Misallocation effects of collusion under uniform pricing in differentiated-product markets[1]

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[1]Legal disclaimer: This paper analyses any alleged cartel activity strictly from an economic point of view. To our knowledge there has been no antitrust investigation into collusive practices in this market.

Collusion and misallocation

- **Question:** Does collusion affect the allocation of production?
- Focus of literature: manufacturing/producer cartels
  - Asker et. al (2019) - OPEC
  - Bridgman et. al (2015) - New Deal sugar cartel

→ Misallocation implied by the use of collusive production quotas
  - High cost firms allocated market share at expense of low cost firms

- **This paper:** Investigates the misallocation of production in retail markets

Retail Cartels

- Allocation not determined through quotas
  - But by the prices firms set and consumers' choices about where to shop
  - Firms/products are differentiated and consumers have heterogeneous preferences
- Moreover, retail cartels typically facilitate coordination by colluding on **few** prices
- The effect of conduct on cost misallocation depends on:
  - Cost pass-through rate under collusion vs competition
  - Differentiation: Willingness of consumers to buy from low-cost suppliers
  - Correlation between consumer preferences for suppliers and productivity
- Collusive pricing may also affect the set of firms that operate in the market
  - Dynamic production inefficiency
- **Research question:** What is the effect of uniform-price collusion on cost misallocation?

What we do

1. Provide suggestive evidence of uniform-price collusion in Quebec City
2. Quantify the degree of spatial differentiation
   - Incorporate consumers' commuting patterns in the canonical RC logit model
3. Pricing optimality conditions and demand estimates
   - Recover the marginal cost of each station
4. Counterfactual analysis to quantify the extent of productive inefficiency
   - Olley & Pakes decomposition
   - Compare data to counterfactual scenarios: (1) Bertrand-Nash, (2) Perfect Competition and (3) Efficient allocation.
5. Examine the effect of collusion on dynamic misallocation
   - Compare the incentive to invest and enter with and without uniform price collusion
   - Measure changes productivity growth during the collusive period

What we find

- Evidence of uniform pricing and high margins in Quebec City's retail gasoline market
- Misallocation increases aggregate production costs by roughly 1 cpl (compared to retail margin of roughly 10 cpl)
- Persistent negative correlation between marginal cost and market shares
  - Low-cost stations located close to consumers and have attractive characteristics
  - Limits the extent of misallocation
- Preliminary evidence of inefficiency of investment decisions

Contribution to the literature

- Cartels and Misallocation
  - Asker et al (2019), Bridgman et al (2015), Asker (2010), Röller and Steen (2006)
- Cartels and Damages
  - Miller & Weinberg (2017), Clark et al (2018), Kim et al (2023)
- Collusion in retail gasoline
  - Assad et al (2024), Sorgard and Steen (2024), Chaves and Duarte (2022, 2024), Byrne and deRoos (2019), Clark and Houde (2013, 2014)
- Uniform Pricing
  - DellaVigna and Gentzkow (2019), Hitsch, et al (2021), Gabrielsen et al (2023), Adams and Williams (2019)

Overview

1. Institutional Background
2. Evolution of Conduct
   - Non-cooperative pricing
   - Price war
   - Collusion
3. Empirical Model
   - Demand
   - Supply
4. Quantifying Misallocation
   - Static cost inefficiencies
   - Investment distortions
   - Evidence of dynamic misallocation

Institutional Background

Industry overview

- Gasoline industry is composed of:
  - Refineries
  - Stations
- Three types of stations:
  - Refinery owned
  - Branded independent
  - Unbranded independent
- Price floor:

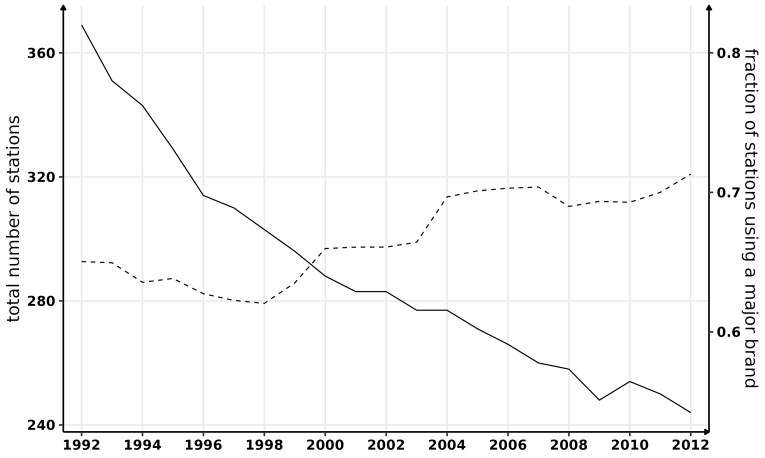
$$MEP_{mt} = w_t + \tau_{mt} + T_{mt},$$

w_t: min wholesale price; τ_{mt}: estimated transportation cost; T_{mt}: federal/provincial taxes

Data

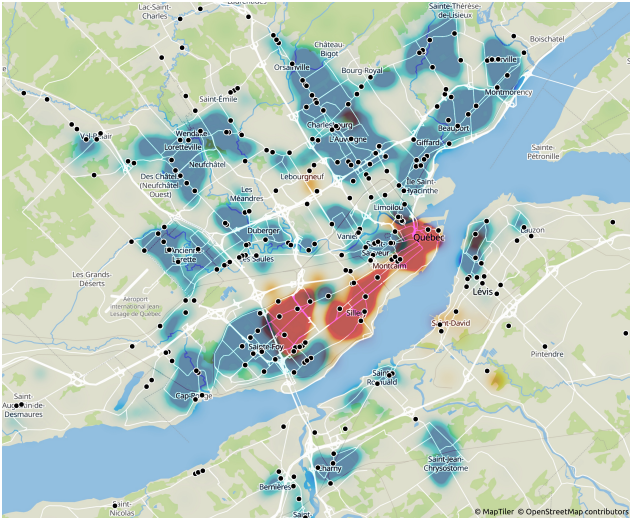
- **Kent Marketing (now Kalibrate)**
  - Bi-monthly station level data (1992 to 2001, and parts of 2004 and 2007):
    - Volumes
    - Posted prices
    - Station characteristics: # pumps, # islands, convenience store, repair shop, carwash, brand
- **Regie de l'energie / MJ Ervin (now Kalibrate)**
  - Weekly survey data (from 2002 to 2012):
    - Posted prices for a sample of stations

Evolution of Number of Stations & Networks of Major Brands



- *Notes*: Total number of stations(solid line) and the network size of the five largest brands(dashed line).

Québec City -station location and net traffic flow



Summary Stats

	Fall-1993		Fall-1999		Fall-2004	
Price (cents/liter)	66.18	(0.67)	66.04	(0.81)	83.96	(0.58)
Volume (ths liters/day)	**3.59**	**(2.21)**	**5.19**	**(3.33)**	**6.13**	**(3.58)**
Number of pumps	**5.87**	**(4.09)**	**7.22**	**(4.96)**	**8.10**	**(5.44)**
Number of islands	**2.20**	**(1.34)**	**2.38**	**(1.40)**	**2.51**	**(1.41)**
Large convenience	0.25	(0.43)	0.31	(0.46)	0.41	(0.49)
Repair shop	0.31	(0.46)	0.24	(0.43)	0.21	(0.41)
Carwash	0.20	(0.40)	0.19	(0.39)	0.19	(0.39)
Major brands share	0.70	(-)	0.76	(-)	0.79	(-)

- Stations are asymmetric in size and get larger over time

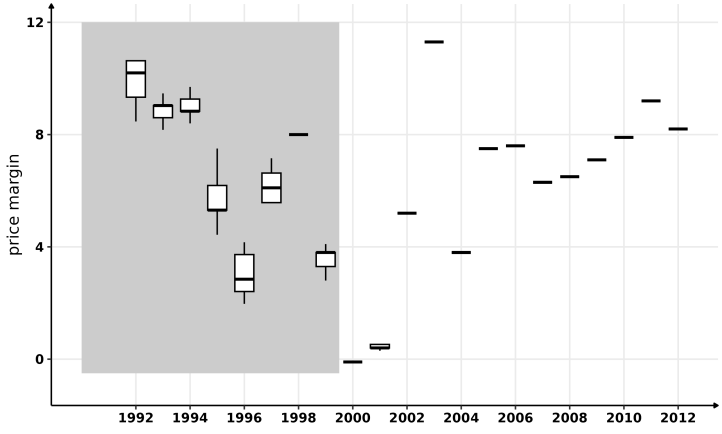
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- Stations have different amenities

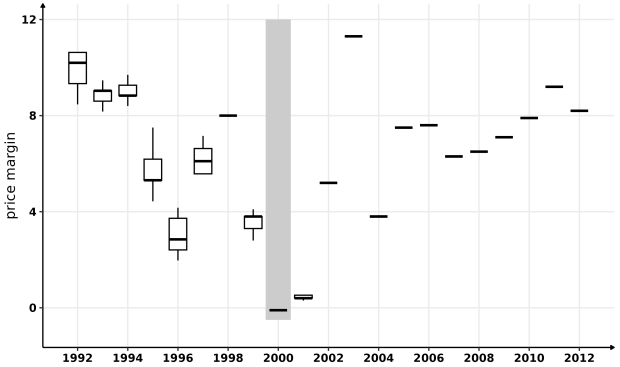
Evolution of conduct: 1992-1999

- Non-cooperative period:
  - Stable price dispersion
  - Declining margins due to excess capacity
- Implementation of price floor in 1997



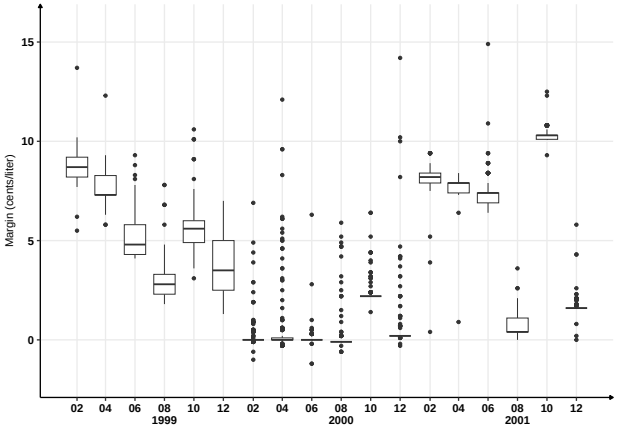
Evolution of conduct: 2000

- Price-war period:
  - Approximately zero margins (floor)
  - Uniform prices across most neighborhoods
- Cause: Clark, Duarte, and Houde (2024)
  - Margin support clauses
  - Deviation from RPM
  - City-wide punishment



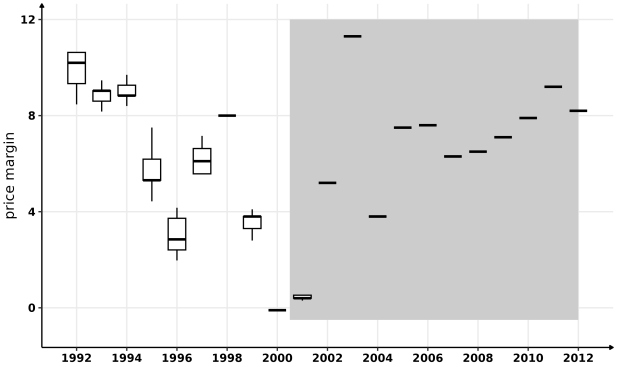
Evolution of conduct: 2000

- Price war duration:
  - Zero margin period lasted approximately 1 year
  - Government investigation led to a temporary increase of the price floor

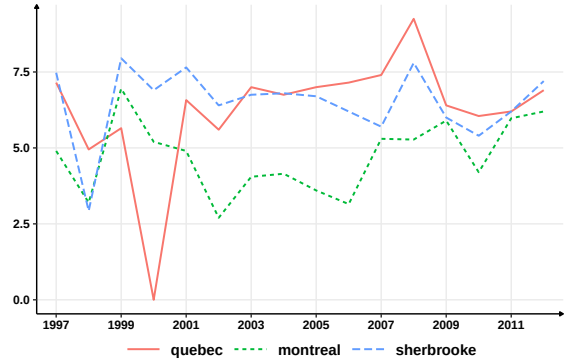


Margins distribution over time in Quebec City: **2001-2012**

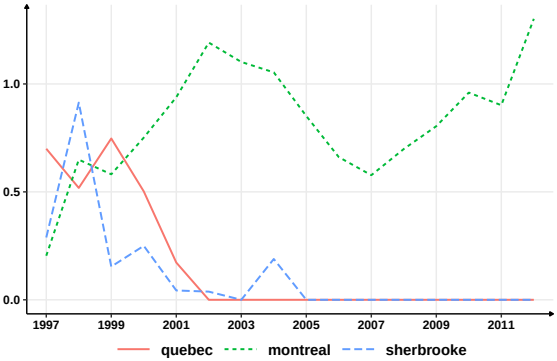
- Collusion period:
  - Increase in margins
  - Uniform prices
- Why inconsistent with competition?
  - Firm asymmetries: Location + Cost
  - Existence of short-run profitable deviation



Evolution of weekly margins and dispersion in Québec City, Montreal and Sherbrooke



(a)



(b)

Source: Régie de l'Énergie du Québec (1998-2001), and MJ Ervin (2001-2012).

Additional evidence of collusion: Price adjustments and Bureau investigation

Source: Clark and Houde (2013, 2014)

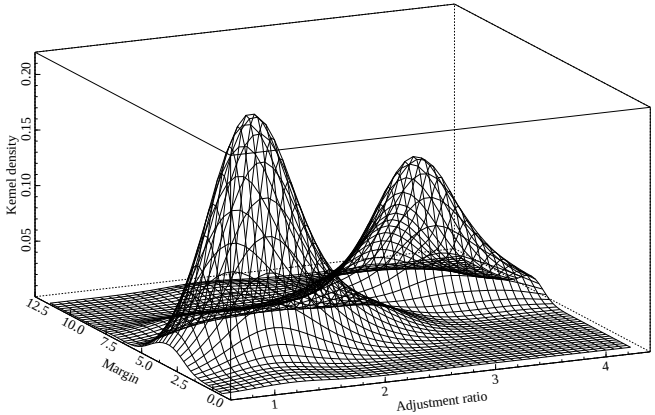
- Markets on eastern side of the province (including Quebec City) feature pricing similar to nearby cartel uncovered by Competition Bureau
  - High margins
  - Asymmetric pricing adjustments (price changes $\neq$ cost changes)

$$\text{Adjustment ratio}_{jt} = \frac{\text{Median price increases}_{jt}}{\text{Median price decreases}_{jt}} \Big/ \frac{\text{Median floor increases}_{jt}}{\text{Median floor decreases}_{jt}} > 1$$

- Markets on western side of the province:
  - Low margins
  - Symmetric pricing adjustments

Two groups of markets: 2001-2004

Source: Clark and Houde (2013, 2014)



Effect of investigation announcement on margins and price adjustments

Source: Clark and Houde (2013, 2014)

Median margins (cpl) and Adjustment ratios

MARKETS	Cartel Period		After		Differences	
	Margin (cpl)	Adjustment Ratio	Margin (cpl)	Adjustment Ratio	Margin (cpl)	Adjustment Ratio
Avg. target (T_D)	6.96	3.08	4.59	1.75	-2.37	-1.33
Avg. East (T_E)	7.42	3.41	6.37	2.54	-1.05	-.871
Competitive (C)	3.84	1.57	3.76	1.78	-.085	.210
Differences: $T_D - C$	3.11	1.52	.83	.03	-2.28	-1.54
Differences: $T_E - C$	3.57	1.85	2.61	.77	-.97	-1.08

Empirical Model

Model Overview

Follows Houde (2012) to take seriously spatial differentiation

- Consumers
  - Discrete choice over (spatially) differentiated gas stations
  - Purchase gasoline from one of the stations or the outside option of not purchasing fuel
- Firms
  - Model of price competition
  - Assume brands set stations' prices
  - Consider the pre price war sample period

Consumer Heterogeneity

- A consumer i is modeled as an origin-destination (o,d) pair
  - QC is divided in 950 regions
  - Data on number of individuals that live and work in each region
- $r(\cdot,\cdot)$: function that determines the shortest driving time between two points
- D_{ik}: *additional* driving time incurred by i from its commuting path when driving to k

$$D_{ik} = r(o,k) + r(k,d) - r(o,d)$$

- D_{ik} is our measure of distance between i and k

Utility Function

- The conditional indirect utility of station j, for consumer i in market t is:

$$u_{ijt} = X_{jt}\beta + \xi_{jt} - \alpha p_{jt} \; + \; \lambda D_{ij} + \epsilon_{ijt}$$

$$i = 1, ..., I_t; \;\; j = 0, ..., J_t; \;\; t = \text{bimonthly 92-01, two bimonths in 04,07}$$

where,

- X_{jt}: K-dimensional vector of observed station characteristics
- ξ_{jt}: unobserved (to the econometrician) product characteristic
- p_{jt}: posted retail price
- α**: price sensitivity**
- λ**: travel cost**
- ϵ_{ijt}: consumer's i idiosyncratic taste for station j - i.i.d T1EV

Market Shares

- Define,

$$u_{ij} = \underbrace{X_j\beta + \xi_j - \alpha p_j}_{\delta_j} + \underbrace{\lambda D_{ij}}_{\mu_{ij}} + \epsilon_{ij}$$

$$u_{i0} = \epsilon_{i0}$$

- For each i – (o,d) pair – integrate out the T1EV shock:

$$Pr_{j,(o,d)} = \frac{\exp(\delta_{jt} + \mu_{(o,d)j})}{1 + \sum_k \exp(\delta_{kt} + \mu_{(o,d)k})},$$

- For each station j, the predicted market share is:

$$s_j(\mathbf{p}_t, \boldsymbol{\xi}_t, J_t) = \sum_d \sum_o Pr_{j,(o,d)} T_{(o,d)}$$

where, $T_{(o,d)}$ is the density of consumers in each OD pair

Supply

- Brands simultaneously choose posted retail prices at their stations to max variable profits:

$$\pi_f^*(\mathbf{p}_f, \mathbf{p}_{-f}) = \max_{\mathbf{p}} \sum_{j \in J_f} (p_j - c_j) \times Q_j(\mathbf{p}_f, \mathbf{p}_{-f})$$

- Equilibrium of the game is characterized by system of FOC:

$$\mathbf{q}(\mathbf{p}) + (\mathbf{\Omega} * \mathbf{\Delta})(\mathbf{p} - \mathbf{c}) = 0$$

$$\Delta_{(j,\ell)} = \frac{\partial q_j}{\partial p_\ell}$$

- Where quantity data unavailable: $c_j = W_j\gamma + \theta MEP + \omega_f + \eta_j$,

Identification

- Price sensitivity (α) identified with exogenous changes in ownership
  - Ultramar/Sunoco merger in 1997
  - Involved all Ultramar and Sunoco stations, so change in ownership not correlated with station-level demand shocks
- Travel cost (λ) identified using measures of local competition:
  - Proximity to low price stations during 2000 price war
  - Number of nearby stations with same type as station j i.e., self/full (differentiation IV)
- Marginal cost parameters identified with co-movements between implied mc and station characteristics

Model estimates

Demand		Supply	
Linear parameters - δ		*Marginal Cost*	
price (α)	-0.14 (0.027)	MEP	0.698 (0.0041)
# pumps	0.026 (0.003)	# pumps	-0.022 (0.005)
# islands	-0.003 (0.012)	no conv. store	0.383 (0.088)
repair shop	-0.277 (0.049)	repair shop	0.384 (0.102)
carwash	0.118 (0.036)	carwash	-0.117 (0.081)
conv. store	-0.146 (0.035)	self-service	0.12 (0.07)
self service	0.122 (0.028)	ultramar	-1.15 (0.084)
		constant	15.45 (0.242)
Non-linear parameters			
travel cost (λ)	-0.418 (0.103)		
J stat	0.853	Avg. Markup(cents)	8.11
# IVs	7	Avg. Marginal Cost (cents)	
λ/α	2.99	R-squared	0.922
Med. Own price elast.	-8.82	Obs.	1,773
Obs.	14,938		

Cross-price elasticities

- Cross-price elasticities decrease substantially when driving distance between stations increases above 1000m

Cross Price E	$\leq$ 500m	$(500m, 1000m]$	$(1000m, 1500m]$	$>$ 1500m
Mean	0.327	0.30	0.21	0.02
SD	0.35	0.32	0.20	0.004
P10	0.073	0.07	0.06	0.01
P90	0.75	0.68	0.45	0.02
Avg. # Stations	0.71	1.3	1.7	252

Quantifying Misallocation

Quantifying misallocation due to collusion

- **Question:** What is the effect of collusion under uniform prices on the cost misallocation of production?
- We focus on two mechanisms of misallocation:
  1. **Static:** Are gasoline sales allocated to low-cost sellers?
  2. **Dynamic:** Are low-cost stations incentivized to enter and invest?

Quantifying Misallocation: Static considerations

Measurement: Olley and Pakes decomposition

- Decompose the sales-weighted marginal cost (c_t) into two components:

$$c_t = \bar{c}_t + \sum_{j=1}^{Jt} \underbrace{(c_{jt} - \bar{c}_t)}_{\Delta(c_{jt})} \underbrace{(s_{jt} - 1/J_t)}_{\Delta(s_{jt})},$$

  - $\bar{c}_t$: unweighted average of firm specific marginal cost
  - $\sum_{j=1}^{Jt} \Delta c_{jt} \Delta s_{jt}$: covariance between shares and marginal cost
    - < 0 **low-cost** firms have larger market shares
    - > 0 **high-cost** firms have larger market shares

Static misallocation under uniform prices

- Compare four observed and counter-factual market environments:
  1. *Uniform price collusion:* Observed prices/quantities (2004)
  2. *Bertrand-Nash:* Non-cooperative benchmark with market-power
  3. *Perfect-competition:* Marginal-cost pricing
  4. *Cost-minimization:* Efficient allocation
- **Implementation:** Use cost estimates based on 1999 to predict costs in 2004

$$c_{j,t} = x_{j,t}\hat{\gamma}, \quad t = 2004.$$

  - Note 1: This ignores residual cost differences between stations.
  - Note 2: Cost account for changes in station characteristics and turnover.

Cost-minimization benchmark

- **Goal:** Measure the potential gain from allocating sales to the most efficient sellers, accounting for spatial differentiation and limited service capacity
- Cost-minimizing algorithm:
  1. Draw a consumer i
  2. Allocate the consumer to a gas station
     - Find all stations within a driving-time bandwidth
     - If there is no station within the bandwidth, back to 1
     - Consumer purchases from the station with lowest mc that is available (not at capacity)
  3. Algorithm stops when $\sum_i q_i = Q_{agg}$

Counterfactual summary statistics

	Mean	SD	P10	P90	Total
Marginal Cost, net of common cost component (cpl)					
	14.99	0.85	13.98	16.18	
Markups (cpl)					
Uniform Price	13.34	1.06	12.11	14.38	
Bertrand-Nash	8.33	0.79	7.43	9.24	
Joint Profit	18.01	3.14	14.85	23.50	
Quantity (L/day)					
Uniform Price	6,676	3,923	2,833	11,540	1.8mn
Bertrand-Nash	8,109	4,789	3,289	14,581	2.2mn
P = MC	9,822	5,952	3,393	18,338	2.7mn
Joint profit maximization	5,562	3,340	1,963	10,411	1.5 mn

Results: Olley and Pakes decomposition

	c_t	$\bar{c}_t$	$\sum_j \Delta c_{jt} \Delta s_{jt}$	Extra time (min.)
Uniform price collusion	14.86	14.99	-0.135	1.75
Bertrand-Nash	14.83	14.99	-0.165	2.18
P = MC	14.80	14.99	-0.194	2.79
Cost minimization				
Lowest cost station	13.62	14.99	-1.375	28.06
Max travel: 3.25 min.	14.06	14.99	-0.935	1.76

- **Takeaway 1:** Low-cost stations have valuable amenities and/or locations
- **Takeaway 2:** Very small effect of conduct on cost misallocation
  - *Collusion:* Uniform vs Bertrand = 1/100 cpl
  - *Market-power:* Bertrand vs Competition = 2/100 cpl
  - *Differentiation:* Competition vs Efficiency = 68.2/100 cpl

What are the demand factors leading to cost misallocation?

- Recall that consumers sort based on:

$$u_{ijt} = \underbrace{X_{jt}\beta + \xi_{jt} - \alpha p_{jt}}_{\text{Vertical differentiation}} + \underbrace{\lambda D_{ij} + \epsilon_{ijt}}_{\text{Horizontal differentiation}}$$

	Covariance	Outside share	HHI
Perfect competition	-0.19	0.18	1475
Counter-factual demand:			
No vertical differentiation ($\beta = \xi = 0$)	0.02	0.36	1302
No spatial differentiation ($\lambda = 0$)	-0.25	0	1369
No random-utility shocks ($\epsilon = 0$)	-0.64	0.43	1767
Vertical differentiation only ($\lambda = \epsilon = 0$)	-1.52	0	10,000

- **Takeaways:**
  - Horizontal differentiation between stations explain nearly all of the cost misallocation
  - Negative correlation between cost and quality

Quantifying Misallocation: Investment decisions

Incentive to enter and invest in cost-reducing technologies

- Assuming cartel stability:
  - Collusion leads to excess entry
  - But do the "right" firms enter?
- Two sources of inefficiencies:
  1. Zero pass-through of cost shocks under collusion
  2. Fixed-cost and efficient scale of low-cost stations
- **Example:** Cost pass-through under Bertrand-Nash model (zero under uniform pricing)

		Mean	SD	P10	P90
$\frac{\Delta P_j}{\Delta c_j}$	Bertrand-Nash	0.96	0.04	0.91	0.99
$\frac{\%\Delta Q_j}{\Delta c_j}$	Bertrand-Nash	0.136	0.012	0.12	0.15

Misallocation of investment decisions

- Use model estimates to understand differences in effect of uniform-price collusion on variable profits of low and high-cost stations
  1. How much do incumbent stations benefit from the adoption of cost-reducing technologies?
  2. Which type of incumbent station benefits the most from the collusive agreement?
  3. What type of station would be willing to enter?
- Abstract from fixed-cost and efficient scale considerations
- To answer these questions, we:
  - Measure expected eqm profit obtained by incumbent stations and potential entrants
  - Use demand model and mc estimates to quantify how collusive uniform prices reduce incumbent stations' gains from investing in cost-reducing technologies

What is the return to investment in cost-reducing technologies under collusion?

- Return to investment under competition and collusion:

$$\text{Competition:} \quad \left(\frac{dp_j^*}{dc_j} - 1\right) D_j(p_j^*, p_{-j}^*) + (p_j^* - c_j)\frac{dD_j(p_j^*, p_{-j}^*)}{dc_j}$$

$$\text{Collusion:} \quad -D_j(p^c)$$

$\Delta\Pi^{\text{incumbent}}$ after 1 SD reduction in cost ($)			
	Collusion	Bertrand-Nash	Ratio
Mean	21,048	29,747	0.73
P10	8,933	11,270	0.62
P90	36,387	54,224	0.85

- **Takeaway 1:** The return to investment under collusion is 30% smaller than under competition.

What is the effect of collusion on the entry decisions of potential entrants?

- Potential entrants locations:
  1. Look at all stations that are in the market in 2005-2013 but not in 2004

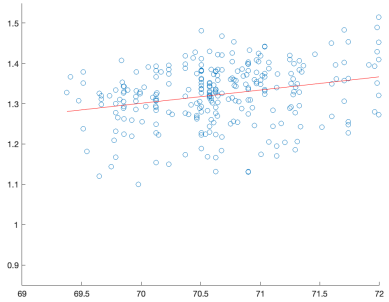
  → Sixteen locations
- Potential entrants characteristics:
  1. Consider different marginal cost values ranging from 67 cpl to 71.5 cpl
  2. Amenities: Unbranded self-service station with a carwash, convenience store, twenty-four pumps, and six islands.
- **Assumption:** As we add a station, we hold fixed the cartel arrangement.

Variable profits comparison - Uniform Price vs Competitive Benchmark

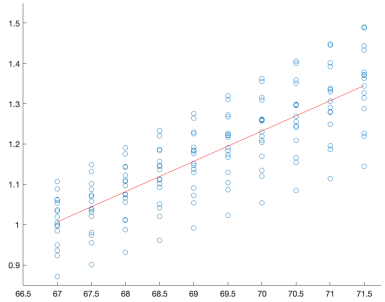
Yearly expected profits ($)						
	Incumbents			Potential Entrants		
	Collusion	Bertrand	Ratio	Collusion	Bertrand	Ratio
Avg.	343,472	260,191	1.32	230,126	197,566	1.16
P10	118,795	90,871	1.3	35,524	33,082	1.07
P90	629,395	478,662	1.31	598,314	514,655	1.16

- Collusion increases the average variable profits of incumbent and potential entrants
- But, not all potential entrants experience increase

Expected profit ratio: Collusion vs Bertrand-Nash



(c) Incumbent Stations



(d) Potential Entrants

- **Takeaway 2:** Uniform-price collusion reduces industry turnover
  - Potential entrants benefit less from collusion than incumbents
  - Low cost entrants earn less profit under collusion than competition

Did productivity improvements slowed down during the collusive period?

- Contribution of different groups of firms to our measure of aggregate marginal cost:
  - Survivors (S): stations that were active in $t-1$ and are active in t
  - Entrants (E): stations that were out of the market in $t-1$ and enter the market in t
  - Exiters (X): stations that are active in t but are out of the sample in $t+1$
- At period t:

$$\hat{c}_t = \bar{c}_{st} + cov(s_{j/s}, c) + s_{Xt}(\hat{c}_{Xt} - \hat{c}_{St})$$

- At period $t+1$:

$$\hat{c}_{t+1} = \bar{c}_{st+1} + cov(s_{j/s}, c) + s_{et}(\hat{c}_{Et} - \hat{c}_{St})$$

$$\Delta\hat{c} = \underbrace{\Delta\bar{c}_s + \Delta cov(s_{j/s}, c)}_{Surviving\ firms} + \underbrace{s_{et}(\hat{c}_{Et} - \hat{c}_{St}) - s_{Xt}(\hat{c}_{Xt} - \hat{c}_{St})}_{Industry\ turnover}$$

Dynamic Olley and Pakes

Quebec City					
	$\Delta\hat{c}$	$\Delta\bar{c}_s$	$\Delta cov(s_s, c_s)$	Exit	Entry
92 to 98	-0.217	-0.071	-0.081	-0.053	-0.013
98 to 04	-0.15	-0.098	-0.014	-0.035	-0.005
01 to 07	-0.073	0.05	-0.014	-0.008	-0.001

Sherbrooke					
	$\Delta\hat{c}$	$\Delta\bar{c}_s$	$\Delta cov(s_s, c_s)$	Exit	Entry
92 to 98	-0.127	-0.0356	-0.0962	0.0001	0.0046
98 to 04	-0.093	-0.1128	0.0744	-0.0381	-0.0163
01 to 06	-0.025	0.0147	-0.0037	-0.0175	-0.0189

Conclusions

- Two contributions:
  - Identify widespread uniform-price collusion[2] in Quebec-City's retail gasoline market
  - Measure the effect of the collusion arrangement on the cost misallocation of gasoline sales
- Key findings:
  - Collusion and market-power have *negligible* effects on misallocation among incumbents
  - Why? Horizontal differentiation limit the ability of consumers to arbitrage cost differences
  - Collusion have potentially larger dynamic misallocation consequences:
    - Lower incentives to invest and negotiate lower costs
    - Reduction in industry turnover
  - Evidence consistent with dynamic misallocation in collusive cities:
    - Slow-down in productivity growth due to industry turnover

[2] Allegations have not been proven in court. Ongoing civil lawsuits.