MISG Project: Calibrating the Mean Reverting Jump Diffusion Model to Australian Spot Electricity Prices

About Integral Energy

Integral Energy's Retail business provides electricity to customers by purchasing wholesale electricity from the National Electricity Market ("NEM"), and on-selling this at a margin to retail customers, who vary greatly in terms of load demanded. By purchasing electricity at wholesale prices from the NEM, and selling retail electricity to customers, Integral Energy incurs a commodity price exposure equal to the difference between its purchase price for electricity from the NEM, and its sale price to its retail customers. Integral Energy uses the electricity hedge market, customer contract management, the Electricity Tariff Equalisation Fund ("ETEF"), and market forecasting to reduce its exposure to electricity price risk.

1) Electricity Hedge Market

Integral Energy operates in the electricity hedge market, to offset its physical exposure to the NEM. This is achieved by entering into financial hedges, such as swaps and options.

2) Customer Contract Management

Through ongoing management of its contractual arrangements with new or existing contestable customers, Integral Energy seeks to reduce its electricity price exposure at the customer level.

3) Electricity Tariff Equalisation Fund ("ETEF")

Integral Energy is a participant in ETEF, a NSW Government fund which provides a financial hedge between NSW State-owned generators and retailers, by offsetting their exposure to the prices for sales and purchases of electricity, respectively, against each other.

4) Market Forecasting

Electricity market forecasting assists Integral Energy in optimally managing its electricity price exposure. Forecasting is carried out for electricity load to retail customers, daily temperatures, and spot electricity prices.

This project is concerned with the forecasting component of Integral Energy's electricity price risk management strategy. The generation of spot electricity price forecasts represents a significant mathematical challenge. Once the necessary data has been identified, and a model selected, calibration of the model must be conducted. The quality of forecasts generated by the calibrated model must be assessed prior to business implementation of the model.

Problem Outline

Integral Energy is exploring alternative methods for modelling spot electricity prices. Spot price models are used to generate forecasts of the pool electricity price, and these forecasts are subsequently used to calculate the Earnings at Risk (EaR) for Integral Energy's electricity portfolio.

The most frequently referenced model for this task in the current literature is the Mean Reverting Jump Diffusion (MRJD) model. While the analytic fundamentals and features of this model are well established, the issue of how accurately the model can be calibrated to historical data remains unaddressed. This issue needs to be resolved, in order to determine the suitability of the MRJD model for the purpose of generating spot electricity price forecasts.

The aim of this project is to determine a means of calibrating the MRJD model to historical Australian spot electricity prices, such that the model will accurately capture all the features of the data, and all necessary model parameters can be determined efficiently.

1) Data Features

Electricity spot prices are directly influenced by many different factors. On the demand side, factors such as the time of day and maximum daily temperature directly influence the spot price, whilst the supply side is influenced by current generator capacity and the status of connections within the grid. These factors combine to create deterministic and random components in the spot electricity price time series.

The historical distribution of spot electricity prices is highly skewed to the right, displaying a much "thicker" right-hand tail than the lognormal distribution. The MRJD model has the potential, in theory, to generate a probability density function that is consistent with all the features present in spot electricity price data.

2) Model Parameters

Calibrating the MRJD model will require a combination of time series techniques with methods for calibrating the parameters of a stochastic process to observed data. The parameters fall into two broad categories: the parameters for the jump process, and the parameters for the level reversion process.

The MRJD model typically features between five and six parameters which must be calibrated, although more may arise, depending on the specification for the jump size distribution. With the possible exception of the jump size density parameters some, if not all, of the remaining parameters, are expected to vary with time.

The MRJD model is challenging to calibrate, because of the large number of parameters that must be determined, many of which are time dependent. The scope of the model provides a large amount of flexibility for capturing the features observed in spot electricity price data, but at the cost of requiring a very complex calibration procedure. This makes efficient calibration of the MRJD a substantial undertaking.

Desired Outcomes

The primary goal for Integral Energy is to generate spot electricity price forecasts for the purpose of calculating the EaR for Integral Energy's electricity portfolio. This quantity forms a critical component in Integral Energy's risk strategy for managing electricity price risk. There are three primary outcomes sought by Integral Energy for this project: the development of a calibration methodology for the MRJD, an assessment of the suitability of the model relative to historical data, and the generation of realistic forecasts for future prices.

1) Model Accuracy for Historical Data

Demonstration of the suitability, or otherwise, of the MRJD model for capturing all the critical features (i.e. all seasonal trends, long-run level reversion and price "spikes") observed in Australian spot electricity prices. This includes being able to reproduce the price levels observed in the data through which the model is calibrated. Over-fitting must be avoided, since the ultimate goal is to generate long-term price forecasts.

2) Model Calibration Methodology

Integral Energy seeks a robust procedure for the calibration of the MRJD model. Since the model will need to be recalibrated frequently, the calibration procedure should be designed in such a way that automation will be possible. This is necessary to minimise the time required to calibrate the model, and also to minimise the potential for operational risk during calibration.

3) Forecasting Potential

Integral Energy seeks evidence that the calibrated model is capable of generating realistic forecasts for the spot energy price for up to five years into the future. These forecasts are a deliverable output that will be used to compute the EaR for Integral Energy's electricity portfolio. Such forecasts must reflect the long term level evident in the historical data.