[P2P RISK BASIS MANAGEMENT FOR RENEWABLE PRODUCTION PARAMETRIC INSURANCE]

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Overview

This work presents a framework for peer-to-peer (P2P) risk basis management tailored to renewable energy production, specifically focusing on solar energy. It integrates physically-based models to derive day-ahead production forecasts and actual realized outputs. By comparing forecasted and realized production, the framework quantifies financial losses attributable to forecasting errors. A parametric insurance mechanism mitigates these losses by coupling payouts with predefined weather parameters. This framework further incorporates a P2P market structure to redistribute basis risks, fostering collaboration and financial stability among participants. Leveraging data from German solar producers, this study highlights the potential of combined parametric insurance and P2P mechanisms to enhance financial resilience in renewable energy markets.

Methods

We define a two-tiered insurance framework. First, a parametric insurance mechanism is designed to compensate financial losses using weather indices as triggers. Second, a P2P mechanism redistributes residual basis risks among participants. The parametric component relies on the conditional expectation of financial losses given weather data, calibrated through Generalized Linear Models (GLMs). The P2P component employs risk-sharing rules based on individual conditional variances. Data collection spans historical weather variables (e.g., solar radiation and temperature) and solar production data from German power plants, with forecasts and actual outputs processed via the PVlib Python library. The optimization of weather indices ensures minimal variance in basis risks across participants.

One key aspect of our methodology is the aggregation of data from multiple producers or solar farms, specifically their coefficients obtained from locally calibrated GLMs. Each producer independently calibrates their GLM based on their data and provides only the resulting coefficients to the centralized model. This process ensures anonymity, as individual losses or sensitive data are not shared among participants. The model requires only the aggregated coefficients, which are then used to construct a representative index. This method enhances trust and simplifies data sharing while maintaining the privacy of each participant’s production data.

Results

The study finds that integrating parametric insurance with a P2P mechanism effectively reduces the variability of financial losses. GLM calibration demonstrates a strong relationship between weather variables (solar radiation and temperature) and production losses. The optimized weather index, constructed as a weighted sum of covariates, significantly minimizes basis risk variance. Empirical results indicate that risk pooling through the P2P mechanism enhances equity and reduces individual exposure to production variability. Figures illustrate the reduction in financial loss variance after risk sharing for selected German solar farms, confirming the robustness of the proposed approach.

Conclusions

This framework demonstrates the potential for parametric insurance and P2P mechanisms to jointly address the dual challenges of price and production risks in renewable energy markets. By quantifying financial losses and redistributing risks collaboratively, this approach offers a sustainable pathway for enhancing the financial resilience of solar producers. Future research could explore extending the model to multi-energy systems and incorporating intraday price variations for improved accuracy.

References

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