Trucks without Bailouts :
Equilibrium Product Characteristics for Commercial Vehicles

Wollmann, 2018, AER

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Motivation

- Many firms have a **stable set of firms**, but a rapidly **changing** set of **product** offerings.
  - e.g. US automotive industry, aircraft industry
- Since entry and exit tend to work in opposite direction of the price mechanism, not accounting for them can **overstate the impact** of a change in market structure to prices and purchases.
  - e.g. Bankrupcy of a firm $\rightarrow$ Market power increases $\rightarrow$ Higher markups and profits $\rightarrow$ More entrants (new firms/products) $\rightarrow$ Prices fall
- **Counterfactuals** following market structure change depend on accurately determining where and to what extent **product/model-level** entry and exit will occur.

This Paper

- Assess impact of product-level entry and exit decisions on policy choice
  - Emphasis on **subsidization** and **antitrust**
- Develops tractable model of equilibrium product offerings
  - Recover **sunk cost** of product entry/exit decision and compute counterfactuals
- Looks at US commercial vehicle segment from 1987-2012
  - 2008-2009 $85 billion government bailout

Why the commercial vehicle market?

- No entry/exit of firms in 3 decades
- Ownership concentrated in about 10 firms
- Manufacturers can quickly swap parts and introduce new models
- Differs from other vehicle markets due to weight, tariff structure and legal standing

Main Question:

*"What would have happened to output and prices had the government **not** rescued automakers?"*

- Alternate policies: Liquidation and acquisition by rivals.

Preview of Results

- Product entry and exit have a **dramatic impact** on prices and purchases.
  - Acquisition: 65% markup without considering entry/exit vs. 17% considering entry/exit.
  - Liquidation: 27% markup without considering entry/exit vs. 6% considering entry/exit.
- **Overstate lost of wages** for commercial segment autoworkers by over $480 million annually.
  - Could be pivotal for the bailout decision.

Related Literature

- Eizenberg (2014) : Studies this problem in the context of PC manufacturer's decisions over which processors to include in new laptops to help identify fixed costs.
  - This paper relies on observable heterogeneity in buyer preferences.
- Sweeting (2013) : Studies switching of radio station formats.
  - Since it is a dynamic demand, it requires a more restricted action space than this paper.
- Goolsbee and Krueger (2015) : Argue in favor of the same bailout for the noncommercial segment, mainly on the basis of negative macro feedback effects.
  - The commercial segment is much smaller and macro feedback effects are second-order.

Roadmap

Commercial Vehicle Segment of US Automotive Industry

- About 10% of total US automotive sales, or 5% of GDP.
- Any on-road vehicle rated over 10,000 lbs and sold domestically.
- Broad user base: delivery vans, trucks, dump trucks, highway-trailers.
- Largest loads are in excess of 250,000 lbs: oil rigs, turbine engines, etc.

Data Sources

- *The Truck Blue Book*: Panel of all commercial **vehicle models** sold in the US from 1986 to 2012.
  - Brand, model, year, product characteristics (MSRP – in 2005 dollars, load capacity, chassis, etc.)
- R.L. Polk and Co.'s *New Vehicle Registration Database*: US **vehicle sales** of Class 3 and above.
- US Census Surveys: **Microdata** on commercial vehicle purchases.
  - Information about vehicle type, its use and the owners of the vehicles.

Product Characteristics

Short lists of product characteristics:

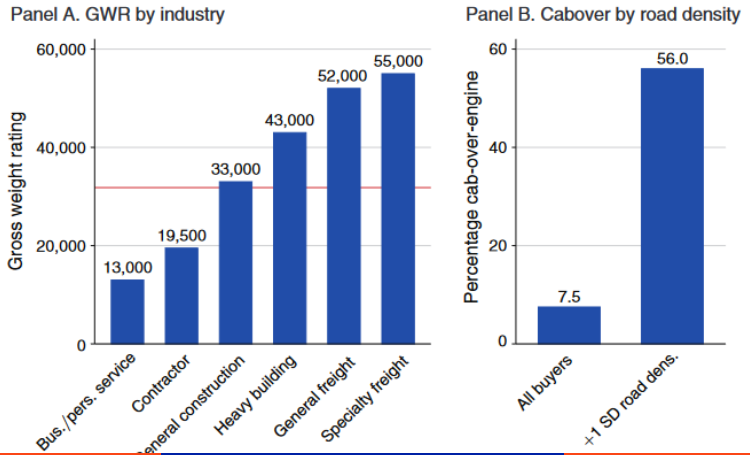
- Gross Vehicle Weight Rating (GWR): Maximum load that may legally rest on the axles ($\geq$ 10,000 lbs.)
- Style of cab: Portion of vehicle that encloses the passengers
  - Three distinct varieties: conventional, "cabover" (flat front) and long/extended (long or difficult hauls).

			Average over each period		
	Min.	Max.	1986–1994	1995–2003	2004–2012
Panel A. Count of product offerings by type					
Light-medium GWR conventional	20	24	21.0	21.7	22.3
Medium GWR conventional	14	27	25.0	20.8	20.4
Heavy GWR conventional	28	36	31.6	33.0	32.9
Light-medium GWR cabover	8	11	10.0	10.3	9.8
Medium GWR cabover	2	12	11.0	8.1	5.1
Heavy GWR cabover	0	8	7.4	1.8	0.0
Compact-front-end (all GWRs)	3	5	3.0	3.3	4.1
Long/extended cab (all GWRs)	9	16	15.4	11.6	9.7
All types	62	85	77.6	75.4	75.7

			Average over each period		
	Min.	Max.	1992–1994	1995–2003	2004–2012
Panel B. Prices charged and units sold					
Price (in 2005 $)	$70,324	$75,588	$73,075	$73,448	$72,104
Quantity (in 000s of units)	165,678	584,057	286,246	395,879	369,985

			Average over each period		
	Min.	Max.	1986–1994	1995–2003	2004–2012
Panel C. Proportion of potential vehicle buyers by type (%)					
Freight-related industries	22.1	32.1	25.2	28.0	28.6
Construction-related industries	36.5	50.4	43.3	45.6	44.7
Business- and personal service-related industries	22.8	37.1	31.5	26.4	26.8

Average Product Characteristics Conditional on Buyer Type and Road Density



Firms

- Focus on automotive assembly firms (9), treating upstream and downstream operations as independent or completely determined by assembly operations
  - Assemblers are few in numbers but large in size
  - They serve as central party to contracts
- Commercial dealers often carry competing brands.
- Assembly firms map directly to the "brand" (14) of the vehicle.
- Separate from foreign market counterparts due to 25% import tariff on trucks.

The Bailout

- $85 billion federal assistance to GM and Chrysler in 2009 constitutes the largest government bailout in modern history (besides financial industry).

Main factors that caused it:

1. Global recession beginning in 2008
2. Rise in fuel prices
3. Legay costs and retiree healthcare benefits

- ***What would've been the response of surviving firms?***

Roadmap

Overview

Two stage model:

1. Firms simultaneously choose **what products** to offer
2. After realizing a set of sunk cost disturbances, firms choose **what prices** to charge

Information:

1. Last period's products, demand and MC shifters, and realization of set of sunk cost disturbances
2. Realization of demand and MC disturbances

Stage 2: Demand

Each buyer r decided whether to purchase a vehicle j among J choices to maximize utility. Utility from product j is:

$$U_{r,j} = x_j(\beta_x + \beta_x^o z_r^o + \beta_x^u z_r^u) + p_j\beta_p + \xi_j + \epsilon_{r,j}$$

- z_r^o, z_r^u: observed and unobserved buyer attributes

Using logit, market shares are obtained for a given set of parameters, which can be used to calculate the **unit sales** using the market size:

$$q_{j,t} = M_t s_{j,t}$$

Stage 2: Prices

Firm f offering set of products $J_{f,t}$ chooses to maximize profits given by

$$\Pi_{f,t} = \sum_{j \in J_{f,t}} [p_{j,t} - mc_{j,t}] \cdot s(x_{j,t}, x_{-j,t}, p_t, z_t; \beta, \xi_t) M_t$$

Firms get the FOC w.r.t. prices and set it equal to 0.

Cost Side:

- $\log mc_{j,t}$ is linear in observable product characteristics, wages, time, and unobserved product time factors $\omega_{j,t}$
- Coefficients are denoted γ

Stage 1: Product Offerings – Profits

Creating expectations over $\xi_{j,t}, \omega_{j,t}$, the expected second stage profits are

$$\pi(J_{f,t}, J_{-f,t}, z_t, w_t; \beta, \gamma, F_\xi, F_\omega) \equiv \int_{\xi', \omega'} \Pi(J_{f,t}, J_{-f,t}, z_t, w_t; \beta, \gamma, \xi', \omega') dF_{\xi'} dF_{\omega'}$$

Trade-off: Added profits of new/continued product offerings vs. sunk costs

$$SC_{f,j,t,J_{f,t-1}} = x_j' \tilde{\theta}_{f,x_j,t} \times [\mathbb{1}\{j \in J_{f,t},, j \notin J_{f,t-1}\} + \lambda \cdot \mathbb{1}\{j \in J_{f,t},, j \in J_{f,t-1}\}]$$

- $\lambda \leq 0$: scrap value factor recovered from retiring a model

Stage 1: Product Offerings – Motivation

From the former head of GM Commercial Division:

> *"Each year we look at demand, what we offer, and what the competition is going to offer. We consider changing the lineup like adding a vehicle ... We know who the customers would be, what we can charge, and the production costs—so we have the added margin. The margin over the investment gives a return on capital, and* ***we'll build it when it crosses some threshold*** *(emphasis added)."*

- Because of this, Wollmann introduces the idea of **hurdle rates**.

Stage 1: Product Offerings – Hurdle Rates

Assumption 1:

For all firms f at time t with information set $\mathcal{I}_{f,t}$, equilibrium product offerings $J_{f,t}$ satisfy:

$$\frac{\Delta\pi(J_{f,t}, J'_{f,t}, J_{-f,t}, z_t, w_t)}{\mathcal{E}[\Delta SC_f(J_{f,t}, J'_{f,t}, J_{f,t-1})|\mathcal{I}_{f,t}]} \geq HurdleRate \quad \forall J'_{j,f} \in \mathcal{J}$$

Where $\mathcal{J}$ is the feasible set of product offerings.

- Allows firms to make expectational errors, while holding that they know $\Delta\pi$.
- It also rules out economies of scope, simplifying the problem.

Roadmap

Stage 2: Demand

Follows closely from Petrin (2002), using GMM with an objective function based on two sets of moments:

1. Standard BLP Moments: $E[\xi|x, w] = 0$, with wage estimates from BLS as an instrument
2. Microdata Moments: matching mean and variance of buyer attributes from data to the model-predicted analogs.

Stage 2: Marginal Costs

- MC are obtained from rearranging Nash Conditions and using the demand-side estimates.
- Graphically, Wollmann determines that the log of MC is roughly linear in the continues characteristic, such that $\ln(mc) = [x, w]\gamma + \omega$
- He then solves for γ using least squares, since $E[\omega, x, w] = 0$.
- With this, he can obtain unbiased estimates of ω.

Stage 1: Sunk Costs – Hurdle Rates

Rearranging the hurdle rate inequality, and using the equation for SC, we find that firms are **weighing expected profit changes vs. sunk costs**[1]:

- For $j \in J_{f,t}$:

$$\Delta\pi(J_{f,t}, J_{f,t} \setminus j, J_{-f,t}, z_t, w_t) + x'_j(\mathbb{1}\{j \notin J_{f,t-1}\} - \lambda\mathbb{1}\{j \in J_{f,t-1}\}) \cdot \mathcal{E}[\theta_{f,x_j,t}|\mathcal{I}_{f,t}] \geq 0$$

- for $j \notin J_{f,t}$:

$$\Delta\pi(J_{f,t}, J_{f,t} \cup j, J_{-f,t}, z_t, w_t) - x'_j(\mathbb{1}\{j \notin J_{f,t-1}\} - \lambda\mathbb{1}\{j \in J_{f,t-1}\}) \cdot \mathcal{E}[\theta_{f,x_j,t}|\mathcal{I}_{f,t}] \geq 0$$

[1] Since the sunk cost is estimate as scaled by hurdle rate, the hurdle rate does not need to be estimated. $\theta_{f,x_j,t} = -HurdleRate \cdot \tilde{\theta}_{f,x_j,t}$

Stage 1: Sunk Cost – Additional Assumptions

Assumption 2

For firm f at time t, the sunk cost parameter $\theta_{f,x_j,t}$ is given by $\theta_f + \nu_{2,t}$, where

$$\theta_f = [\theta_0 + \theta_0^{Big3} + \theta_0^{Jpn},\ \theta_g + \theta_g^{Big3},\ \theta_{cabover} + \theta_{cabover}^{Jpn},\ \theta_{compact},\ \theta_{long}]$$

and $\nu_{2,t}$ is a vector of mean zero disturbances, with elements $\nu_{2,k,t}$.

- If actions differ beyond that allowed by this decomposition, it is attributed to ν_1, expectational errors made by firms.

Assumption 3

Second stage profits are measured without error.

Stage 1: Sunk Cost – Moment Inequalities

After these two additional assumptions, the previous inequalities can be used to create moments that bound the (scaled) sunk cost parameters θ_f, λ:

$$\frac{1}{XTF}\sum_{x_j}\sum_{t}\sum_{f} h^i_{f,x_j,t}\mathbb{1}\{j \in J_{f,t}\}$$
$$\times \left[\Delta\hat{\pi}(J_{f,t}, J_{f,t}\setminus j, z_t, w_t) + x_j'\theta_f(\mathbb{1}\{j \notin J_{f,t-1}\} - \lambda\mathbb{1}\{j \in J_{f,t-1}\})\right] \geq 0$$
$$\frac{1}{XTF}\sum_{x_j}\sum_{t}\sum_{f} h^i_{f,x_j,t}\mathbb{1}\{j \notin J_{f,t}\}$$
$$\times \left[\Delta\hat{\pi}(J_{f,t}, J_{f,t}\cup j, z_t, w_t) - x_j'\theta_f(\mathbb{1}\{j \notin Jf, t-1\} - \lambda\mathbb{1}\{j \in J_{f,t-1}\})\right] \geq 0$$

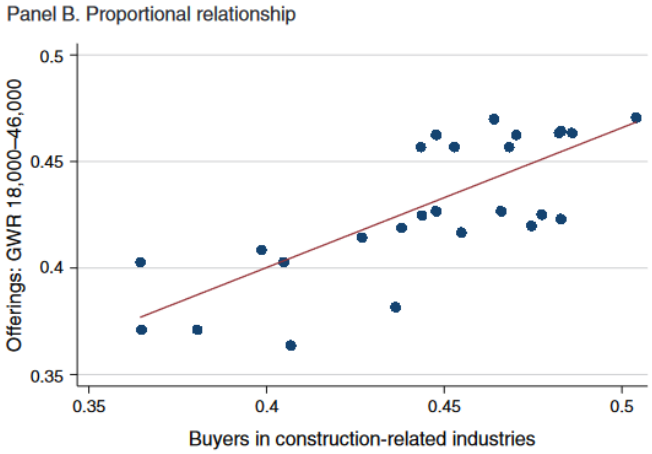
where h are weights placed on observations, which depend on the identity of the firms, characteristics of the product offerings, mean buyer attributes as they vary across t, what was offered last period, and what is offered in the current period.

Roadmap

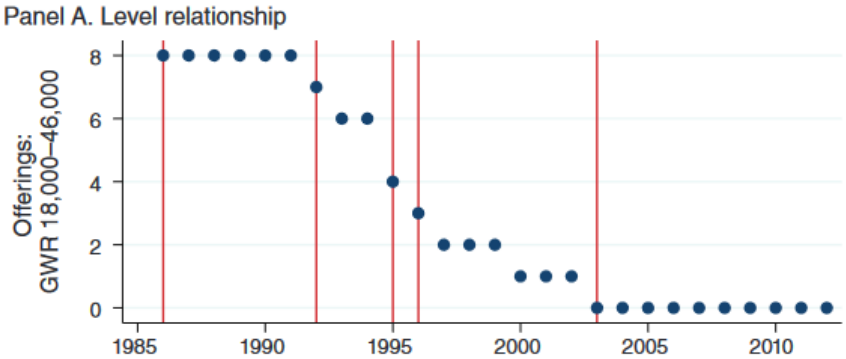
Validity

- Prior summaries reveal that distribution of potential buyer types vary over time and that different buyers have strongly heterogeneous preference.
- ... but do firms actually behave as the model describes?

Firms adjust product offerings to changing demand



Reduced-Form Evidence from Regulation of the Freight Industry



Roadmap

Demand

	Parameter estimate	Standard error
Demand		
Mean parameters		
GWR (in 0,000s of lbs.)	2.298	0.873
Indicator for cabover	−24.805	2.026
Indicator for compact-front-end	−1.425	0.273
Indicator for long option	1.026	0.424
Price (in 000s of 2005$)	−0.44	0.037
Constant	0.066	0.32
Buyer attribute interactions		
GWR × specialty freight industry	23.023	1.574
GWR × general freight industry	16.434	0.553
GWR × heavy building industry	11.162	0.495
GWR × general construction industry	7.35	0.896
GWR × contractor industry	3.693	0.915
Indicator for cabover × general freight industry	0.906	0.261
Indicator for cabover × general freight industry × length laws	−1.183	0.881
Indicator for cabover × urban	35.053	2.283
Indicator for compact-front-end × urban	0.945	0.725
Indicator for long option × freight industry × $z^{u}_{2,r}$	5.842	1.754

Marginal Costs

Marginal costs		
GWR	0.385	0.06
Indicator for cabover	0.002	0.033
Indicator for compact-front-end	−0.089	0.04
Indicator for long option	0.073	0.012
Wage ($ per hour)	0.016	0.004
t (year count)	0.041	0.053
Constant	2.132	0.215
Observations	1,575	

- GWR in 10,000 lbs

Sunk Costs (from moment inequalities)

	95 percent confidence interval
Sunk cost parameters (in 000s of 2005$)	
Mean parameter	
GWR (in 0,000s of lbs.)	[$3,163, $4,664]
Indicator for cabover	[5,052, 7,478]
Indicator for compact-front-end	[−8,852, 3,411]
Indicator for long option	[−6,339, −3,433]
Constant	[−27,145, −21,103]
Firm identity interactions	
Constant × indicator for *Big3*	[−3,066, 7,732]
GWR × indicator for *Big3*	[−2,143, 299]
Constant × indicator for *Jpn*	[−5,204, −400]
Indicator for cabover × indicator for *Jpn*	[9, 5,289]
Scrap value scale parameter ($-\lambda$)	[0.531, 0.613]
Observations	11,123
Moments	97

Roadmap

Status Quo: GM and Chrysler Products in 2009

Parent	Brand	GWR	Conv.	Cabover	Compact-front-end	Long/extended
Chrysler	Dodge	12,000	×			
Chrysler	Dodge	13,500	×			
Chrysler	Dodge	16,000	×			
Chrysler	Dodge	19,500	×			
GM	Chev./GMC	12,000			×	
GM	Chev./GMC	12,000	×			
GM	Chev./GMC	13,500	×			
GM	Chev./GMC	14,500		×		
GM	Chev./GMC	16,000	×			
GM	Chev./GMC	19,500		×		
GM	Chev./GMC	19,500	×			
GM	Chev./GMC	21,500	×			
GM	Chev./GMC	28,000	×			
GM	Chev./GMC	33,000		×		
GM	Chev./GMC	40,000	×			

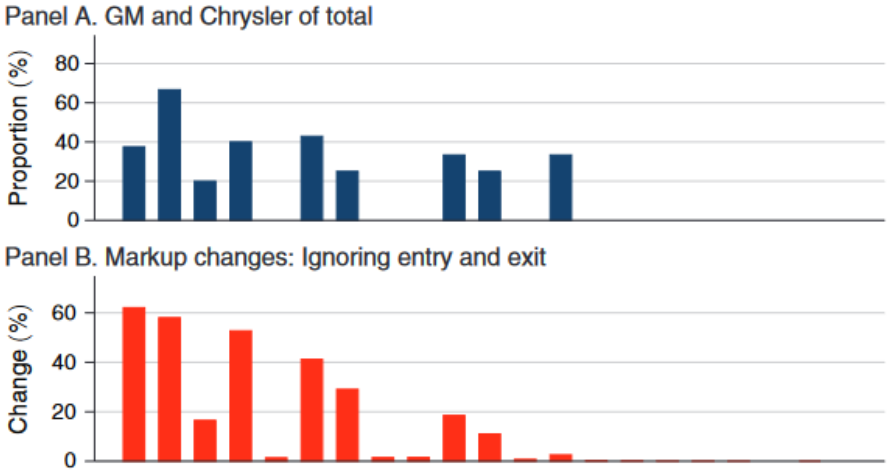
- These products will be eliminated or transferred to another firm in the event that GM and Chrysler were liquidated or acquired, respectively

Policy Alternatives

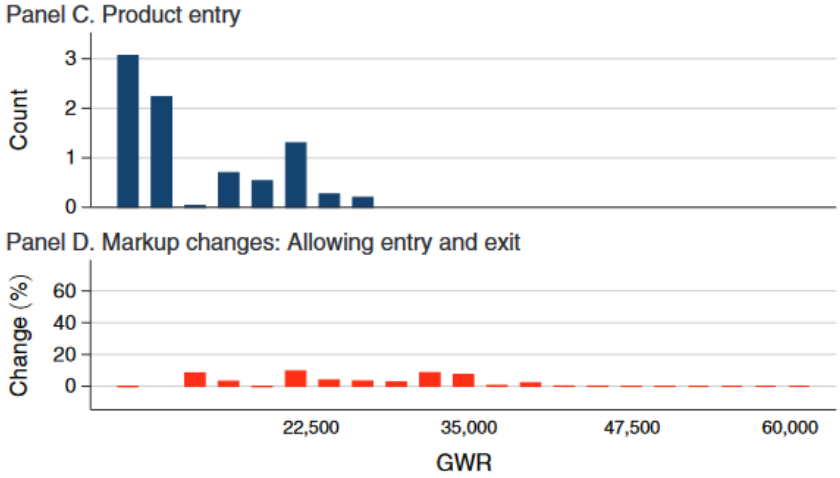
	Product entry and exit ignored			Product entry and exit allowed		
	Ford acq.	PACCAR acq.	Liq.	Ford acq.	PACCAR acq.	Liq.
Markups (percent)						
Most affected model	62.1	23.0	26.9	16.8	15.4	6.2
Most affected vehicle type	53.2	13.0	32.3	9.6	7.6	5.3
Market	10.9	3.0	4.0	0.8	0.5	−0.0
Output (percent)						
Most affected model	−34.4	−18.0	NR	6.7	16.5	8.9
Most affected vehicle type	−30.0	−8.6	−100.0	−63.9	−54.9	−64.7
Market	−5.1	−1.4	−11.2	−1.3	−1.3	−1.6
Compensating variation	119.0	33.0	253.0	22.0	26.0	28.0

- Follow Lee and Pakes (2009) 's learning process for equilibrium. Eizenberg (2014) 's setting has orders of magnitude less possible equilibria.

Findings: Ford Acquisition



Findings: Ford Acquisition (cont.)



Roadmap

Concluding Remarks

- Accounting for endogenous changes in product offerings has **first-order impacts** on prices, output, and potentially employment in differentiated product markets like autos
- In the 2009 auto bailout context, allowing for product entry/exit rather than fixing offerings **dramatically affected** markups, production levels, and consumer welfare
- Exits of major producers could drastically increase markups/market power, but this spurs **entry of new models** by rivals increasing variety and competition
- Swift product entry/exit following demand shifts suggests **sunk costs are low** enough that firms will reoptimize product lineups chasing profits
- Ignoring this margin of reoptimizing product lineups can severely **distort analysis** of major policy changes like subsidies, taxes, or mergers

References I

[ ]Eizenberg, Alon. 2014. "Upstream Innovation and Product Variety in the u.s. Home PC Market." *The Review of Economic Studies* 81 (3): 1003–45. https://doi.org/10.1093/restud/rdu004.

[ ]Goolsbee, Austan D., and Alan B. Krueger. 2015. "A Retrospective Look at Rescuing and Restructuring General Motors and Chrysler." *Journal of Economic Perspectives* 29 (2): 3–24. https://doi.org/10.1257/jep.29.2.3.

[ ]Lee, Robin S., and Ariel Pakes. 2009. "Multiple Equilibria and Selection by Learning in an Applied Setting." *Economics Letters* 104 (1): 13–16. https://doi.org/10.1016/j.econlet.2009.03.004.

References II

[ ]Petrin, Amil. 2002. "Quantifying the Benefits of New Products: The Case of the Minivan." *Journal of Political Economy* 110 (4): 705–29. https://doi.org/10.1086/340779.

[ ]Sweeting, Andrew. 2013. "Dynamic Product Positioning in Differentiated Product Markets: The Effect of Fees for Musical Performance Rights on the Commercial Radio Industry." *Econometrica* 81 (5): 1763–803. https://doi.org/10.3982/ECTA7473.