.5% of electricity prices' volatility are explained by fossil fuel price fluctuations in Brazil and Canada, respectively. Besides, fossil fuel price volatility is related to 13% and 11% by the electricity prices of Brazil and Canada, respectively.

The main finding showed a bidirectional relationship between the electricity spot price and the fossil fuel with greater weight in the exports of each country. The economies of Brazil and Canada are some of the largest in America and are related to developing and developed countries by trade and capital flows [12,13]. Besides, the electricity market is a relevant indicator of development and can influence the dynamic of the commodity

exploitation sector. Hence, Brazil is a net oil exporter, and it is observed a bidirectional relationship between the electricity price and crude oil prices. Similarly, Canada is a net natural gas exporter, and it is evinced a link between the electricity price and natural gas price.

Conclusions

The volatility spillovers between the electricity spot prices of Brazil and Canada and fossil fuel prices were analyzed. The electricity spot prices of these countries are net shock transmitters. Besides, a bidirectional relationship between the Brazilian electricity price and crude oil price and between the Canadian electricity price and natural gas price is observed. Likewise, the research shows the risk network of the hydrothermal power generation market depending on the type of event that is taking place, e.g., dry seasons or non-renewable source price fluctuations. For this reason, the study contributes to regulatory policy design to reduce exposure to the electricity market.

Finally, the information related to the volatility of energy prices is relevant to energy planning policies. This provides different elements to producers and market agents to anticipate the shocks and improves the energy sector's response to the risk due to price fluctuations. Therefore, future research proposals should evaluate the mechanism by which fossil fuel prices transmit their dynamic on the electricity market of each country.

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