

Water Valuation Under Imperfect Competition

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Outline

- This talk is about problems and not solutions!
- Are resource valuations (in particular water) different in perfectly competitive vs. imperfectly competitive markets?
- Where might this matter?
 - Swaps in the ownership of hydro assets.
 - Allocation of permits for irrigation.

Water values

- Over 65% of our electricity is produced through hydro resources.
- Accurate valuation of water has implications about
 - running the system,
 - modelling of the running of the system,
 - valuing shares in SOEs,
 - best utilization of water between different uses,
 - contracts governing a fair release of water (e.g. in the Waitaki chain).
 - Water valuation and participant behaviour are intimately linked.

Central plan vs. monopoly water values

- Consider a 5 period time horizon,
- a hydro generator with a single reservoir,
- a thermal fringe with a linear cost curve of slope 1,
- fixed demand per period (of 200 MW),
- let us also assume that water has no value beyond the time horizon.

Central planner's valuation

- From a central planning perspective, overall social welfare is aimed to increase.
- In the central plan, the welfare savings, per period, of producing x_t from hydro is given by

$$S_t(x_t) = x_t(200 - x_t) + \frac{1}{2}x_t^2$$

- Over our time horizon, a central planner will want to maximize $\sum_{t=1}^T S_t(x_t)$.
- This can be done using dynamic programming.

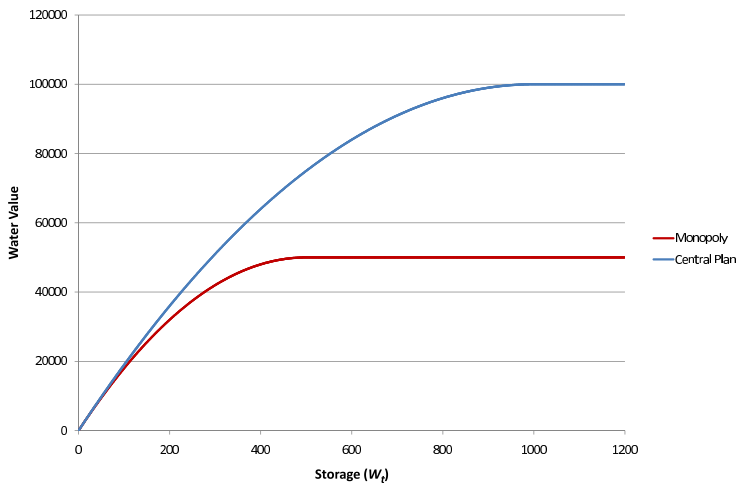
Monopolist's valuation

- The monopolist hydro generator has a different perspective from the central planner.
- The monopolist will want to maximize total profits over the time horizon.
- In this example the profits per period, given a dispatch of x_t is given by

$$P_t(x_t) = x_t(200 - x_t)$$

- Over our time horizon, the monopolist will want to maximize $\sum_{t=1}^T P_t(x_t)$.
- This can be done using dynamic programming.

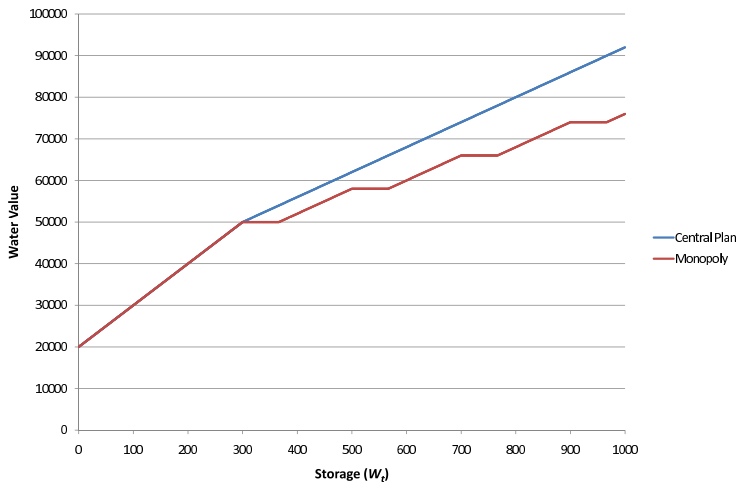
Different water value curves



Another example

- Same set up as the previous example except for the thermal,
- supply curve for the thermal consists of \$60/MW for 200 MW and \$100/MW for the next 200 MW,
- fixed demand per period (of 300 MW),

Different water value curves

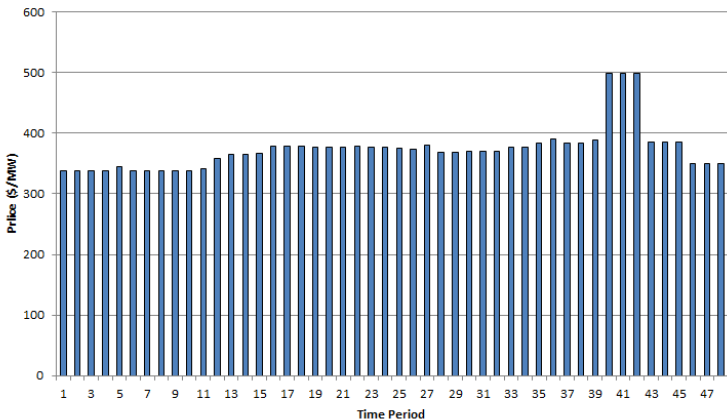


- What happens when we go to a duopoly or an oligopoly?
- May not even be well defined if modelled as a subgame perfect equilibrium (i.e. the equilibrium may not exist).
- Yet, imperfectly competitive markets operate.
- We want to understand how, and simulating decisions through some simplifications and limited rationality over a repeated game may help.

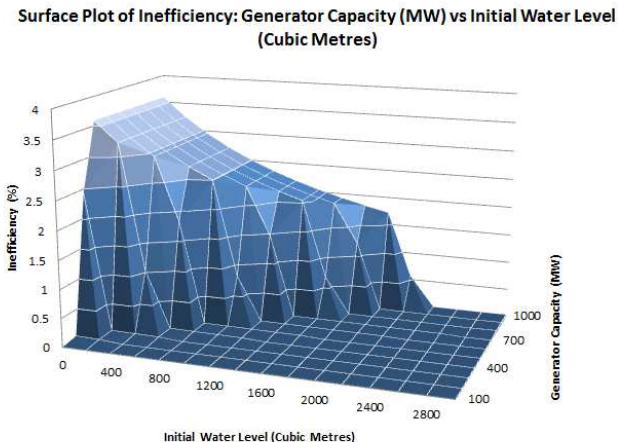
Breaking up a river chain's ownership

- Under a central plan, or in a perfectly competitive market, the break up of a river chain would not change production behaviour.
- What sorts of things may happen when competition is not perfect?
- Consider a price taker (and assume that any production up to capacity can be absorbed by demand).
- We look at production under a single ownership regime vs. break up of the upstream and downstream reservoirs.

Price Sequence for 30th June 2008: Price vs Time Period



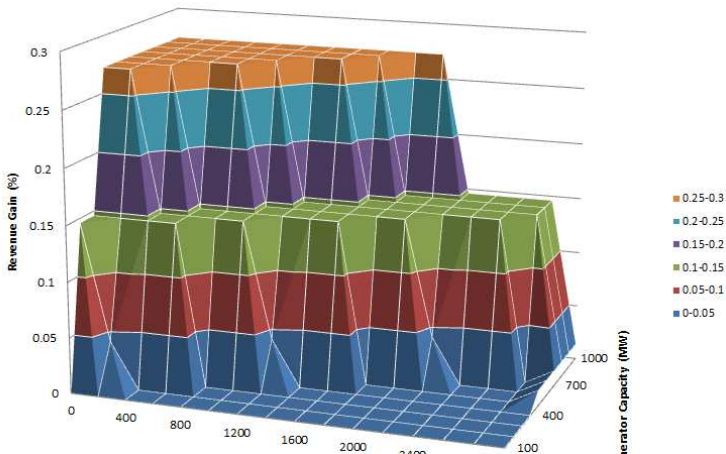
Overall percentage loss in revenue due to breakup



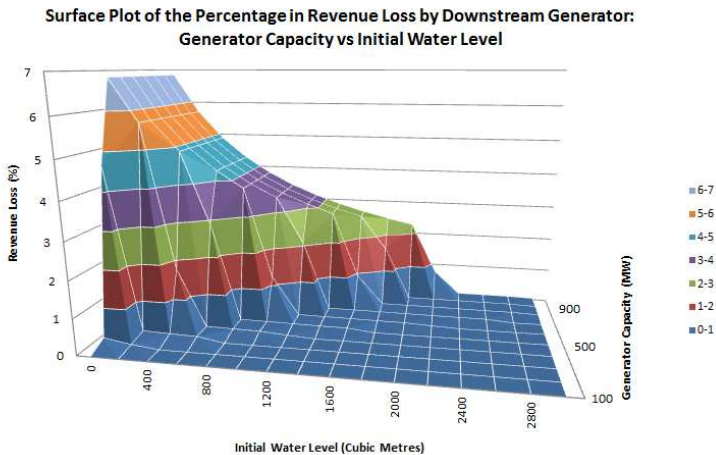
We observe a departure from the competitive behaviour in the price taker case.

Revenue gain by upstream generator

Surface Plot of the Percentage in Revenue Gain by Upstream Generator:
Generator Capacity vs Initial Water Level

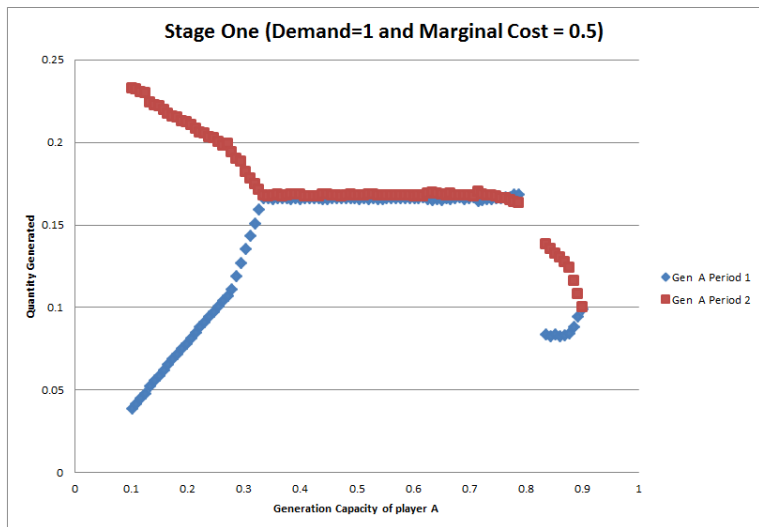


Revenue *loss* by downstream generator

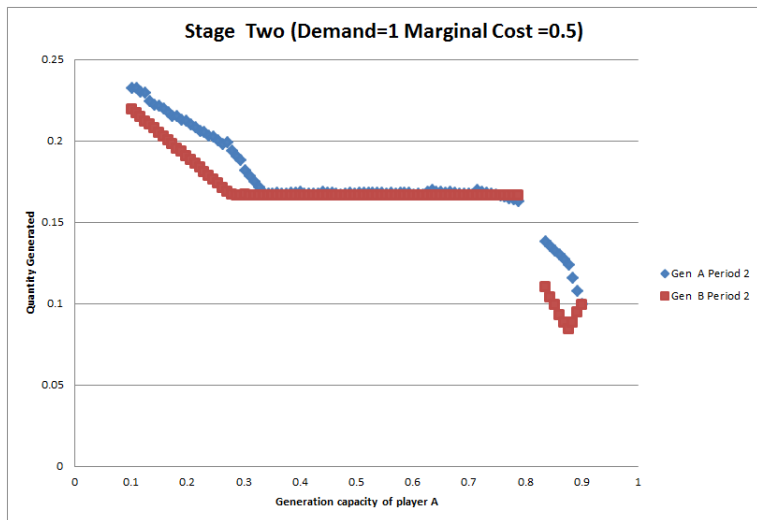


- What if we decrease competitiveness further?
- Examine a monopoly owning a river chain vs. a duopoly by splitting the upstream and downstream ownership?
- We will assume a linear demand (setting the price) and generator(s) offering in Cournot quantities.
- We will need to capture the steady state behaviour (of the duopoly) for any comparisons.
- This means that we have to (attempt) to compute a subgame perfect equilibrium. Note that these don't always exist.
- The second stage game (in the duopoly,) will always have an equilibrium and the equilibria can be categorized. When the subgame perfect equilibrium exist, we find it through exhaustive search.

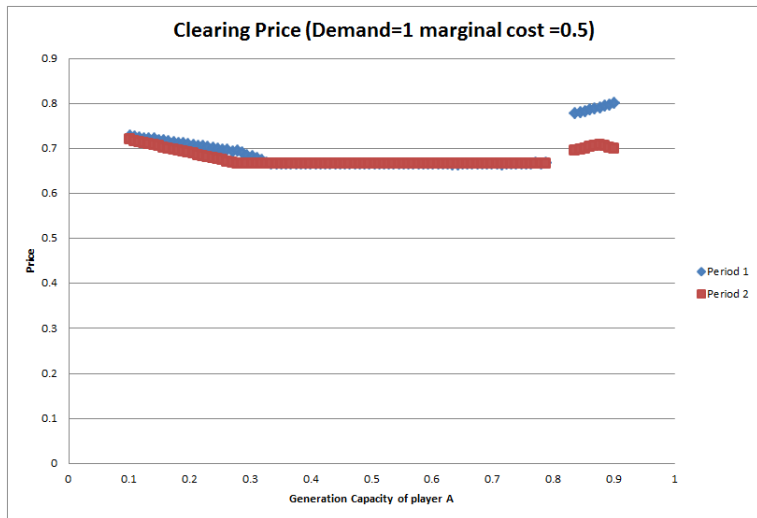
Behaviour of price maker duopoly (1)



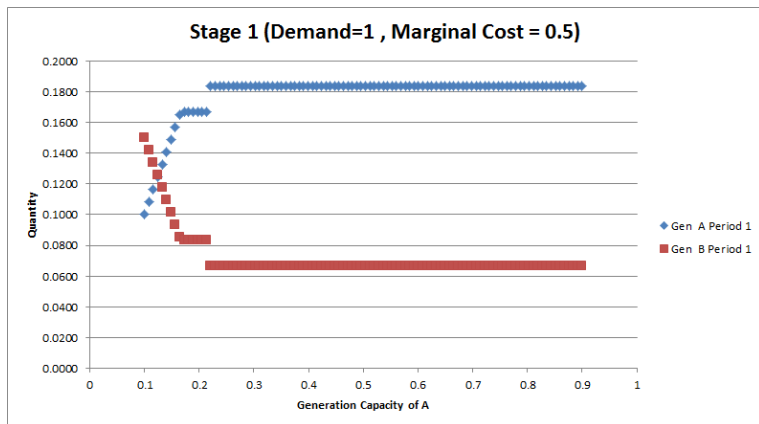
Behaviour of price maker duopoly (2)



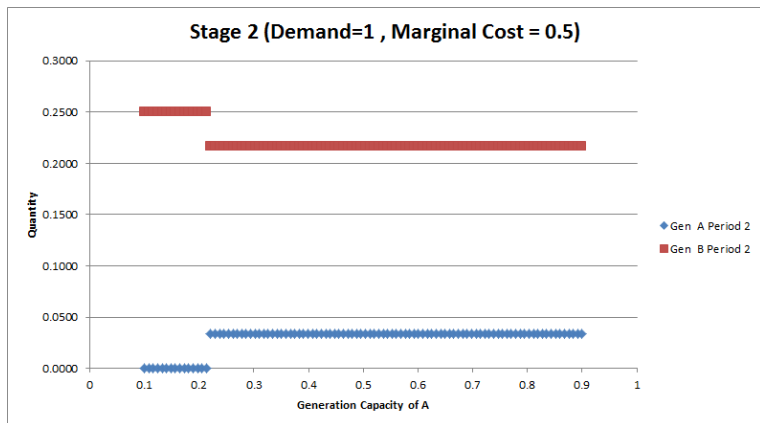
Prices in the price maker duopoly



Behaviour in the Monopoly (1)



Behaviour in the Monopoly (2)



- Water is in need for agricultural (irrigation) as well as energy use.
- Should water be allocated for agricultural purposes?
- If so how much total irrigation should be allowed and how much is this costing.
- Again the question of water value surfaces.
- We can look at a total cost to the nation under a central plan (or perfect competition).
- We can also consider this from the perspective of one firm under a *price taking* model.
- Zabin Farishta's part iv project co-supervised with Andy Philpott.

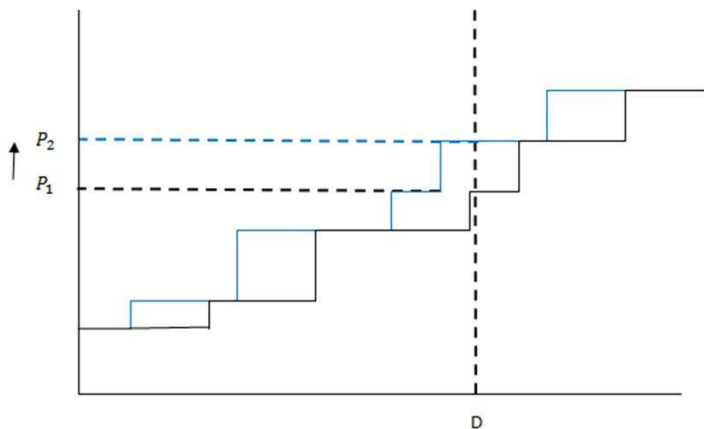
Irrigation under perfect competition

- To study the cost of irrigation we use DOASA.
- Effectively a stochastic programming tool with various inflow sequences as possible scenarios.
- We look at total thermal use in 2008 with the given CDS inflows.
- We then add approximately 2 cumecs of inflow over a 3 month summer period to test the case when there is no inflow taken from Taupo to irrigate in the Waikato region.
- We find the expected annual cost of irrigation for a 2008 (like) year is approximately \$4.5 million.

Irrigation cost to a price taker firm

- What if a firm such as MRP was a price taker and some of its water were used for irrigation? What would the cost be to this firm?
- We looked at a price taker firm optimizing against the price sequence for 2008.
- The firm is assumed to know the price.
- Here we also report on the case when the inflows are deterministic (and known).
- The loss of revenue to the firm is about \$500,000 in that year.
- Reminder about zero added value in the monopoly vs. central planner.
- We need to also take into account any loss in welfare.

A possible model for loss in welfare



- Models are needed that would capture behaviour in the NZEM better.
- These require (and are required by) water valuation tools that work for imperfectly competitive markets.
- NZIEMS simulator and how we may progress.
- My apologies if this has been a stream of consciousness.