Real Time Pricing and Market Power in Electricity Markets

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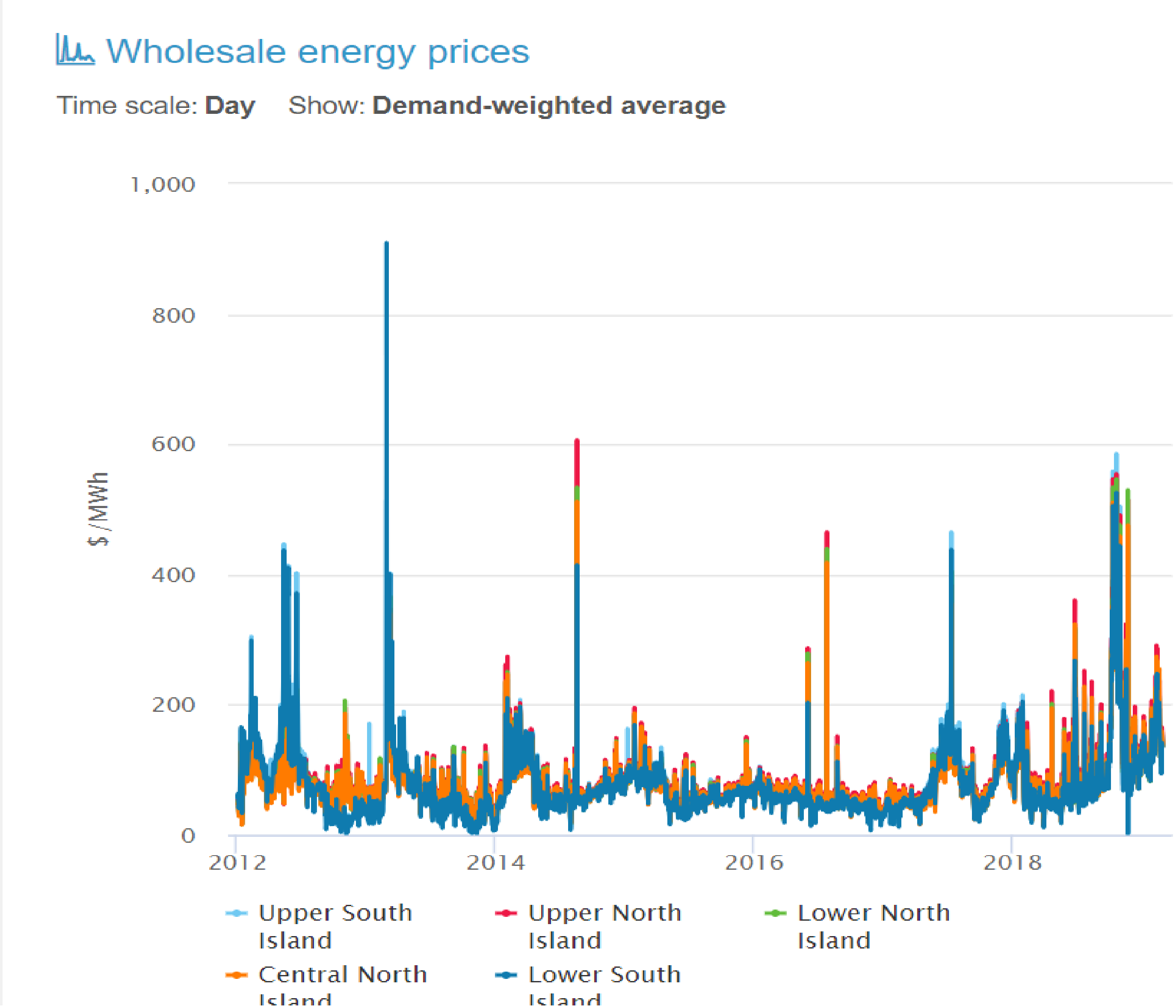
Outline

- Introduction/Motivation
- Research questions
- Model
- Results/Intuitions
- NZ Market Simulation

Intro: NZ market prices daily average

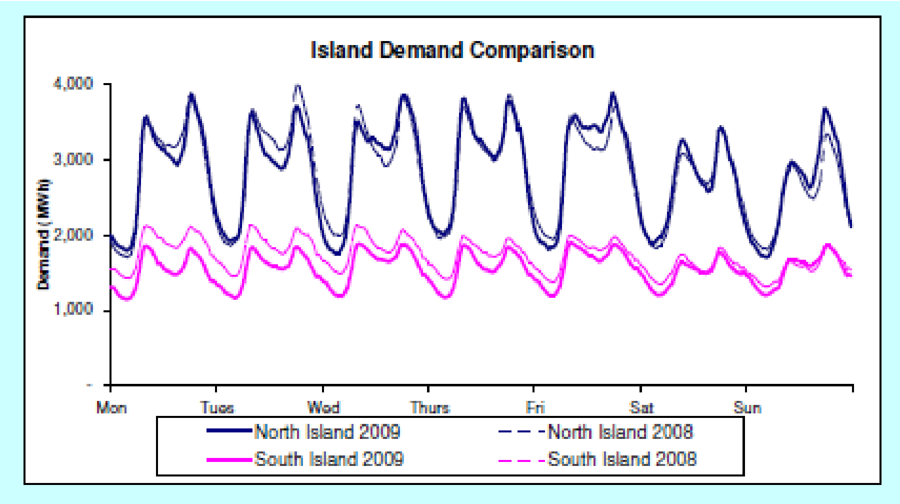


Electricity Markets Issues.

- **Very little demand response.**
- Spot market real-time price can vary over a day by 100% or more and price spikes of 10 or even 100 times the average price are not uncommon.
- Many customers pay a fixed price p for electricity price which doesn't depend on time of use (meter reads monthly or more)

- Leads to limited demand response to spot-prices.
- Leads to supply adequacy concerns and possible rolling black-outs
- AND higher system costs with a less efficient capacity mix
- AND leads to market power concerns

Efficiency gains with more RTP

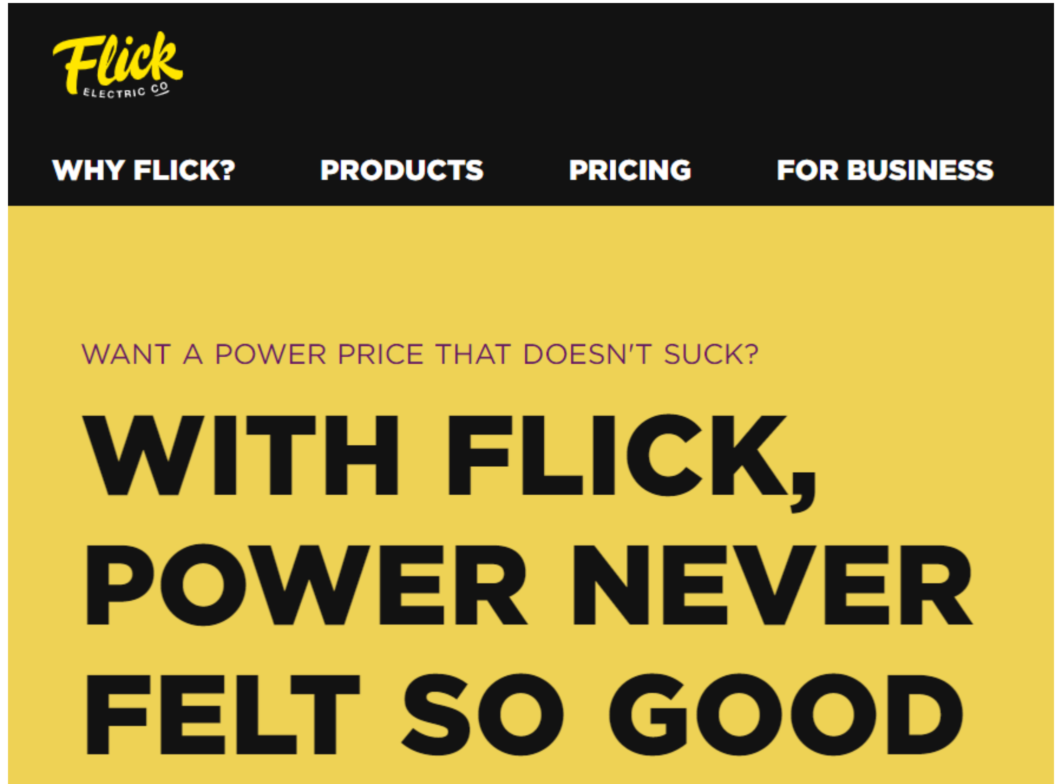


- Until recently meter technology has limited uptake
- However in many countries smart metres are being rolled out
- Numerous studies show customers can respond to RTP
- Technology that can automate customer response expected to further increase demand response

Many authors see RTP as desirable to increase the efficiency of the market and alleviate market power.

- **Borenstein (2002) concludes his analysis of California's power crisis failure**
- "....Electricity Markets have proven to be more difficult to restructure than many other markets that served as models for deregulation --- including airlines, trucking, natural gas and oil --- due to the unusual combination of extremely inelastic supply and extremely inelastic demand. **Real-time pricing……….** can help to control the soaring wholesale prices recently seen in California (p210)."
- Stoft (2003) also argues that inelastic demand is a key reason the electricity market does not function smoothly.

NZ example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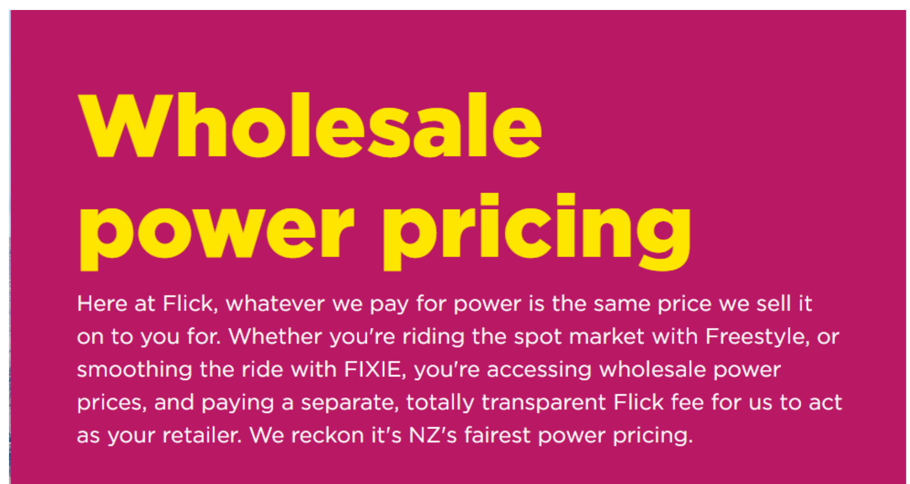
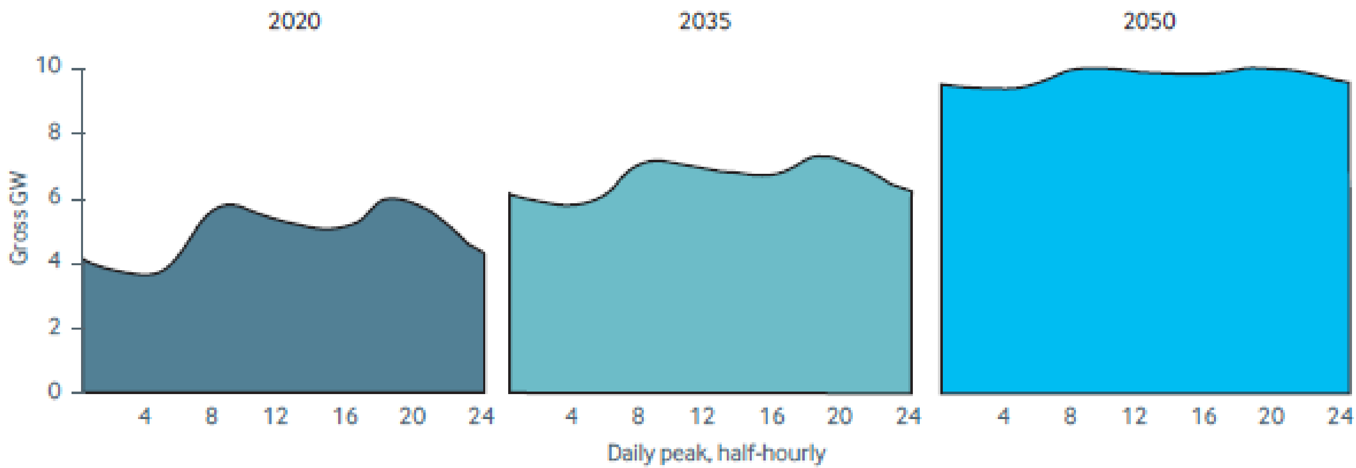

Wholesale power pricing
Here at Flick, whatever we pay for power is the same price we sell it on to you for. Whether you're riding the spot market with Freestyle, or smoothing the ride with FIXIE, you're accessing wholesale power prices, and paying a separate, totally transparent Flick fee for us to act as your retailer. We reckon it's NZ's fairest power pricing.

Real Time Pricing is the future!

Exhibit 5: Average daily winter load profile estimated



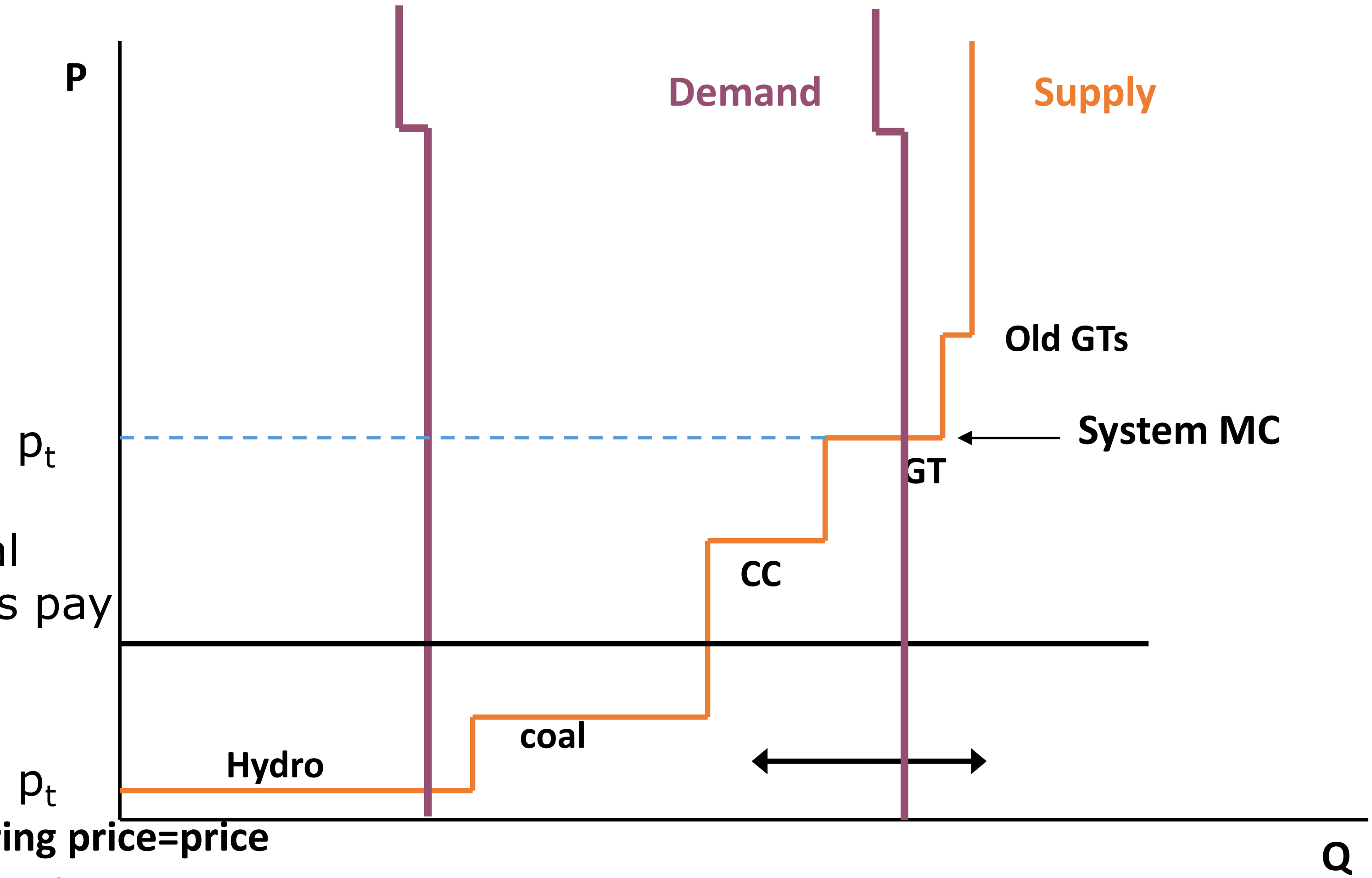
Note: Analysis based on average winter day, not the most "peaky" day of the year.

EV charging is smoothed to avoid mass charging in times of high demand…….

Instead, charging will occur slowly overnight and during the midday demand trough.

In a future world with digital and smart technologies, ***charging outside of peak demand times will be convenient and financially attractive to households and industry.***

Typical electricity market cost supply curve



Traditional customers pay p

Market clearing price=price paid by RTP customers

Retail Companies buy at price p_t and onsell to RTP customers at p_t and traditional customers at p.

Literature.......

- Borenstein and Holland (2005, RAND)

- Perfect Competition “Increasing the share of customers on RTP is likely to improve efficiency, ……Efficiency gains from RTP are potentially quite significant”

Research Questions

- **Aim: To build a model which explicitly includes market power.**

AS customers switch to RTP contracts what is impact on

- Prices
- Capacity
- Profits
- Consumer Welfare
- System costs
- Social Welfare

Model

- States of nature denoted by *t* with frequency f_t *(For example two states: Peak and Off Peak)*
- Fraction β of customers on real time metres (RTP) and pay the spot price p_t.
- The rest are on traditional meters and face fixed price contracts *p*

- *Total Demand is:*

$$D_t(p_t, p) = \beta D_t(p_t) + (1-\beta) D_t(p)$$

Retail Competition-prefect competition

TWO PART TARRIFS (Differs from Borenstein....).

(Josckow and Tirole, RAND 2006)

- Perfect competition in Retail Sector
- Real time customers results are standard. Retail firms set usage fee at marginal cost so p_t=*spot price*, No fixed fee.
- Look at traditional customers

First order conditions for retail firm profit maximisation.

1. Price *p* (for both time periods) is weighted average of the spot price in each period.

2. With A determined from zero profit constraint for Retail firms

$$\Leftrightarrow \sum [f_t (p - p_t) D'_t (p)] = 0$$

$$A = -\sum [f_t (p - p_t) D_t (p)]$$

Wholesale Market

- Assume that time periods are exogenous with demand increasing with “t”.
- Have different technologies with investment costs decreasing $I_t < I_{t-1}$ *and constant marginal operating costs increasing with “t”* $c_t > c_{t-1}$. ***(i.e merit order)***
- Cournot assumptions about other firms behaviour.
- Complete information so the representative firm knows, usage fee (and hence residual demand) as a function of their wholesale prices.
- N symmetric firms

Breakeven prices

- Define the breakeven prices

$$\sum_{s=t}^{T} f_s(p_s^* - c_s) = I_t$$

- Revenue just equals running and investment costs for each type pf plant
- Fixed price *p** found as above.
- Joskow and Tirole (2007, RAND) these prices are the socially optimal RTP prices (with or without customers on fixed price contracts).

- Representative firm “i” builds capacity K_1^i for lowest demand period given other firms capacity choices K_1^j
- These capacities run for all higher demand periods as well.

- So revenue for capacity built in the first period is

$$f_1(p_1-p_1^*)K_1^i + f_2(p_2-p_1^*)(K_1^i + K_2^i) + \ldots\ldots\ldots$$

APPROACH HERE

Use prices as variables and consider ***residual demand*** (and impose constraint that demand equals supply) so write $K_1^i = D_1(p,p_1) - \Sigma K_1^j$ so revenue for installed baseload is

$$f_1(p_1-p_1^*)(D_1(p,p_1)-\Sigma K_1^j) + f_2(p_2-p_1^*)(D_1(p,p_1)-\Sigma K_1^j) + \ldots\ldots$$

Find price that maximises profit with Cournot Assumptions

Market Power: Solutions for Linear Demand and symmetric firms.

- The spot prices are found. Equal to socially optimum prices + markup:

$$p_t = p_t^* + \frac{1}{(N+1)}\left[\frac{A_t}{B_t} - p_t^*\right] + \frac{1-\beta}{\beta}\sum_{s=0}^{s=T} \bar{f}_t[\frac{A_t}{B_t} - \frac{A_s}{B_s}]$$

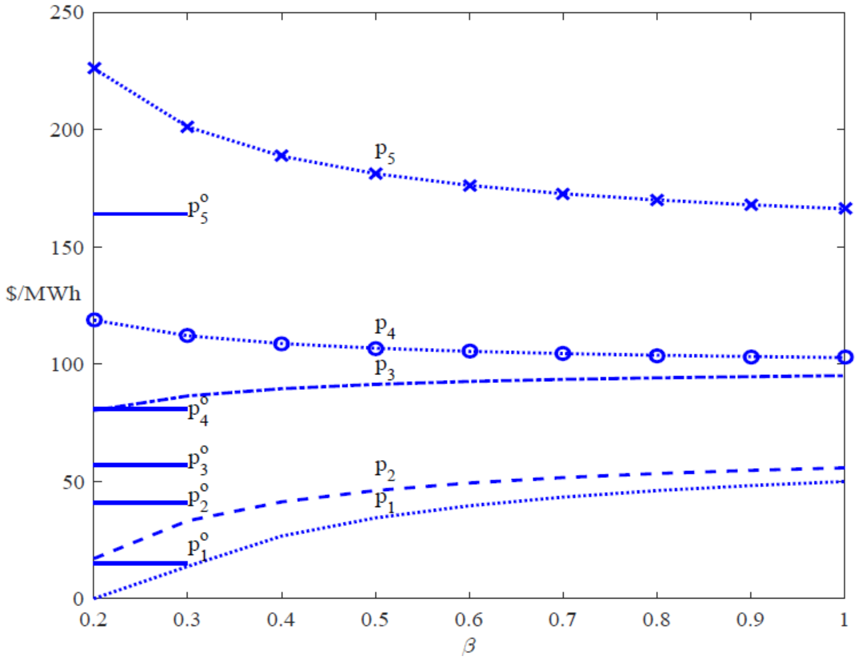
- Where $\overline{f_t}$ is the weights used to determine the fixed price

$$p = \sum \overline{f_t} p_t$$

- So the spot price changes as number of customers on RTP changes (not true with PC where always=p*)

Remarks

- Prices for off-peak periods are ***pushed down*** with more customers on traditional contracts. **And may be less than competitive prices!**
- Peak prices (t close to T) sees prices pushed up
- Prices are more dispersed due to customers having traditional contracts



Capacity and Consumer Surplus

As more customers switch to RTP plans

Capacity:

TOTAL Capacity decreases, Baseload increases and Peak capacity decreases.

Consumer Surplus:

Increases *- both for those who switch and those who remain (externality)*

NB. This externality only there with market power

Profits, System Costs and Social Welfare

As consumers switch to RTP contracts

Profits

equilibrium profits decline

Intuition. Roughly speaking as customers switch to RTP contracts their demand is more sensitive to price changes and hence firms face a more elastic demand curve which reduces their ability to exercise market power.

Social Welfare

Increases

System Costs

Decreases

NZ market simulation

- So far results are qualitative.
- To understand relative size of market impact as more customers switch to RTP-contracts fit model to NZ electricity market.
- Demand and cost function parameters estimated
- Assume 5 periods.
- **Technology**
- geothermal/hydro with zero MC.
- Gas CCGT is marginal plant
- Peak: OCT gas
- Estimate β=0.2

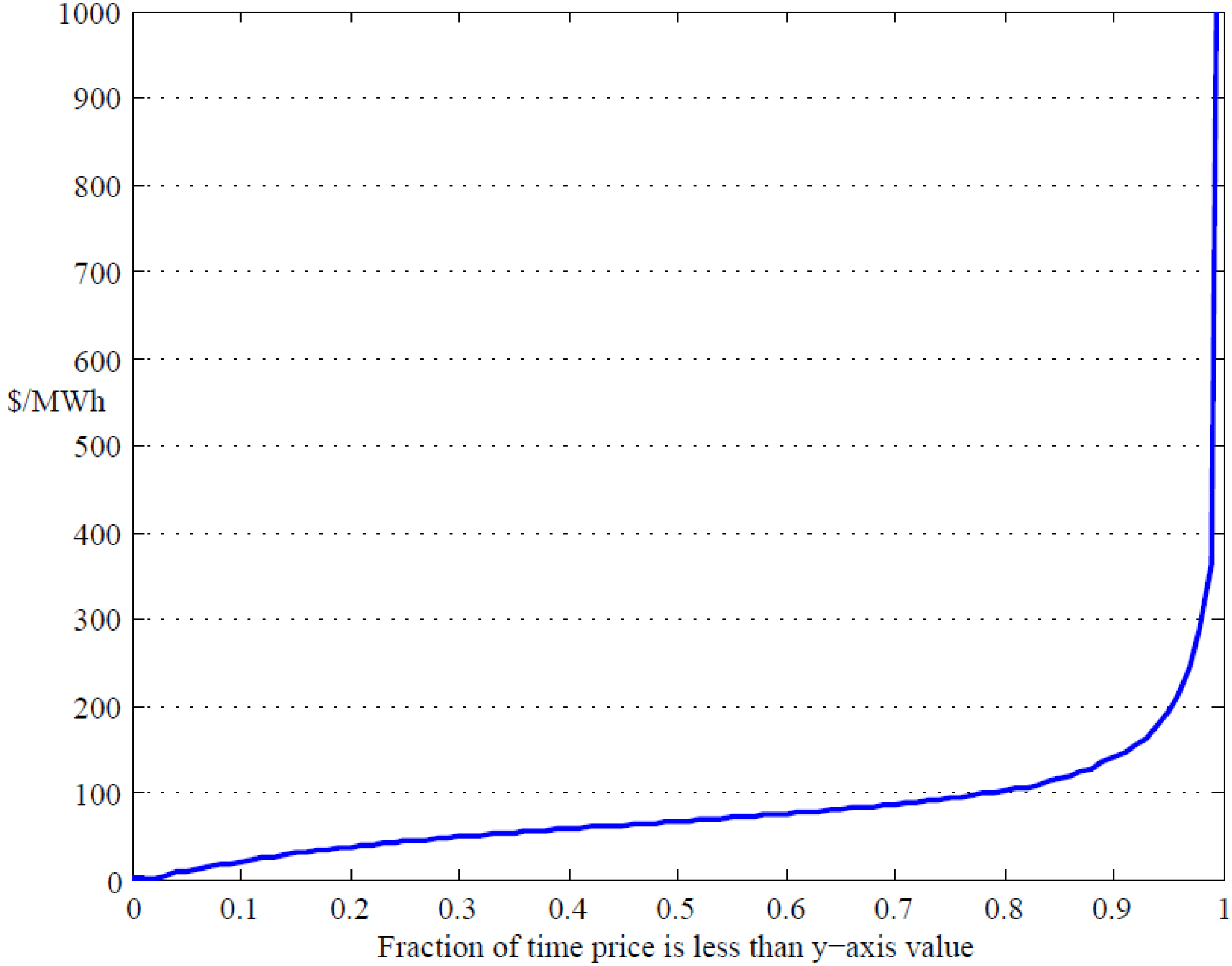


Figure 1: Price duration curve. The vertical axis has been truncated at \$1,000/MWh.

NZ market Simulation: Prices

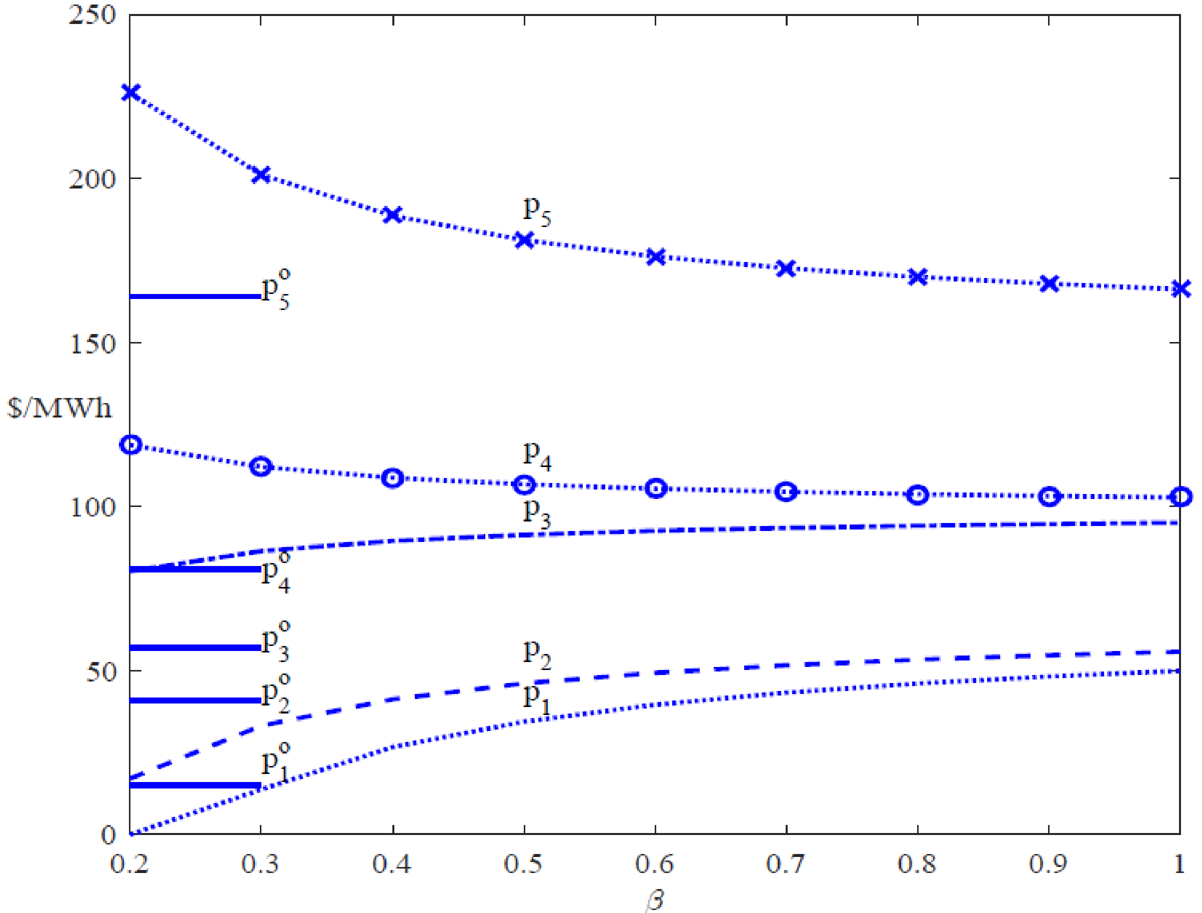


Figure 2: Predicted prices as a function of β. The solid lines are the observed prices.

NZ Market simulation: Capacity

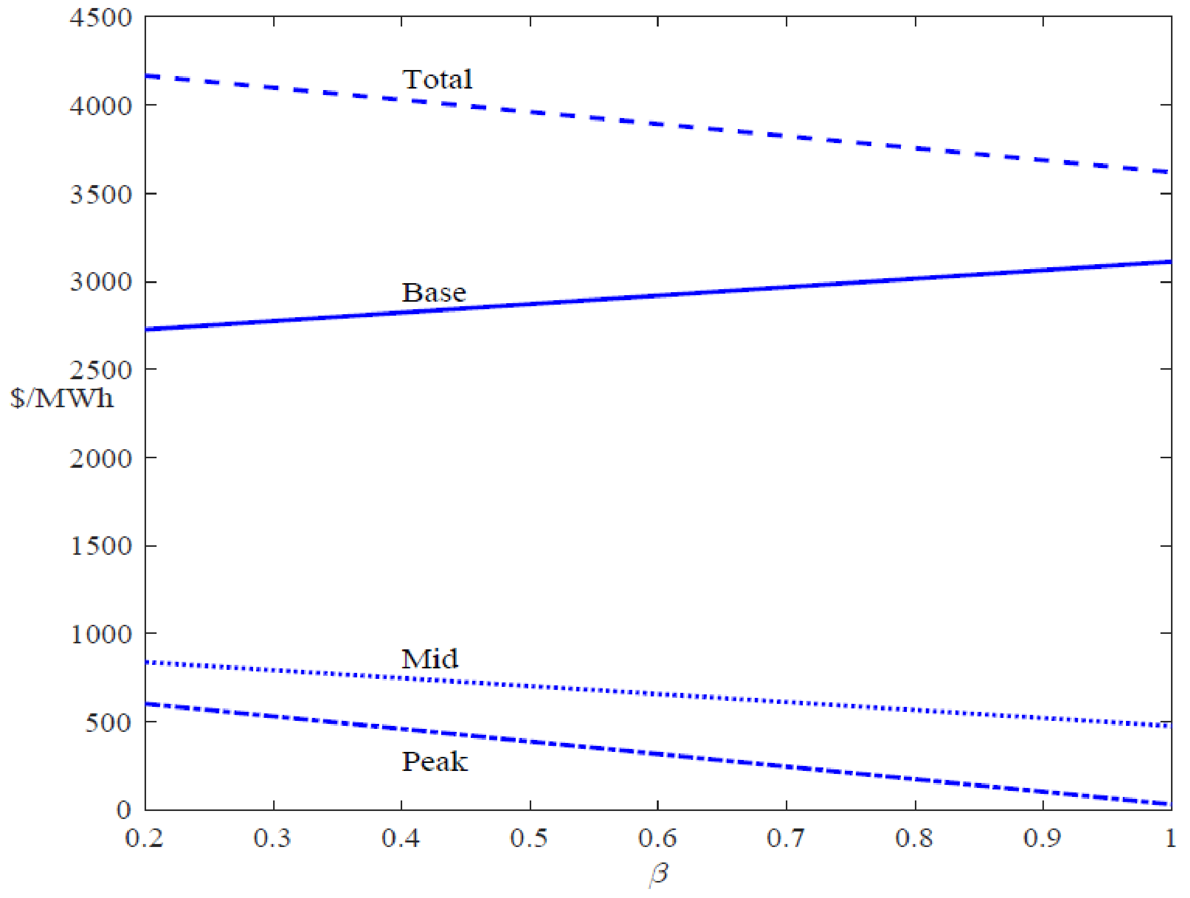


Figure 3: Capacity Changes

Market Power is considerable – about 49% of revenue (demand elasticity = -0.3)

Table 3: Outcomes as a function of β

β	π	$\% \Delta\pi$	CS	$\% \Delta CS$	TC	$\% \Delta TC$	SW	$\% \Delta SW$	SW*	$\% \Delta SW*$
0.2	1.65	0.0	3.19	0.0	1.70	0.0	4.84	0.0	5.00	0.0
0.3	1.54	-6.4	3.31	3.9	1.69	-0.8	4.86	0.4	5.01	0.2
0.4	1.49	-9.5	3.38	5.9	1.68	-1.6	4.87	0.7	5.02	0.3
0.5	1.46	-11.4	3.42	7.2	1.66	-2.4	4.88	0.9	5.03	0.5
0.6	1.44	-12.5	3.45	8.2	1.65	-3.2	4.89	1.1	5.04	0.7
0.7	1.43	-13.3	3.47	8.9	1.63	-4.0	4.90	1.3	5.04	0.8
0.8	1.42	-13.9	3.49	9.4	1.62	-4.8	4.91	1.5	5.05	1.0
0.9	1.41	-14.3	3.51	9.9	1.61	-5.7	4.92	1.7	5.06	1.2
1	1.41	-14.6	3.52	10.4	1.59	-6.5	4.93	1.9	5.07	1.3

Note: Figures are presented in $NZ billions and percent changes. The last two columns are for social welfare changes under perfect competition.

Social Welfare, Profits, Consumer Surplus and System Costs (for elasticity=-0.3)

- As β increase from 0.2 to 1

(1) Profits **decrease** by 14.1%

(2) Total Consumer Surplus **increases** by 10.1%

(3) System costs **decrease** by 6.7%

(4) Social Welfare **increases** by 1.9%

(5) Competitive benchmark sees social welfare increase by less at 1.4%

Conclusion

- Social Welfare gains are modest
- BUT
- Consumer surplus increases by a lot
- Profits decrease by a lot
- System costs decrease by a lot.

Importance of result depends how much weight policy makers place on these measures as opposed to overall social welfare gains.

And positive externality of customers switching to RTP-contracts on non switching customers provides a possible rational for policy intervention

THE END

QUESTIONS