Collusion under Private Monitoring with Asymmetric Capacity Constraints

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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 ≥ 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**
Unobservable demand fluctuations: \( G(m) \) with \( g(m) > 0 \) on \( [m, \bar{m}] \) 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: \( m \geq K - k_1 = k_2 + \cdots + k_n \)  (highest-priced firm always has positive sales)

● Not restrictive if firms never can collectively supply demand: \( m \geq K \)
● Less restrictive for \( m \) closer to \( K \) when \( m < K \)

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

\[
s_{it} = \begin{cases} 
  k_i, & \text{if } p_i < p_t^{max} \\
  \min \left\{ \frac{k_i}{K - \sum_{j \in \Omega(p_i)} k_j} \left( m_t - \sum_{j \in \Omega(p_i)} k_j \right), k_i \right\}, & \text{if } p_i = p_t^{max}
\end{cases}
\]
Static Nash equilibrium

There exists:

● A unique pure strategy Nash equilibrium with $\pi_i^N = k_i$ if $m \geq K$

● A mixed strategy Nash equilibrium if $m < K$, where profit and average price increases in $k_n$

Intuition:
If $m \geq K$, each firm has monopoly over residual demand

If $m < K$, 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
**PERFECT PRIVATE MONITORING**

Largest firms must detect deviation by the smallest

Proposition 1: There exists a unique level of market demand such that private monitoring in perfect if \( \bar{m} < \bar{m}^*(k_1) \)

Perfect monitoring ensures firms can employ trigger strategies

\[
\delta \geq \frac{\pi^d_i - \pi^m_i}{\pi^d_i - \pi^N_i} = \frac{k_n}{K} \equiv \delta^*(k_n)
\]

(Trigger strategies are optimal given proportional rule)

Corollary 1: \( \delta^*(k_n) \) is strictly increasing \( k_n \), and \( \bar{m}^*(k_1) \) is strictly increasing in \( k_1 \)

Symmetry aids incentives and monitoring
In a collusive phase:

- collude if all firms' sales are only consistent with all firms charging the same price
- otherwise, revert to static Nash for T periods, then collude again

Each firm has a trigger level of sales: \( s_i \equiv m_{-1}^{*} \frac{k_i}{K} \)

Punishment is triggered if \( s_{it} \leq s_i \) for some \( i \)

Trigger event is common knowledge

- if all collude and demand low, then \( s_{it} \leq s_i \) for all \( i \)
- if deviation, deviant gets \( s_{it} = k_i \) & others \( s_{it} \leq s_i \)

(Common knowledge off the equilibrium path as well)
Equilibria in trigger-sales strategies

Firm $i$’s sales

\[
\begin{align*}
\bar{m} \frac{k_i}{K} & \quad k_i \\
\frac{m}{K} & \quad k_i \\
\frac{m^*}{K} & \quad k_i \quad \frac{k_i}{K-k_1} (\bar{m} - k_1) \\
0 & \quad m - (K-k_i)
\end{align*}
\]

\[
V_{iH}^c = \pi_i^c + \delta[(1 - G(m_{-1}^*))V_{iH}^c + G(m_{-1}^*)V_{iL}^c]
\]

\[
V_{iL}^c = \sum_{\tau=0}^{T-1} \delta^\tau \pi_i^N + \delta^T V_{iH}^c
\]

Solve simultaneously, then check no incentive to deviate in a collusive phase:

\[
V_{iH}^c \geq V_{iH}^d
\]

where

\[
V_{iH}^d = \pi_i^d + \sum_{\tau=1}^{T} \delta^\tau \pi_i^N + \delta^{T+1} V_{iH}^c
\]

(When $T$ set to maximise $V_{iH}^c$ subject to ICC, equilibrium equivalent to optimal symmetric PPE)
Parameter space of collusion

- Collusion under perfect private monitoring
- Collusion under imperfect private monitoring
- Collusion is unsustainable

Maximum market demand ($\bar{m}$)
An Example

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

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

Private monitoring is PERFECT: when fluctuations in demand small
- collusion easier as largest firm ↓
- monitoring is perfect for larger fluctuations as smallest firm ↑

Private 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

(a) Increasing the smallest firm’s capacity

\( k_\alpha > k_1 \)
COMPETITIVE EFFECTS OF MERGERS: increasing the largest firm

(b) Increasing the largest firm’s capacity 
\( k_v > k_n \)
Main results

Private monitoring is PERFECT: when fluctuations in demand small

Results similar to Compte et al (2002)

- no price wars on the equilibrium path
- collusion easier as largest firm ↓ (less incentive to deviate)

DIFFERENCE: monitoring is perfect for larger fluctuations as smallest firm ↑

Private monitoring is IMPERFECT: when fluctuations in demand not small

Results similar to Tirole (1988)

- price wars on the equilibrium path where play static Nash for T periods
- coordinated punishment: punishment triggered when chance of a deviation

FINDING: collusion easier as largest firm ↓ and smallest firm ↑
best average price is higher as smallest firm ↑