Vertical Contracting with Endogenous Market Structure

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Manufacturers in different industries use different structures of retail networks.
Motivation

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  - monopolistic retailers for car manufacturers
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⇒ Analyze endogenous retail market structures with asymmetric information between manufacturer and retailers
Research Questions

- Monopolistic manufacturer chooses the **number of retailers**
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3. Which factors determine the number of retailers?
4. What are the effects on welfare?
Results

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- Market is ‘small’ and price is ‘rigid’
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- Lower number of retailers or vertical merger may increase welfare
Related Literature

- Opportunism problem with multiple retailers:
  - Effect of off-equilibrium beliefs: McAfee and Schwartz 1994, Rey and Vergé 2004
  - Segal and Whinston 2003: menus of two-part tariffs reduce opportunism problem

- Dequiedt and Martimort 2015: informational opportunism with asymmetric information and public contracting

- Contracting with externalities: Segal 1999
Multiple Retailers

- Asymmetric retailers (e.g., Hansen and Motta 2012)
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... we focus on asymmetric information
Outline

- Model
- Two Types
- Optimal Market Structure
- Example
- Welfare
Manufacturer $M$ sells to retailers $R_i, i = 1, ..., N$
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Contracts

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\[ \{x_i(m_i), T_i(m_i)\} \]
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- **Secret bilateral contracts** fully determined by $m_i$, and independent of other retailers’ reports and quantities
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Contracts

- **M** offers to **R**<sub>i</sub>
  \[
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  \]

  - \(x_i(m_i)\) = quantity sold by **R**<sub>i</sub>
  - \(T_i(m_i)\) = tariff paid to **M**
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    (equivalent to non-linear tariff \(T(x)\))

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  ⇒ Opportunism problem and no full rent extraction
Timing

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   - Long-term choice that cannot be secretly changed
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2. \( M \) offers contracts

\[
\pi_i = \sum_{N_i=1}^{T} \left( m_i \right) c + \sum_{N_i=1}^{T} x_i \left( m_i \right)
\]

\[
u_i = h \sum_{j=1}^{N} x_j m_j \theta_i x_i \left( m_i \right) T_i \left( m_i \right)
\]

Perfect Bayesian Equilibrium with passive (and wary) beliefs
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3. Retailers compete in downstream market
   - $M$’s profit is
     \[
     \pi = \sum_{i=1}^{N} T_i (m_i) - c \left( \sum_{i=1}^{N} x_i (m_i) \right)
     \]
   - $R_i$’s profit is
     \[
     u_i = \left[ P \left( \sum_{j=1}^{N} x_j (m_j) \right) - \theta \right] x_i (m_i) - T_i (m_i)
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Basic Insights: Two Types

- $\theta \in \{0, \bar{\theta}\}$, with $\text{Pr} [\theta = \bar{\theta}] = \frac{1}{2}$
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- \( M \) chooses between 1 and 2 retailers
Monopolistic Retailer

- $N = 1$: monopolistic screening
Monopolistic retailer

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- Incentive compatibility constraint of low-cost type and participation constraint of high-cost type bind

Information rent of low-cost type is $u = \theta$ (incentive to report $\theta$, sell $x$ and pay lower $T$)

High-cost type’s quantity is downward distorted
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  \( \Rightarrow \) High-cost type’s quantity is downward distorted
Opportunism Problem with Complete Information

- $N = 2$: competing retailers

$M$: market

$R_1$, $R_2$: retailers

Consumers
\( N = 2 \): competing retailers

With secret contracting, \( M \) has incentive to increase quantity sold to each retailer to maximize bilateral profit.
$N = 2$: competing retailers

With secret contracting, $M$ has incentive to increase quantity sold to each retailer to maximize bilateral profit

$\Rightarrow M$ cannot obtain monopoly profit
Competing Retailers with Private Information

- **Information rent** of low-cost type is

\[
u_i = \theta \bar{x}_i - \left[ P(\bar{x}_i + \bar{x}^*) - P(\bar{x}_i + \bar{x}^*) \right] \bar{x}_i
\]

\[
= \underbrace{\theta \bar{x}_i}_{\text{standard rent}} - \underbrace{(\bar{x}^* - \bar{x}^*) \bar{x}_i}_{\text{competing contracts}}
\]

where \(\bar{x}^*\) and \(\bar{x}^*\) are eqm quantities of low- and high-cost type
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- **Competing-contracts effect**: when \( R_i \) with cost 0 reports \( \bar{\theta} \), he knows that \( R_j \) has cost 0 (since costs are equal).
Information rent of low-cost type is

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Competing-contracts effect: when \( R_i \) with cost 0 reports \( \bar{\theta} \), he knows that \( R_j \) has cost 0 (since costs are =)

\[ \Rightarrow R_j \text{ sells a larger quantity and reduces market price } P (\bar{x}_i + x^*) \]
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Competing Retailers with Private Information

- **Information rent** of low-cost type is

\[ u_i = \dot{\theta} \bar{x}_i - [P(\bar{x}_i + \bar{x}^*) - P(\bar{x}_i + \bar{x}^*)] \bar{x}_i \]

\[ = \dot{\theta} \bar{x}_i - (\bar{x}^* - \bar{x}^*) \bar{x}_i \]

where \( \bar{x}^* \) and \( \bar{x}^* \) are eqm quantities of low- and high-cost type

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  but \( T \) neglects this, since \( M \) assumes retailers’ cost is \( \dot{\theta} \) and market price is \( P(\bar{x}_i + \bar{x}^*) \)

  \[ \Rightarrow R_i \text{ has lower incentive to misreport } \theta \text{ (than without } R_j) \]
One vs. Two Retailers

- **Proposition.** If $\bar{\theta} = 0$, then $\pi_{N=1}^* > \pi_{N=2}^*$. \\
\[ \forall \bar{\theta} > 0, \exists \beta^* \text{ such that } \pi_{N=2}^* > \pi_{N=1}^* \iff \beta > \beta^*. \]
One vs. Two Retailers

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- With complete information, $M$ chooses 1 retailer to eliminate opportunism problem
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- Large $c''(X)$ implies:
  - weaker opportunism problem
  - stronger incentive to misreport $\theta$
  because increasing production is costly
One vs. Two Retailers

- **Proposition.** If $\bar{\theta} = 0$, then $\pi^*_N = 1 > \pi^*_N = 2$.

  $\forall \bar{\theta} > 0$, $\exists \beta^*$ such that $\pi^*_N = 2 > \pi^*_N = 1 \iff \beta > \beta^*$.

- With complete information, $M$ chooses 1 retailer to eliminate opportunism problem.

- Large $c''(X)$ implies:
  - weaker opportunism problem
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  because increasing production is costly

  $\Rightarrow$ With asymmetric information, $M$ chooses 2 retailers to reduce information rent


Main Model

- \( N \) retailers
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- $N$ retailers

- $\theta \sim [\underline{\theta}, \overline{\theta}]$ with c.d.f. $F(\theta)$ and p.d.f. $f(\theta)$
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- $h(\theta) \triangleq F(\theta)/f(\theta)$ increasing
Main Model

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- "Well behaved" demand $P(X)$
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- "Well behaved" demand $P(X)$

- $M$'s cost $c(X)$
Benchmark with Complete Information

- $N$ bilateral contracting problems:
  
  $\max_{x_i(\theta)} \left[ P(\cdot) - \theta \right] x_i(\theta) - c(\cdot)$
Benchmark with Complete Information

- \( N \) bilateral contracting problems:

\[
\max_{x_i(\theta)} \left( P(\cdot) - \theta \right) x_i(\theta) - c(\cdot)
\]

- With symmetry, FOC yields

\[
P(\mathcal{N}x^C(\theta)) + P'(\mathcal{N}x^C(\theta))x^C(\theta) = \theta + c'(\mathcal{N}x^C(\theta))
\]
Benchmark with Complete Information

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\( \Rightarrow \) \( M \) does not internalize effect of increasing \( R_i \)'s quantity on other retailers' profit: Cournot quantities \( x^C(\theta) \)
Benchmark with Complete Information

- $N$ bilateral contracting problems:

$$\max_{x_i(\theta)} \left[ P(\cdot) - \theta \right] x_i(\theta) - c(\cdot)$$

- With symmetry, FOC yields

$$P(Nx^C(\theta)) + P'(Nx^C(\theta))x^C(\theta) = \theta + c'(Nx^C(\theta))$$

$\Rightarrow$ $M$ does not internalize effect of increasing $R_i$’s quantity on other retailers’ profit: Cournot quantities $x^C(\theta)$

- Proposition. With complete information, $M$ uses 1 retailer
Benchmark with Complete Information

- \( N \) bilateral contracting problems:

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\( \Rightarrow \) \( M \) does not internalize effect of increasing \( R_i \)'s quantity on other retailers' profit: Cournot quantities \( x^C(\theta) \)

- **Proposition.** *With complete information, \( M \) uses 1 retailer*

- Monopolistic retailer eliminates opportunism problem
Asymmetric Information

- $R_i$’s information rent is

\[
u_i(\theta) = \int_\theta^{\bar{\theta}} x_i(z) \, dz - (N - 1) \int_\theta^{\bar{\theta}} P'(\cdot) \dot{x}^*(z) x_i(z) \, dz
\]

\[\text{Competing-contracts effect}\]

When $R_i$ over-reports $\theta$, other retailers sell larger quantity, lowering market price. M's tariff neglects this, reducing $R_i$'s utility. As $N$ increases, $R_i$ faces lower price when he over-reports $\theta$. Competing-contracts effect strengthens, stronger competition among retailers reduces their information rents.
Asymmetric Information

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**Competing-contracts effect**

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  \[\Rightarrow\] lower market price
Asymmetric Information

- $R_i$’s **information rent** is

$$u_i(\theta) = \int_{\bar{\theta}}^{\theta} x_i(z) \, dz - (N - 1) \int_{\theta}^{\bar{\theta}} P'(\cdot) \, x^*(z) \, x_i(z) \, dz$$

- Competing-contracts effect

- When $R_i$ over-reports $\theta$, other retailers sell larger quantity
  ⇒ lower market price

- $M$’s tariff neglects this, which reduces $R_i$’s utility
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  \[ \Rightarrow \text{Competing-contracts effect strengthens} \]
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  $\Rightarrow$ Competing-contracts effect strengthens

- Stronger competition among retailers reduces their information rents
Optimal Bilateral Contract

- $M$ solves

\[
\max_{x_i(\cdot)} \int^{\bar{\theta}}_{\theta} \left[ (P(\cdot) - \theta - h(\cdot)) x_i(\cdot) - c(\cdot) \right] dF(\theta) + \\
+ \int^{\bar{\theta}}_{\theta} h(\cdot) (N - 1) P'(\cdot) \dot{x}^* (\cdot) x_i (\cdot) dF(\theta)
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- FOC yields non-linear differential equation

$$\dot{x}^*(\theta) = \frac{\theta + h(\theta) + c'(\cdot) - (P'(\cdot) x^*(\theta) + P(\cdot))}{h(\theta) (N - 1) (P'(\cdot) + P''(\cdot) x^*(\theta))}$$

with boundary condition $x^*(\theta) = x^C(\theta)$
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with boundary condition $x^*(\theta) = x^C(\theta)$

- Lemma. $x^*(\theta) < x^C(\theta)$ for every $\theta > \underline{\theta}$ and $\dot{x}^*(\theta) < 0$
Optimal Retail Network

- $\pi^*(N) = M$’s profit with $N$ (continuous number of) retailers

**Theorem**

*M never uses a single retailer because*

$$\lim_{N \to 1^+} \frac{\partial \pi^*(N)}{\partial N} > 0.$$  

*Optimal $N$ is finite because $\pi^*(1) > \lim_{N \to \infty} \pi^*(N)$.*
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- At $N = 1$, opportunism problem vanishes and negative effect of increasing $N$ is second order
Linear-Quadratic Example

- To address the integer constraint on $N$, let
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$M$’s expected profit is

$$\pi^*(N) = \frac{2Nb + \beta N^2}{2} \int_0^1 x^*(\theta)^2 \ d\theta^{\frac{1}{\lambda}}$$

where

$$x^*(\theta) = \frac{a}{b(N+1) + \beta N} - \frac{\theta(1+\lambda)}{b(N+1) + \beta N + \lambda b(N-1)}$$
Proposition. \( \pi^* (2) > \pi^* (1) \) if: (i) \( a \) is small or (ii) \( \beta / b \) is large
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\[ \Rightarrow \] weaker opportunism problem and higher information rents
As $\lambda$ increases, retailers’ are more likely to have low cost and information rents increase.

Parameters: $a = 5$, $b = 1.0$, $\beta = 3.0$
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$\Rightarrow$ Optimal $N$ is increasing in $\lambda$: 3 for $\lambda = 1$, 6 for $\lambda = 2$
Consider a regulator who maximizes welfare by
- choosing the **number of retailers** or
- allowing/prohibiting a **vertical merger**
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- Linear-quadratic framework, $\lambda = 1$
**Proposition.** If $\beta/b$ is large, $M$ chooses more retailers than socially optimal.
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With flat demand (i.e., $b$ small), increase in $N$ has:

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Suppose $M$ learns $\theta$ by merging with an exclusive retailer (empirical evidence that efficiency drives vertical mergers)
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A vertical merger eliminates:
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A vertical merger eliminates:

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Large $\beta/b \Rightarrow$ large distortion to reduce information rent (because profit of a retailer who overreports cost is large)
Extensions

- Wary beliefs
- Price competition
- Imperfect cost correlation
- Alternative mechanisms:
  - Sequential contracting
  - Auction among retailers
Wary Beliefs

When $R_i$ is offered a contract $C_i$, he believes that:
Wary Beliefs

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- When $R_i$ is offered a contract $C_i$, he believes that:
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  - \( R_{-i} \) reasons the same way
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- $R_i$’s (linear) belief is $x_{-i}(\theta, x_i)$
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- $N = 1, 2$
Proposition. With wary beliefs and complete information:

(i) Beliefs are \( \frac{dx_i(\cdot)}{dx_i} = -\frac{\beta}{2} \)

(ii) Quantities are larger than with passive beliefs

(iii) \( M \) uses one retailer
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Market is more competitive with wary beliefs
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Market is more competitive with wary beliefs

- When \( M \) offers larger quantity to \( R_i \),
  - \( R_i \) assumes that \( M \) sells less to \( R_j \) and
  - \( R_i \) is willing to pay higher tariff
Asymmetric Information

- $R_i$’s information rent is

\[
\begin{align*}
    u_i(\theta) &= \int_\theta^{\bar{\theta}} x_i(z) \, dz \\
    &- \int_\theta^{\bar{\theta}} P'(\cdot) \left[ \frac{d x_{-i}(\cdot)}{d z} + \frac{d x_{-i}(\cdot)}{d x_i(z)} \dot{x}_i(z) \right] x_i(z) \, dz, \\
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- Qualitative results similar to passive beliefs
Price Competition

- Contracts are two-part tariffs \( \{ T_i(m_i), w_i(m_i) \} \)
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**Competing-contracts effect**
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- When \( R_i \) over-reports \( \theta \), other retailers charge low prices
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- Eqm with passive beliefs may not exist (Rey and Vergé 2004)
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- Retailers’ costs are (e.g., Armstrong and Vickers 2010):
  - identical with prob. \( \nu \)
  - i.i.d. with prob. \( (1 - \nu) \)
- \( R_i \)’s information rent is

\[
u_i(\theta_i) = \int_{\theta_i}^{\bar{\theta}} x_i(z) \, dz + \]
\[- \nu (N - 1) \int_{\theta_i}^{\bar{\theta}} P'(x_i(z) + (N - 1) x_N^*(z)) \dot{x}_N^*(z) x_i(z) \, dz\]

Competing-contracts effect

- With asymmetric retailers, higher \( N \) increases output variance and profit (function convex in price)
Alternative Mechanisms

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  - $M$ would obtain monopoly profit but retailers have no incentive to participate.
  - With sequential entry, only 1 retailer participates and the auction price is 0.
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• Although opportunism problem provides incentive to foreclose, competition among retailers reduces information rents

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• Foreclosure is less likely in markets where asymmetric information is more relevant

• Welfare may increase with fewer retailers or vertical merger