# Competition with Capacity Constraints and Non-linear pricing, with an Application to Mergers

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# Introduction

# Introduction

- In homogeneous goods markets, firms typically compete in **price given existing capacity** constraints (e.g., steel, aluminium, chemicals,…)
- The canonical model to analyze such markets is **Bertrand-Edgeworth competition** (e.g., Levitan-Shubik, 1972; Dasgupta-Maskin, 1986)
- Unfortunately, Bertrand-Edgeworth competition is well-known to suffer from **serious shortcomings** which have severely limited its use both in economic theory and applications
- E.g., typically **no pure strategy equilibrium**, multiple equilibria, significant discontinuities between strategy and payoff → may lead to **highly unrealistic predictions** and hard to handle technically

# Introduction

- E.g., in merger control (Chen-Li, 2018, Hirata, 2009) only very **limited results** based on strong assumptions (three firms, symmetry, shift in support)
- Our paper: aims to devise **tractable model** of price competition with capacity constraints with **credible predictions** that can be readily used in applications
- Our model differs from BE in two main ways: (i) **allow for non-linear pricing**, (ii) **rationing rule** to allocate scarce capacities with price discrimination
- As a result, the model becomes **highly tractable** and is capable of providing **policy guidance** also in complex market environments

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# Introduction

- Specifically, we **apply model to merger control** to determine the drivers of competitive effects in markets with price competition and capacity constraints
- **Companion paper** to Reisinger & Zenger (2023) on Cournot mergers (price competition versus quantity competition)
- The model allows deriving simple **closed-form solutions** for calibration
- Price effects driven by (i) **change in pivotality** caused by merger, (ii) efficiency differences in **off-equlibrium capacity** of insiders and outsiders
- Model thus **provides micro-foundation** for use of pivotality analysis

# Rectangular demand

# Rectangular demand

- Consider a market for a **homogeneous product** with $p(x) = v$ for $x \leq \theta$ and $p(x) = 0$ for $x > \theta$ (**rectangular demand**)
- $n \geq 2$ firms with marginal cost $c$, **capacity** $k_i > 0$ and $k := \sum_i k_i > \theta$
- Firms can set **non-linear prices schedules** $p_i(u_i)$ for units $u_i \in [0, k_i]$
- As firms are capacity constrained, a **rationing rule** is required to allocate scarce units to customers
- We adapt Kreps-Scheinkman (1983) and Vives (1986) „**efficient rationing**“ to non-linear pricing: (i) offers that generate the **highest consumer surplus** serve consumers first, or (ii) **Walrasian purchaser** (equivalent outcome)

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# Rectangular demand

- Let **pivotal capacity** of firm $i$ be denoted by $\tilde{k}_i = max\{\theta - k_{-i}, 0\}$ (with $k_{-i} := \sum_{j \neq i} k_j$ and $\tilde{k} = \sum_i \tilde{k}_i$)

**Proposition 1**: *In the unique equilibrium outcome, each firm $i$ obtains a profit $v - c$ for pivotal units $\tilde{k}_i$ and zero for non-pivotal units $k_i - \tilde{k}_i$.*

- Let **pivotality** as percentage of **capacity** be $\gamma_i := \tilde{k}_i / k$ (with $\gamma = \sum_i \gamma_i$)
- Let **pivotality** as percentage of **demand** be $\mu_i := \tilde{k}_i / \theta$ (with $\mu = \sum_i \mu_i$ )
- Thus, the average **equilibrium price** is given by: $\bar{p} = \mu v + (1 - \mu) c$
- I.e., pivotality $\mu$ is a **conduct parameter** that measures the degree of market power in a given market

# Rectangular demand

- It therefore makes sense to **inspect pivotality** in some more detail
- Let $s_i = k_i/k$ be firm $i$'s **capacity share** and $e = (k - \theta)/k$ be the market's **excess capacity** as a percentage of total capacity
- Then **one can show** that $\gamma_i = max\{s_i - e, 0\}$ and $\mu_i = max\left\{\frac{s_i - e}{1 - e}, 0\right\}$
- Pivotality can thus be viewed as a **concentration measure** that additionally accounts for an industry's **capacity utilization**

**Lemma 1**: *For a given capacity allocation* $\{k_1, \ldots, k_n\}$*, (i)* $\mu$ *and* $\gamma$ *are (weakly) decreasing in* $e$*, (ii)* $\mu$ *and* $\gamma$ *are (weakly) increasing in* $HHI = \sum_{i=1}^{n} s_i^2$*.*

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# Merger effects

# Post-merger equilibrium

- Next, let firms 1 and 2 **merge** (without loss of generality, let $k_1 > k_2$)
- If a merger **increases** $\mu$, it increases prices:

**Proposition 2**: *With rectangular demand,* $\forall \mu > 0$, *the price effect of a merger is given by:*

$$\frac{\Delta \bar{p}}{\bar{p}} = \frac{\Delta \mu}{\mu} m$$

- Merger effects larger with larger **pre-merger market power** ($m$) and larger merger-specific **increment** ($\Delta \mu / \mu$)
- It is therefore important to **assess** when $\Delta \mu / \mu$ is large depending on $s_1 + s_2$

# Post-merger equilibrium

**Proposition 3**: $\forall \mu > 0$, *the pivotality change caused by a merger is given by:*

$$\frac{\Delta\mu}{\mu} = \frac{\Delta\gamma}{\gamma} = \begin{cases} e/\gamma & if\ e \in [0, s_2[ \\ s_2/\gamma & if\ e \in [s_2, s_1[ \\ (s_1 + s_2 - e)/\gamma & if\ e \in [s_1, s_1 + s_2[ \\ 0 & if\ e \geq s_1 + s_2 \end{cases}$$

- Proposition 3 thus determines a simple **closed-form solution for merger effects** that is solely based on simple observable parameters
- Use of pivotality has largely been confined to regulatory context in electricity markets, but our results provide a **micro-foundation** and show that it has far wider applicability (it‘s about changes not levels for mergers)

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# Comparative statics

# Comparative statics

- From Lemma 1, higher capacity utilization implies **larger market power**
- One might therefore expect that higher utilization **increases merger effects** (as is the case for market shares from Proposition 3), yet:

**Corollary 1**: (i) *The impact of capacity utilization on* $\Delta\mu$ *caused by a merger follows an inverted U-shape with maximum at* $e = s_1$*. (ii) In markets with large excess supply (*$e \geq s_1 + s_2$*) or excess demand (*$e \leq 0$*),* $\Delta\mu = 0$*.*

- Merging parties often argue that excess capacities of rivals would **undermine any attempt** to raise prices as goods are homogeneous
- But from Corollary 1, this requires $e \geq s_1 + s_2$ (parties not pivotal pre- or post-merger) → **extreme excess capacity** (e.g., 40% for 40% share merger)

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# Comparative statics

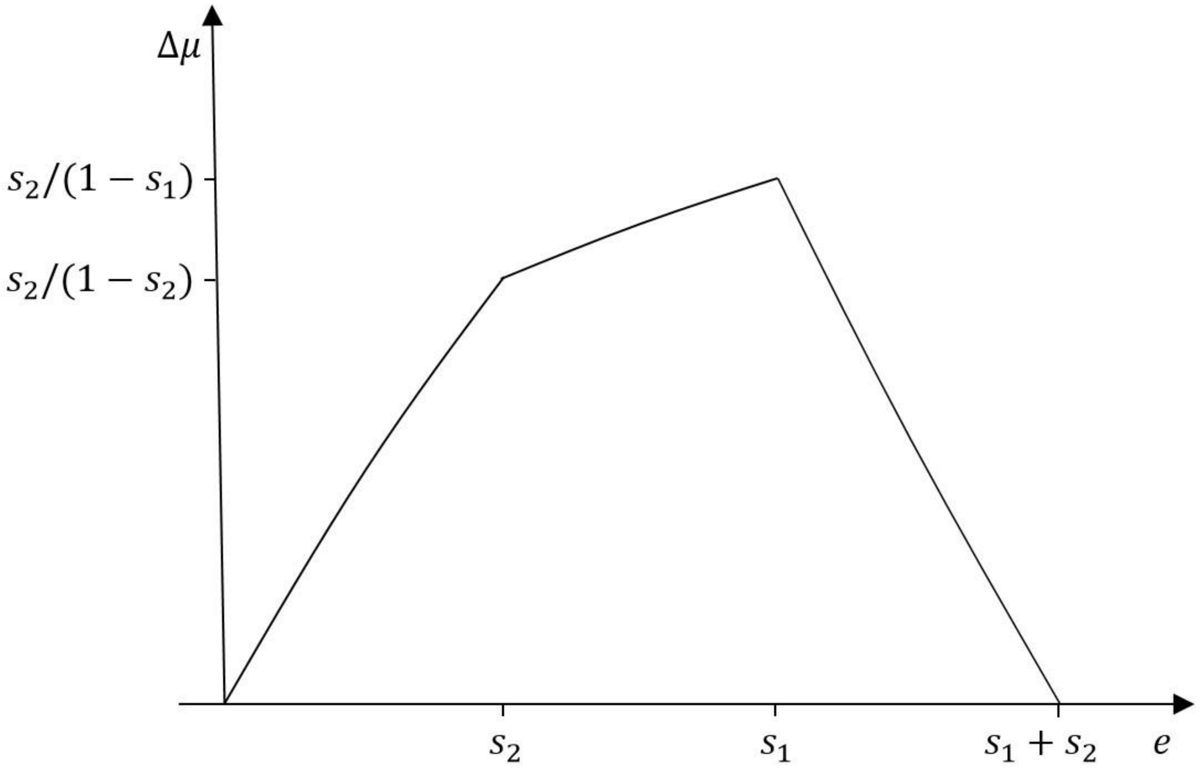


**Figure 1**: The impact of capacity utilization on merger effects

# Comparative statics

- If either of the merging firms earns positive margin pre-merger, this shows that rival excess capacity did not beat price increase **even pre-merger**
- Post-merger, the ability and incentive of rivals to prevent price increases will **decline even further**
- **Extensions**:
  - **Downward-sloping demand**
  - **Heterogeneous costs**
  - **Other applications**: e.g., inflation and business cycles

# Thank you



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