Royalty Stacking in the U.S. Freight Railroads: Cournot vs. Coase*

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*The views expressed are not purported to reflect those of any of the employers of the authors.

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Pricing Complementary Products: Cournot (1838)

- You need copper and zinc to make brass.
- Compare the prices that a brass producer would pay when there is a copper monopolist and a zinc monopolist vis-à-vis with a monopolist of copper and zinc
- Two monopolists selling complementary products charge higher prices than a single, two-product monopolist would.
- Prices are “strategic substitutes”, so if I am selling copper and I raise my price, the zinc monopolist lowers its price in response, effectively partially subsidizing my price increase.
- In equilibrium, copper and zinc prices are higher than what a monopolist would charge: everyone worse off.

But lots of money left on the table: Coase (1960)

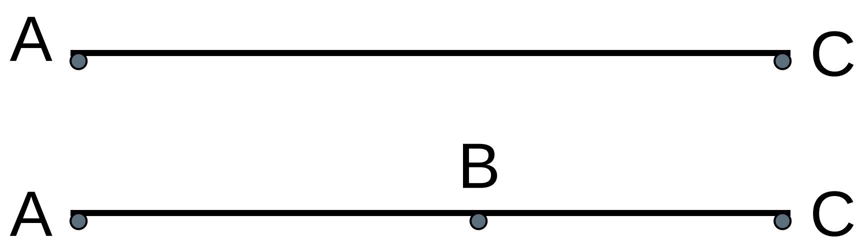
- If the market is close to efficient then a solution should develop
- The prices of two monopolists selling complements should be closer to the single-monopolist price
- Single-monopolist price is a Pareto improvement
- Same issue with double marginalization in the vertical context (with the solution in that context being nonlinear pricing)

Applications

- Patent thickets, especially with standard essential patents
- Tragedy of the anticommons
- Mergers of firms selling complements

The Setting

- Example



- Compare P_{AC} and $(P_{AB}+P_{BC})$

Data

- STB waybill data, 2001-2003, unmasked (thanks, STB!), data for 1-3% of all waybills depending on the year
- 4 largest US freight railroads (80% of the market)
- Only use coal -- as homogeneous of a product as we could find, yet a major product so many observation points (17% of the market)
- For each shipment we have the route, the price, and over 100 other variables

Model Specification

We follow Jim Mac Donald (1989) and Christensen Associates (2010) in modeling:

$$
\begin{aligned}
lnRPTM = {} & \beta_{interest} treatment + \\
& + \overline{\beta} \times [lnMiles + lnTons + lnTonsCar + lnVolTons + DOwn + HHI_{origin} \\
& + HHI_{term} + DM_{origin} + DM_{term} + lnCosts + CalcRate] + FE_{origin} + FE_{term} \\
& + FE_{railroadorigin} + FE_{railroadterm} + FE_{quarter}.
\end{aligned} \quad (1)
$$

RPTM = Revenue per ton-mile (standard industry price metric)

treatment = indicator of either a junction or a rebill

Identification

- We believe that treatment is exogenous: much of the railroad ownership determined in the 19th century

- We perform various robustness checks to address concerns about treatment endogeneity and the model specification

Results. Table 1

Table: Effect of either a junction or a rebill on price

	(1) lnRPTM Whole	(2) lnRPTM Whole	(3) lnRPTM Trim at 1 %	(4) lnRPTM Trim at 1 %	(5) lnRPTM Trim at 5%	(6) lnRPTM Trim at 5%	(7) lnRPTM Trim at 5% exclude missing rebill
Treatment	-0.007	-0.013	0.001	-0.014	0.004	-0.006	-0.002
	(0.023)	(0.008)	(0.023)	(0.008)	(0.024)	(0.008)	(0.009)
Other controls	✓	✓	✓	✓	✓	✓	✓
Fixed Effects	–	✓	–	✓	–	✓	✓
N	78,629	78,569	77,057	77,007	70,769	70,728	52,447
R2	0.86	0.96	0.86	0.97	0.83	0.96	0.97

Standard errors in parentheses. $*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$.
All models with fixed effects include fixed effects for country of origin, destination county, railroad serving the origin, railroad serving the termination point, and quarter-year.
Standard errors are clustered by country of origin, destination county, and quarter-year.

Robustness Checks: Model Specification

- Robustness check 1: Blocking, Imbens and Rubin (2015)
- By dividing the data on subgroups that have treatment and control groups that are very similar -- reduces biases that arise because of the systematic differences between control and treatment groups.
- More precise estimates

- Robustness check 2: Machine Learning -neural networks, Chernozhukov, Chetverikov, Demirer, Duflo, Hansen, and Newey (2016)
- Very flexible, data-driven approach to functional form of the regression

Blocking Results (Independent OLS within Blocks)

Block	N	Est.	S.E.
1	2,069	0.06	0.04
2	1,201	0.00	0.01
3	358	-0.09	0.03
4	151	0.05	0.04
5	455	0.01	0.02
6	90	0.01	0.01
7	255	0.00	0.02
8	251	-0.23	0.03
9	58	-0.14	0.07
10	118	0.00	0.00
11	78	0.40	0.05
12	78	0.10	0.08
13	97	-0.02	0.11
14	147	-0.30	0.06
15	120	-0.09	0.08
16	50	0.11	0.04
17	167	0.08	0.07
18	1,088	-0.06	0.06
19	838	-0.40	0.10
20	314	-0.01	0.02
ATE		-0.05*	0.02

$* \ p < 0.05$, $** \ p < 0.01$, $*** \ p < 0.001$

Machine Learning

- Still some concerns about specification: what if we add quadratic terms, cubic, interactions...?
- Machine learning techniques (ML) provide a very flexible way to estimate functional dependencies
- We use the method developed by Chernozhukov et al (2016) to get causal estimates using ML (neural networks)

Table: Effect of either a junction or a rebill on price, double machine learning.

ATE	-0.06***
	(0.016)
N	70,728

Standard errors in parentheses.

$*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$

Robustness check: Coal shipments before and after BNSF merger (December 31st, 1996)

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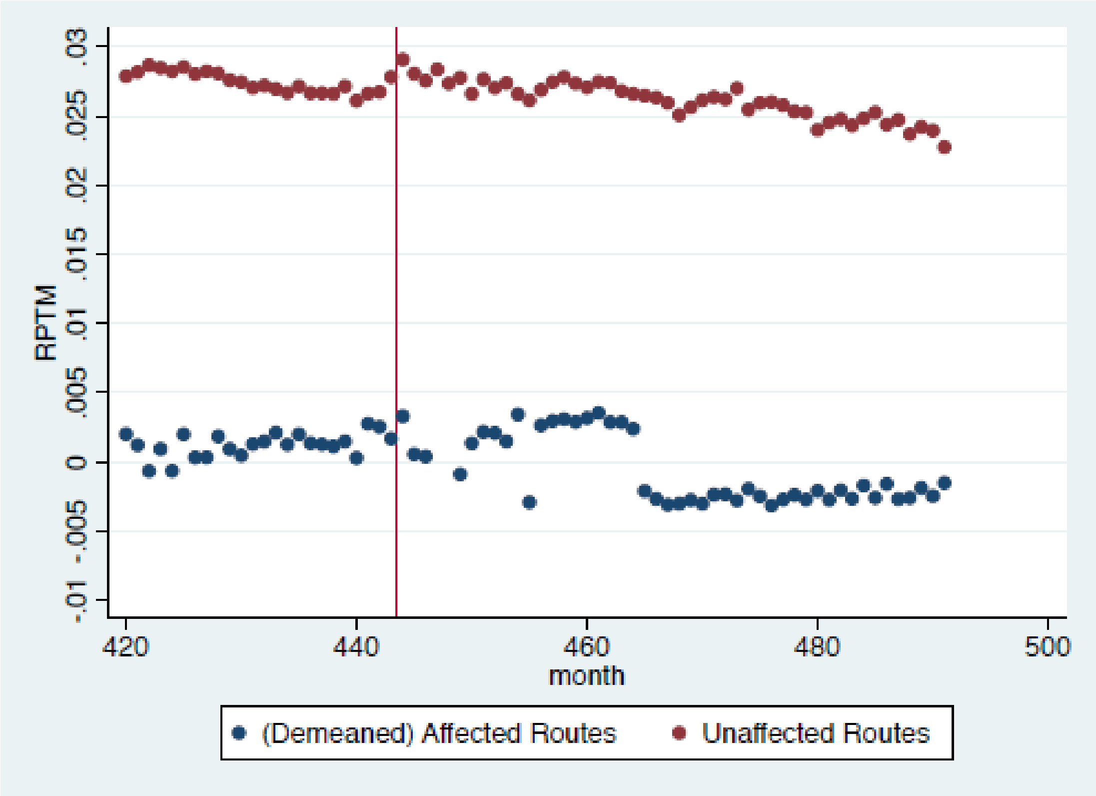
- Primarily a parallel merger, but there were some routes on which they provided joint line service
  - Three coal routes originating in Wyoming
  - Trackage rights were awarded on one, so we test the other two
- We use a difference-in-difference specification with these two routes being treated over 1995-1999

$$
\begin{aligned}
lnRPTM = {} & \beta_{interest} Post \times AffectedRoutes + \beta_{post} Post + \beta_{affected} AffectedRoutes \\
& + \overline{\beta} \times [lnMiles + lnTons + lnTonsCar + lnVolTons + DOwn \\
& + HHI_{origin} + HHI_{term} + DM_{origin} + DM_{term} + lnCosts + CalcRate] \\
& + FE_{origin} + FE_{term} + FE_{railroadorigin} + FE_{railroadterm} + FE_{quarter}.
\end{aligned}
\tag{2}
$$

Parallel Trends



- Figure: Pricing trends for affected and unaffected routes, with the merger occurring on December 31st 1996

Effect of Merger. Results

Table: Effect of merger on price of affected routes

	(1) lnRPTM	(2) lnRPTM (without 1997Q1)	(3) lnRPTM (without 1997Q1 & Q2)	(4) lnRPTM (without 1997)
DD	0.00355	0.0125	0.0214	0.00978
	(0.0359)	(0.0397)	(0.0399)	(0.0426)
post	-7605.9	-1972.3	1409.2	-242.3
	(5118458.0)	(2691777.1)	(3536224.9)	(2711872.8)
affectedroutes	-0.239*	-0.257*	-0.568***	-0.595***
	(0.114)	(0.118)	(0.0664)	(0.0695)
N	191565	183418	174784	157296

Standard errors in parentheses

$* \ p < 0.05$, $** \ p < 0.01$, $*** \ p < 0.001$

Conclusion

- Two main tests (and robustness checks) for pricing of complements in context of US rail shipments of coal

- In both tests, unable to reject hypothesis that separate railroads price shipments the same as a single railroad

- Consistent with Coase and Nash, inconsistent with Cournot: In this case, small numbers sellers do not seem to leave money on the table

- Calls into question efficiencies of vertical mergers in rail industry: small numbers railroads exchanging traffic may already avoid double marginalization