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A simple model of insurance market dynamics

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Purpose

- To construct and study a simple but realistic model of an insurance market
- Model to be **minimalist**
  - As few parameters as possible
  - While maintaining realism
    - Deletion of any one would destroy realism
- To study the effect of each parameter on the functioning of the market
  - To examine the effects of regulatory interventions
Preview

- Literature survey
- Definition of the model
  - Description of parameters
- Simulations of market
  - Same data set throughout
  - With variation of parameters individually
- No catastrophes up to this point
  - Add in a catastrophe and observe effects
Literature survey
Literature survey (1)

- Plenty of literature on isolated aspects of the insurance market
  - Not so much on integration of all market dynamics into a single model
- Special mention of Coutts & Devitt (1989)
  - Forerunner of DFA
  - Stochastic modelling of a single insurance operation
    - But not linked to market through competitive dynamics
- See also Daykin et al (1987)
Literature survey (2)

- Models containing competitive dynamics
  - Daykin & Hey (1990)
  - Daykin, Pentikäinen & Pesonen (1994)
- Main focus was on behaviour of a single insurer in a market
  - Market cycles were exogenous
Definition of the model
Components of model

1. Target premiums
2. Competitive premiums
3. Underwriting results
4. Balance sheet results
5. Entry & exit of capital
6. Loss experience
7. Re-allocation of market shares
Model parameters

- Divided into two groups
  - Environmental parameters
    - Describe the environment within which the market exists
  - Dynamical parameters
    - Describe the market dynamics within that environment
Environmental parameters

- Total exposure (number of units) for whole market
- Steady state capital per unit exposure
- Risk free rate of return
- Stock market expected rate of return
- Expected CAT claim frequency (for whole market)
- Expected CAT claim size (for whole market)
- Expected non-CAT claim frequency per exposure unit (common to all insurers)
- Expected non-CAT claim size (common to all insurers)
Dynamical parameters

- Insufficient time to give all the mathematics of each component
- Will just describe main features
- Full detail in paper (Taylor, 2008)
Components of model (cont’d)

- Target premium increases as solvency decreases
- 1 parameter: premium-to-solvency sensitivity

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Components of model (cont’d)

- **Competitive premium:**
  - Decreases as average premium of 4 nearest competitors (by market share) decreases
  - Depends partly on previous period’s premium

- 2 parameters:
  - *competition intensity*
  - *competitive inertia*
Components of model (cont’d)

- Competitive premium:
  - Decreases as average premium of 4 nearest competitors (by market share) decreases
  - Depends partly on previous period’s premium
- 2 parameters:
  - competition intensity
  - competitive inertia
- 2 additional optional parameters: upper and lower bounds on premiums
Components of model (cont’d)

- Usual accounting manipulations
- 0 parameters
Components of model (cont’d)

- Exit if solvency ratio below threshold

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Components of model (cont’d)

- Exit if solvency ratio below threshold
- Entries if profitability of each of last 2 years sufficiently high

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Components of model (cont’d)

- Exit if solvency ratio below threshold
- Entries if profitability of each of last 2 years sufficiently high
- Number of entries proportional to profitability in excess of threshold
Components of model (cont’d)

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- Number of entries proportional to profitability in excess of threshold
- Capitalisation of each new entry proportional to total market capitalisation

Diagram:
1. Target premiums
2. Competitive premiums
3. Underwriting results
4. Balance sheet results
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Components of model (cont’d)

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4 parameters:
- minimum viable solvency ratio
- threshold capital attraction
- profit margin
- new capital attraction per unit market profitability
- new entrant capitalisation
Components of model (cont’d)

- **Dividend payout:**
  - None if company exiting
  - None if would leave solvency ratio below target
  - Otherwise, dividend proportional to excess capital over target
- 1 parameter: **dividend payout ratio**
Transfer of market share from insurer r to insurer s increases as:
- Premium rate of s decreases relative to r
- Their market shares increase
Transfer of market share from insurer r to insurer s increases as:
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- Their market shares increase
- There is a lower limit on the effect of market share of s
Components of model (cont’d)

- Transfer of market share from insurer r to insurer s increases as:
  - Premium rate of s decreases relative to r
  - Their market shares increase
- There is a lower limit on the effect of market share of s
- Insurer exits if market share below a threshold
Transfer of market share from insurer r to insurer s increases as:
- Premium rate of s decreases relative to r
- Their market shares increase
- There is a lower limit on the effect of market share of s
- Insurer exits if market share below a threshold
- 3 parameters:
  - market price-sensitivity
  - market presence limit
  - minimum viable market share
Components of model (cont’d)

- Total of 11+2 dynamical parameters

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Simulations of market
Base case

- Generally stable premium rates and solvency
- Largely stable number of market participants but with the occasional entrant or exit
- A marked diversity of premium rates available in the market
- An average profit margin that is variable but generally positive
Base case (cont’d)

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Cyclic market behaviour

- Reduction of competition intensity parameter from base case
  - Induces market cycles
  - Further reduction amplifies cycles
- Intuition might have suggested that cyclic behaviour would have resulted from increased competition

Average premium for varying k2
Diversity of premium rates

- Diversity increases with market price-sensitivity parameter (base case: $k_7=0.10$)
- Similar to increased price elasticity
Diversity of premium rates (cont’d)

- High market price-sensitivity also induces cycles
- Cycles generated by consumer behaviour rather than insurer competition
Number of market participants and market concentration

- Effect of increasing dividend payout ratio (k_{10})
  - Base case: k_{10} = 70%
Number of market participants and market concentration (cont’d)

\[ k_5 = 30 \]

- Effect of increasing new capital attraction per unit market profitability \((k_5)\)
  - Base case: \(k_5 = 30\)

- Increasing \(k_5\) to 45 causes:
  - Cyclic influxes of capital
  - High rate of insolvency
    - About 10\% (0.15\% in base case)
Number of market participants and market concentration (cont’d)

$k_5 = 30$

- Effect of increasing new capital attraction per unit market profitability ($k_5$)
  - Base case: $k_5 = 30$
- Increasing $k_5$ to 45 also induces cycles in market capacity and premiums

$k_5 = 45$

![Market solvency diagram](image)
Effects of competition
Effects of competition

- Controlled by:
  - premium-to-solvency sensitivity ($k_1$)
  - competition intensity parameter ($k_2$)
- Market response to these parameters complex
  - Reminiscent of catastrophe theory
Effects of competition (cont’d)

- As preoccupation with solvency ($k_1$) increases, cyclic behaviour more difficult to avoid
- Regulatory penalties for low solvency may have unwelcome effects
- Cyclic behaviour likely to emerge if competition either too strong or too weak
Effects of competition (cont’d)

- $k_1$ = premium-to-solvency sensitivity
- $k_2$ = competition intensity parameter

![Graph showing profit margin for varying $k_1$ and $k_2$]

Profit margin for varying $k_1$ and $k_2$

- Profit margin averaged across whole market and all 60 years

Graph legend:
- $k_1=0.60$
- $k_1=0.67$
- $k_1=0.75$
Regulatory controls
Barriers to entry

- Threshold capital attraction profit margin ($k_4$)
  - Affects number of market participants
  - Base case: $k_4 = 0.20$
Barriers to entry (cont’d)

- Threshold capital attraction profit margin ($k_4$)
  - Also affects longevity of market participants
  - Base case: $k_4 = 0.20$
Price regulation – premium floor

- Premium floor = $k_{11} \times$ full funding premium
- Affects number of market participants
- Base case: $k_{11} = 0$

![Graph showing the effect of premium floor on market participants with $k_{11} = 0.80$ and $k_{11} = 1.00$.](image)
Price regulation – premium floor

- Premium floor = \( k_{11} \) x full funding premium
- Requiring full funding decreases average profit margin

Market profitability for changing \( k_{11} \)

<table>
<thead>
<tr>
<th>Year</th>
<th>Average market profit margin</th>
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<tr>
<td>1</td>
<td>-10%</td>
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<tr>
<td>5</td>
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<td>15%</td>
</tr>
<tr>
<td>25</td>
<td>20%</td>
</tr>
<tr>
<td>29</td>
<td>25%</td>
</tr>
</tbody>
</table>

\( k_{11} = 0.90 \)

\( k_{11} = 0.95 \)

\( k_{11} = 1.00 \)
Price regulation – premium ceiling

- **Premium floor** = $k_{12} \times $full funding premium
  - Affects diversity of premium rates
  - Base case: $k_{12} = $unlimited

Diversity of market premium rates

- $k_{12} = 1.05$
- $k_{12} = 1.20$
Price regulation – premium stability

- Competitive inertia ($k_{13}$) parameter controls premium stability
  - $k_{13}$ is weight given to last period’s premium in present period
  - Increased $k_{13} \rightarrow$ increased stability
- Difficult to regulate $k_{13}$ as such
  - But might regulate something similar, e.g. percentage change in premium from period to period
Price regulation – premium stability (cont’d)

- Same parameter could be used to control depth of cycles
- Example: competition intensity parameter $k_2 = 0.15$ (base base: $k_2 = 0.25$)
Solvency maintenance

- Breach of floor solvency ratio \( (k_3) \) causes exit of insurer from market
  - Base case: \( k_3 = 0.1 \)

- Trebling this ratio
  - Drives out a large proportion of market participants
  - As well as creating violent market cycles
Solvency maintenance (cont’d)

- Effect of new entrant capitalisation parameter \((k_6)\) is similar
- Base case: \(k_6 = 0.0033\)
- Trebling this ratio
  - Also creates violent market cycles
Effects of catastrophes
Catastrophe experience

- Effect of single major event studied
- It increases total losses for the period by more than 50%
- It accounts for 83% of steady state market capital
Effects of catastrophe

- Assume base case parameters
- Catastrophe induces deep market cycles
- Empirical evidence (Cummins & Danzon, 1991) that major reserve adjustments produce similar effects
Effects of catastrophe (cont’d)

- As earlier, market cycles attenuated by the imposition of premium ceiling
  - Ceiling = $k_{12} \times$ economic premium
Conclusions
Conclusions (1)

- Even in this very simple model of a simple market, system responses are complex
- Some are counter-intuitive
Conclusions (2)

- Competition
  - Some effects are intuitive
    - e.g. increasing competition lowers average profit margin
  - Traditionally viewed as a de-stabiliser of markets (e.g. Winter, 1991)
  - Results here more complex
    - Both high and low degrees of competition can de-stabilise
  - Competition between insurers interacts with price sensitivity of consumers
    - High price sensitivity induces market cycles
Conclusions (3)

- **Policy variables**
  - Must be used with care because of counter-intuitive effects
  - Perhaps even reverse effects
    - e.g. requirement of full funding premium rates leads to **lower**, not higher, average premiums
  - **Upper limits on prices**
    - Can mitigate market cycles
    - But, taken too far, produce a bland market
  - **Dividend payout ratios**
    - Prevention of high values reduces likelihood of market cycles
Conclusions (4)

- Catastrophe events
  - Induces market cycles
    - These can have a surprisingly long persistency
  - This effect can be mitigated by price controls
Questions?
References (1)


References (2)