Centre for Competition Law and Economics

Analysing cartel episodes:
A Markov-switching application

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RATIONALE

- In many cartelized markets, periods of collusion are periodically interrupted by periods of competition
  - **Price wars**

- Studying empirical modelling of recurrent collusion speaks to core questions of collusive overcharge
  - **Empirical models of damage estimation commonly accept period of harm as a given**
  - **Studying transition to/from collusion**

RATIONALE

- Features of empirical model of recurrent collusion

  - **Establish ‘collusive’ episodes**
  - **Distinct data-generating processes during collusive and non-collusive periods**
  - **Estimate overcharge across collusive episodes**
  - **Account for transitions between collusive and non-collusive periods**

LITERATURE

- Collusion is state-dependent, often related to demand
  - **Rotemberg & Saloner (1986); Haltiwanger & Harrington (1991); Bagwell & Staiger (1997), Fabra (2006)**
  - **State dependence implies recurrent nature**

- Empirical studies
  - **More important work on structural break tests**
  - **Boswijk *et al.* (2017), Crede (2015)**

METHODOLOGY: RS

- Reduced-form, regime-switching model:

$$p_t = \begin{cases} c_0 + \omega + \sum_{l=1}^{m} a_l\, p_{t-l} + \sum_{l=0}^{n} \boldsymbol{\gamma}_l \boldsymbol{x}_{t-l} + \varepsilon_t\,, & S_t = 1 \\ c_0 + \sum_{l=1}^{m} a_l\, p_{t-l} + \sum_{l=0}^{n} \boldsymbol{\gamma}_l \boldsymbol{x}_{t-l} + \varepsilon_t\,, & S_t = 2 \end{cases}$$

with $\varepsilon_t \sim N(0, \sigma^2)$, p_t price, $\boldsymbol{x}_t$ vector of demand and cost drivers

- S_t denotes regime in operation: $S_t = 1$ for collusive regime and $S_t = 2$ for non-collusive regime

- Alternative specifications also possible

METHODOLOGY: OVERCHARGE

- Replace intercept in ARDL with smoothed probabilities (α_{it})

$$p_t = \beta\alpha_{it} + \sum_{l=0}^{m} a_l p_{t-l} + \sum_{l=0}^{n} \gamma_l \boldsymbol{x_{l-t}} + \varepsilon_t$$

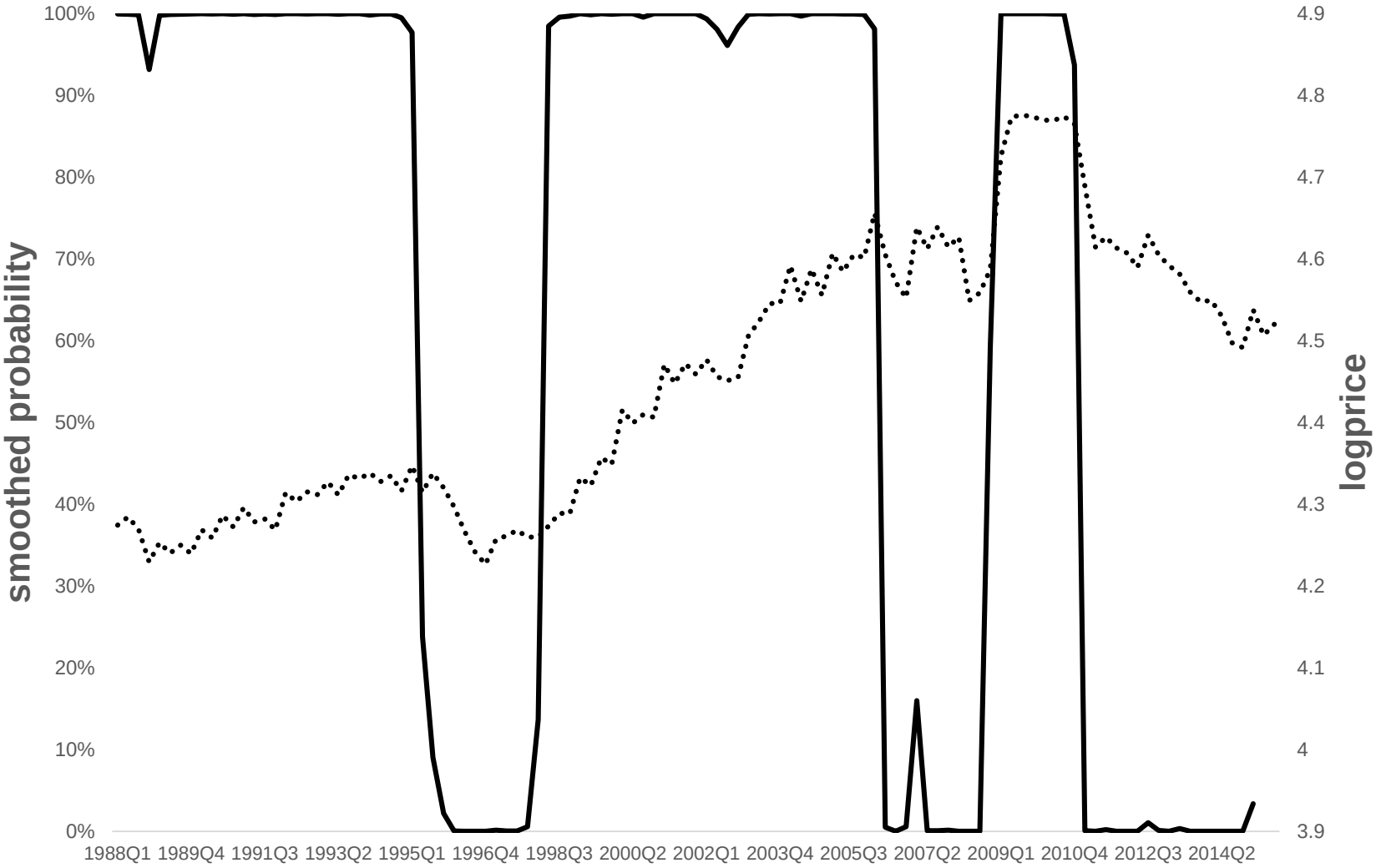
  - $\alpha_{it} = \xi(S_t = i|\Omega_T; \boldsymbol{\theta})$ **is the smoothed probability from the RS model**
  - p_t **is the cement price**
  - $\boldsymbol{x_t}$ **is a vector of demand and cost drivers**

- Dynamic overcharge is taken as
  - $100 \times (e^{\beta} - 1) \times \alpha_{1,t}$

CASE STUDY: SA CEMENT MARKET

- History
  - **Legal cement cartel 1940s until 1986**
  - **Exemption from competition law until 1996**
  - **New agreement in 1998, starting 1999**
  - **Inconclusive competition law investigation in 2000**
  - **Investigation in 2008 and subsequent leniency and settlement agreements**
  - **Court established illegal collusion from 1999 to 2009**
- Sample period 1988 – 2015
- Drivers in model
  - **Electricity, lime and limestone**
  - **House prices, sales volumes**

RESULTS: REGIME PROBABILITIES

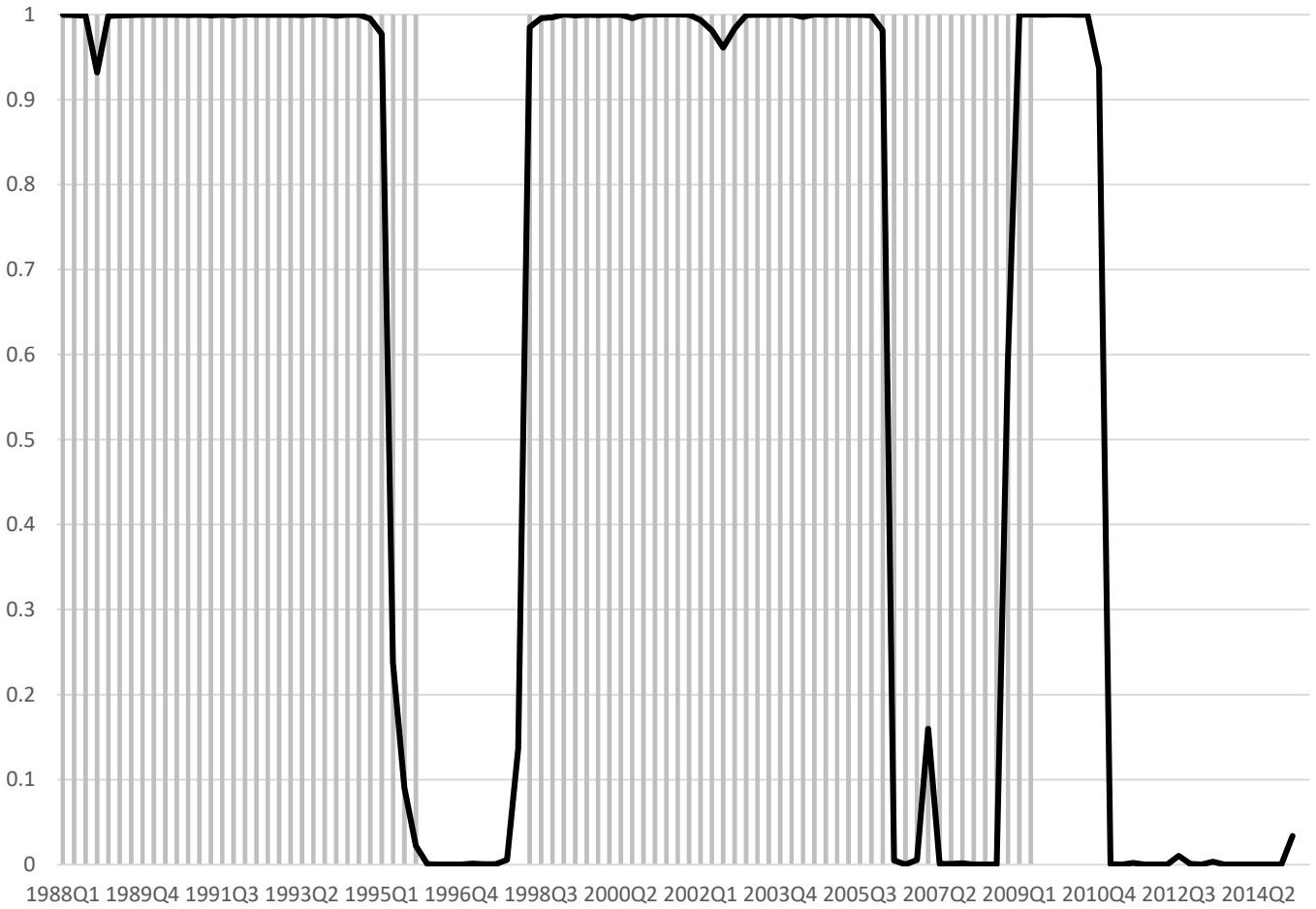


RESULTS: STATIC ESTIMATES FOR OVERCHARGE

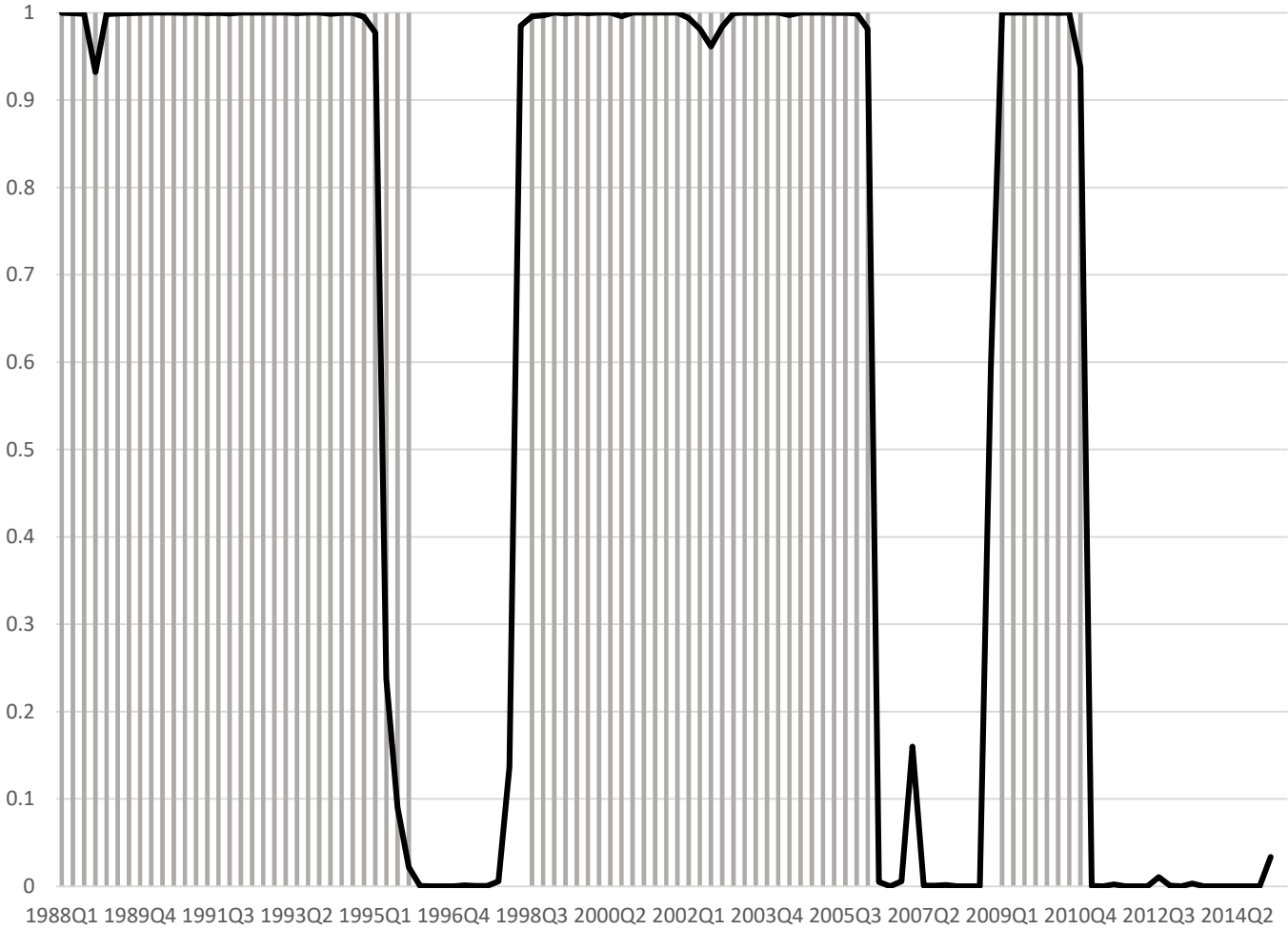
$$p_t = \beta\alpha_{it} + \sum_{l=0}^{m} a_l p_{t-l} + \sum_{l=0}^{n} \gamma_l \boldsymbol{x_{l-t}} + \varepsilon_t$$

Variable	Coefficient	Std. Error	t-Statistic	p-value
Lime and limestone	0.22	0.09	2.33	0.02
House price	0.18	0.02	9.59	0.00
Sales	0.54	0.09	5.74	0.00
Electricity prices	0.05	0.02	0.63	0.53
Overcharge	0.18	0.09	1.94	0.05

RESULTS: COMPARISON TO COURT DETERMINED DUMMY



RESULTS: DUMMY WITHOUT TRANSITION



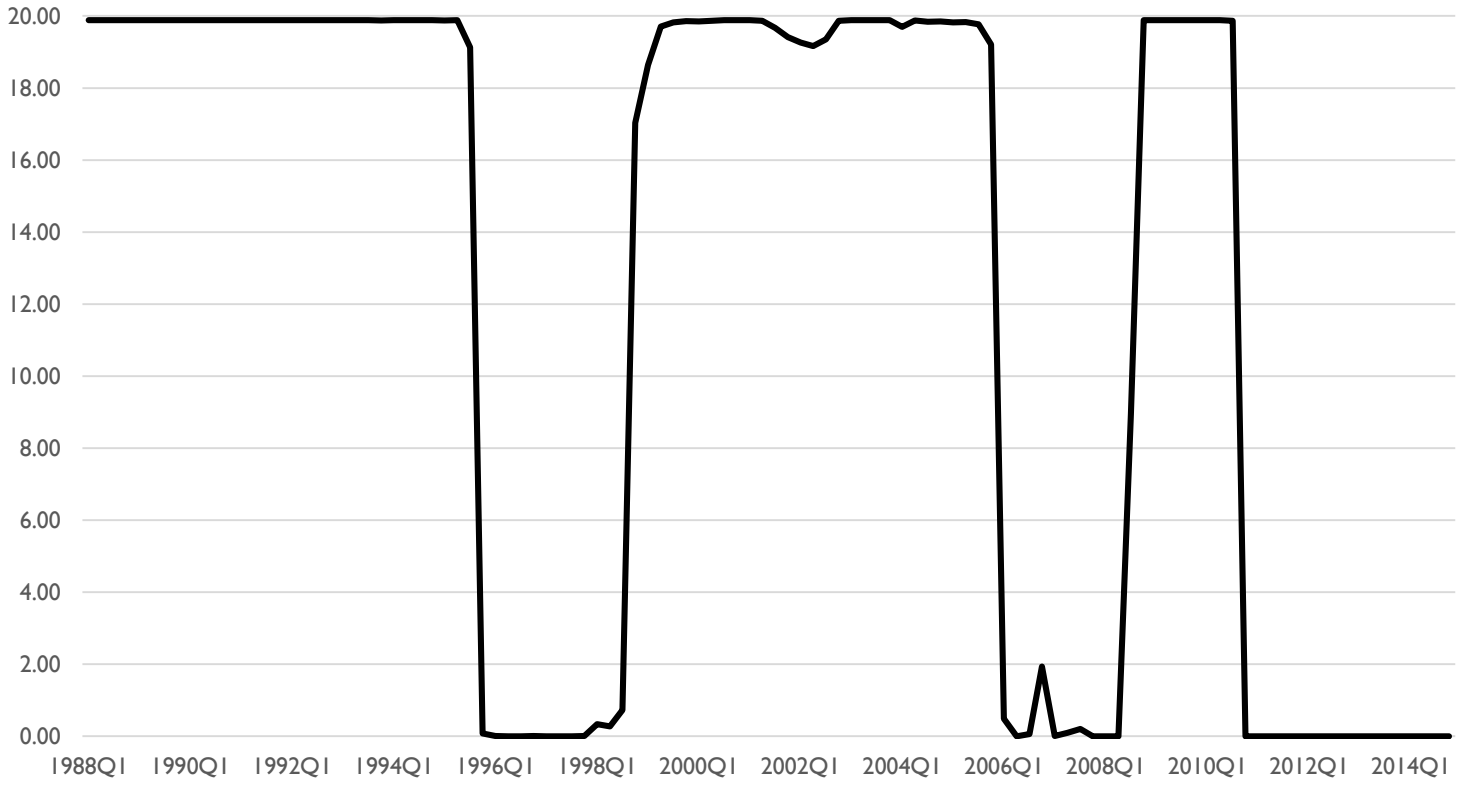
RESULTS: AVERAGE OVERCHARGE COMPARISON

Smoothed probabilities	'Official' dummy	Dummy based on Bai-Perron structural break	Smoothed probabilities but excluding transitions
OUR MODEL			
18%	**1%**	**4%**	**13%**
STATIC OLS MODEL			
12%	**2%**	**2%**	**11%**

Average overcharge (18%) higher than standard dummy variable approaches

RESULTS: DYNAMIC OVERCHARGE

$$100 \times \left(e^{\beta} - 1\right) \times \alpha_{1,t}$$



RESULTS: DIAGNOSTICS OF ARDL WITH COURT DUMMY

TEST	Test statistic	p-value
Jarque-Berra	$\chi^2(2) = 15.38$	0.26
Breusch-Godfrey Serial correlation LM	$(n-2) \times R^2 = 8.66$	0.01
Breusch-Pagan-Godfrey Heteroskedasticity	$n \times R^2 = 42.03$	0.01
ARCH-LM	$n \times R^2 = 1.18$	0.28

RESULTS: DIAGNOSTICS OF ARDL WITH SMOOTHED PROBABILITY

TEST	Test statistic	p-value
Jarque-Berra	$\chi^2(2) = 15.38$	0.73
Breusch-Godfrey Serial correlation LM	$(n-2) \times R^2 = 41.87$	0.23
Breusch-Pagan-Godfrey Heteroskedasticity	$n \times R^2 = 29.96$	0.62
ARCH-LM	$n \times R^2 = 13.17$	0.11

RESULTS: RS DIAGNOSTIC TESTS

TEST	Test statistic	p-value
Jarque-Berra	$\chi^2(2) = 4.28$	0.978
Ljung-Box	$\chi^2(8) = 9.48$	0.3
ARCH-LM	$n \times R^2 = 13.17$	0.12

CONCLUSIONS

- This paper suggests an empirical model of recurrent collusion using a RS methodology
  - **Allows explicit testing for presence of multiple regimes**
  - **Allows simultaneous detection of periods of collusive harm and estimation of overcharge**
  - **Allows for smooth transitions between collusive and non-collusive episodes**

Thank you