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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

$$P_A = \_{}_{A,0} + \_{}_{A,1} F_1 + \_{}_{A,2} F_2 + noise_A$$

$$P_B = \_{}_{B,0} + \_{}_{B,1} F_1 + \_{}_{B,2} F_2 + noise_B$$

$$P_C = \_{}_{C,0} + \_{}_{C,1} F_1 + \_{}_{C,2} F_2 + noise_C$$

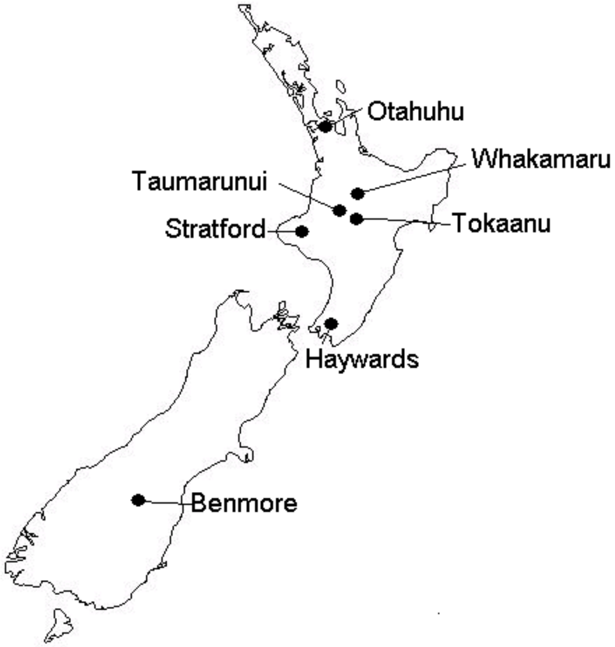
and so on.

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:



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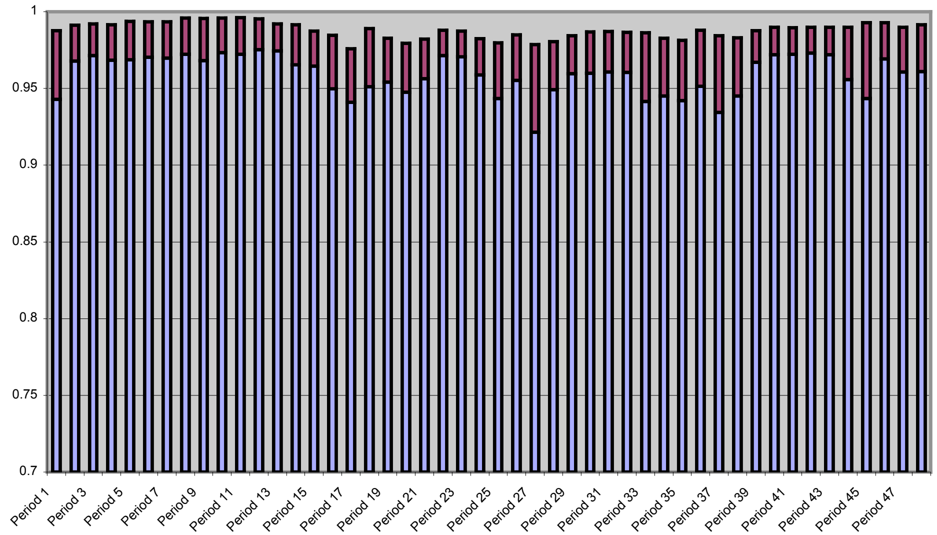
How many factors are there?

- 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:

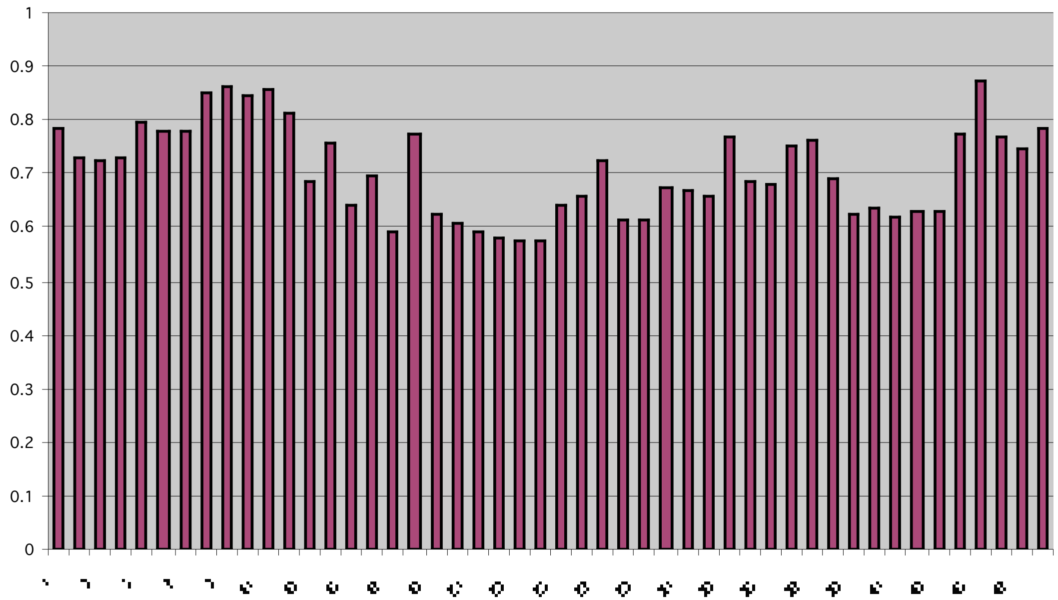
  $$P^*_A = P_A - \_{A,0} - \_{A,1} F_1 = \_{A,2} F_2 + \text{noise}_A$$
  $$P^*_B = P_B - \_{B,0} - \_{B,1} F_1 = \_{B,2} F_2 + \text{noise}_B$$
  $$P^*_C = P_C - \_{C,0} - \_{C,1} F_1 = \_{C,2} F_2 + \text{noise}_C$$

  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.

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So where are these markets?

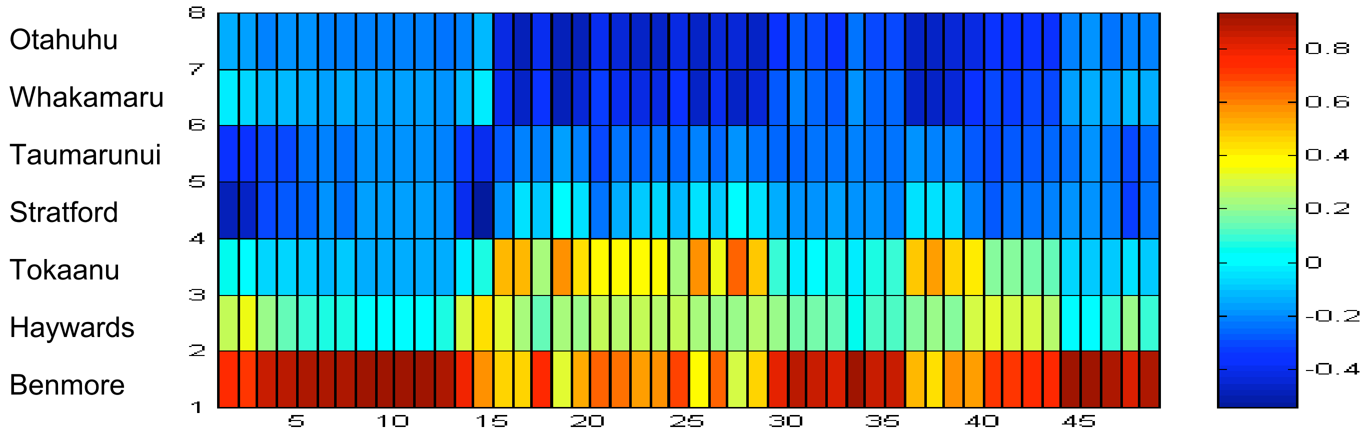
- Recall the relationship between prices and factors:

$$P^*_A = P_A - {}_{\_A,0} - {}_{\_A,1} F_1 = {}_{\_A,2} F_2 + \text{noise}_A$$
$$P^*_B = P_B - {}_{\_B,0} - {}_{\_B,1} F_1 = {}_{\_B,2} F_2 + \text{noise}_B$$
$$P^*_C = P_C - {}_{\_C,0} - {}_{\_C,1} F_1 = {}_{\_C,2} F_2 + \text{noise}_C$$

- 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?

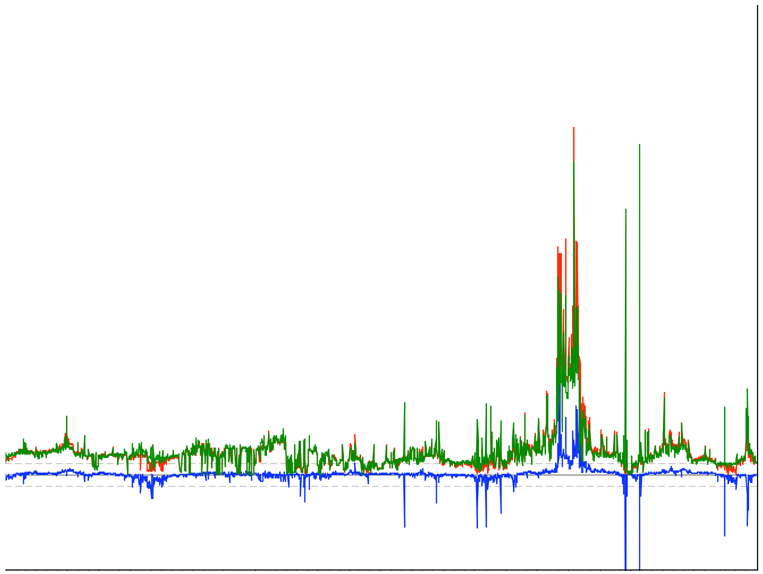
- Recall the relationship between prices and factors:

$$P^*_A = P_A - \text{\_}_{A,0} - \text{\_}_{A,1}\, F_1 = \text{\_}_{A,2}\, F_2 + \text{noise}_A$$

- We decompose the price at node A into two components:
  - $\text{\_}_{A,0} + \text{\_}_{A,1}\, F_1$ 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.

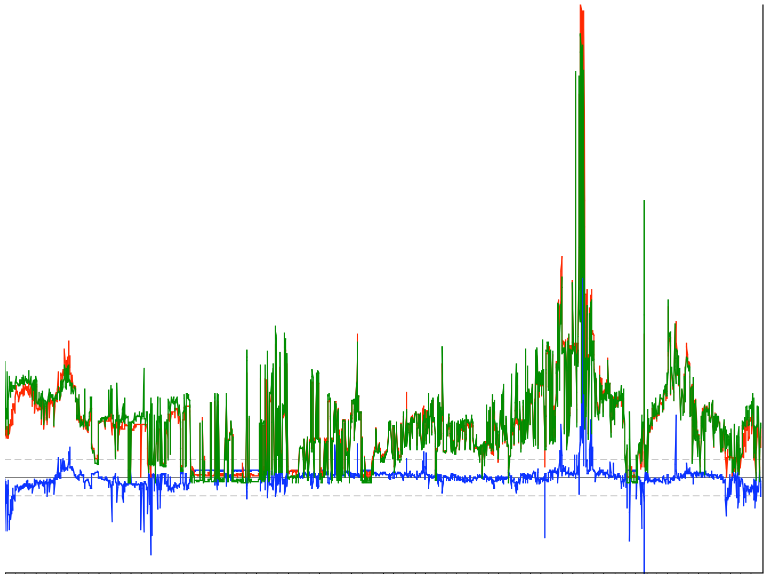
But are they economically significant?

Peak (period 35)



But are they economically significant?

Off peak (period 11)



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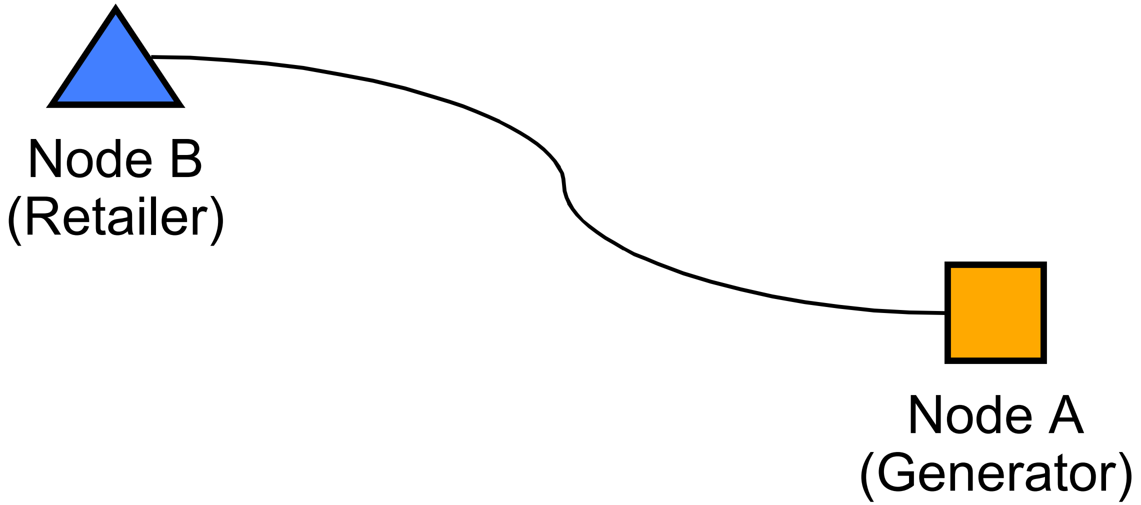
What can we say about the number of markets in the NZEM?

- 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



Strategy 3

Some combination of
Strategies 1 (1 - □) and 2 (□).

Identifying the sources of risk

- The generator's net revenue equals

  $X = (1-\square)p_A + \square(f + p_A - p_B)$

- There are two sources of risk.
  - Base price risk: $(1- \square)\ p_A$
  - Transmission price risk: $\square(f + p_A - p_B)$
- The generator will choose
  - $\square$ close to 0 if base price risk is relatively low, and
  - $\square$ close to 1 if transmission price risk is relatively low.
- We therefore use $\square$* as a measure of market integration.

Optimal risk-management

- Suppose the generator has the mean-variance utility function

  Utility = mean – γ 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:

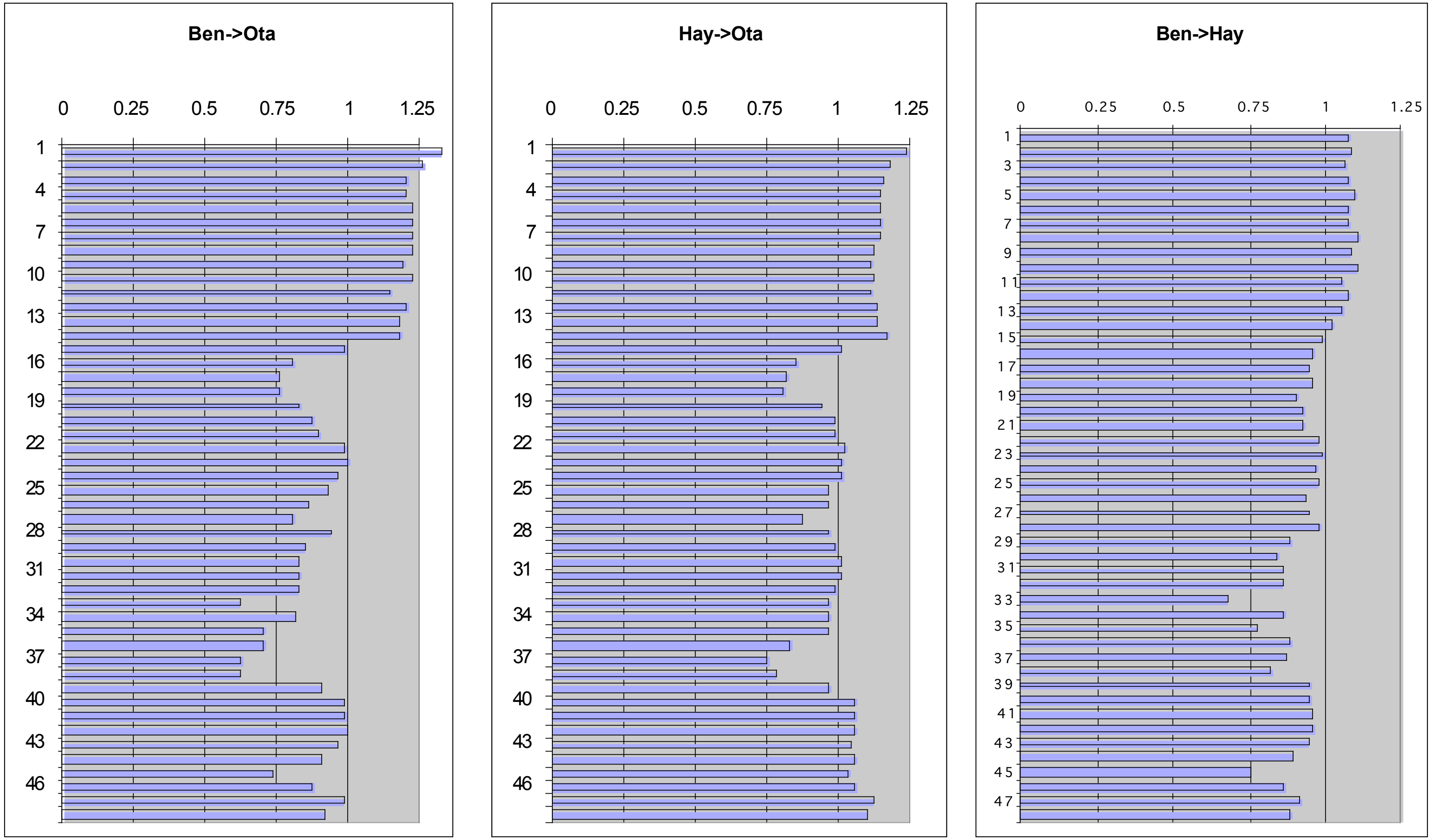
  Pure hedging component: $\lambda_H = \rho\left(\frac{\sigma_A}{\sigma_B}\right)$

  Pure speculative component: $\lambda_S = \frac{f - \bar{p}_B}{2\gamma\sigma_B^2}$

- We can estimate the pure hedging component λ_H via a simple regression:

  $p_A = \alpha + \lambda_H p_B$ + 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 □* indicate that transmission price risk is relatively low in the NZEM. That is, the market is reasonably integrated.

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