Is New Zealand One Market or Many?
Implications for Locational Portfolios

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Outline

• We describe a key feature of the NZEM,
  – its effect on the potential for market power abuses, and
  – its effect on the behaviour of prices.

• We use factor analysis to
  – identify the number of markets in the NZEM, and to
  – identify the location of each of these markets.

• We analyze a hedging problem faced by generators.
  – What is the best way to sell electricity?
  – What does this tell us about the performance of the NZEM?
The NZEM is a pool market

- A stylized description:
  - Electricity enters and exits the “pool” at 480 different nodes.
  - Given consumers’ demand, the network administrator selects the combination of generators which minimizes the total cost of electricity.
- Anything which restricts the administrator’s choice raises (at least, does not lower) the total cost of electricity.
  - transmission constraints
  - transmission losses
Competition in a pool market

• In a single integrated pool market,
  – each generator competes with every other generator in the pool.
• If the NZEM is segmented,
  – some generators face reduced competition.
• Example:
  – Suppose a North Island generator withholds supply.
  – The market administrator can choose from all other NZ generators if the market is integrated.
  – The market administrator may not be able to choose an alternative supplier if the generator is protected by a transmission constraint.
Prices in a pool market

• If the NZEM is a single integrated pool market,
  – There is one price across the entire NZEM.

• If the NZEM is segmented,
  – There will be different prices for the different component markets of the NZEM.

• Example:
  – Consider a positive shock to demand in the North Island.
  – Prices at all nodes increase if the market is integrated.
  – Only prices at North Island nodes increase if the Cook Strait cable is out.

• Prices reveal information about the integration of a pool market.
Factor Analysis

• We observe prices at 244 nodes in the NZEM:
  – \( P_A, P_B, P_C, \) and so on
• We believe that these prices are driven by a much smaller number of “factors”
  – Temperature,
  – Lake levels,
  – Hydro inflows, and so on.
• Factors determine prices.
  – If two factors suffice, then
    \[
    \begin{align*}
    P_A &= \_A,0 + \_A,1 F_1 + \_A,2 F_2 + \text{noise}_A \\
    P_B &= \_B,0 + \_B,1 F_1 + \_B,2 F_2 + \text{noise}_B \\
    P_C &= \_C,0 + \_C,1 F_1 + \_C,2 F_2 + \text{noise}_C \\
    \end{align*}
    \]
  and so on.
How do we use factor analysis?

- To implement factor analysis, we need to know the correlation structure of the prices at different nodes.
- Factor analysis can reveal
  - how many factors drive prices,
  - how each factor affects each price, and
  - how each factor behaves over time.
- Factor analysis cannot tell us exactly what the factors are.
How do we use factor analysis?

- We use factor analysis to investigate the factor structure of each trading period’s prices at the following nodes:
How many factors are there?

- We analyze each _-hour trading period separately.
- In each trading period, the first factor explains at least 90% (and usually more than 95%) of the variation in prices.

- The second factor raises this to 98% explained.
- This suggests there are no more than two distinct markets in the NZEM, even in the peak periods.
Filtering out the first factor

• But this could be misleading.
  – There are obvious cycles in prices.
  – A temperature factor could affect prices in different markets.
• That is, one factor could explain a large percentage of the variation in prices even if there are two markets.
• Our response is to filter out the first factor’s influence on prices. Filtered prices are:

  \[ P_A^* = P_A - _{A,0} - _{A,1} F_1 = _{A,2} F_2 + \text{noise}_A \]
  \[ P_B^* = P_B - _{B,0} - _{B,1} F_1 = _{B,2} F_2 + \text{noise}_B \]
  \[ P_C^* = P_C - _{C,0} - _{C,1} F_1 = _{C,2} F_2 + \text{noise}_C \]

  and so on.
• The new prices are essentially deviations from a market-wide index of prices.
How do price deviations behave?

• If there is one market,
  – prices will deviate randomly from the market-wide index
  – and there will be no common factor to price deviations.

• If there are two markets,
  – price deviations in one market will have positive signs,
  – price deviations in the other market will have negative signs,
    and
  – a single factor should explain most of the variation in price
deviations.
How do price deviations behave?

- In each trading period, one factor explains approximately 60% or more of the variation in price deviations.
- This suggests there are two distinct markets in the NZEM, even in the peak periods.
So where are these markets?

- Recall the relationship between prices and factors:
  \[ P^*_A = P_A - \_A,0 - \_A,1 F_1 = \_A,2 F_2 + \text{noise}_A \]
  \[ P^*_B = P_B - \_B,0 - \_B,1 F_1 = \_B,2 F_2 + \text{noise}_B \]
  \[ P^*_C = P_C - \_C,0 - \_C,1 F_1 = \_C,2 F_2 + \text{noise}_C \]

- If nodes A and B are in the same market, the signs of \_A,2 and \_B,2 will be the same. If node C is in the other market, the sign of \_C,2 will be opposite.
So where are these markets?

- Our estimated coefficients:

- Our conclusions:
  - The market splits North-to-South.
  - The composition of the market varies with the time of day.
But are they economically significant?

- Recall the relationship between prices and factors:
  \[ P^*_A = P_A - A_{0} - A_{1} F_1 = A_{2} F_2 + \text{noise}_A \]

- We decompose the price at node A into two components:
  - \( A_{0} + A_{1} F_1 \) is the part of the price which is explained by the first factor.
  - \( P^*_A \) is the part which is not explained by the first factor.

- The following graphs plot these components for Benmore prices in peak and off-peak periods.
But are they economically significant?

Peak (period 35)
But are they economically significant?

Off peak (period 11)
What can we say about the number of markets in the NZEM?

- There seem to be at most two separate markets.
- The NZEM splits along north-south lines.
- The position of the split varies with the time of day.
Risk-management and the NZEM

- Generating and selling electricity is inherently risky.
- We use a simple model of decision-making under uncertainty to analyze the risks generators face.
  - We identify risks which the NZEM structure imposes on generators.
  - We show how these risks can be managed.
  - We use optimal risk-management policies to study the extent of market integration in the NZEM.
Selling electricity: Some alternatives

Node B (Retailer)

Node A (Generator)

Strategy 3

Some combination of Strategies 1 (1 - \( l \)) and 2 (\( l \)).
Identifying the sources of risk

• The generator’s net revenue equals
  \[ X = (1 - \bar{\gamma})p_A + \bar{\gamma}(f + p_A - p_B) \]

• There are two sources of risk.
  – Base price risk: \((1 - \bar{\gamma})p_A\)
  – Transmission price risk: \(\bar{\gamma}(f + p_A - p_B)\)

• The generator will choose
  – \(\bar{\gamma}\) close to 0 if base price risk is relatively low, and
  – \(\bar{\gamma}\) close to 1 if transmission price risk is relatively low.

• We therefore use \(\bar{\gamma}^*\) as a measure of market integration.
Optimal risk-management

- Suppose the generator has the mean-variance utility function
  \[ \text{Utility} = \text{mean} - \gamma \text{variance} \]

- The generator’s optimal portfolio is
  \[ \lambda^* = \frac{f - \bar{p}_B}{2\gamma \sigma_B^2} + \rho \left( \frac{\sigma_A}{\sigma_B} \right) \]

- There are two components:
  - Pure hedging component: \( \lambda_H = \rho \left( \frac{\sigma_A}{\sigma_B} \right) \)
  - Pure speculative component: \( \lambda_S = \frac{f - \bar{p}_B}{2\gamma \sigma_B^2} \)

- We can estimate the pure hedging component \( \lambda_H \) via a simple regression:
  \[ p_A = \alpha + \lambda_H p_B + \text{seasonal \\& other dummies + noise} \]
Some results (2000-02)
What does this analysis tell us?

- The optimal risk-management policy varies over the course of the day.
- Generators should sell a large proportion (75%+) of their electricity using fixed price contracts.
- Transmission price risk increases by more than base price risk during peak periods.
- The high values of \( \gamma^* \) indicate that transmission price risk is relatively low in the NZEM. That is, the market is reasonably integrated.
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