



The Actuarial Profession

making financial sense of the future

GIRO Convention

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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)

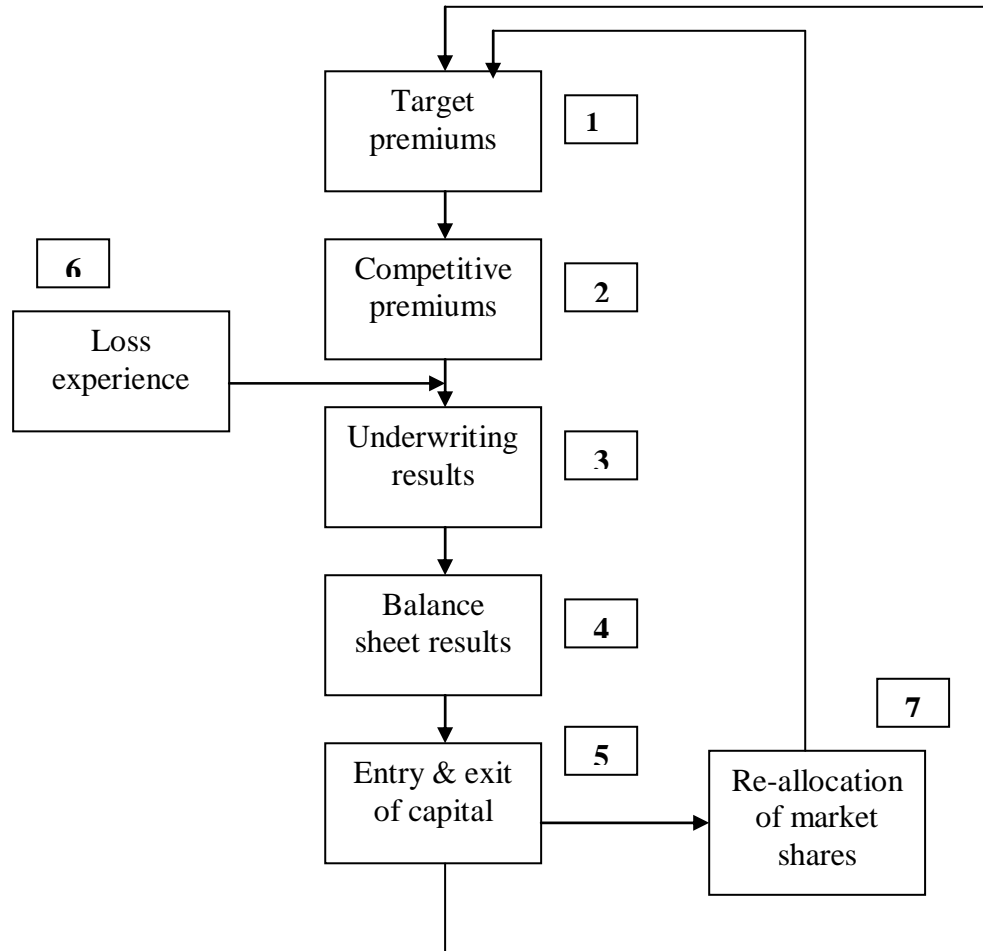
- Plenty of literature on isolated aspects of the insurance market
 - Not so much on integration of all market dynamics into a single model
- Special mention of Coutts & Devitt (1989)
 - Forerunner of DFA
 - Stochastic modelling of a single insurance operation
 - But not linked to market through competitive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



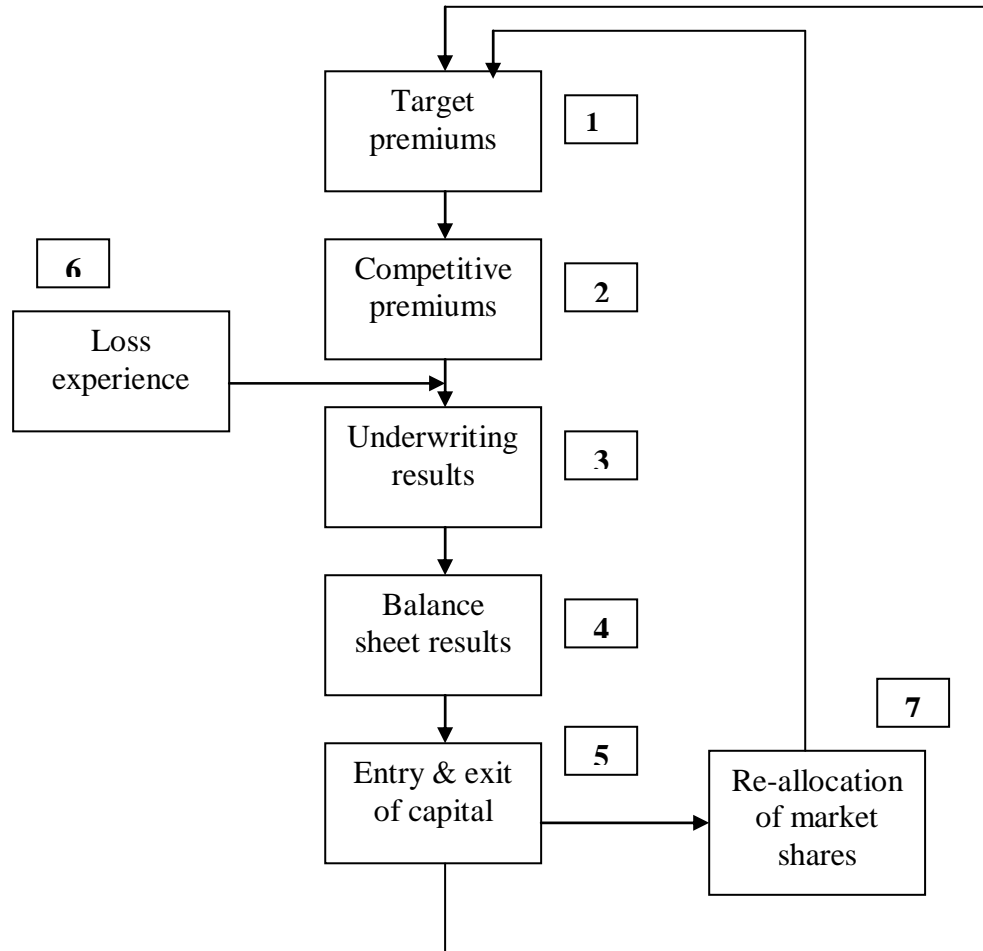
Model parameters

- 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

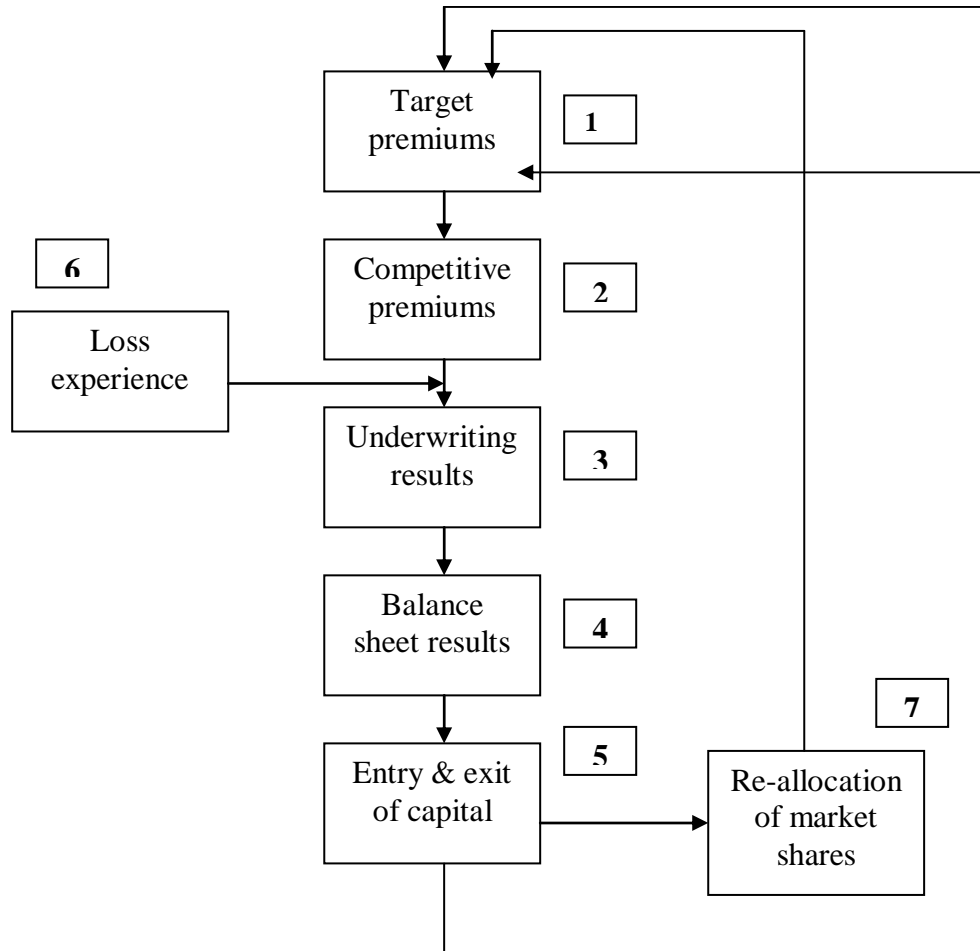
- Total exposure (number of units) for whole market
- Steady state capital per unit exposure
- Risk free rate of return
- Stock market expected rate of return
- Expected CAT claim frequency (for whole market)
- Expected CAT claim size (for whole market)
- Expected non-CAT claim frequency per exposure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

Dynamical parameters



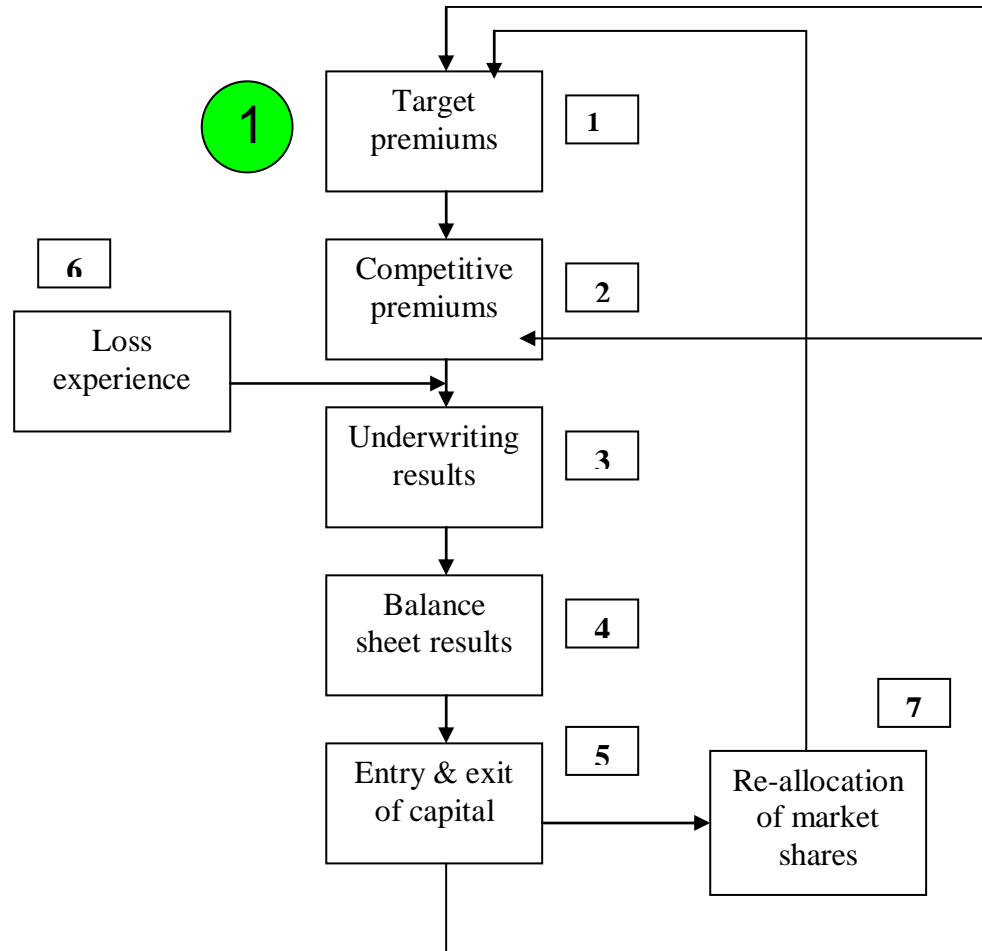
- Insufficient time to give all the mathematics of each component
- Will just describe main features
- Full detail in paper (Taylor, 2008)

Components of model (cont'd)



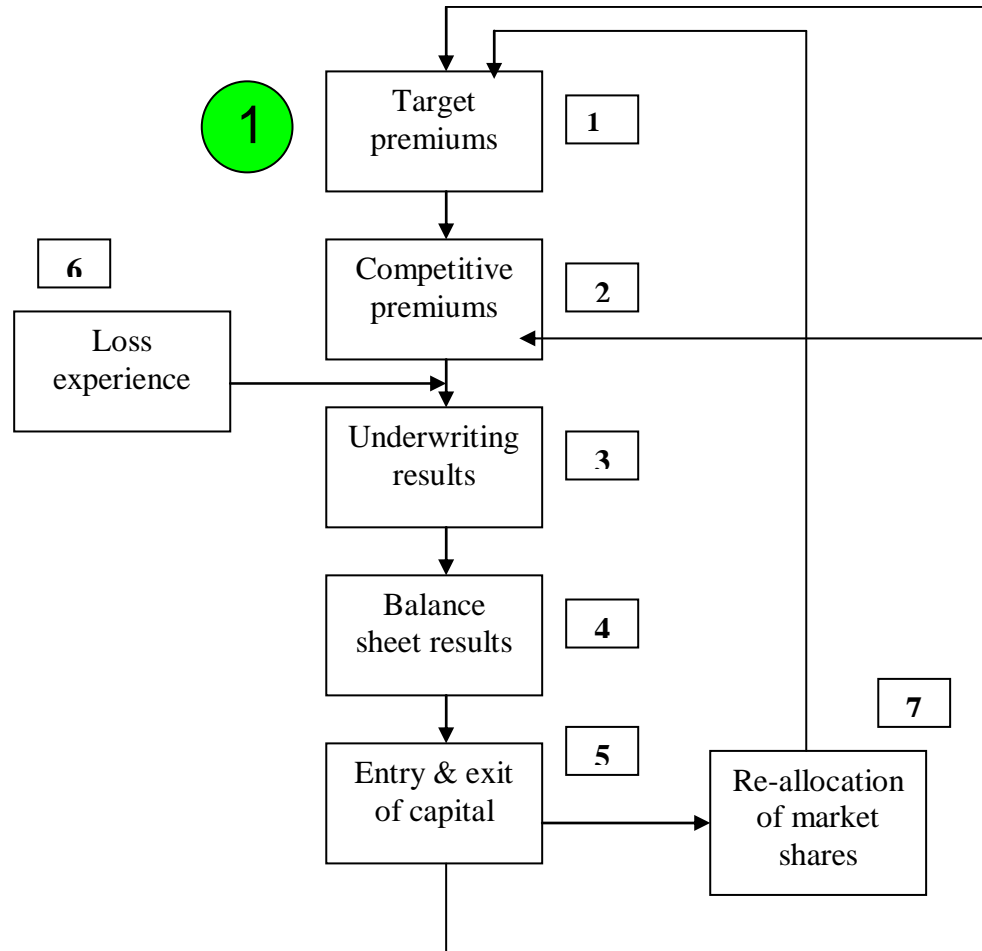
- Target premium increases as solvency decreases
- 1 parameter: **premium-to-solvency sensitivity**

Components of model (cont'd)



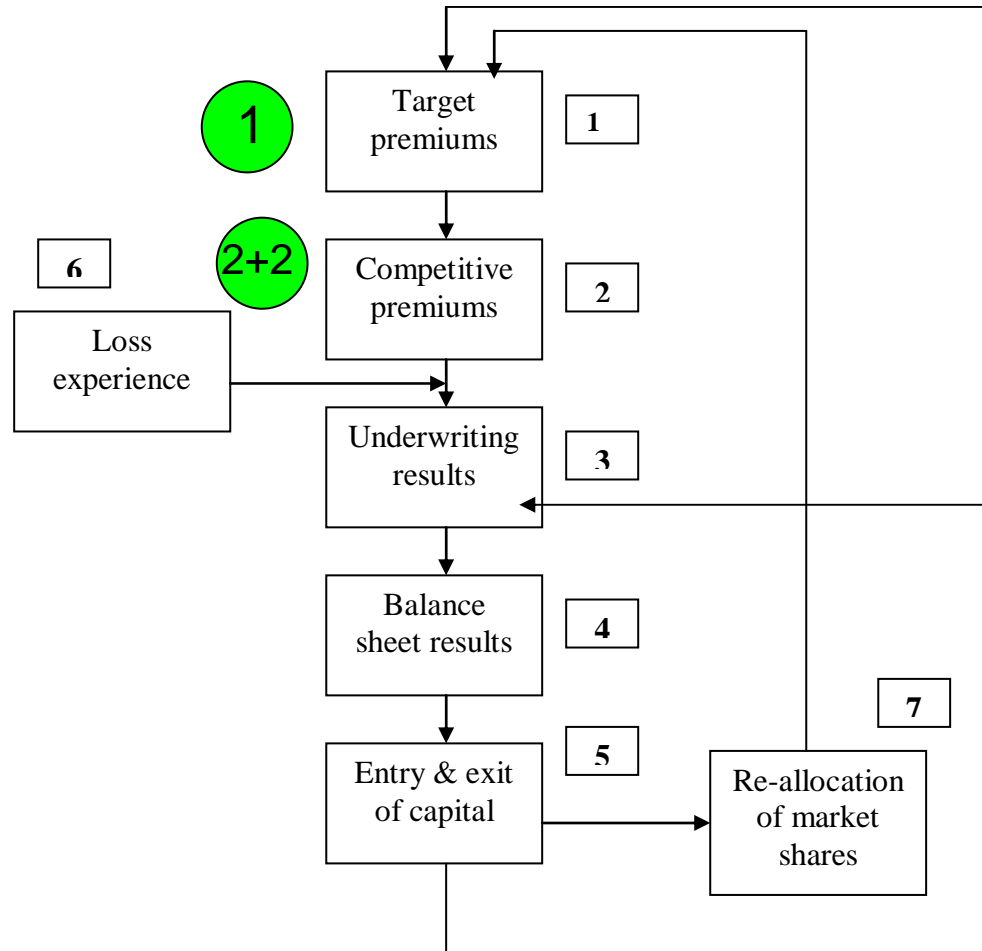
- Competitive premium:
 - Decreases as average premium of 4 nearest competitors (by market share) decreases
 - Depends partly on previous period's premium
- 2 parameters:
 - **competition intensity**
 - **competitive inertia**

Components of model (cont'd)



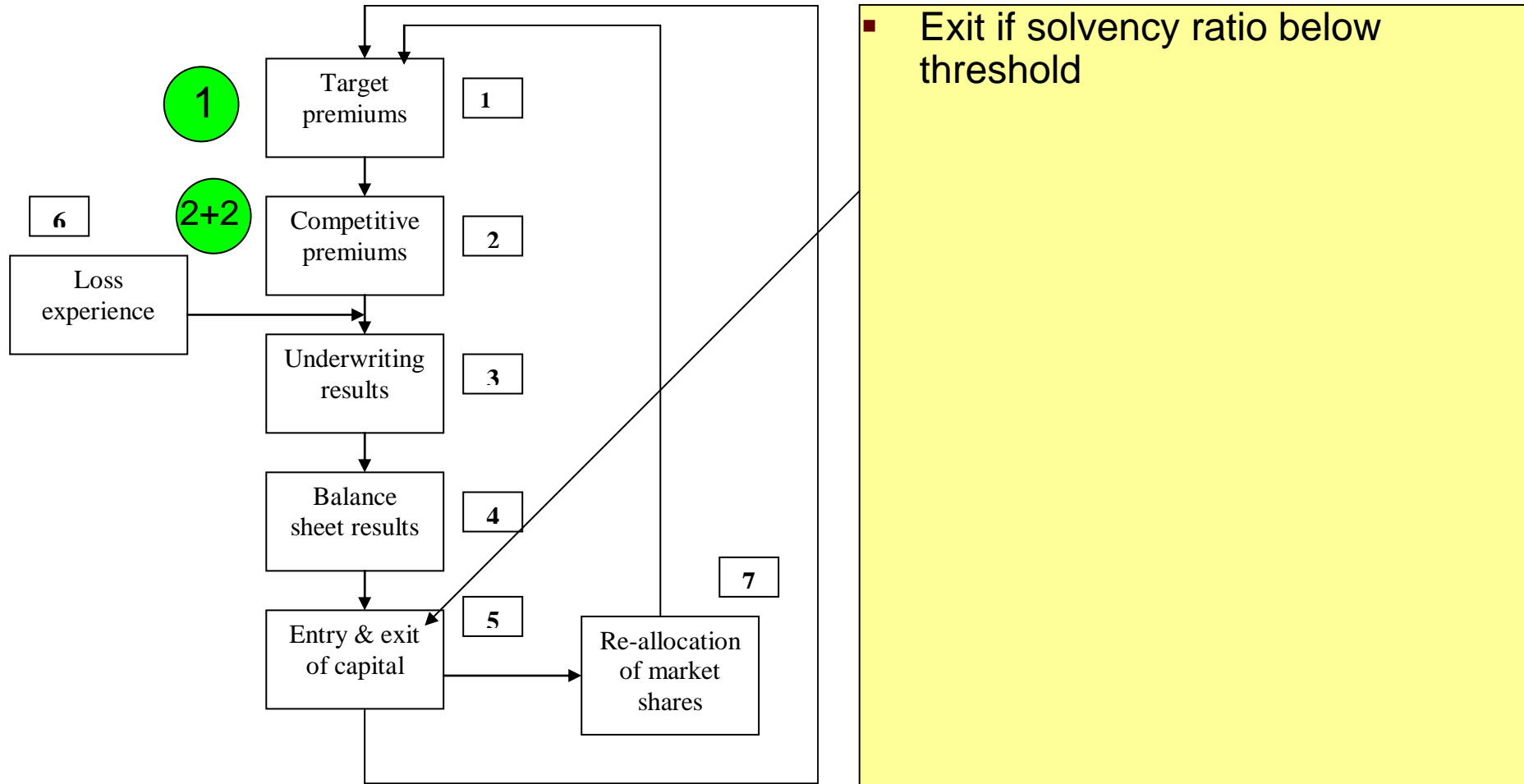
- Competitive premium:
 - Decreases as average premium of 4 nearest competitors (by market share) decreases
 - Depends partly on previous period's premium
- 2 parameters:
 - **competition intensity**
 - **competitive inertia**
- 2 additional optional parameters: **upper and lower bounds on premiums**

Components of model (cont'd)

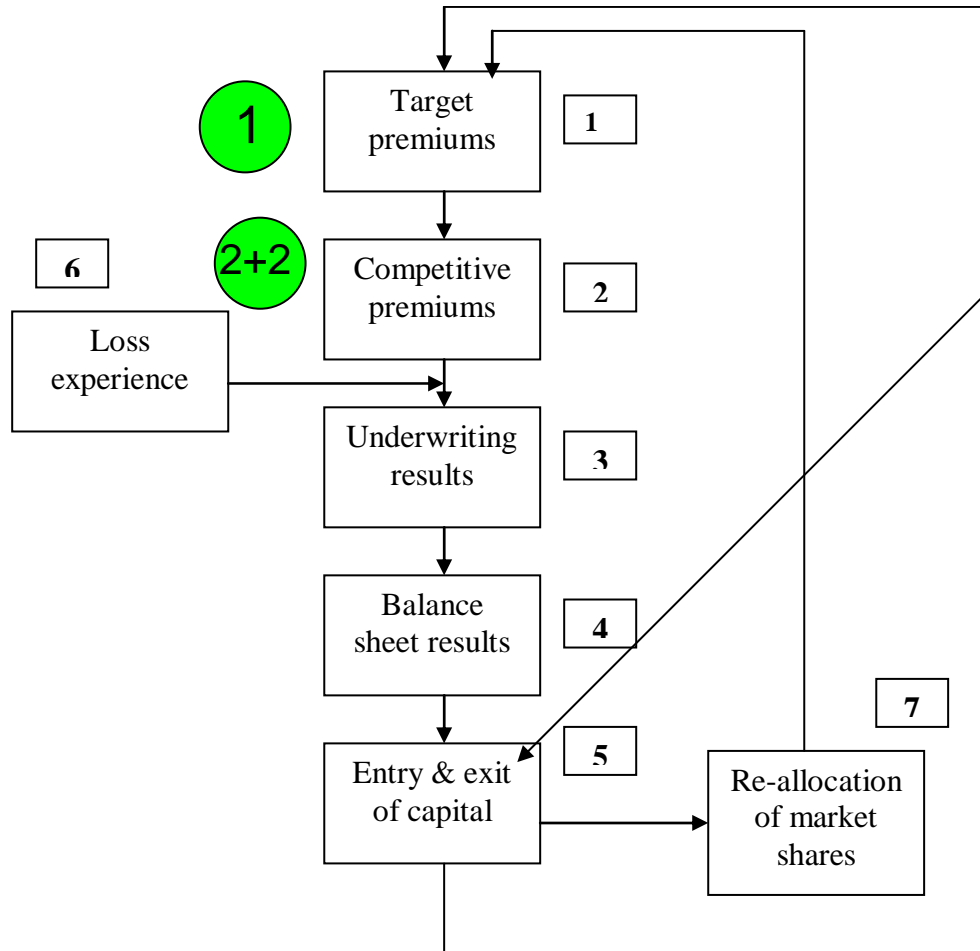


- Usual accounting manipulations
- 0 parameters

Components of model (cont'd)

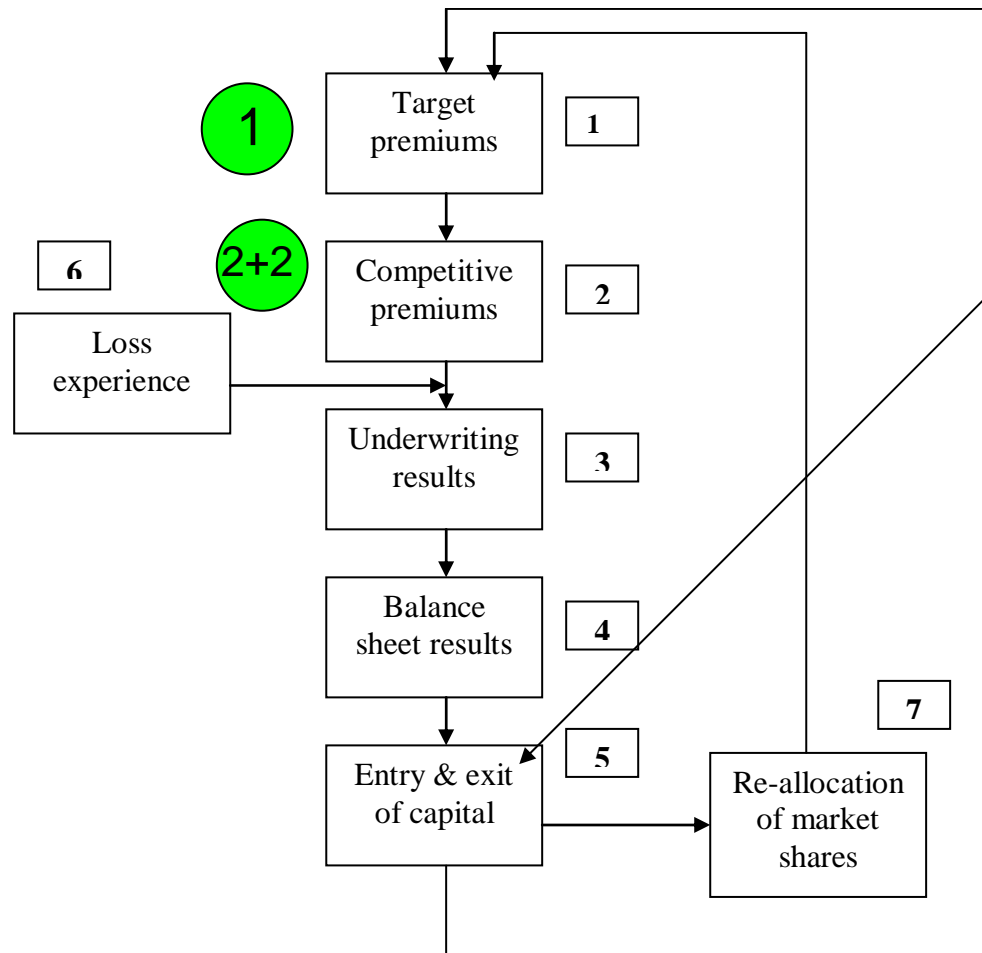


Components of model (cont'd)



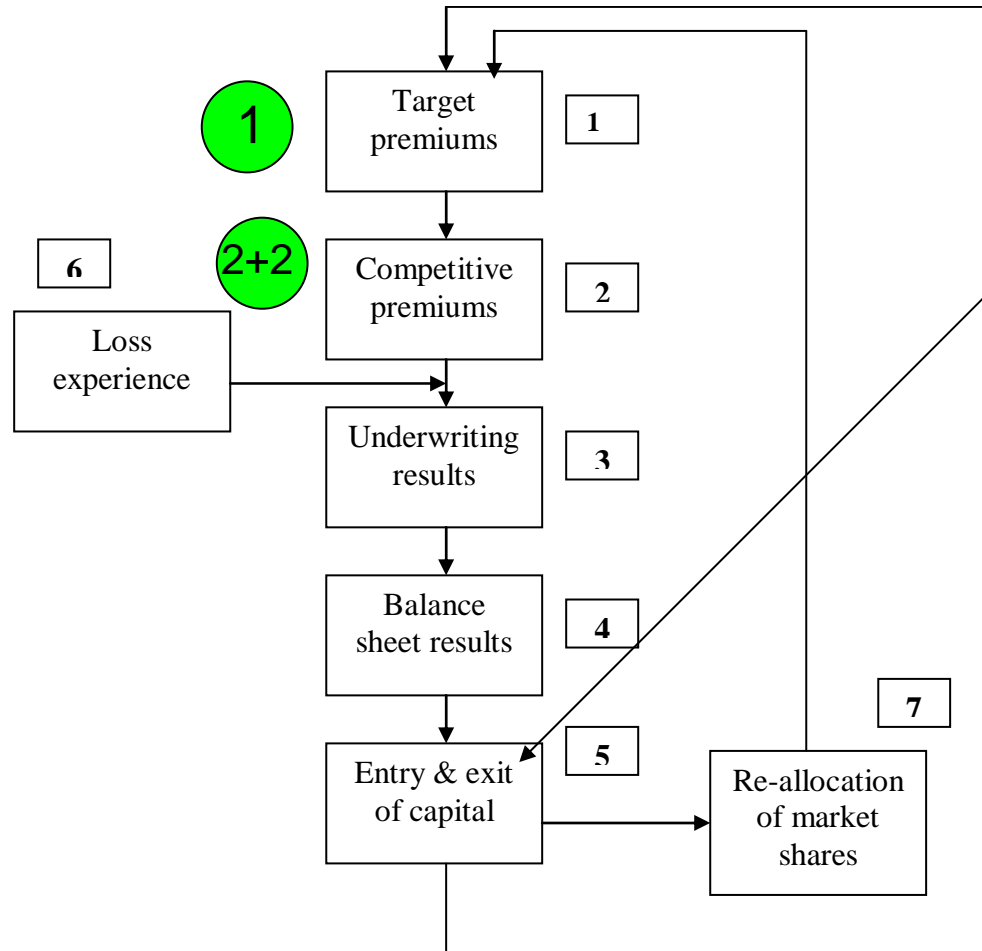
- Exit if solvency ratio below threshold
- Entries if profitability of each of last 2 years sufficiently high

Components of model (cont'd)



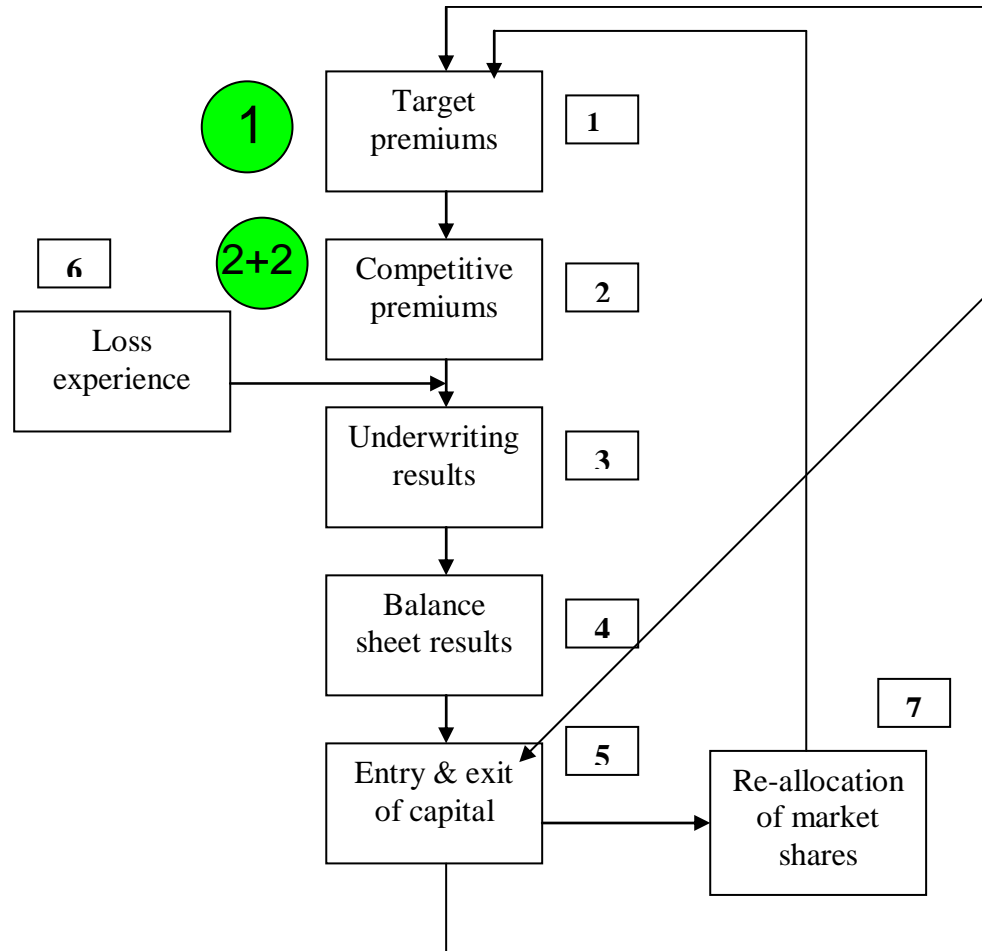
- Exit if solvency ratio below threshold
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- Number of entries proportional to profitability in excess of threshold

Components of model (cont'd)



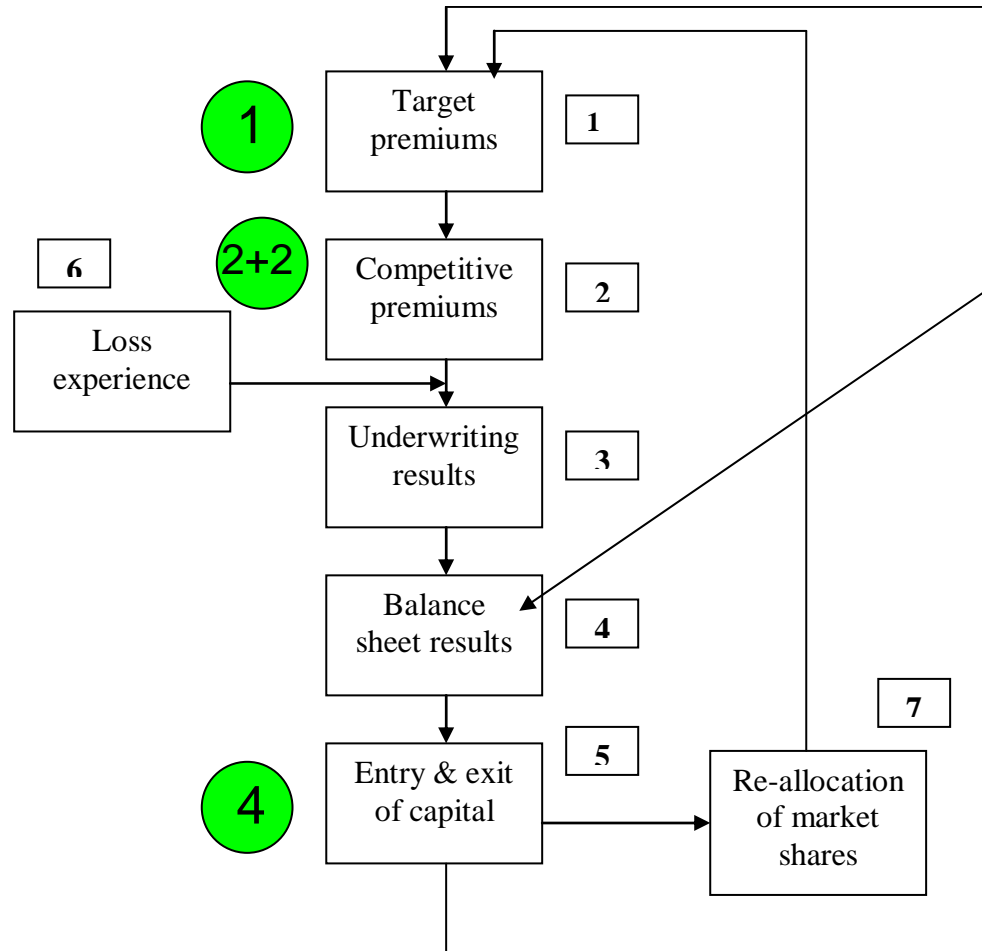
- Exit if solvency ratio below threshold
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- Number of entries proportional to profitability in excess of threshold
- Capitalisation of each new entry proportional to total market capitalisation

Components of model (cont'd)



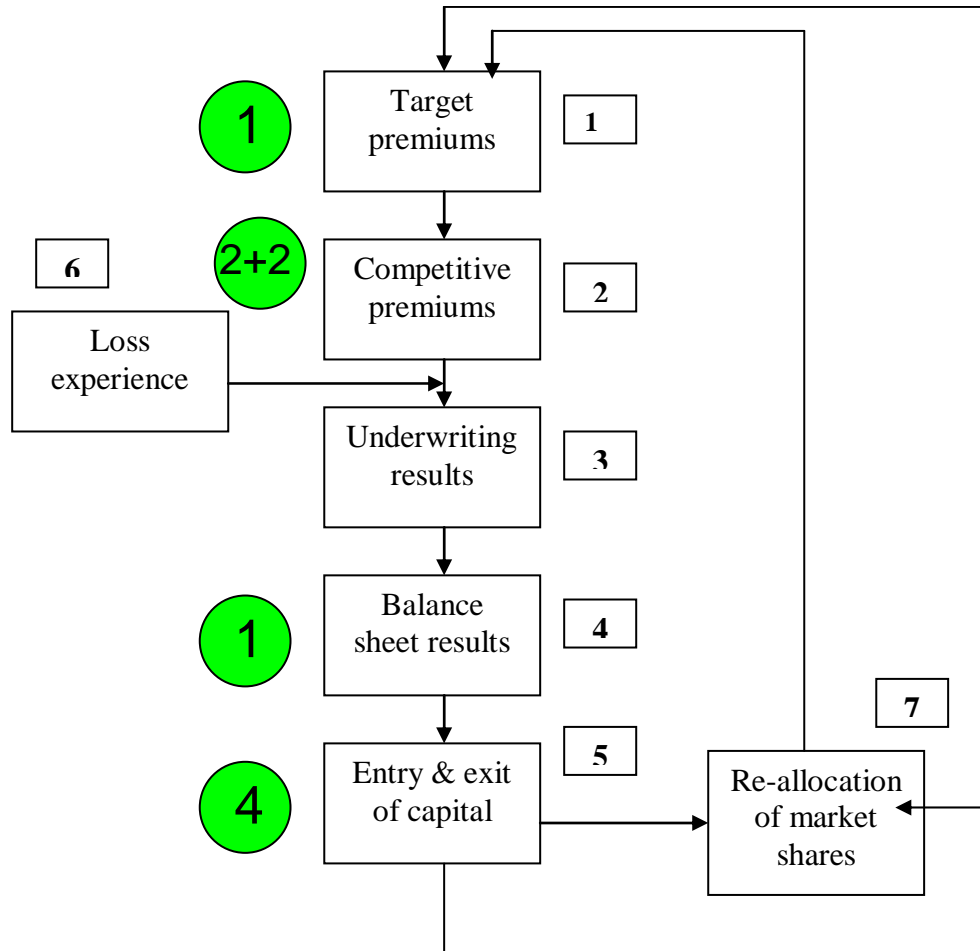
- Exit if solvency ratio below threshold
- Entries if profitability of each of last 2 years sufficiently high
- Number of entries proportional to profitability in excess of threshold
- Capitalisation of each new entry proportional to total market capitalisation
- 4 parameters:
 - **minimum viable solvency ratio**
 - **threshold capital attraction profit margin**
 - **new capital attraction per unit market profitability**
 - **new entrant capitalisation**

Components of model (cont'd)



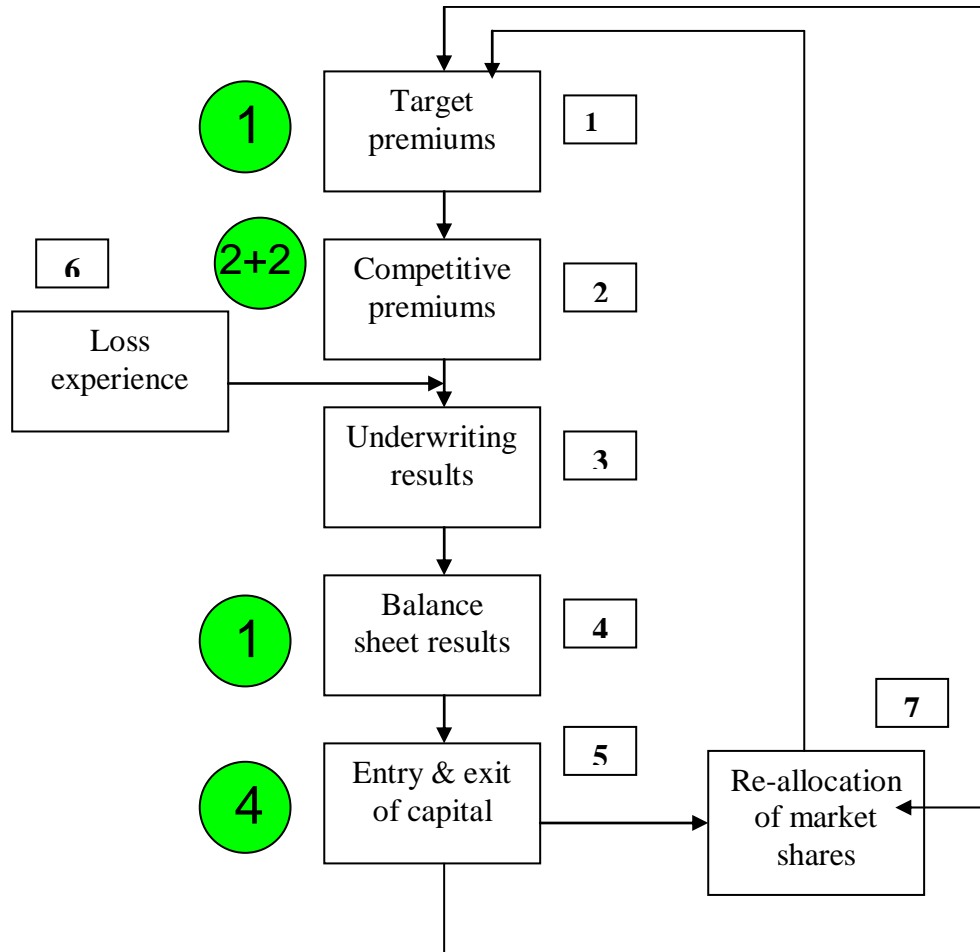
- **Dividend payout:**
 - None if company exiting
 - None if would leave solvency ratio below target
 - Otherwise, dividend proportional to excess capital over target
- 1 parameter: **dividend payout ratio**

Components of model (cont'd)



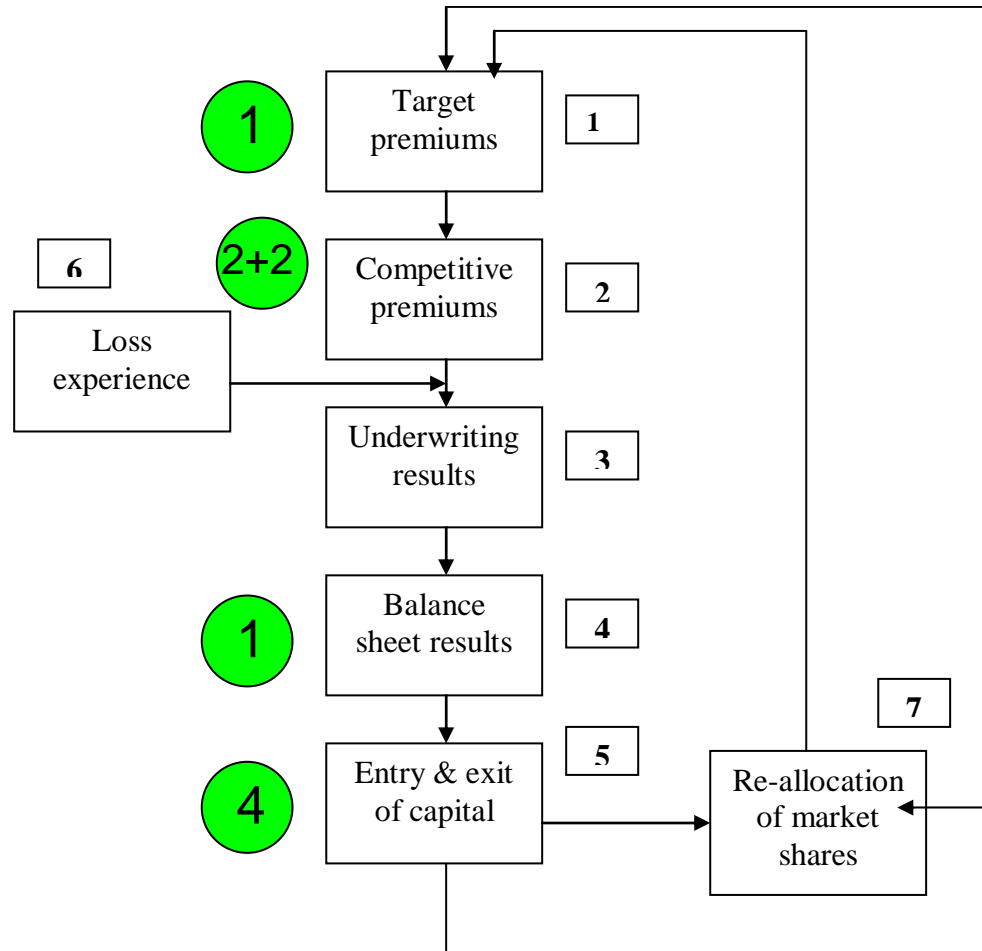
- Transfer of market share from insurer r to insurer s increases as:
 - Premium rate of s decreases relative to r
 - Their market shares increase

Components of model (cont'd)



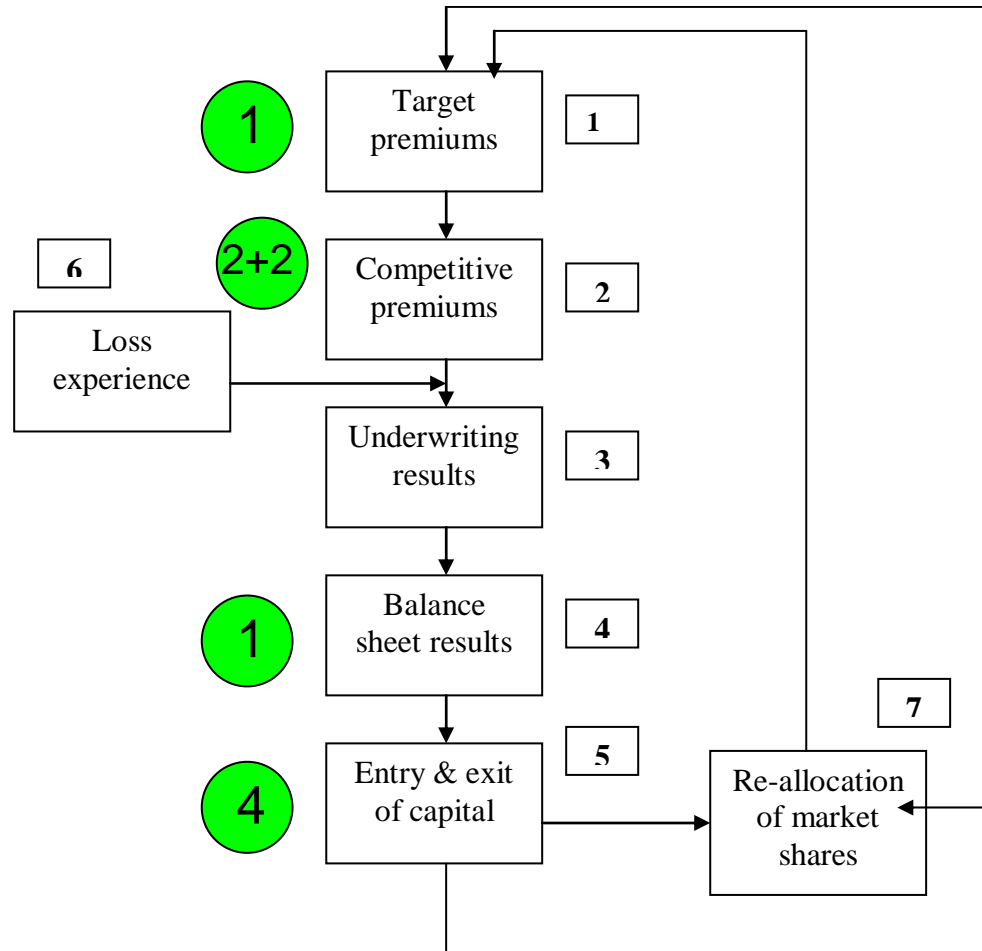
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- There is a lower limit on the effect of market share of s

Components of model (cont'd)



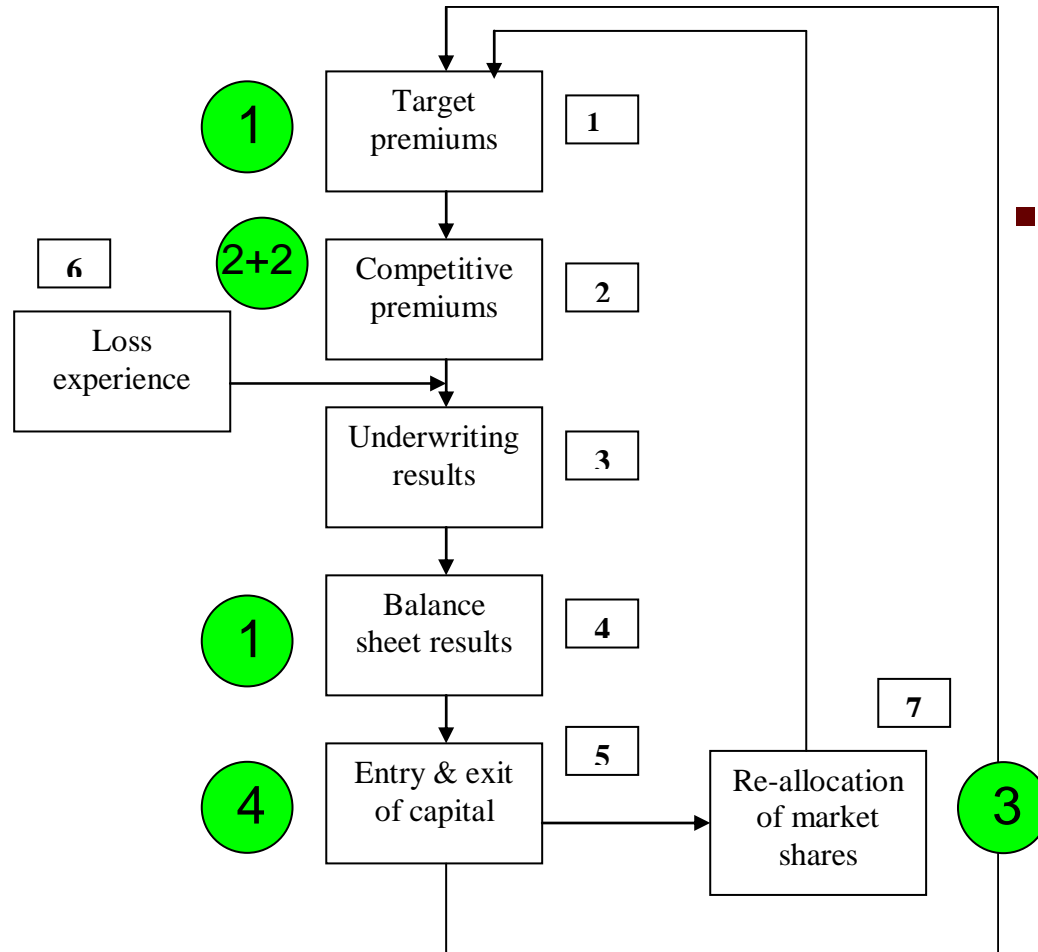
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 - Premium rate of s decreases relative to r
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- There is a lower limit on the effect of market share of s
- Insurer exits if market share below a threshold

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
- 3 parameters:
 - **market price-sensitivity**
 - **market presence limit**
 - **minimum viable market share**

Components of model (cont'd)

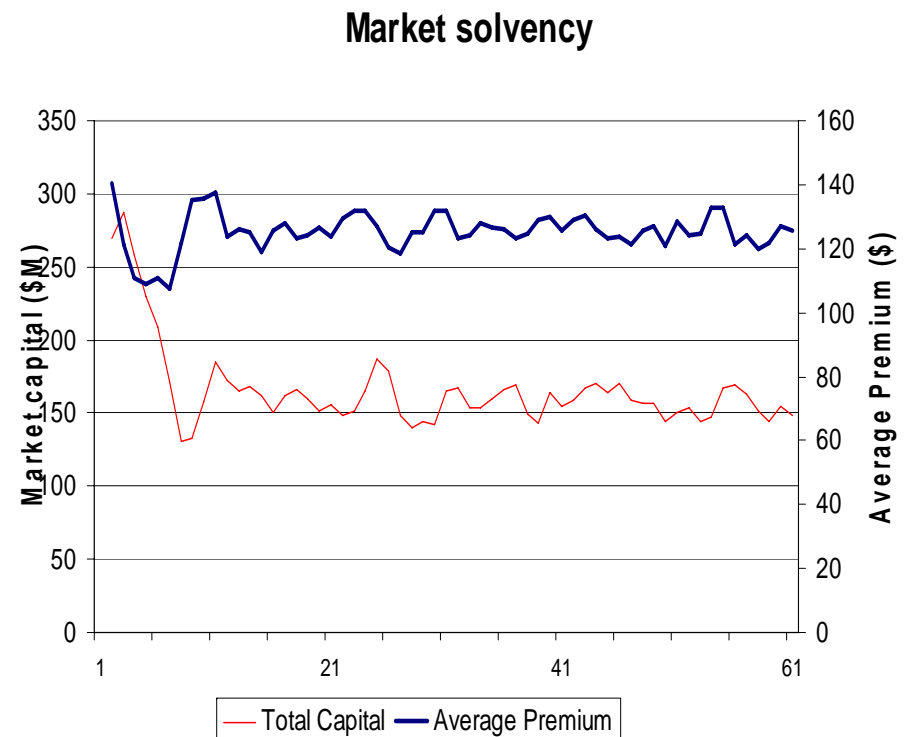


- Total of **11+2** dynamical parameters

Simulations of market

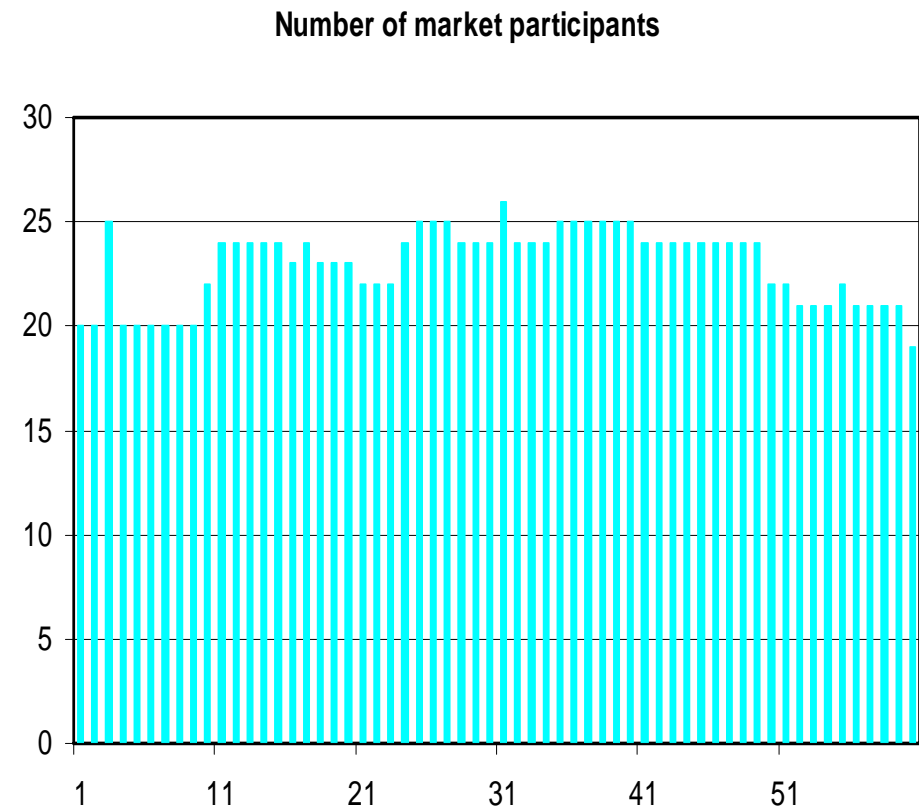
Base case

- **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



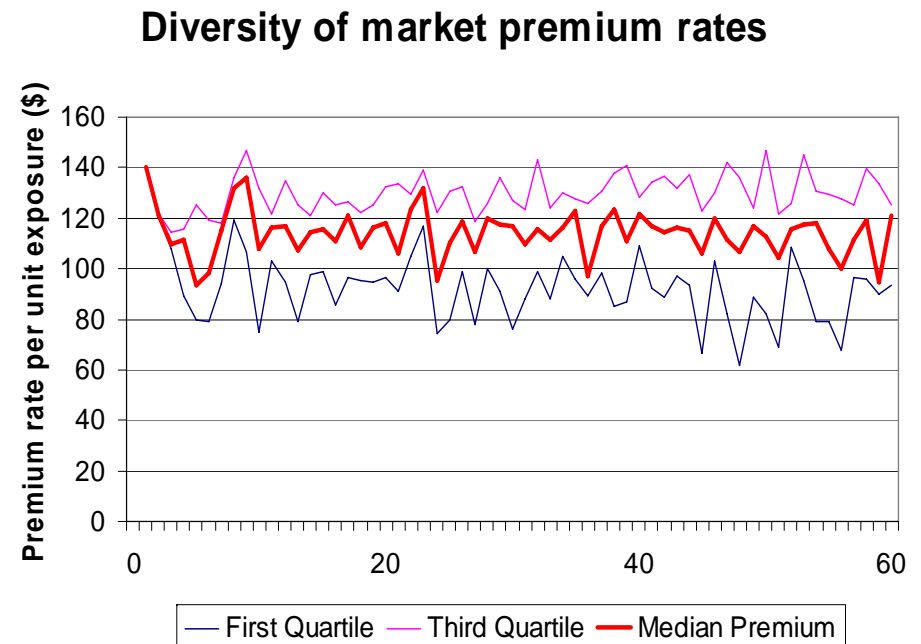
Base case (cont'd)

- Generally stable premium rates and solvency
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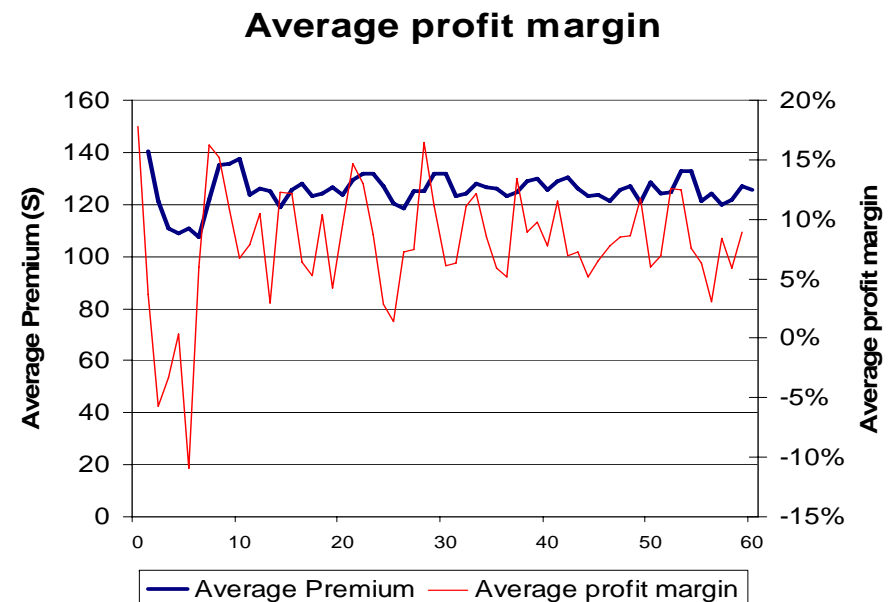
Base case (cont'd)

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Base case (cont'd)

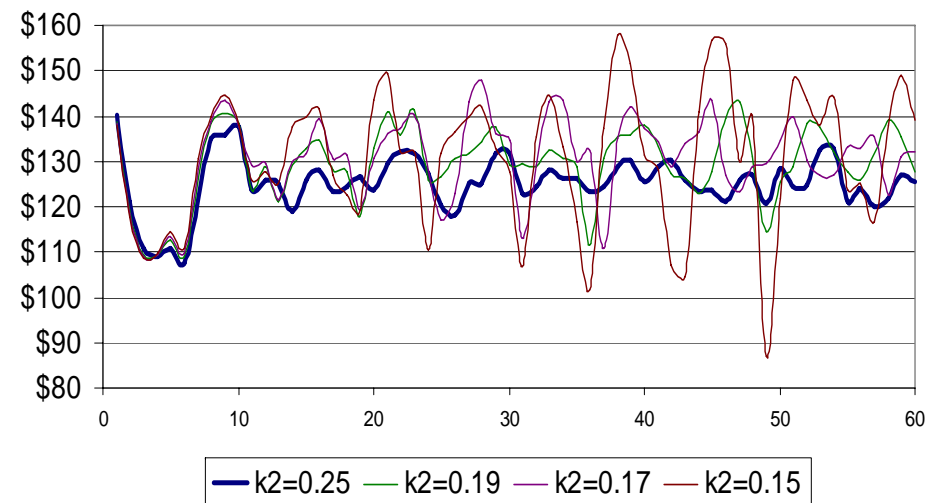
- Generally stable premium rates and solvency
- Largely stable number of market participants but with the occasional entrant or exit
- A marked diversity of premium rates available in the market
- **An average profit margin that is variable but generally positive**



Cyclic market behaviour

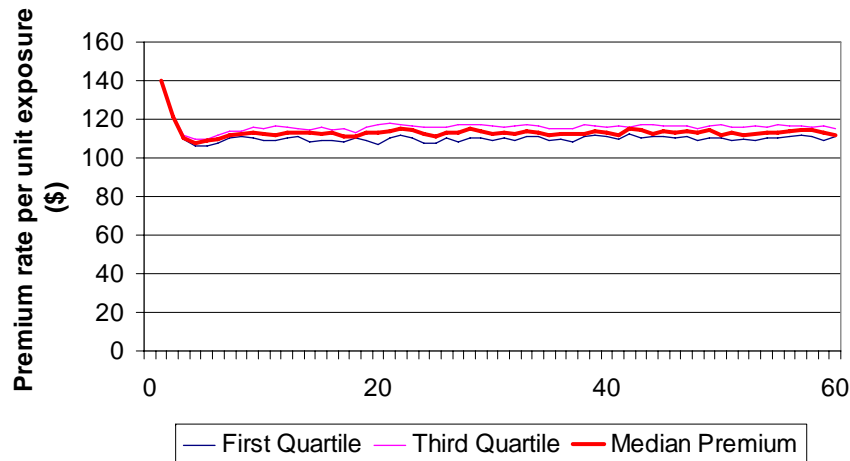
- Reduction of **competition intensity** parameter from base case
 - Induces market cycles
 - Further reduction amplifies cycles
- Intuition might have suggested that cyclic behaviour would have resulted from **increased** competition

Average premium for varying k_2

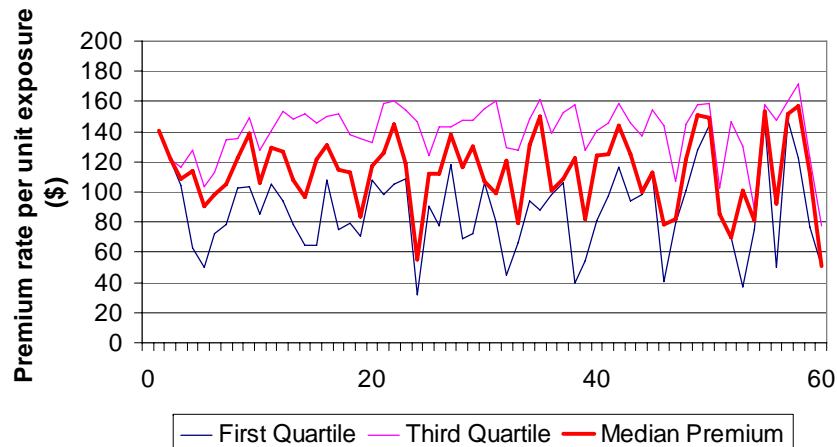


Diversity of premium rates

Diversity of market premium rates
 $k_7=0.04$



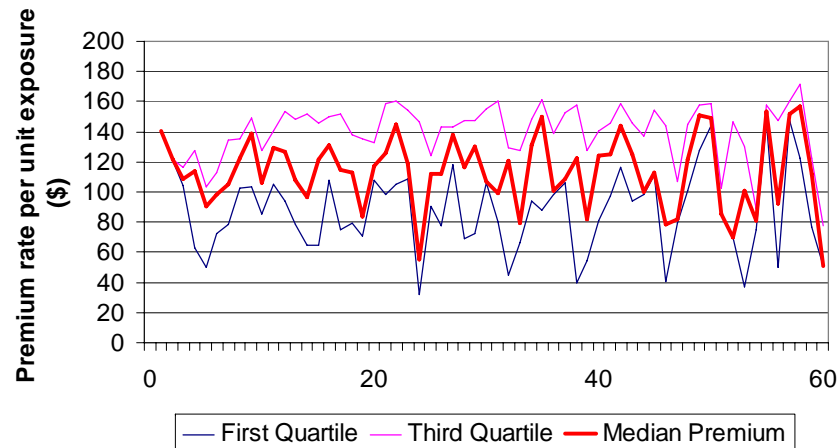
Diversity of market premium rates
 $k_7=0.17$



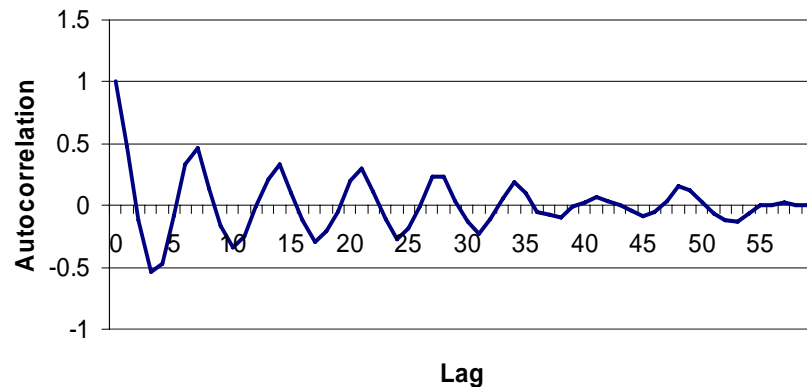
- Diversity increases with **market price-sensitivity** parameter (base case: $k_7=0.10$)
 - Similar to increased **price elasticity**

Diversity of premium rates (cont'd)

Diversity of market premium rates
 $k7=0.17$



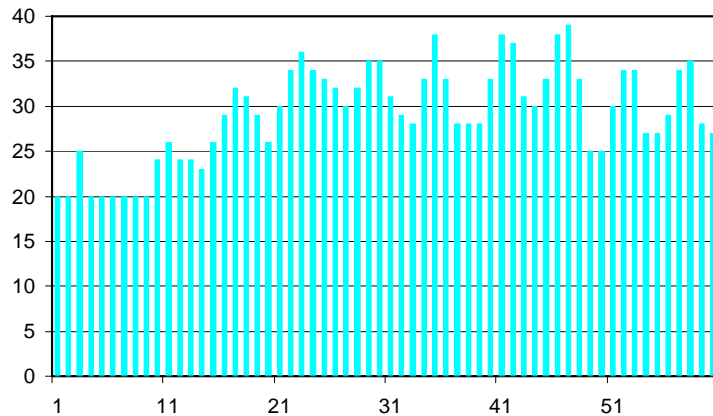
Average Premium Autocorrelation Plot
 $k7=0.17$



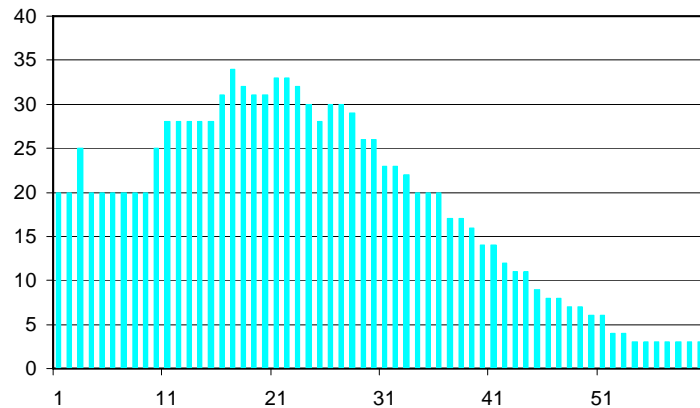
- High market price-sensitivity also induces cycles
 - Cycles generated by consumer behaviour rather than insurer competition

Number of market participants and market concentration

Number of market participants
 $k_{10} = 0.8$

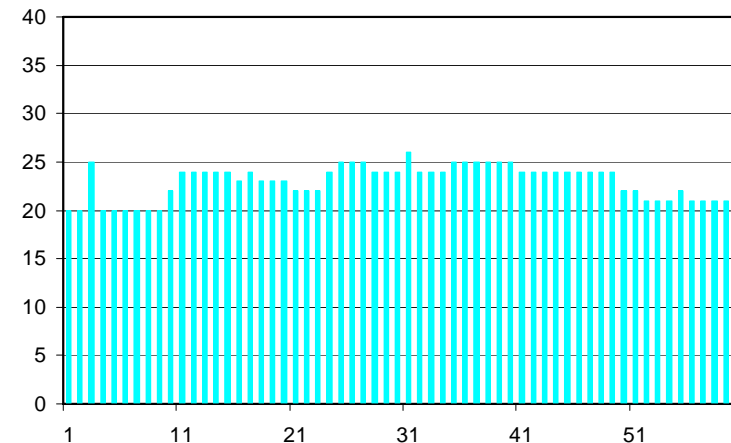


Number of market participants
 $k_{10} = 0.9$



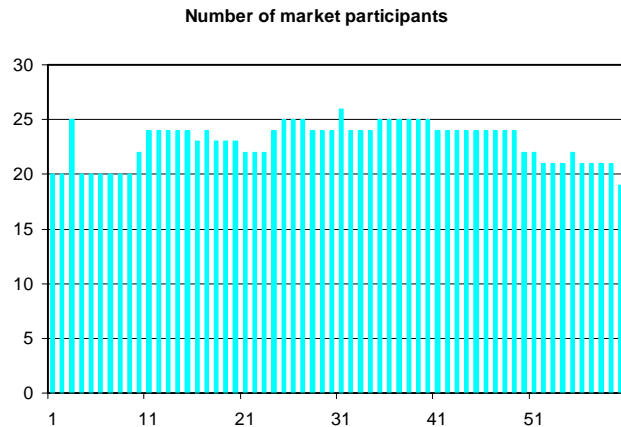
- Effect of increasing dividend payout ratio (k_{10})
 - Base case: $k_{10} = 70\%$

Number of market participants
 $k_{10} = 0.7$

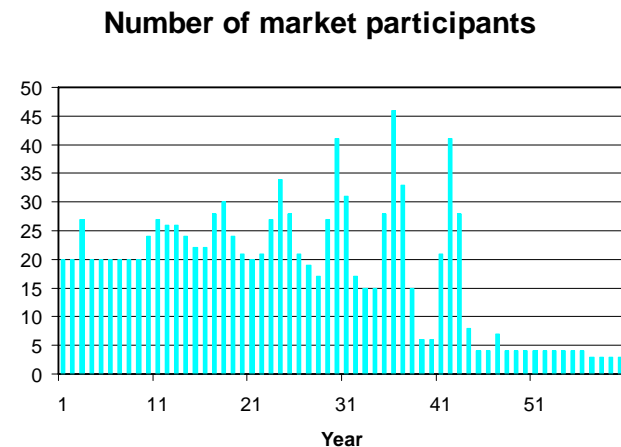


Number of market participants and market concentration (cont'd)

$$k_5 = 30$$



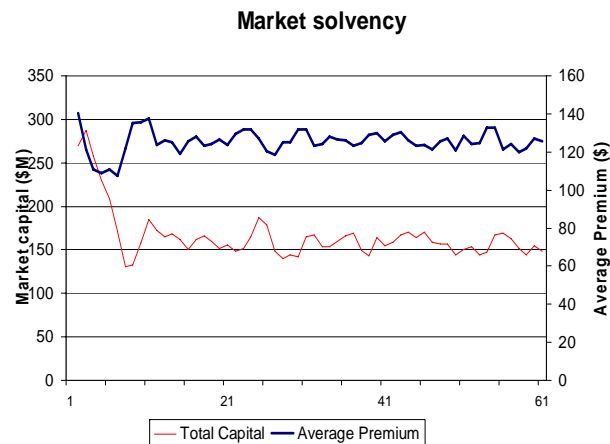
$$k_5 = 45$$



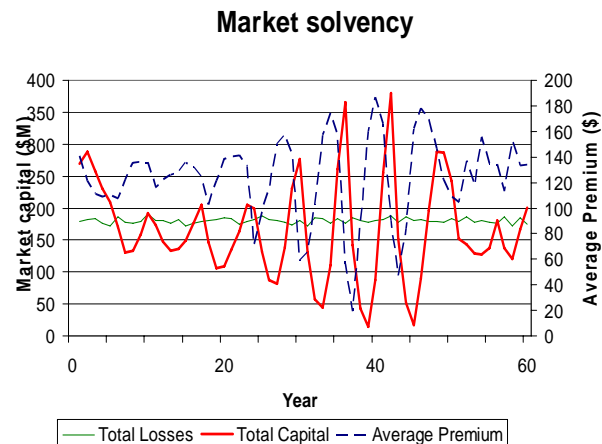
- Effect of increasing new capital attraction per unit market profitability (k_5)
 - Base case: $k_5 = 30$
- Increasing k_5 to 45 causes:
 - Cyclic influxes of capital
 - High rate of insolvency
 - About 10% (0.15% in base case)

Number of market participants and market concentration (cont'd)

$$k_5 = 30$$



$$k_5 = 45$$

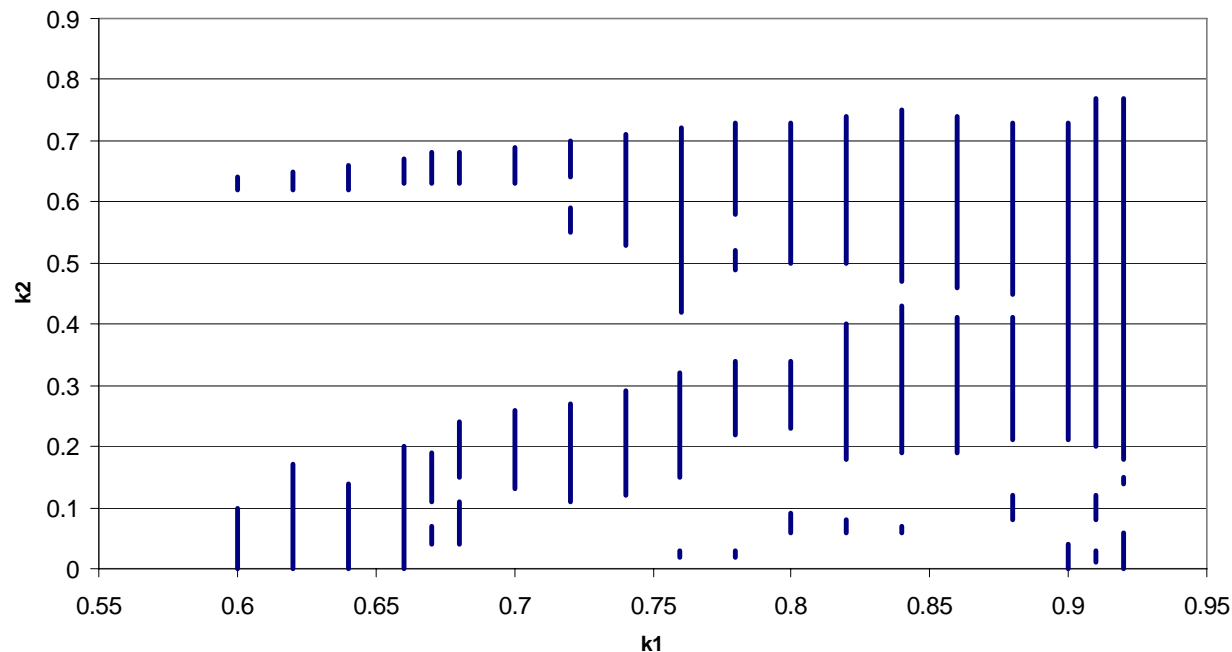


- Effect of increasing new capital attraction per unit market profitability (k_5)
 - Base case: $k_5 = 30$
- Increasing k_5 to 45 also induces cycles in market capacity and premiums

Effects of competition

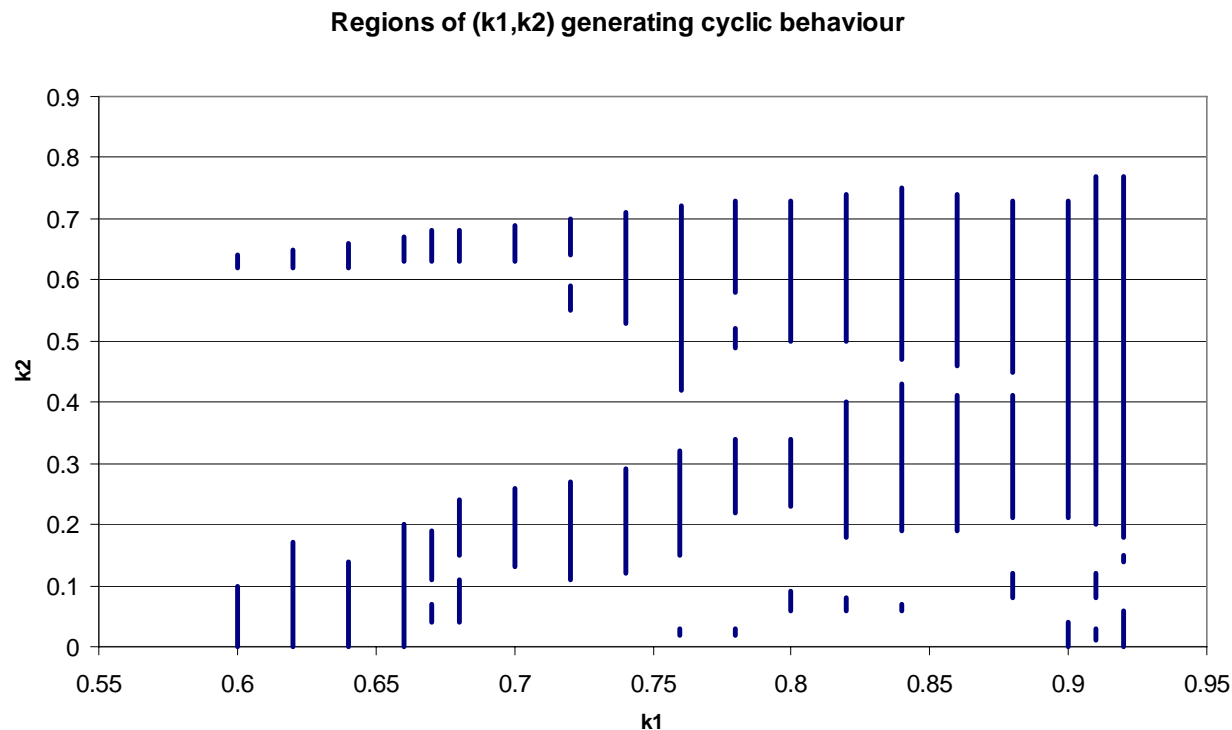
Effects of competition

Regions of (k_1, k_2) generating cyclic behaviour



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

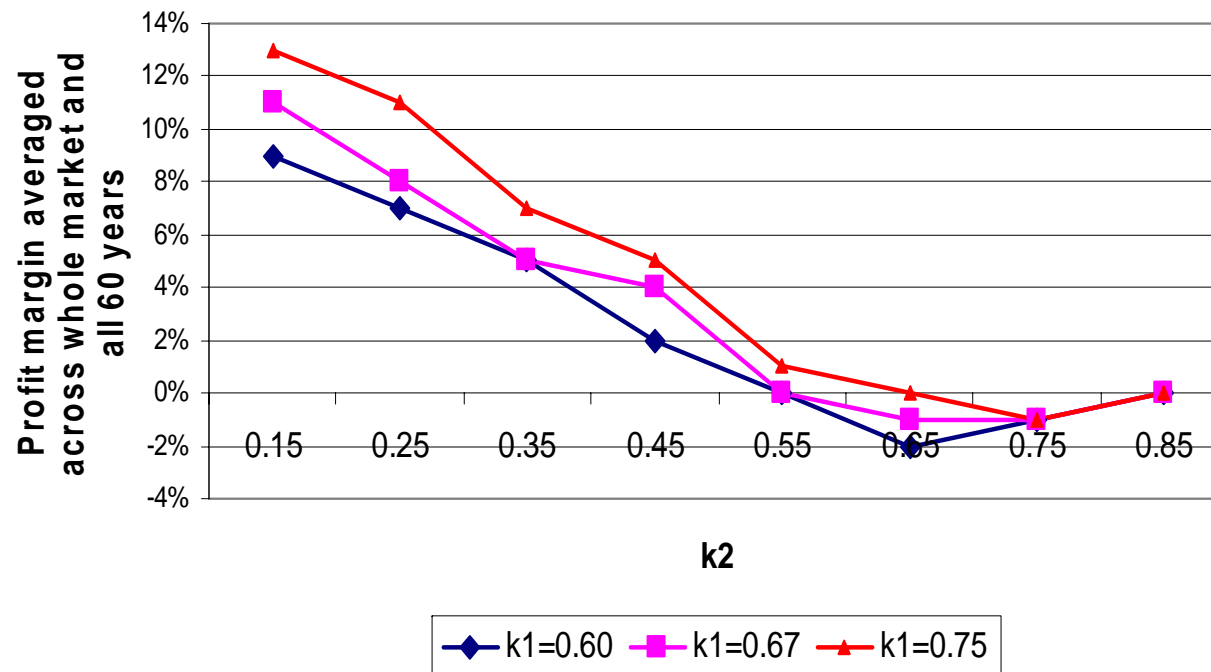
Effects of competition (cont'd)



- 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)

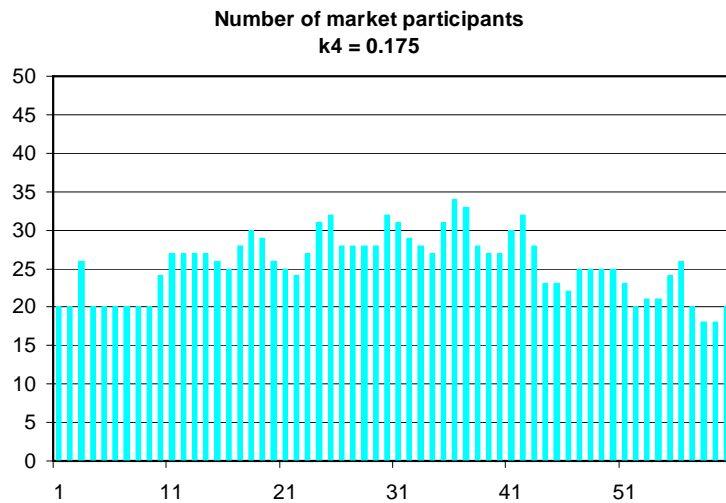
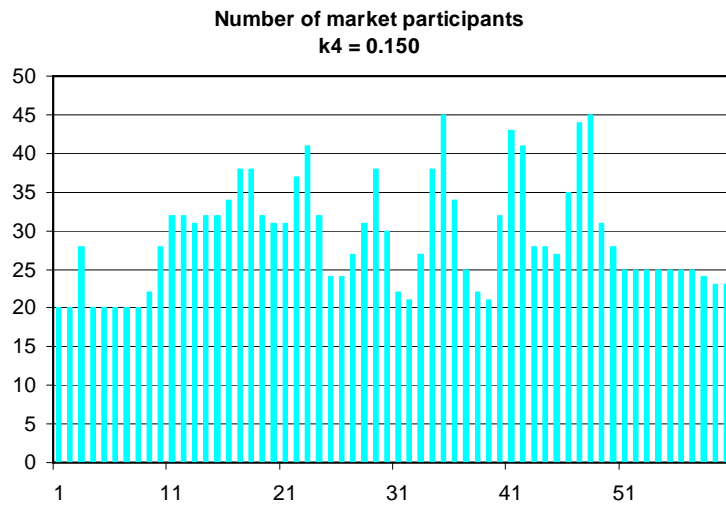
Profit margin for varying k_1 and k_2



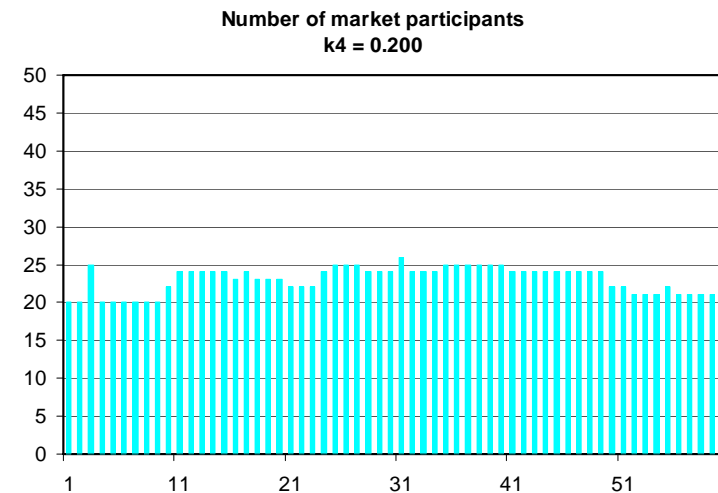
- k_1 = premium-to-solvency sensitivity
- k_2 = competition intensity parameter

Regulatory controls

Barriers to entry

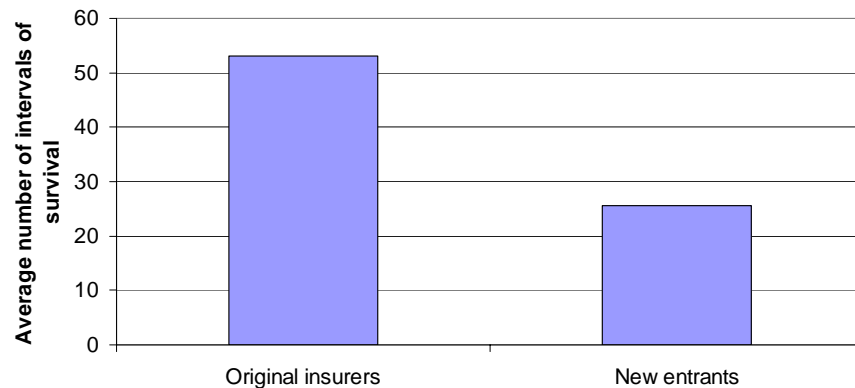


- Threshold capital attraction profit margin (k_4)
 - Affects number of market participants
 - Base case: $k_4 = 0.20$



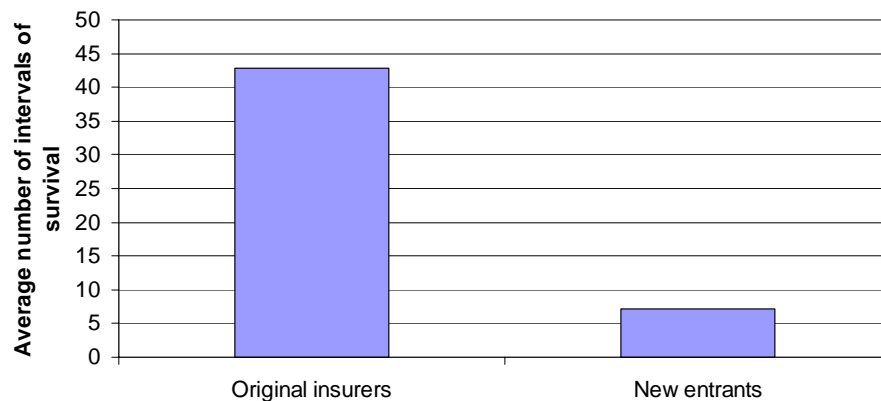
Barriers to entry (cont'd)

Longevity of market participants
 $k_4 = 0.20$



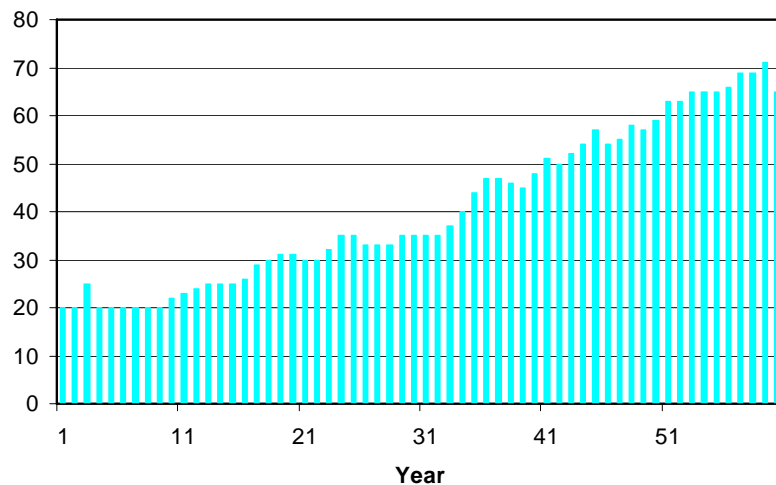
- Threshold capital attraction profit margin (k_4)
 - Also affects longevity of market participants
 - Base case: $k_4 = 0.20$

Longevity of market participants
 $k_4 = 0.15$

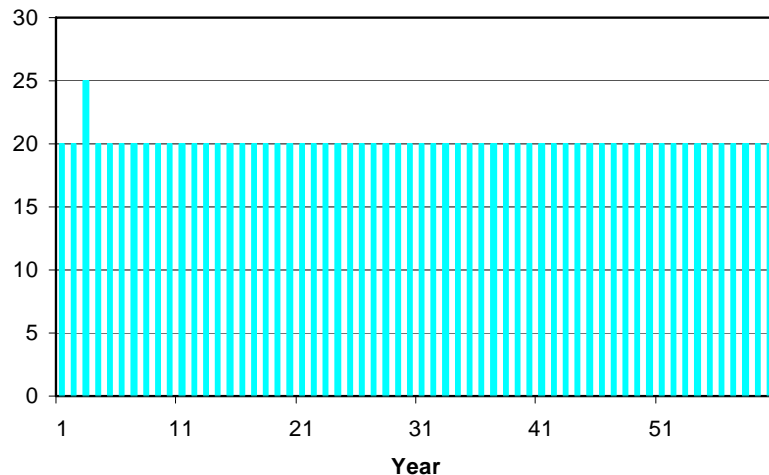


Price regulation – premium floor

Number of market participants
 $k_{11} = 0.80$

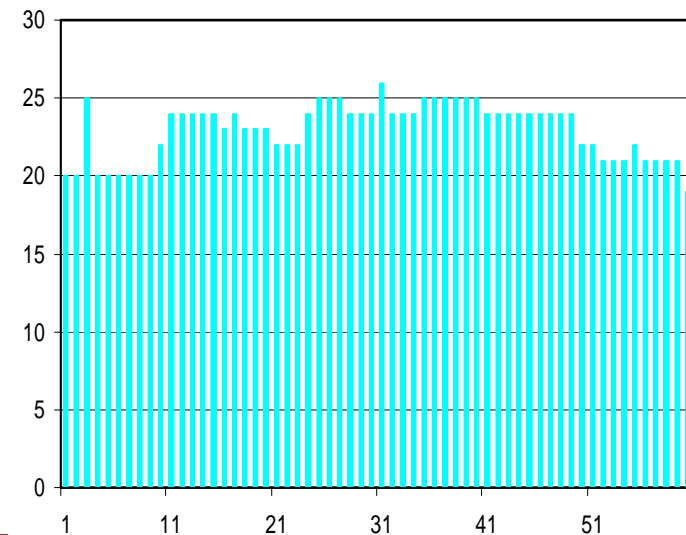


Number of market participants
 $k_{11} = 1.00$



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

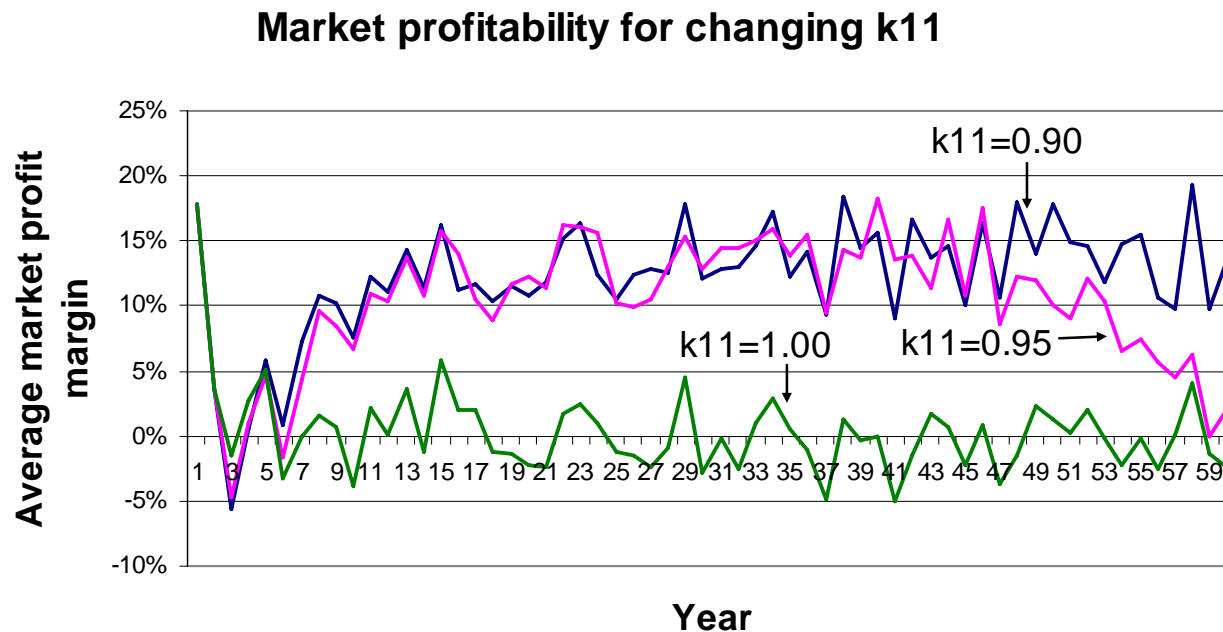
Number of market participants



Price regulation – premium floor

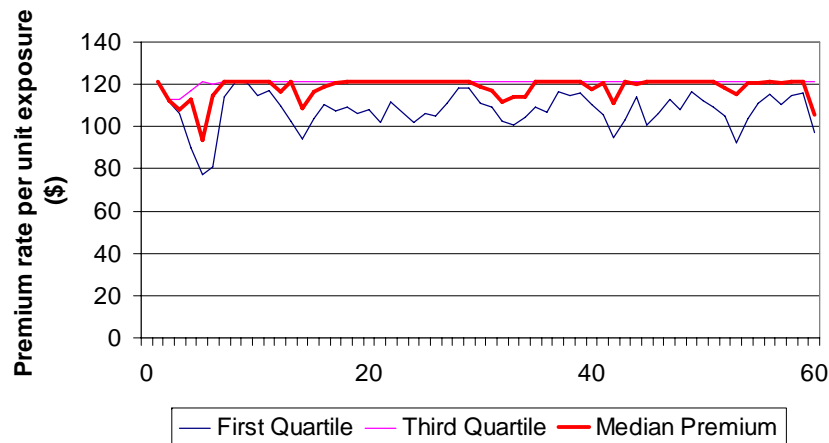
- Premium floor = k_{11} x full funding premium

- Requiring full funding **decreases** average profit margin

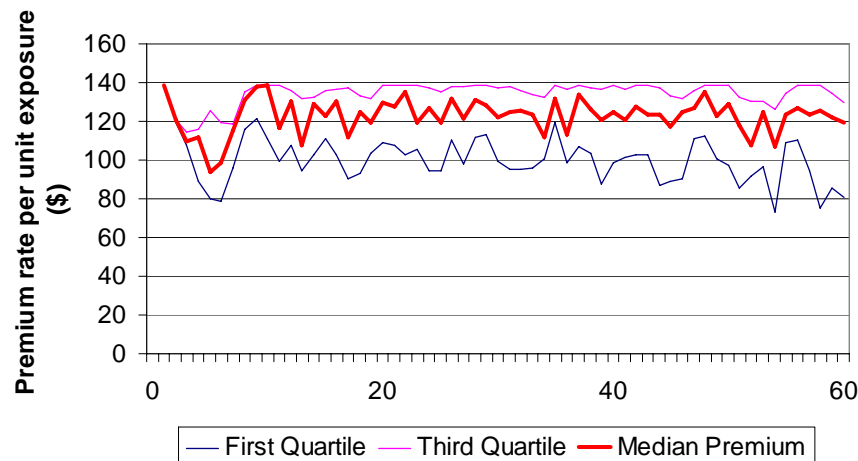


Price regulation – premium ceiling

Diversity of market premium rates
 $k_{12}=1.05$

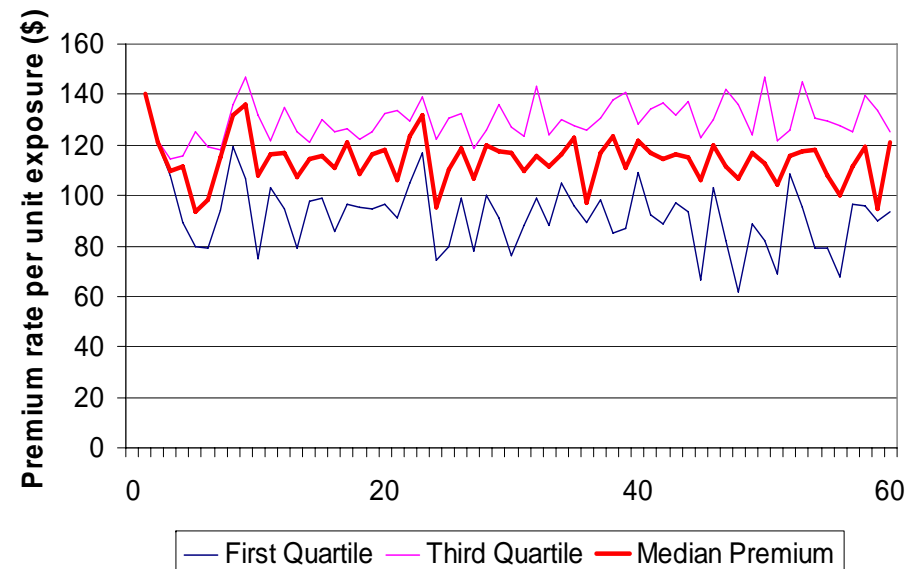


Diversity of market premium rates
 $k_{12}=1.20$



- Premium floor = k_{12} x full funding premium
- Affects diversity of premium rates
- Base case: k_{12} = unlimited

Diversity of market premium rates

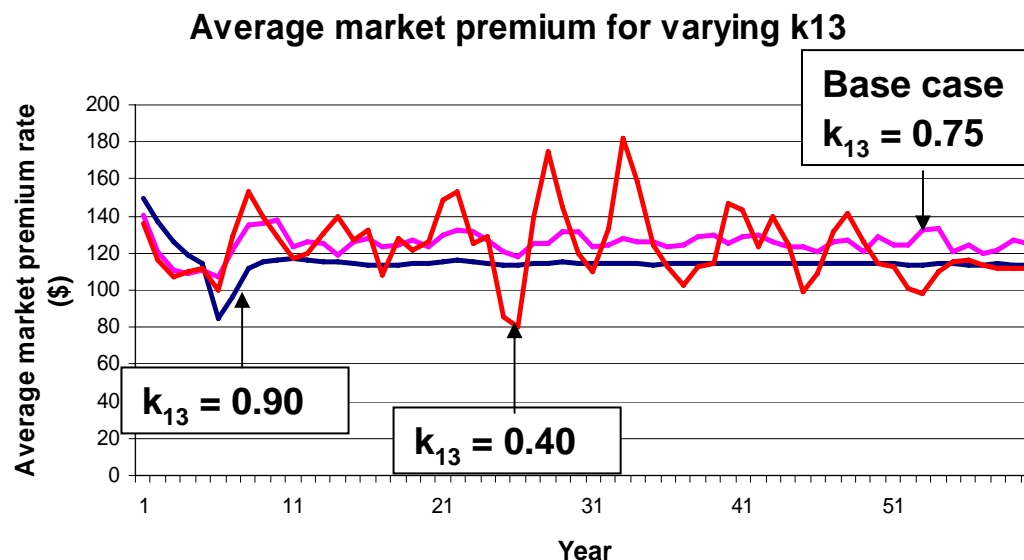


Price regulation – premium stability

- Competitive inertia (k_{13}) parameter controls premium stability
 - k_{13} is weight given to last period's premium in present period
 - Increased k_{13} → increased stability

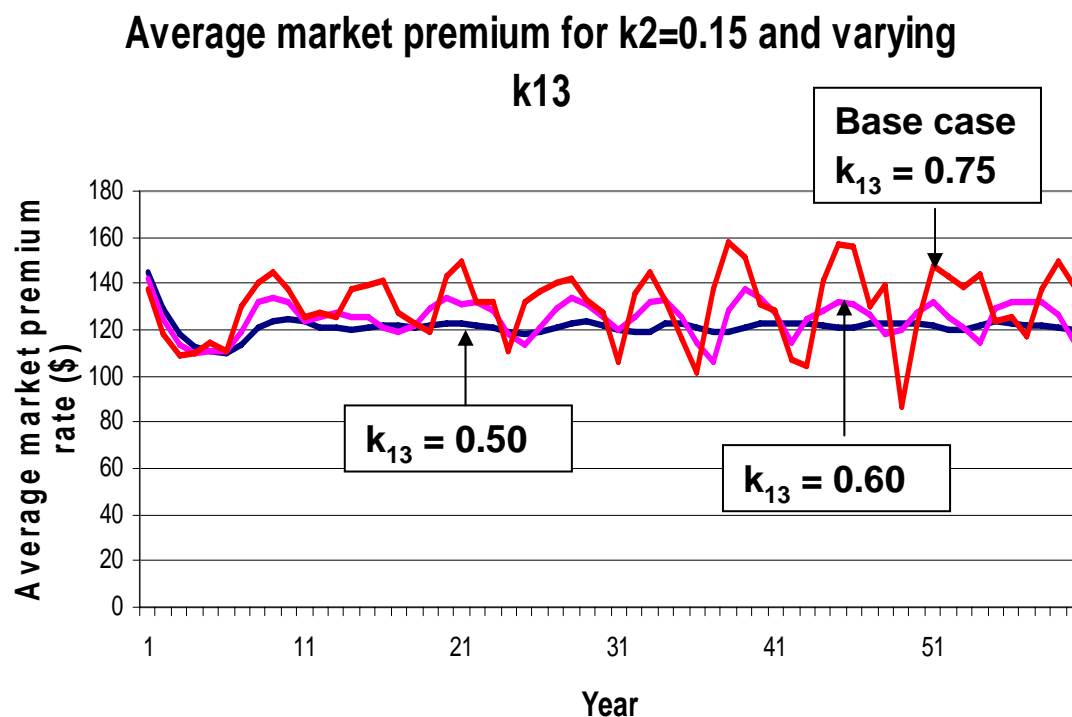
Difficult to regulate k_{13} as such

- But might regulate something similar, e.g. percentage change in premium from period to period



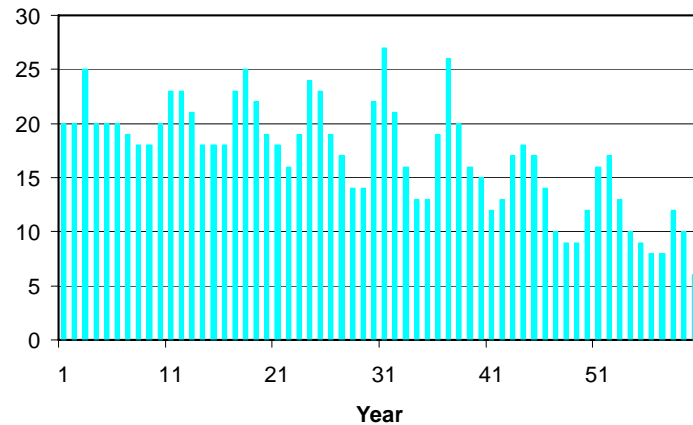
Price regulation – premium stability (cont'd)

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

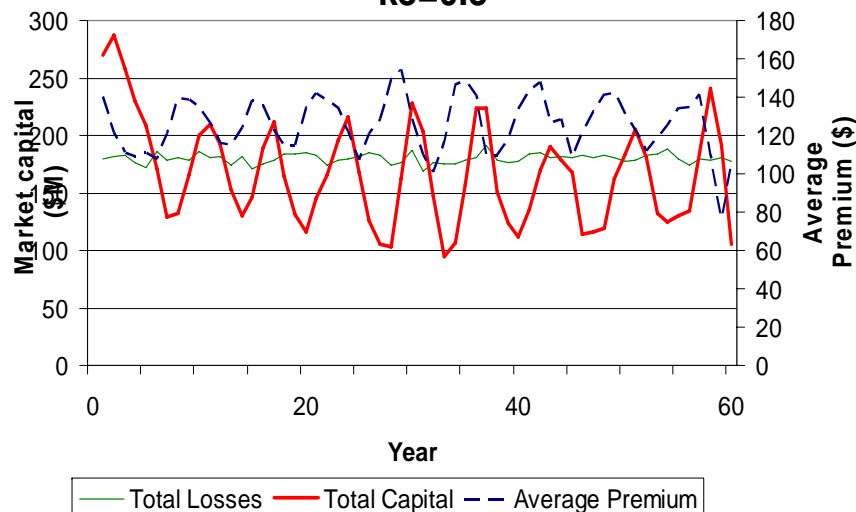


Solvency maintenance

Number of market participants
 $k_3=0.3$

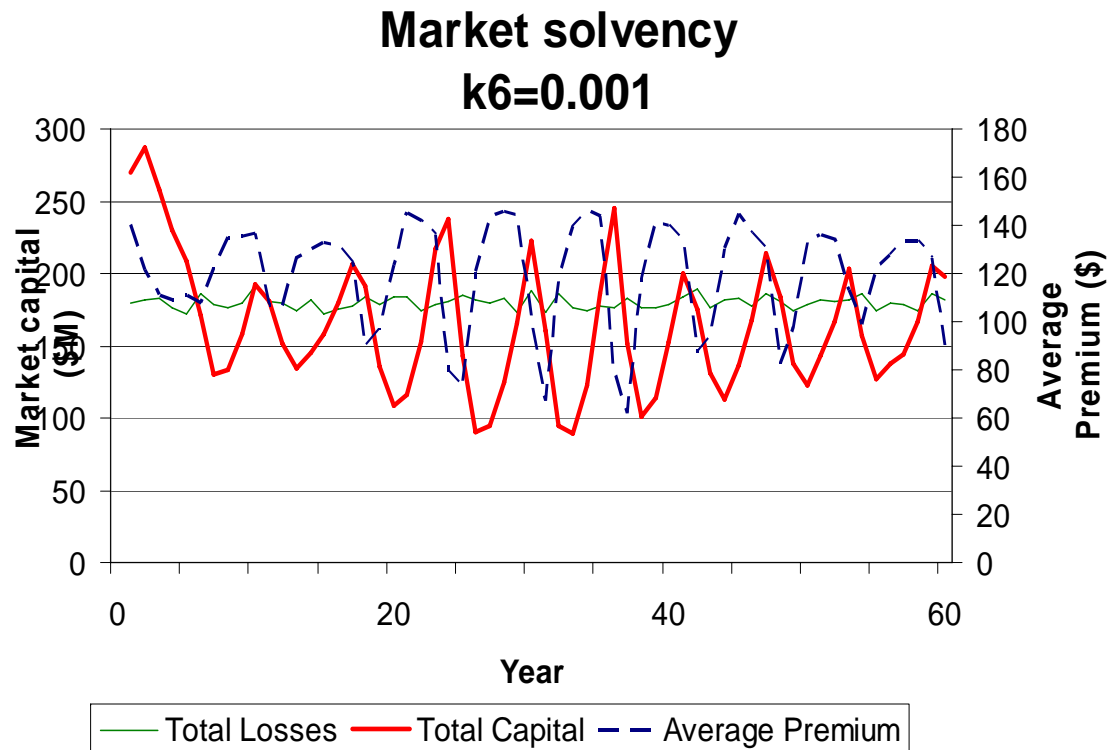


Market solvency
 $k_3=0.3$



- 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)

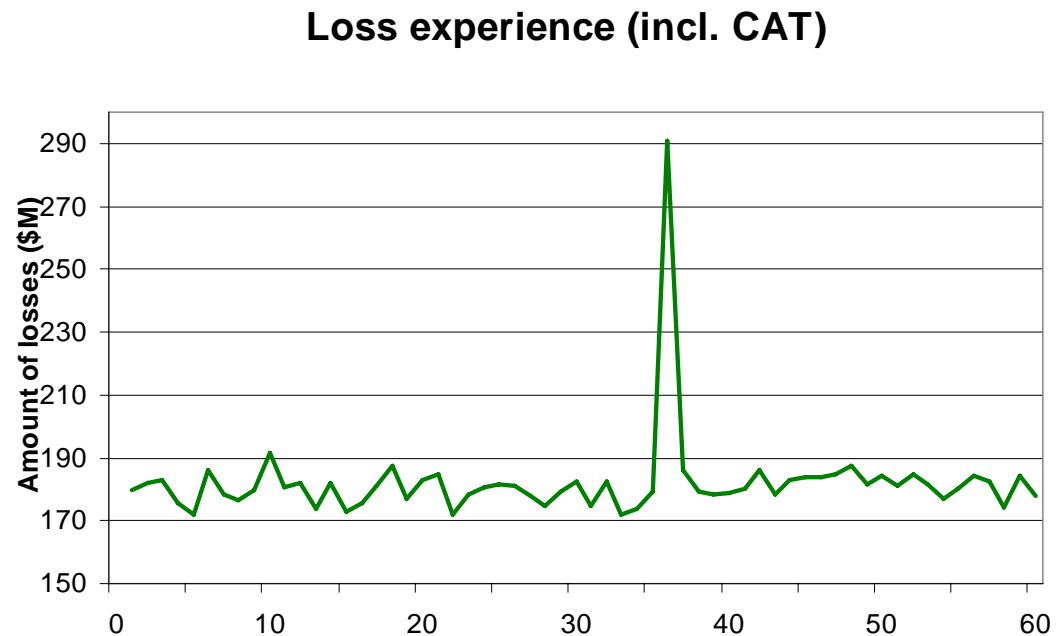


- Effect of **new entrant capitalisation parameter** (k_6) is similar
- Base case: $k_6 = 0.0033$
- Trebling this ratio
 - Also creates violent market cycles

Effects of catastrophes

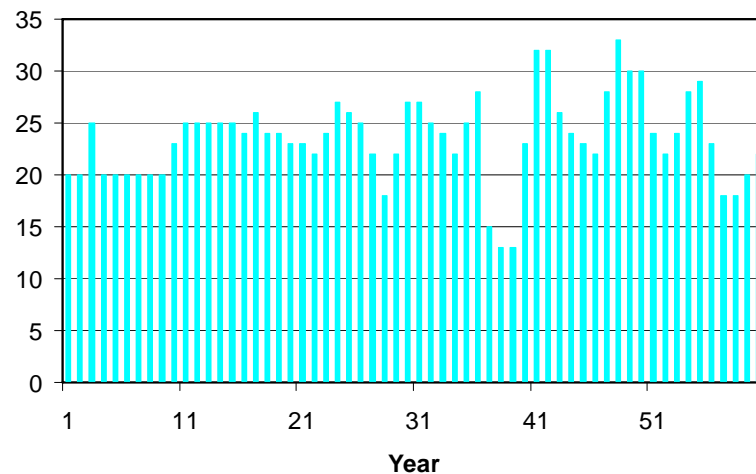
Catastrophe experience

- 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

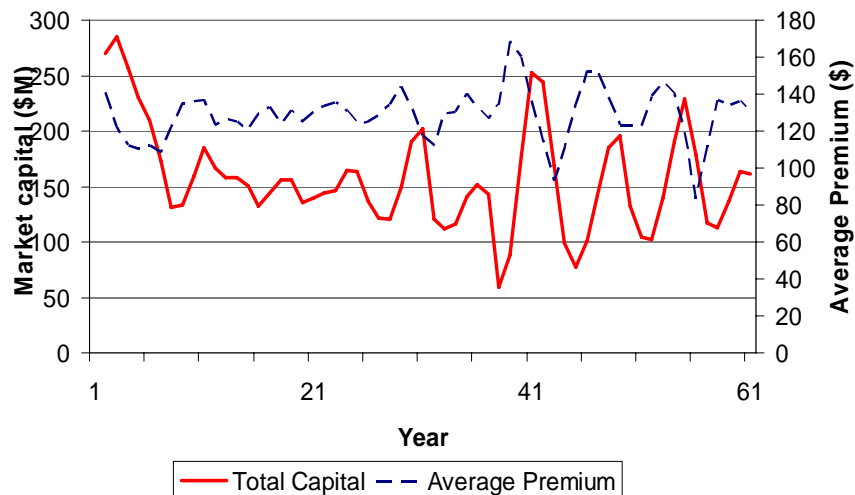


Effects of catastrophe

Number of market participants



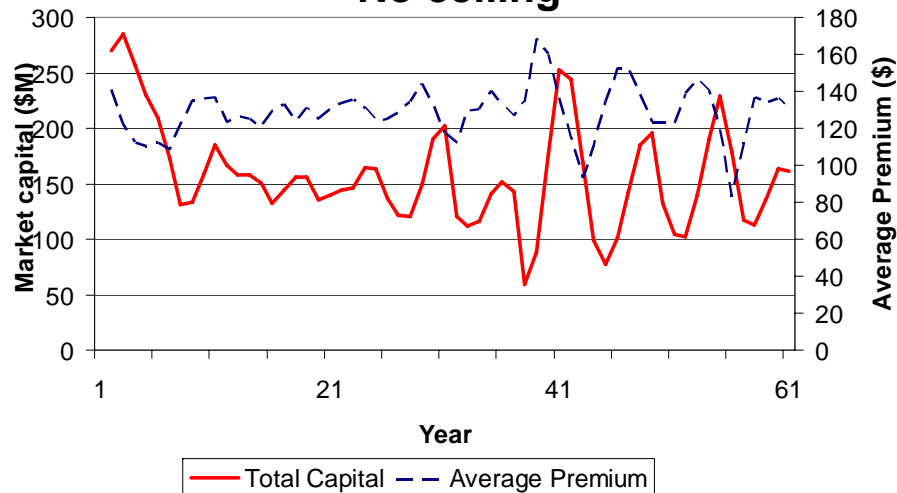
Market solvency



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

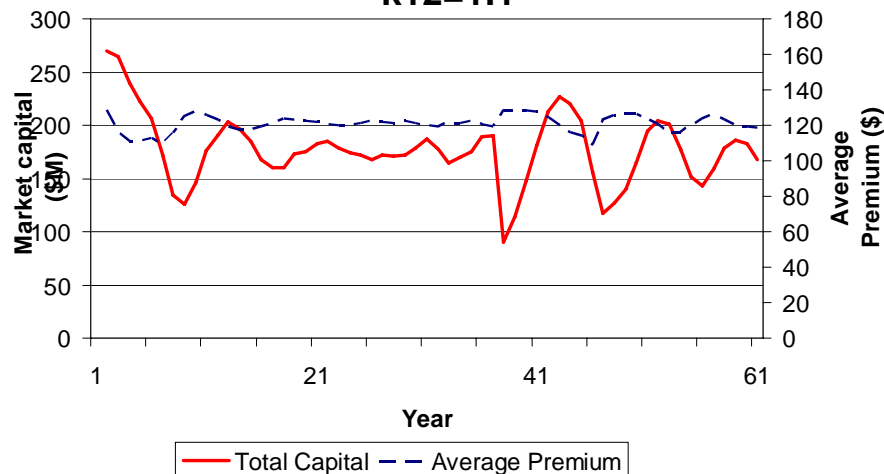
Effects of catastrophe (cont'd)

**Market solvency
No ceiling**



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

**Market solvency
 $k_{12}=1.1$**



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?

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