Collusion under Imperfect Monitoring with Asymmetric Firms

Matthew Olczak

Aston Business School, Aston University, UK

(joint with Luke Garrod)

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INTRODUCTION: Motivation

Recent collusion theory literature important for coordinated effects of mergers:

asymmetries undermine stability of collusion

● Capacities (Compte et al, 2002; Vasconcelos, 2005; Bos and Harrington, 2010)
● Number of differentiated products (Kühn, 2004)

These papers assume 'perfect observability'

Many mergers occur in markets where potential for secret price cuts

● Imperfect monitoring (Green and Porter, 1984; Tirole, 1988; …)

These papers consider symmetric firms

Approach

Extend Compte et al (2002):   firms only ever observe own prices and sales

unobservable fluctuations in demand

IMPLICATIONS: firms may face a non-trivial signal extraction problem

price wars can occur on the equilibrium path

● Similar setting to Stigler (1964)
● Closely related to Tirole (1988, p.262-264)

Analyse whether collusion is facilitated or not as capacity reallocated among firms

Draw implications for merger policy
● Coordinated effects should not be presumed to be more harm than unilateral
● Mergers that disrupt collusion by increasing asymmetry may decrease CW

THE MODEL: Basic Assumptions

Firms

$n \geq 2$ capacity constrained firms compete in prices to sell a homogeneous product

Firm n is largest and firm 1 is the smallest: $k_n \geq k_{n-1} \geq \cdots \geq k_1$

Demand

Mass of m buyers if $p \leq 1$

Unobservable demand fluctuations: $G(m)$ with $g(m) > 0$ on $[\underline{m}, \overline{m}]$ with mean $\hat{m}$

Information

Buyers observe prices but firms never observe rivals' prices or sales

SETTING: buyers willing to search market to find discounts from posted prices

(Enough buyers informed of prices sufficient for main results)

Demand rationing and sales

Proportional allocation rule:

● Demand allocated to cheapest firm first, then second cheapest…

● Demand is allocated in proportion to capacity if firms have same price

A1: $\underline{m} \geq K - k_1 = k_2 + \cdots + k_n$ (highest-priced firm always has positive sales)

● Not restrictive if firms never can collectively supply demand: $\underline{m} \geq K$

● Less restrictive for $\underline{m}$ closer to K when $\underline{m} < K$

Above imply that firm i's sales in period t will be:

$$s_{it} = \begin{cases} k_i, & if\ p_i < p_t^{max} \\ \min\left\{\dfrac{k_i}{K - \sum_{j\in\Omega(p_i)} k_j}\left(m_t - \sum_{j\in\Omega(p_i)} k_j\right), k_i\right\}, & if\ p_i = p_t^{max} \end{cases}$$

Static Nash equilibrium

There exists:

● a unique pure strategy Nash equilibrium with $\pi_i^N = k_i$ if $\underline{m} \geq K$

● a mixed strategy Nash equilibrium if $\underline{m} < K$, where profit and average price increases in k_n

Intuition:

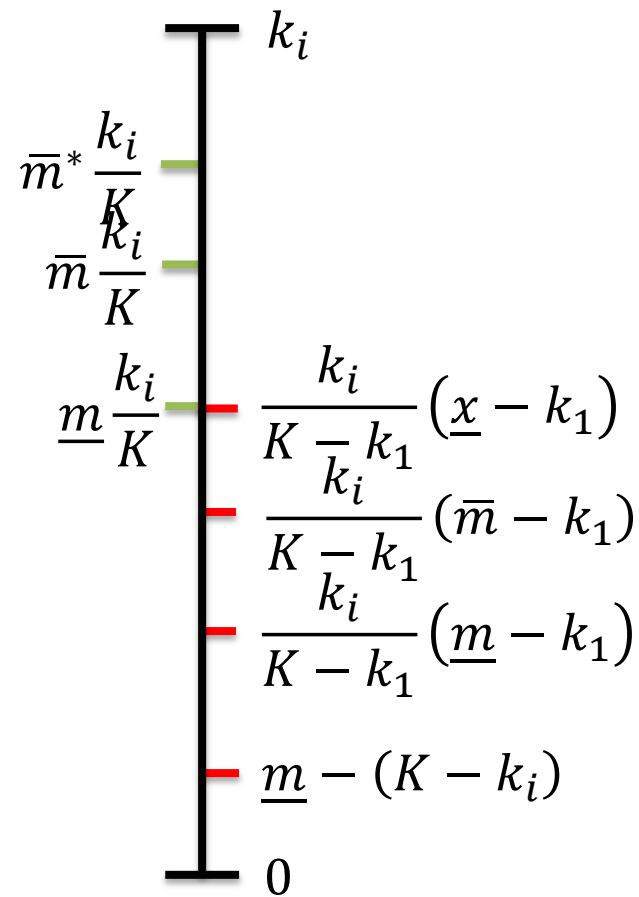If $\underline{m} \geq K$, each firm has monopoly over residual demand

If $\underline{m} < K$, Bertrand-Edgeworth competition with fluctuations in demand

Competition determined by whether largest firm wants to be cheapest firm

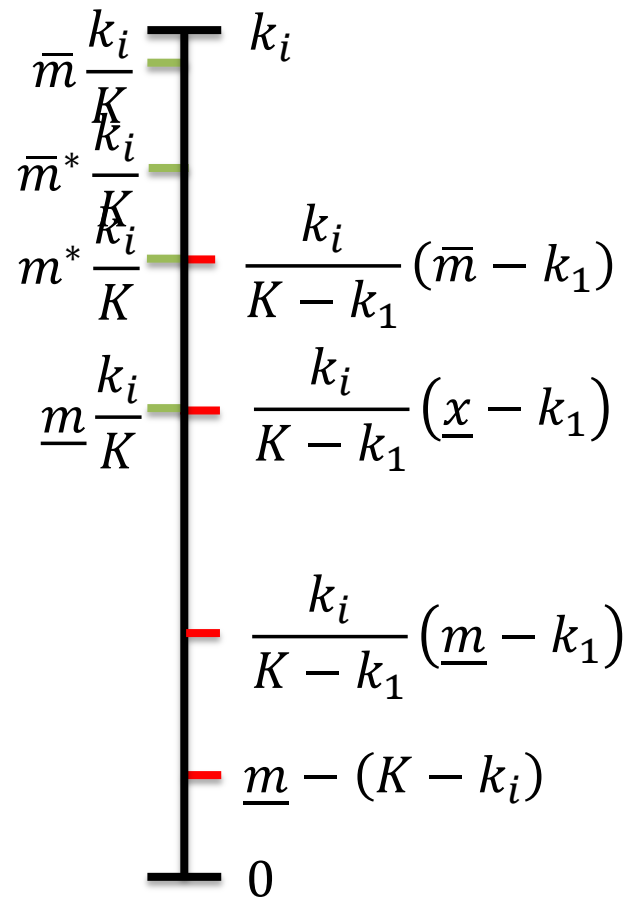Largest firm can set the monopoly price & supply the residual demand

Monitoring **is perfect if fluctuations in demand are small**

Firm i's sales

k_i

$\overline{m}^* \dfrac{k_i}{K}$

$\overline{m} \dfrac{k_i}{K}$

$\underline{m} \dfrac{k_i}{K}$

$\dfrac{k_i}{K - k_1}\left(\underline{x} - k_1\right)$

$\dfrac{k_i}{K - k_1}\left(\overline{m} - k_1\right)$

$\dfrac{k_i}{K - k_1}\left(\underline{m} - k_1\right)$

$\underline{m} - (K - k_i)$

0

Imperfect monitoring

Firm i's sales

$$k_i$$

$$\overline{m}\frac{k_i}{K}$$

$$\overline{m}^*\frac{k_i}{K}$$

$$m^*\frac{k_i}{K} \qquad \frac{k_i}{K-k_1}(\overline{m}-k_1)$$

$$\underline{m}\frac{k_i}{K} \qquad \frac{k_i}{K-k_1}(\underline{x}-k_1)$$

$$\frac{k_i}{K-k_1}(\underline{m}-k_1)$$

$$\underline{m}-(K-k_i)$$

$$0$$

INFORMATION AND MONITORING

There exists some firm-specific "trigger level": $\underline{s}_i = min\left\{\frac{k_i}{K-k_1}(\overline{m}-k_1), k_i\right\}$

This guarantees at least one firm will receive sales below their trigger level, if all firms do not set a common price

This ensures $h^t = (y_0, \dots, y_{t-1})$ is a public history, for all t, where:

$$y_\tau = \begin{cases} \overline{y} & if \quad s_{it} > \underline{s}_i \ for \ all \ i \\ \underline{y} & if \quad\quad otherwise \end{cases}$$
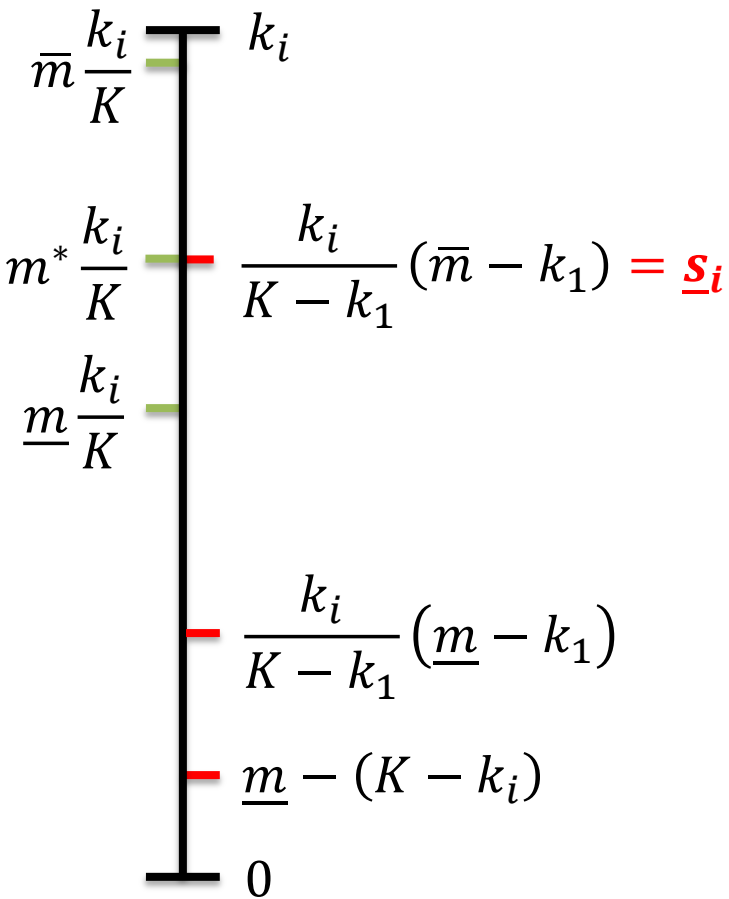
● Trivial if $\underline{s}_i = k_i$

● Intuition of $\underline{s}_i < k_i$:

If firms set common $p \le 1$, then the sales of all firms will exceed trigger levels if demand is high, but sales can fall below their trigger levels if demand is low

If firms do not set a common p, then the sales of the firms with the highest price will not exceed their trigger levels and the others will supply their full capacities
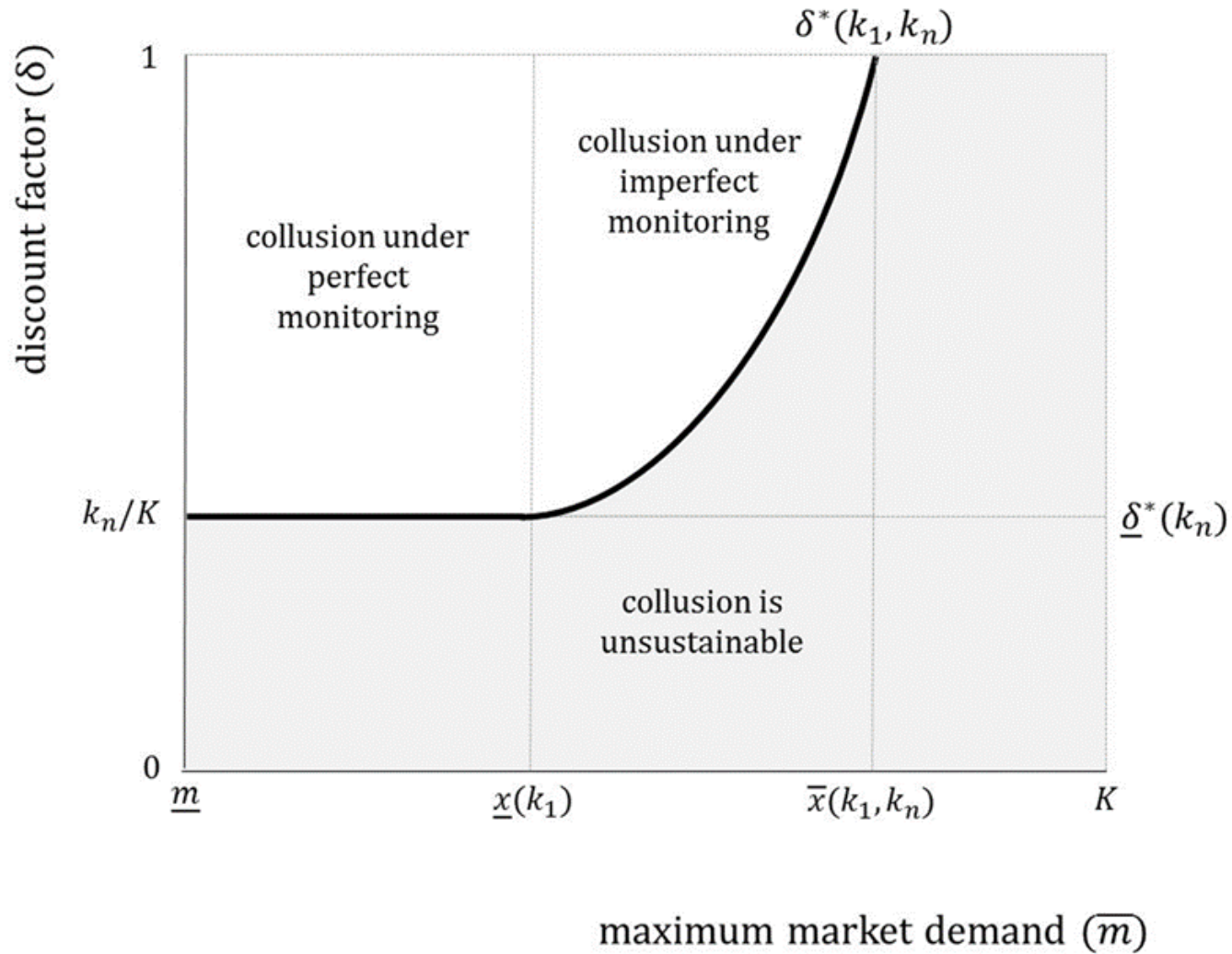
Imperfect monitoring

Firm i's sales

$$\overline{m}\frac{k_i}{K} \qquad k_i$$

$$m^*\frac{k_i}{K} \qquad \frac{k_i}{K-k_1}(\overline{m}-k_1) = \underline{s_i}$$

$$\underline{m}\frac{k_i}{K}$$

$$\frac{k_i}{K-k_1}\left(\underline{m}-k_1\right)$$

$$\underline{m}-(K-k_i)$$

$$0$$

- $\overline{y}$ if they set a common price and demand high
- $\underline{y}$ otherwise

We solve for the set of SPPE payoffs

In an appendix, we generate the same main results by solving the game following the approach of Tirole (1988)
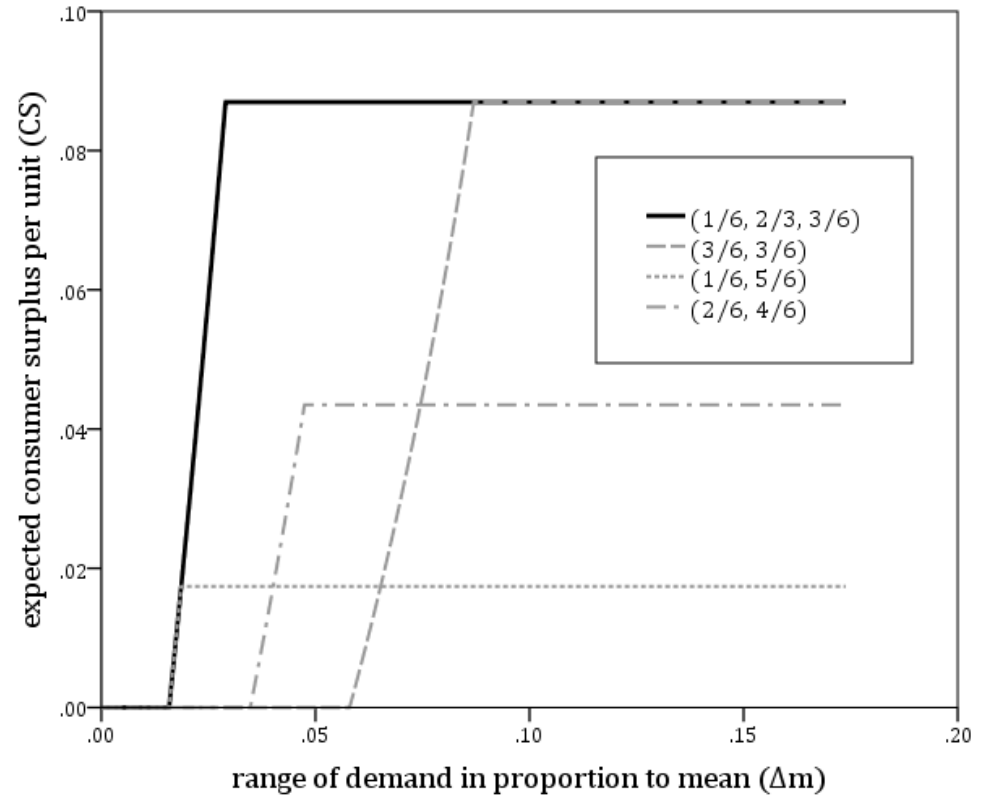
Parameter space of collusion

An Example

Total capacity $K = 100$, demand uniformly distributed, $\widehat{m} = 92, \delta \to 1$

Pre-merger: (1/6, 2/6, 3/6)

Post-merger 1: (3/6, 3/6)
Post-merger 2: (1/6, 5/6)
Post-merger 3: (2/6, 4/6)

- merger that disrupts collusion by increasing asymmetry can raise prices
- Symmetric duopoly can have higher consumer surplus than other duopolies

Concluding remarks

Monitoring is PERFECT: when fluctuations in demand small

● collusion easier as largest firm ↓

● monitoring is perfect for larger fluctuations as smallest firm ↑

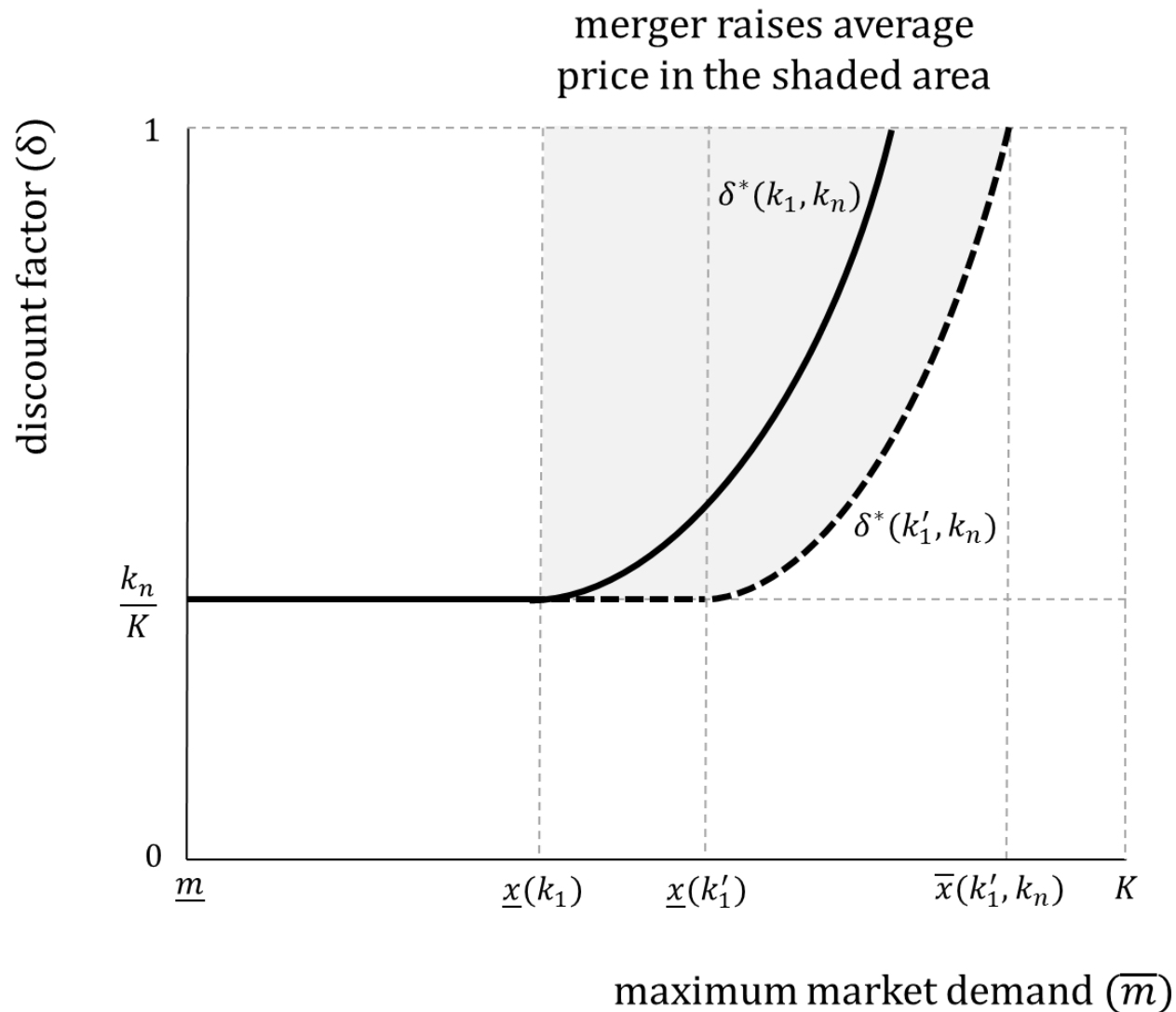Monitoring is IMPERFECT: when fluctuations in demand not small

● collusion easier as largest firm ↓ and smallest firm ↑

● best average price is higher as smallest firm ↑

IMPLICATIONS FOR MERGER POLICY

1) Coordinated effects should not be presumed to be more harm than unilateral
Unilateral effects worse when demand fluctuations are sufficiently large

2) Lack of market transparency not sufficient to rule out coordinated effects
Problems can still arise when the market structure is relatively symmetric

COMPETITIVE EFFECTS OF MERGERS: increasing the smallest firm

merger raises average price in the shaded area

COMPETITIVE EFFECTS OF MERGERS: increasing the largest firm

merger raises average price in the shaded area

discount factor (δ)

$\frac{k'_n}{K}$

$\delta^*(k_1, k'_n)$

$\delta^*(k_1, k_n)$

$\frac{k_n}{K}$

$\underline{m}$ $\underline{x}(k_1)$ $\overline{x}(k_1, k'_n)$ $\overline{x}(k_1, k_n)$ K

maximum market demand ($\overline{m}$)