Estimating competitive contract prices

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Joint work with Ben Guo and Andrew Jin

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Outline

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Are contract prices competitive?

- In 2014, the Wholesale Advisory Group put out a discussion paper on "Hedge Market Development".
- EnergyLink report investigated the relationship between wholesale prices and prices for futures contracts.
- 12% premium at OTA, and 31% premium at BEN, 2009-2014.
- Market making review - strengthening price discovery in the forward electricity markets, Decision paper, April 28, 2026.
- Exploration of the Relationship between ASX Prices and Spot Prices, Infometrics, August 11, 2025.

Outline

Contracting and energy offers

[Allaz & Vila, 1993, Anderson & Hu, 2008]

- When spot price is p and contract price is π a generator with Q contracts generating q earns

$$pq - C(q) + Q(\pi - p)$$

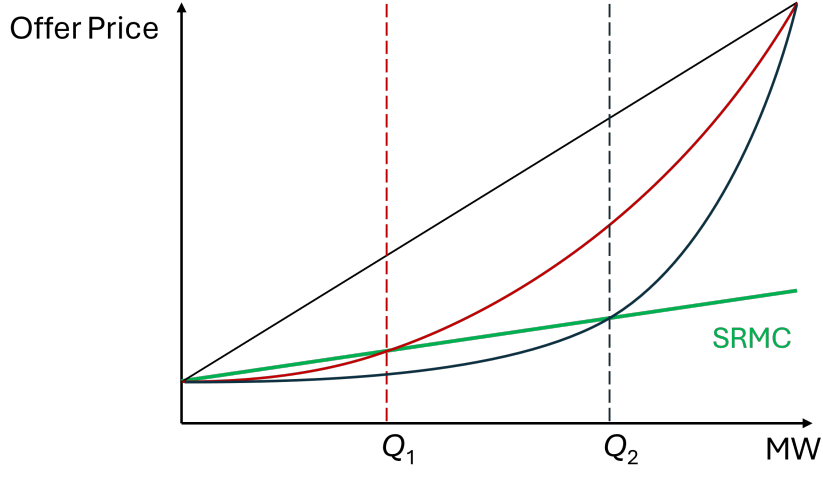
- If generator offer has no effect on p then they choose q to maximize pq-C(q) by offering at SRMC.
- If generator offer affects p then then they choose q to maximize

$$(q - Q)p - C(q) + Q\pi$$

- If $q < Q$, then want p to be small.
- If $q > Q$, then want p to be large.

Symmetric supply function equilibrium

[Anderson & Hu, 2008]



Optimal price-setting offer curves with contracts

What does this imply?

- Contracts affect offer behaviour in spot market through price-setting incentives. ("Ensuring dispatch to meet a contract quantity Q" is not the true reason to offer low for $q < Q$.)
- Price-setting implies ex-post spot prices are likely to be below contract prices.
- Risk aversion also gives an ex-ante contracting premium.
- This work attempts to identify ex-ante risk premium by estimating probability distribution of spot price assuming perfect competition.

Outline

Risk aversion

[Ferris & Philpott, 2022]

- Suppose each market participant is risk averse according to a nested coherent risk measure.
- Market participants trade energy to maximize their risk-adjusted welfare.
- This trading produces a risk-adjusted competitive equilibrium.
- Market participants also trade risk with others through derivative contracts.
- If the market for contracts is complete then all participants end up sharing the same market risk measure in equilibrium.
- [F. & P.] show this equilibrium corresponds to a social planner optimizing generation using the market risk measure.

Social planner optimizes using JADE.jl

`JADE.jl` is a hydrothermal reservoir optimization model of the New Zealand electricity system (developed by Downward and Kapelevich) that minimizes risk-adjusted expected social cost. It applies the stochastic dual dynamic programming algorithm as implemented in the Julia package `SDDP.jl` developed by Oscar Dowson.

`JADE.jl` is made available by NZ Electricity Authority at

`https://www.emi.ea.govt.nz/Wholesale/Tools/JADE`

and source is on github at

`https://github.com/EPOC-NZ/JADE.jl`

Calibrating risk aversion

[B. Guo and A. Jin, 2026]

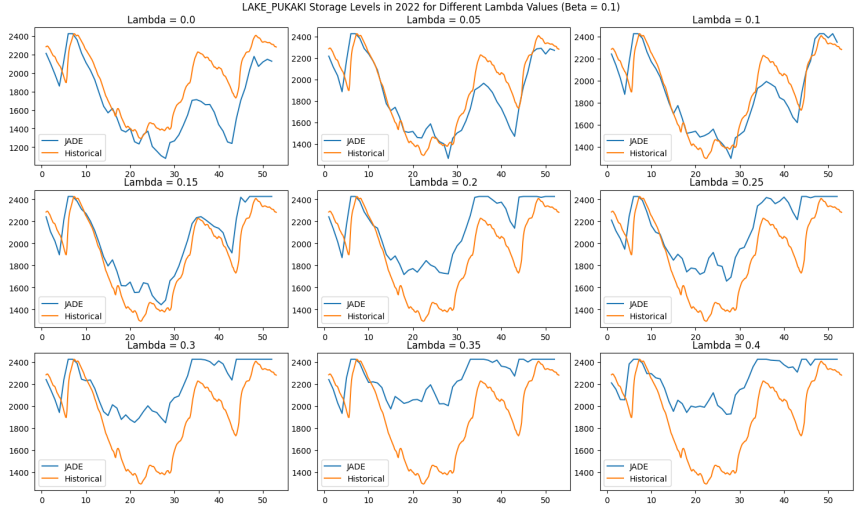
- A system operator computing a socially optimal solution with the market risk measure will replicate the competitive equilibrium.
- Challenge: Identify market risk measure from historical market outcomes.
- Assume nested dynamic risk measure with one-step risk measure

$$\rho(Z) = (1-\lambda)\mathbb{E}[Z] + \lambda \mathrm{CVaR}_{1-\beta}(Z)$$

  and train and simulate `JADE.jl` with different λ and β.
- Choose λ and β to match historical reservoir levels.

Calibrating risk aversion

[B. Guo and A. Jin. 2026]



Lake Pukaki under varying risk aversion

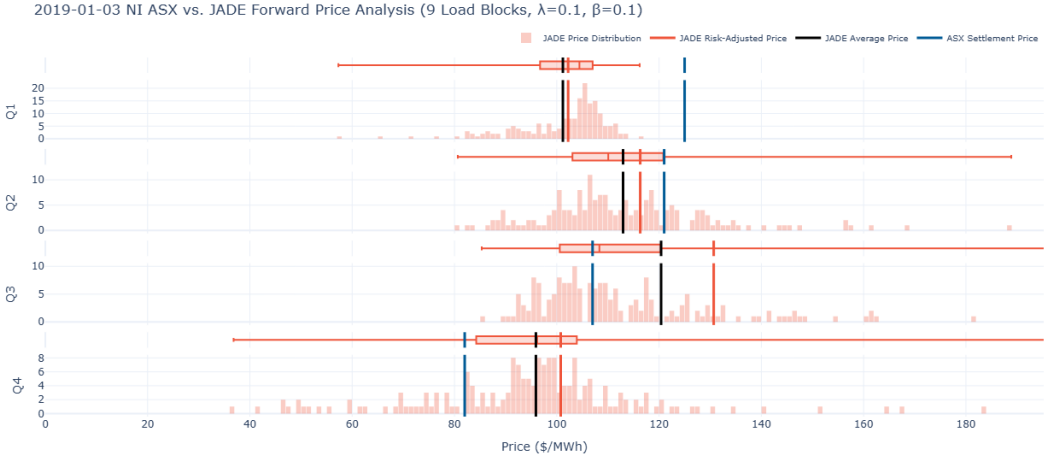
Estimating competitive baseload contract prices

[B. Guo and A. Jin, 2026]

- Train `JADE.jl` with calibrated λ and β.
- Construct synthetic inflow sequences using mFGNS method [Chadwick et al, 2024].
- Simulate `JADE.jl` policy over historical and synthetic sequences to give price distributions.
- Compute time-weighted average prices (TWAPs) over relevant quarter for each simulation.
- Compute expected and risk-adjusted TWAP for quarter.
- Compare with baseload ASX contract price.

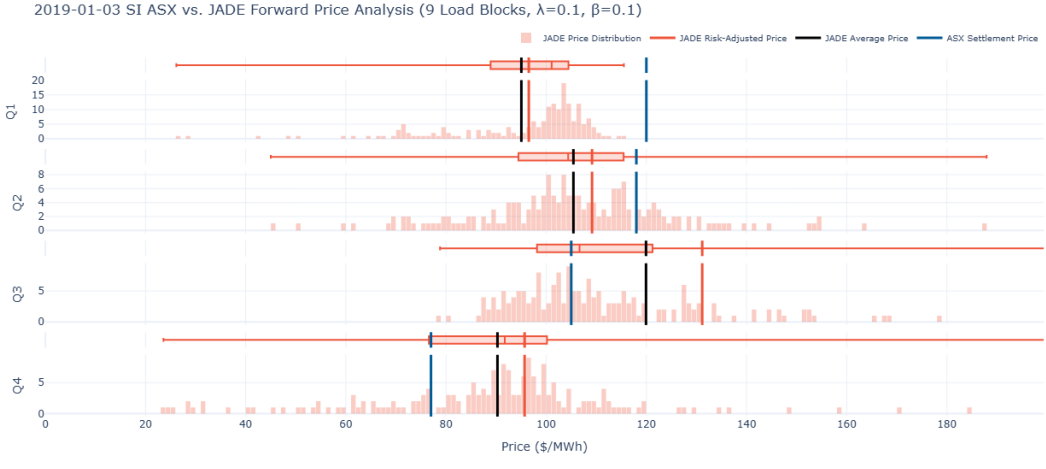
Outline

Preliminary results, Otahuhu 2019



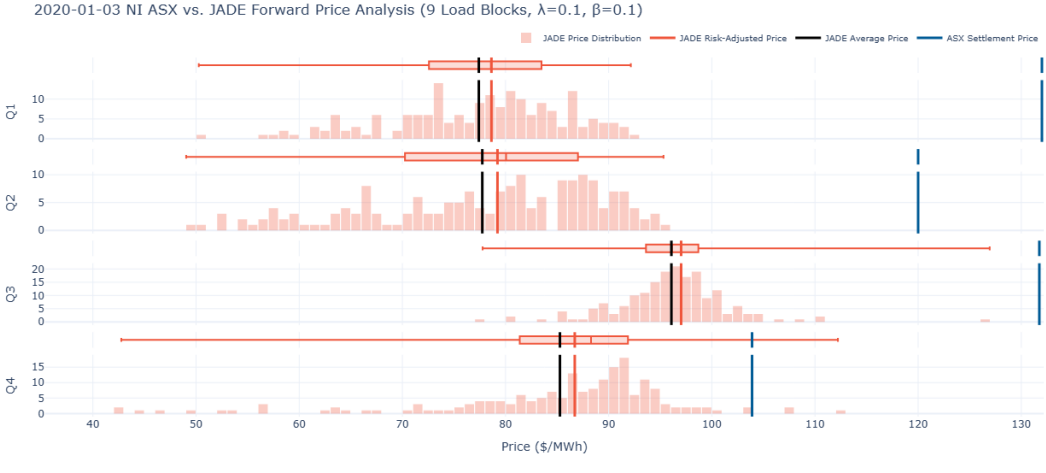
OTA price distributions in each quarter of 2019

Preliminary results, Benmore 2019



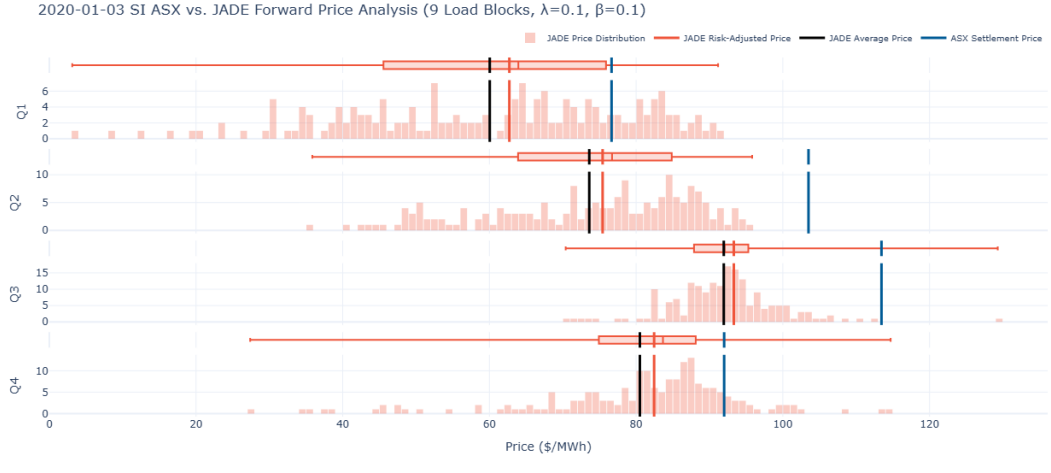
BEN price distributions in each quarter of 2019

Preliminary results, Otahuhu 2020



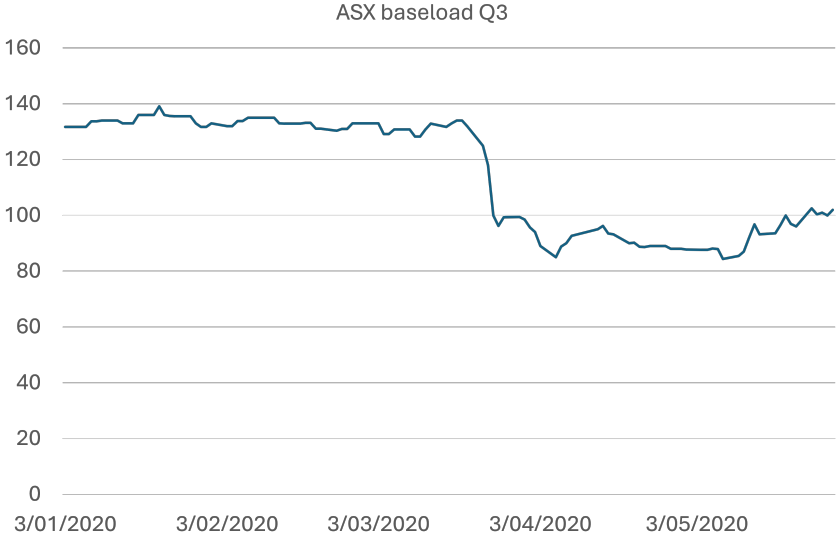
OTA price distributions in each quarter of 2020

Preliminary results, Benmore 2020



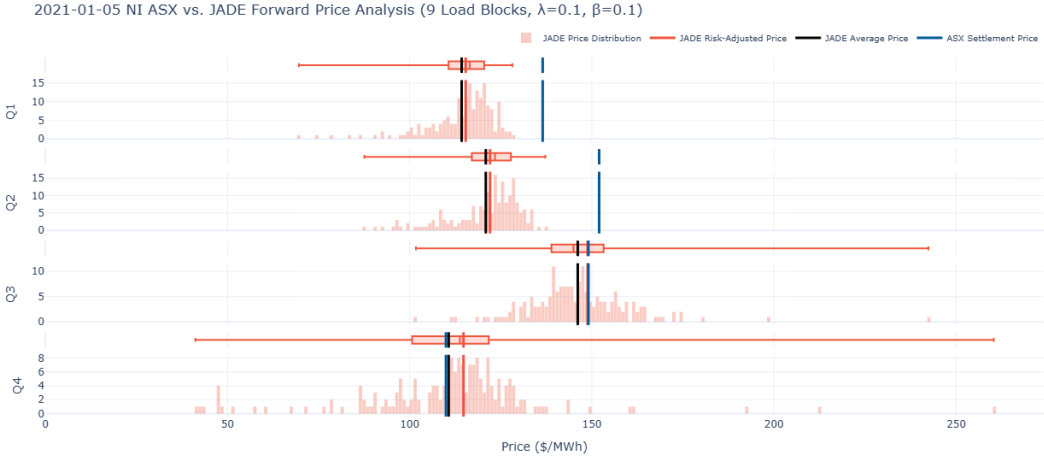
BEN price distributions in each quarter of 2020

The Covid effect, Benmore 2020



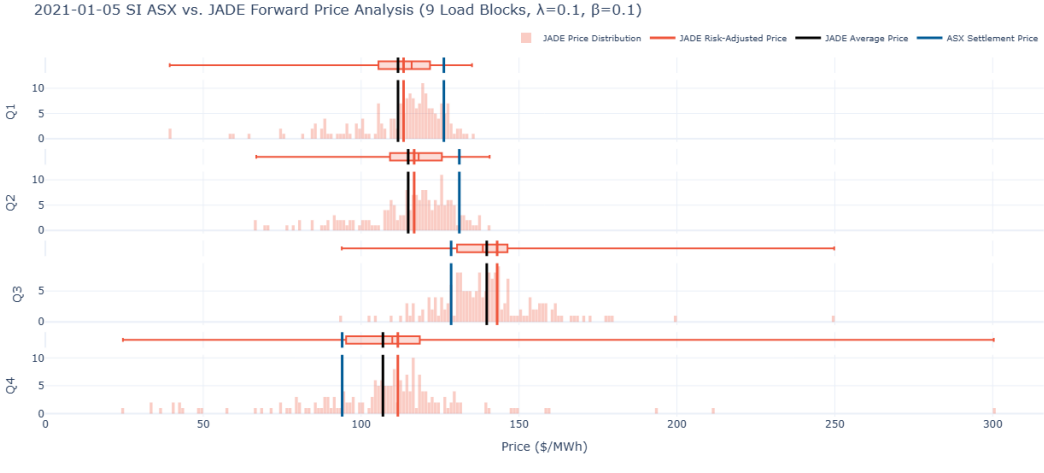
BEN ASX Q3 baseload contract prices by settlement date

Preliminary results, Otahuhu 2021



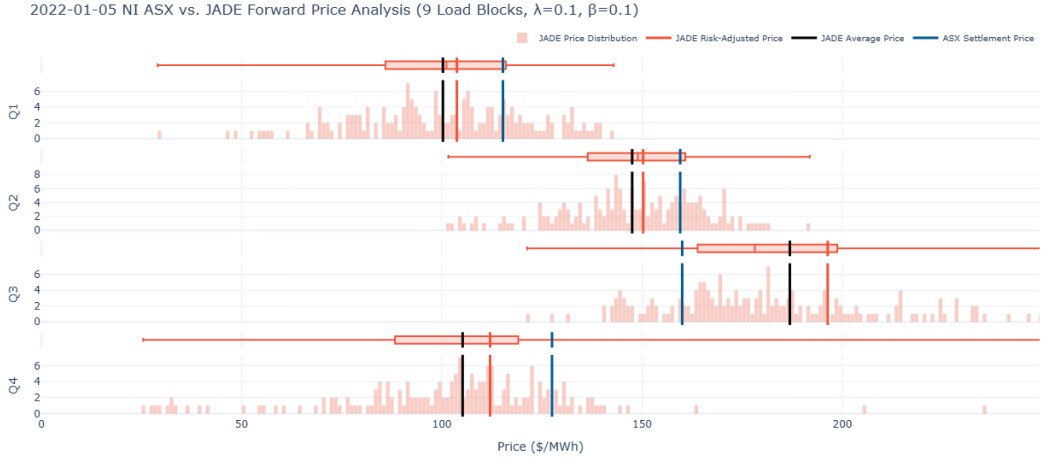
OTA price distributions in each quarter of 2021

Preliminary results, Benmore 2021



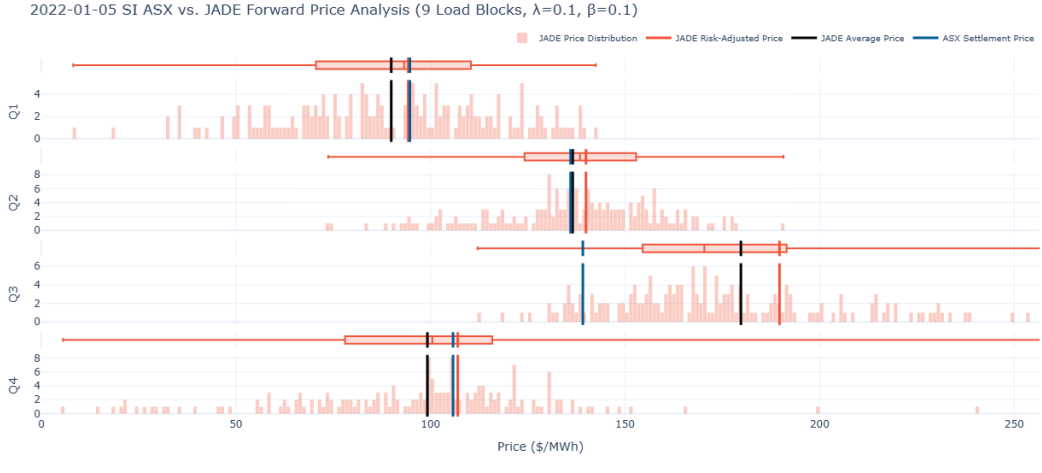
BEN price distributions in each quarter of 2021

Preliminary results, Otahuhu 2022



OTA price distributions in each quarter of 2022

Preliminary results, Benmore 2022



BEN price distributions in each quarter of 2021

Next steps

- Upgrades to JADE.jl are in the works.
  - Uncertain demand;
  - Uncertain plant availability;
  - Fuel constraints;
- Experiments in this talk compare risk adjusted expectations with January ASX contract prices.
- Estimate ASX prices when traded in February or March.
- Requires JADE.jl model to be trained from February or March.
- Repeat experiments for super-peak contracts.

The End

Any questions?