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Using a market game as a tool for teaching strategic behaviour in an electricity industry restructuring course

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Electricity industry restructuring – useful models

- Main commercial markets
- Economic models
- Engineering models
- Physical electricity industry
- Externalities
- Ancillary services & Regulatory actions
- Social policies & priorities

Electricity industry restructuring – useful models
Markets in the restructured electricity industry

- Financial instrument (derivative) trading & spot market projections
- Commercial issues
- Physical issues
- forward-looking ancillary service (AS) “acquisition markets”
- ancillary service “actuation markets” for period t
- ancillary service “actuation markets” for period t+1
Economic (+ perhaps commercial) models for spot mkts
(from Bardak, “Pool prices in the NEM”, 2003)
Strategic behaviour in spot mkts

- Strategic behaviour is
  - Trading actions of generators that can profitably influence spot prices
    - *Individual market power* of a single firm
    - *Tacit collusion* of a group of firms
- Typically exercised by
  - Withholding generation
  - Setting their mkt offers above marginal cost
- The realities of strategic behaviour in actual mkts driven by
  - Mkt design (rules) + structure (players)
  - opportunities: eg. summer peak days, contingencies
  - Particular players
Teaching tools for strategic behaviour in spot mkts

• A range of teaching tools available
  – eg. Finland, Mexico, US…

• UNSW post-grad courses in EI restructuring
  – Power systems operation and control
    • Operation of existing system (20 ms => year)
  – Electricity industry planning and economics
    • Planning for investment (year =>)

• Spot mkts play a key role in both operation + investment
  => Simple spot mkt tool developed for UNSW course
Tool design

- Design criteria were simplicity + clarity
- Model assumes
  - Competition only on supply side amongst generators – deterministic demand + no DSR
  - Transmission network not specifically modelled – loss factors ok
  - No unit commitment or de-commitment
  - No forward contracts in place – revenue only from spot mkt
  - No ancillary services mkts
  - Each generating firm has a portfolio of units – each unit with constant incremental variable cost + max output
  - Firms offers to mkt up to 10 \((price, quantity) \$/MW pairs\)
  - Mkt coordinator solves dispatch to clear mkt at minimum cost
- Both single and day-ahead spot mkts supported
Implementation

• Implemented via two Excel Workbooks
  – Coordinator
    • Mkt clearing mechanism
    • Economic dispatch to benchmark mkt outcome against perfectly competitive response
    • Game reports – concentration (HHI) + monopoly (Learner) indexes
  – Firms scenario analysis tool
    • From an estimate of competitors’ behaviour
      ⇒ Tool generates residual demand curve so that firm can explore strategic offer options
      (Excel solver can be used although not necessarily global optimum)
How the game is played

• Game process
  – Mkt coordinator establishes structure (firms + their portfolios)
  – Firms submit offers to coordinator
  – Coordinator clears mkt + informs all Firms of
    • Dispatch price + quantities for all firms
    • Offers of all firms
    • Profits of all firms
  – Game continues

Communications undertaken via email
Some games

- Six firms ‘staffed’ by UNSW post-grad students
- Motivation – bonus class marks according to firms ranking
- Four games over 14 weeks of class

<table>
<thead>
<tr>
<th>All firms with identical portfolios</th>
<th>Hourly spot mkt</th>
<th>Day-ahead mkt with 24 one-hour trading intervals over daily demand profile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3 large firms with mkt power, 3 without</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Some results

• Identical portfolios + no individual mkt power (not all participants reqd to be dispatched in order to meet demand)
  => almost no tacit collusion emerges

• Identical portfolios + some limited individual mkt power
  => collusion for 3 firms only but not if all six firms competing in mkt

• A mix of portfolios, with some having mkt power
  => fairly cautious use of mkt power with only limited price impacts

• Why such little enthusiasm for exercising mkt power?
  – Engineering students rather than Commerce + Economics students?
  – OR?
A rational response to the bonus structure

- Student firms earn bonus marks for ranking amongst firms
- A firm exercising mkt power has to withdraw generation or increase offer price above marginal costs
  => generally leads to higher mkt price but reduced dispatch
  => other firms do better than the strategic firm

- In actual mkts, firms are motivated by profits rather than just strict rankings
Conclusions + future work

• Existing tool a useful introduction to strategic behaviour in spot mkts, also familiarises students with spreadsheet model

• Possible future work
  – Games with stochastic demand
  – Day-ahead mkts with multiple offers + rebidding
  – Web-based implementation
Established…

– *to formalise* growing interest + interactions between UNSW researchers in Engineering, Commerce + Economics, AGSM…
– *through UNSW Centre* providing Australian research leadership in interdisciplinary design, analysis + performance monitoring of energy + environmental markets, associated policy frameworks
– *in the areas of*
  • Physical energy markets (with an initial focus on ancillary services, spot market + network services for electricity + gas)
  • Energy-related derivative markets (financial + environmental including interactions between derivative and physical markets)
  • Policy frameworks and instruments in energy and environment
  • Experimental market platforms and AI ‘intelligent agent’ techniques to aid in market design
  • Economic valuation methodologies
For more information…..

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