CAUSAL DYNAMICS OF SOLAR PV PRICES AND ELECTRICITY MARKETS: A QUANTILE PERSPECTIVE

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Overview

This study examines the intricate relationship between solar photovoltaic (PV) system price returns and spot electricity price returns across five Australian states (New South Wales, Victoria, Queensland, South Australia, and Tasmania) and the nation. Using monthly data from August 2012 to July 2024, the research employs the Quantile-on-Quantile (QQ) regression method to analyze the interdependence and asymmetries in price dynamics. The study further employs time-varying Granger causality tests to capture the dynamic causal relationships over time, identifying evolutionary patterns and highlighting major influencing events. These findings emphasize significant heterogeneity and nonlinearities in the relationship, shaped by state-specific conditions and broader market trends. This research provides key insights into energy economics, contributing to the understanding of the nexus between renewable energy and electricity markets.

Methods

We employ an innovative dual methodological approach. First, we apply the Quantile-on-Quantile (QQ) regression method to capture nonlinear relationships and asymmetric patterns between the two price return series. This method extends beyond traditional mean regression approaches by examining the relationship across different quantiles of both variables simultaneously. Second, we implement time-varying Granger causality tests to identify the dynamic evolution of causal relationships between these markets. This combined approach allows us to detect both contemporaneous price interactions and lead-lag relationships, while accounting for potential structural changes over time.

Results

The empirical findings highlight three key aspects of the relationship between solar PV system prices and electricity prices. First, through QQ regression analysis, we find significant heterogeneity in the relationship between solar photovoltaic system price returns and spot electricity price returns across the states, emphasizing the importance of state-specific market conditions and regulatory frameworks. Second, our results uncover pronounced nonlinear dynamics, with the influence of solar photovoltaic system price returns differing considerably across varying electricity price return levels. Third, time-varying Granger causality tests reveal an evolving causal link between the two price return series, with distinct regional and temporal patterns.

Conclusions

Our findings yield several crucial implications for energy market integration and policy design. First, the identified temporal variations in price relationships, particularly strengthening after 2017, suggest increasing market integration between solar PV and traditional electricity sectors. Second, the regional heterogeneity in price dynamics emphasizes the importance of state-specific policy frameworks, with different regions showing varying sensitivity to policy interventions. Third, the strong influence of policy changes and external shocks (such as COVID-19) on price relationships suggests that market integration mechanisms must be designed with sufficient flexibility to accommodate policy-driven and unexpected market disruptions. These insights are particularly valuable for

policymakers and market participants navigating Australia's continuing energy transition, highlighting the need for nuanced, region-specific approaches to renewable energy integration.