Introduction to Industrial Organization

Analysis After Demand Estimation

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Outline

- Measuring market power
- Merger simulation
- New products
- Policy evaluation

Measuring Market Power

Supply Side Problem

- After the demand estimation, we obtain an estimated demand system $\mathbf{D}(\mathbf{P}, \mathbf{X}, \boldsymbol{\xi})$.
- For product j, the estimated demand

$$D_j(\mathbf{P}, \mathbf{X}, \boldsymbol{\xi}),$$

  where $\mathbf{P}$ and $\mathbf{X}$ are the price and characteristics vectors for all the products.
- The profits for product j:

$$\Pi_j = D_j(\mathbf{P}, \mathbf{X}, \boldsymbol{\xi})(p_j - \text{MC}_j),$$

  where MC_j is the constant marginal cost for the product j.

Supply Side Problem

- For the firm with multiple products $j \in J$:

$$\sum_{j \in J} \Pi_j = \sum_{j \in J} D_j(\mathbf{P}, \mathbf{X}, \boldsymbol{\xi})(p_j - \text{MC}_j)$$

- We also need to assume a particular model of oligopolistic competition:
  - We usually assume Bertrand (price) competition
  - Note: in the differentiated product case, the equilibrium price is not equal to the marginal cost.
- Under price competition, equilibrium prices are characterized by all the first-order conditions.
- If we assume that the observed prices are optimal, then the marginal costs can be recovered based on those first-order conditions.

Example: Two Firms with Three Products

- Assume that three products in the market. Firm A has the products 1 and 2, and firm B has the product 3.
- The profit maximization problem for firm A:

$$\max_{p_1,p_2} \Pi_A = D_1(p_1,p_2,p_3)(p_1 - \mathsf{MC}_1) + D_2(p_1,p_2,p_3)(p_2 - \mathsf{MC}_2)$$

- First-order conditions:

$$p_1: \quad \frac{\partial D_1}{\partial p_1}(p_1 - \mathsf{MC}_1) + \frac{\partial D_2}{\partial p_1}(p_2 - \mathsf{MC}_2) + D_1(p_1,p_2,p_3) = 0$$

$$p_2: \quad \frac{\partial D_1}{\partial p_2}(p_1 - \mathsf{MC}_1) + \frac{\partial D_2}{\partial p_2}(p_2 - \mathsf{MC}_2) + D_2(p_1,p_2,p_3) = 0$$

- Similarly, the first-order condition for firm B:

$$\frac{\partial D_3}{\partial p_3}(p_3 - \mathsf{MC}_3) + D_3(p_1,p_2,p_3) = 0$$

Example: Two Firms with Three Products

- Three first-order conditions can be written as

$$\begin{bmatrix} \frac{\partial D_1}{\partial p_1} & \frac{\partial D_2}{\partial p_1} & 0 \\ \frac{\partial D_1}{\partial p_2} & \frac{\partial D_2}{\partial p_2} & 0 \\ 0 & 0 & \frac{\partial D_3}{\partial p_3} \end{bmatrix} \begin{bmatrix} p_1 - \mathsf{MC}_1 \\ p_2 - \mathsf{MC}_2 \\ p_3 - \mathsf{MC}_3 \end{bmatrix} + \begin{bmatrix} D_1(p_1, p_2, p_3) \\ D_2(p_1, p_2, p_3) \\ D_3(p_1, p_2, p_3) \end{bmatrix} = 0$$

- Define it as $\Delta\mathbf{D}(\mathbf{P})(\mathbf{P} - \mathbf{MC}) + \mathbf{D}(\mathbf{P}) = 0$, so

$$\mathbf{MC} = \mathbf{P} + (\Delta\mathbf{D}(\mathbf{P}))^{-1}\mathbf{D}(\mathbf{P}).$$

- Then the markups can be measured based on

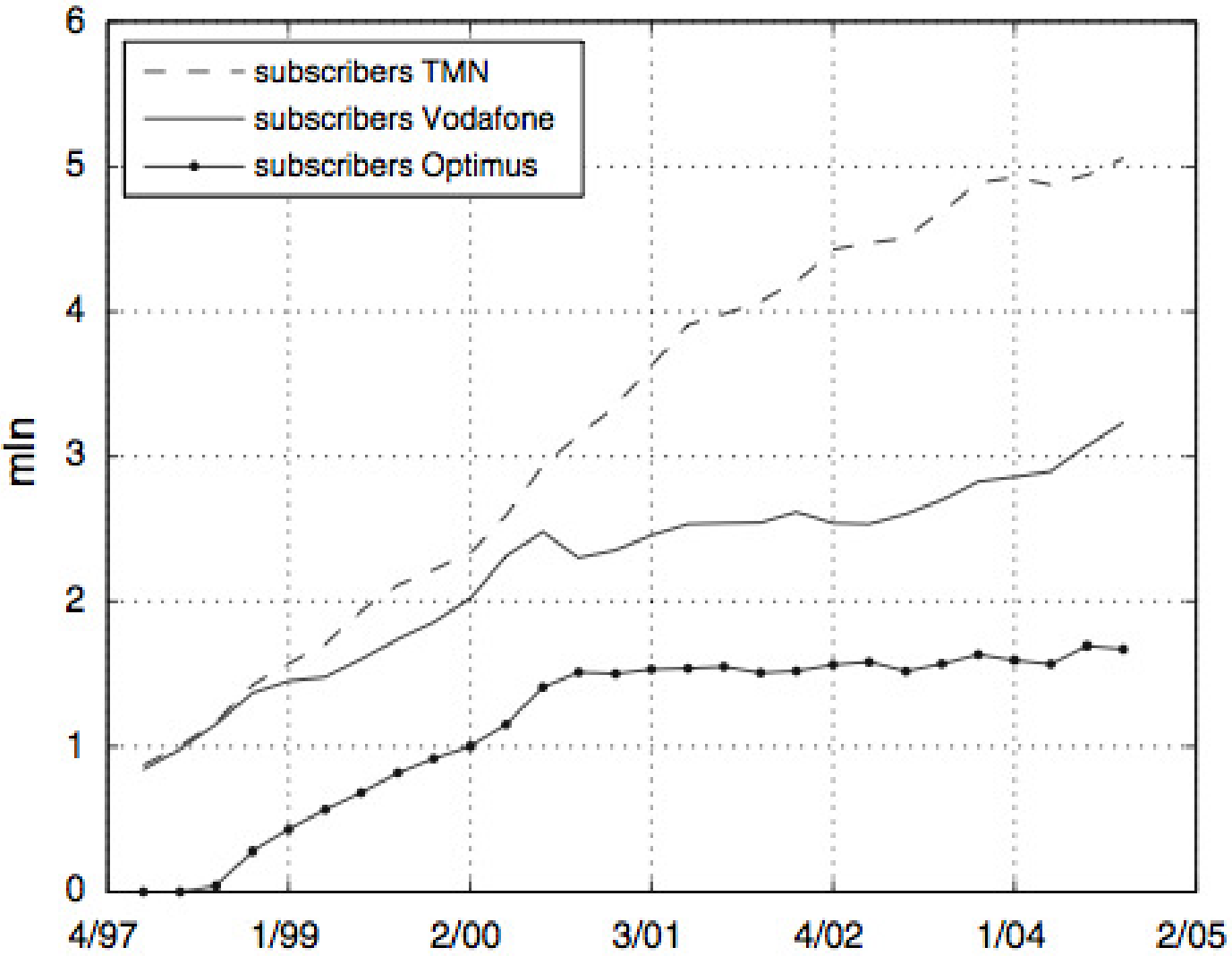
$$\frac{p_j - \mathsf{MC}_j}{p_j}.$$

Merger Simulation

Merger Simulation

- This is an example from Grzybowski and Pereira (2007), "Merger Simulation in Mobile Telephony in Portugal"
- Industry: mobile telephony in Portugal
- Three firms:
  - *Tmn* (50%)
  - *Vodafone* (37%)
  - *Optimus* (13%)
- Demand estimation: nested logit model.

Overview of the Industry



Introduction

- In February 2006, the firm *Sonaecom*, which owns *Optimus*, proposed a transaction that would involve a merger of *Tmn* and *Optimus*
- What's the merger effect? two opposite effects:
  - Reduce the competition between firms.
  - Increase the production efficiency.
- Procedures to obtain the merger effect:
  1. Demand estimation: estimate the cross and own price elasticities for the mobile telephony market.
  2. Marginal costs: based on the demand estimation, we can recover the marginal cost for three firms.
  3. New equilibrium: simulate the equilibrium market share after the merger.

Choice Structure

- All consumers have access to a fixed telephone, and they face two stage problem.
- In the first stage, they decide whether to continue to use only fixed telephony ($g = 0$), or to use also mobile telephony ($g = 1$).
- In the second stage, they decide to which mobile telephony product they subscribe.
- Define U_{i0t} as the utility of the outside option of consumer i at time t.

Demand Estimation: Nested Logit Model

- The utility derived by consumer i from using fixed telephony together with the mobile telephony product j in period t is given by

$$U_{ijt} = U_{i0t} + r_j - \alpha p_{jt} + V_t + \xi_{jt} + \zeta_{gt} + (1-\sigma)\epsilon_{ijt},$$

  where
  - r_j is the stand-alone value of product j
  - p_{jt} is the price of product j in period t
  - V_t is the expected net work benefit in period t
  - ξ_{jt} is the unobserved utility of product j in period t
- The probability that consumer i subscribes to network operator j in period t is

$$P_{ijt} = P_{it}(g=1)P_{ijt}(U_{ijt} > U_{ikt},\ \forall k \neq j,\ k \in G_1).$$

Demand Estimation: Nested Logit Model

- It can be written as:

$$P_{ijt} = \frac{\exp(A_{1t})}{1+\exp(A_{1t})} \frac{\exp(\frac{\delta_{jt}}{1-\sigma})}{D_{1t}},$$

where $A_{1t} = \ln(D_{1t}^{1-\sigma})$, and

$$D_{1t} = \sum_{j \in G_1} \exp(\frac{\delta_{jt}}{1-\sigma}).$$

- Let the market share $s_{jt} = P_{ijt}$.
- Let $s_t = \sum_{j=1}^{N} s_{jt}$ and define $\bar{s}_{jt|g=1}$ as the share of product j of mobile telephony services in period t.

Demand Estimation: Nested Logit Model

- Rewrite the equation as:

$$\ln(s_{jt}) - \ln(1 - s_t) = r_j - \alpha p_{jt} + V_t + \sigma \ln(\bar{s}_{jt|g=1}) + \xi_{jt}.$$

- We can use two-stage least squares (2SLS) estimation to estimate this linear equation.
- Otherwise, generalized method of moments (GMM) can be used to estimate the demand.
- The elasticity of demand for product j with respect to the price of product k is given by:

$$E_{p_{kt}}^{S_{jt}} = \frac{\partial s_{jt}}{\partial p_{kt}} \frac{p_{kt}}{s_{jt}}.$$

Supply Side Problem

- We assume that firms choose prices and play a static Bertrand game.
- Denote Δ as 3×3 ownership matrix:

$$\Delta_{fj} = \begin{cases} 1 & \text{if firm } f \text{ sells product } j; \\ 0 & \text{otherwise.} \end{cases}$$

- Profit function of firm f is given by:

$$\Pi_f = \sum_j^J \Delta_{fj}[(p_j - c_j)s_j m],$$

- First-order condition:

$$\frac{\partial \Pi_f}{\partial p_k} = s_k m + \sum_{j=1}^J \Delta_{fj} \frac{\partial s_j}{\partial p_k} m(p_j - c_j) = 0.$$

Supply Side Problem

- It also could be written as matrix form:

$$\mathbf{s} + (\Delta \cdot S_t)(\mathbf{p} - \mathbf{c}) = 0,$$

where

$$S_t = \begin{bmatrix} \frac{\partial s_{1t}}{\partial p_{1t}} & \frac{\partial s_{2t}}{\partial p_{1t}} & \frac{\partial s_{3t}}{\partial p_{1t}} \\ \frac{\partial s_{1t}}{\partial p_{2t}} & \frac{\partial s_{2t}}{\partial p_{2t}} & \frac{\partial s_{3t}}{\partial p_{2t}} \\ \frac{\partial s_{1t}}{\partial p_{3t}} & \frac{\partial s_{2t}}{\partial p_{3t}} & \frac{\partial s_{3t}}{\partial p_{3t}} \end{bmatrix}$$

- Initially, there are three mobile telephony firms: *Tmn*, *Vodafone*, and *Optimus*. So $\Delta = I$.
- After the merger, the matrix Δ^m should be: $\begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Demand Estimation Results

- Model I: only consumers with contracts are locked-in.
- Model II: consumers with contracts and 50% of consumers with pre-paid cards are locked-in.

Model I	OLS estimates	Std (t)	GMM estimates	Std (t)
r_{opt}	1.141	2.769 (0.41)	−1.886	0.304 (−6.20)
r_{tmn}	−0.656	1.564 (−0.42)	−2.153	0.123 (−17.43)
r_{vod}	0.984	2.432 (0.40)	−1.804	0.285 (−6.32)
$-\alpha$	−9.644	4.464 (−2.16)	−3.258	1.302 (−2.50)
σ	1.676	1.081 (1.55)	0.864	0.118 (7.31)
β	5.645	0.647 (8.72)	4.753	0.311 (15.27)
mse/R-sq Opt.	0.9249	0.59	1.0496	0.51
mse/R-sq Tmn	1.0511	0.57	1.0800	0.52
mse/R-sq Vod.	0.9363	0.63	1.0863	0.53
N*Obj.	72.8092		7.2117	

Demand Estimation Results

- Model I: only consumers with contracts are locked-in.
- Model II: consumers with contracts and 50% of consumers with pre-paid cards are locked-in.

Model II	OLS estimates	Std (t)	GMM estimates	Std (t)
r_{opt}	−0.158	2.395 (−0.07)	−2.470	0.186 (−13.25)
r_{tmn}	−1.539	1.408 (−1.09)	−2.671	0.075 (−35.54)
r_{vod}	−0.141	2.157 (−0.07)	−2.323	0.214 (−10.83)
$-\alpha$	−9.176	4.409 (−2.08)	−3.767	1.489 (−2.53)
σ	1.322	0.970 (1.36)	0.743	0.139 (5.34)
β	5.515	0.657 (8.39)	4.628	0.321 (14.40)
mse/R-sq Opt.	0.9604	0.57	1.0453	0.49
mse/R-sq Tmn	1.0249	0.56	1.0807	0.51
mse/R-sq Vod.	1.0103	0.60	1.1062	0.51
N*Obj.	74.8365		8.9926	

Simulation of Post-Merger Equilibrium

Model I	Pre price	mc	Markup%	Post price	Δp %
		efficiency 0%			
Optimus	0.292	0.225	22.8	0.335	12.88
Tmn	0.188	0.104	44.5	0.214	12.00
Vodafone	0.293	0.213	27.2	0.305	3.49
mean	0.238			0.256	7.13
		efficiency 5%			
Optimus	0.293	0.214	26.9	0.329	9.85
Tmn	0.189	0.099	47.6	0.213	10.42
Vodafone	0.294	0.213	27.5	0.304	2.61
mean	0.238			0.256	6.41
		efficiency 10%			
Optimus	0.292	0.203	30.5	0.319	7.21
Tmn	0.188	0.094	50.2	0.210	9.46
Vodafone	0.294	0.213	27.4	0.301	1.96
mean	0.237			0.253	5.65

- Average prices increase on average by 7%. The largest increase, 13%, occurs for *Optimus*.

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mean	0.237			0.253	5.65

- If the merger generates a 10% reduction in the costs of the merging firms, price increase by 6% on average.

Simulation of Post-Merger Equilibrium

Model II	Pre price	mc	Markup%	Post price	Δp %
		efficiency 0%			
Optimus	0.285	0.193	32.1	0.351	22.47
Tmn	0.183	0.059	67.3	0.217	18.43
Vodafone	0.293	0.187	36.0	0.308	4.88
mean	0.206			0.227	10.25
		efficiency 5%			
Optimus	0.286	0.183	35.9	0.345	19.79
Tmn	0.184	0.056	69.2	0.218	18.13
Vodafone	0.294	0.187	36.3	0.308	4.52
mean	0.207			0.228	10.10
		efficiency 10%			
Optimus	0.286	0.174	39.1	0.337	17.18
Tmn	0.184	0.053	70.8	0.217	17.64
Vodafone	0.294	0.187	36.2	0.307	4.20
mean	0.206			0.227	10.04

- Similar to Model I, the computed post-merger prices increase.

Welfare

Model I			Model II	
	Δ %	$1-\alpha=0.95$	Δ %	$1-\alpha=0.95$
Optimus	9.9	[0.00, 31.91]	5.1	[0.57,17.14]
Tmn	23.7	[0.00, 79.50]	22.0	[9.61,36.03]
Vodafone	38.7	[0.00,116.01]	40.9	[17.28,69.77]
CS	−2.1	[−6.47, 0.00]	−4.4	[−7.74,−1.76]
Welfare	−0.0	[−0.65, 0.05]	−0.4	[−1.13,−0.03]
Optimus	26.1	[4.69, 60.40]	15.5	[8.84,30.94]
Tmn	24.4	[−0.32, 85.66]	21.9	[8.03,37.96]
Vodafone	30.1	[−24.72,121.81]	37.7	[10.82,70.82]
CS	−1.8	[−7.18, 0.74]	−3.8	[−7.23,−1.09]
Welfare	0.0	[−0.27, 0.93]	−0.1	[−0.69, 0.30]
Optimus	47.3	[23.33,118.00]	27.1	[20.34,51.41]
Tmn	25.9	[−0.97, 92.53]	22.1	[8.46,39.05]
Vodafone	25.6	[−31.11,123.33]	35.9	[10.96,70.76]
CS	−1.6	[−7.63, 1.18]	−3.8	[−7.92,-1.14]
Welfare	0.0	[−0.06, 1.96]	0.1	[−0.54, 0.69]

New Products

New Products

- This is an example from Petrin (2002, JPE), "Quantifying the Benefits of New Products: The Case of the Minivan"
- Industry: automobile market in the United States
- Background:
  - Introduced in 1984 by the financially troubled Chrysler Corporation, the Dodge Caravan (its minivan) was an immediate success, with sales of 170,000 in its debut year.
  - General Motors (GM) and Ford quickly responded, introducing their own versions of minivans in 1985 (GM Astro/Safari) and 1986 (Ford Aerostar).

Effect of Minivans

TABLE 3
FAMILY VEHICLE SALES AS A PERCENTAGE OF TOTAL VEHICLE SALES:
U.S. AUTOMOBILE MARKET, 1981–93

Year	Minivans (1)	Station Wagons (2)	Sport-Utilities (3)	Full-Size Vans (4)	Minivans and Station Wagons (5)	U.S. Auto Sales (Millions) (6)
1981	.00	10.51	.58	.82	10.51	7.58
1982	.00	10.27	.79	1.17	10.27	7.05
1983	.00	10.32	3.51	1.04	10.32	8.48
1984	1.58	8.90	5.51	1.20	10.48	10.66
1985	2.32	7.33	6.11	1.05	9.65	11.87
1986	3.63	6.70	5.73	.85	10.43	12.21
1987	4.86	6.47	6.44	.73	11.33	11.21
1988	5.97	5.14	7.18	.69	11.11	11.76
1989	6.45	4.13	7.47	.61	10.58	11.06
1990	7.95	3.59	7.78	.27	11.54	10.51
1991	8.29	3.05	7.80	.29	11.34	9.75
1992	8.77	3.07	9.33	.39	11.84	10.12
1993	9.93	3.02	11.66	.29	12.95	10.71

- While the market share for station wagons fell and the share of minivans climbed, the sum of the shares remained fairly constant over the sample period.

How to Simulate the World Without Minivans?

- Let's skip the complicated demand estimation in the model. (One of the contributions in this paper)
- After the demand estimation, we can simulate the counterfactual environment:
  - Take away the minivan products
  - Besides the minivans, other vehicle prices need to solve the set of equilibrium first-order conditions.
  - Based on the new prices to calculate the market share for each product.
- We can calculate the profits for each firm and the consumer surplus.
- To understand the effect of the new product, we can compare these two scenarios: one with minivans (real world) and the other one without minivans (counterfactual).

TABLE 7

EQUILIBRIUM PRICES WITH AND WITHOUT THE MINIVAN, 1984: 1982–84 CPI-ADJUSTED DOLLARS

	PRICE			
	With Minivan	Without Minivan	ΔPRICE	% ΔPRICE
	A. Largest Price Decreases on Entry			
GM Oldsmobile Toronado (large sedan)	15,502	15,643	−141	.90
GM Buick Riviera (large sedan)	15,379	15,519	−139	.89
GM Buick Electra (large sedan)	12,843	12,978	−135	1.04
GM Chevrolet Celebrity (station wagon)	8,304	8,431	−127	1.51
Ford Cadillac Eldorado (large sedan)	19,578	19,704	−126	.64
Ford Cadillac Seville (large sedan)	21,625	21,749	−125	.57
GM Pontiac 6000 (station wagon)	9,273	9,397	−123	1.31
GM Oldsmobile Ciera (station wagon)	9,591	9,714	−123	1.27
GM Buick Century (station wagon)	8,935	9,056	−121	1.34
GM Oldsmobile Firenza (station wagon)	7,595	7,699	−104	1.35
	B. Largest Price Increases on Entry			
Chrysler LeBaron (station wagon)	9,869	9,572	297	3.10
Volkswagen Quattro (station wagon)	13,263	13,079	184	1.41
Chrysler (Dodge) Aries K (station wagon)	7,829	7,659	170	2.22
AMC Eagle (station wagon)	10,178	10,069	109	1.08

NOTE.—Equilibrium prices without minivans are estimated using the model with microdata and Bertrand-Nash first-order conditions. Bertrand-Nash pricing with random coefficients does not a priori determine signs of firm-specific price changes.

Welfare Analysis

- Consumer side:
  - Overall gains from the introduction of the minivan were large, and consumer benefits far outweighed the costs of development and the profits obtained by the innovator.
  - Almost half of these benefits came from increased price competition and accrued to nonminivan purchasers.
- Producer side:
  - Chrysler obtained large benefits from the introduction of the minivan, easily recouping its initial development costs.

Alternative Ways to Analyzie New Products

- This example is from Irwin and Pavcnik (2004), "Airbus versus Boeing revisited: international competition in the aircraft market".
- Industry: aircraft market
- To know the impact of A-380 entry. (It was first delivered to Singapore Airlines on 15 October 2007)
- The A-380 is designed to compete directly against the Boeing 747 at the high end of the wide-body market.
- How to impose a new product?
  - First, they take the announced prices and characteristics of the A-380 as given.
  - Then they assume that its unobserved quality equals the unobserved quality of A-340 in 1998.

Impact of A-380 Entry

- Simulation results:
  - A-380 could reduce the market share of the 747 by up to 14.8 percentage points in the long-range wide-body market segment
  - However, A-380 would also reduce the market for Airbuss existing wide-bodies by an even greater margin.

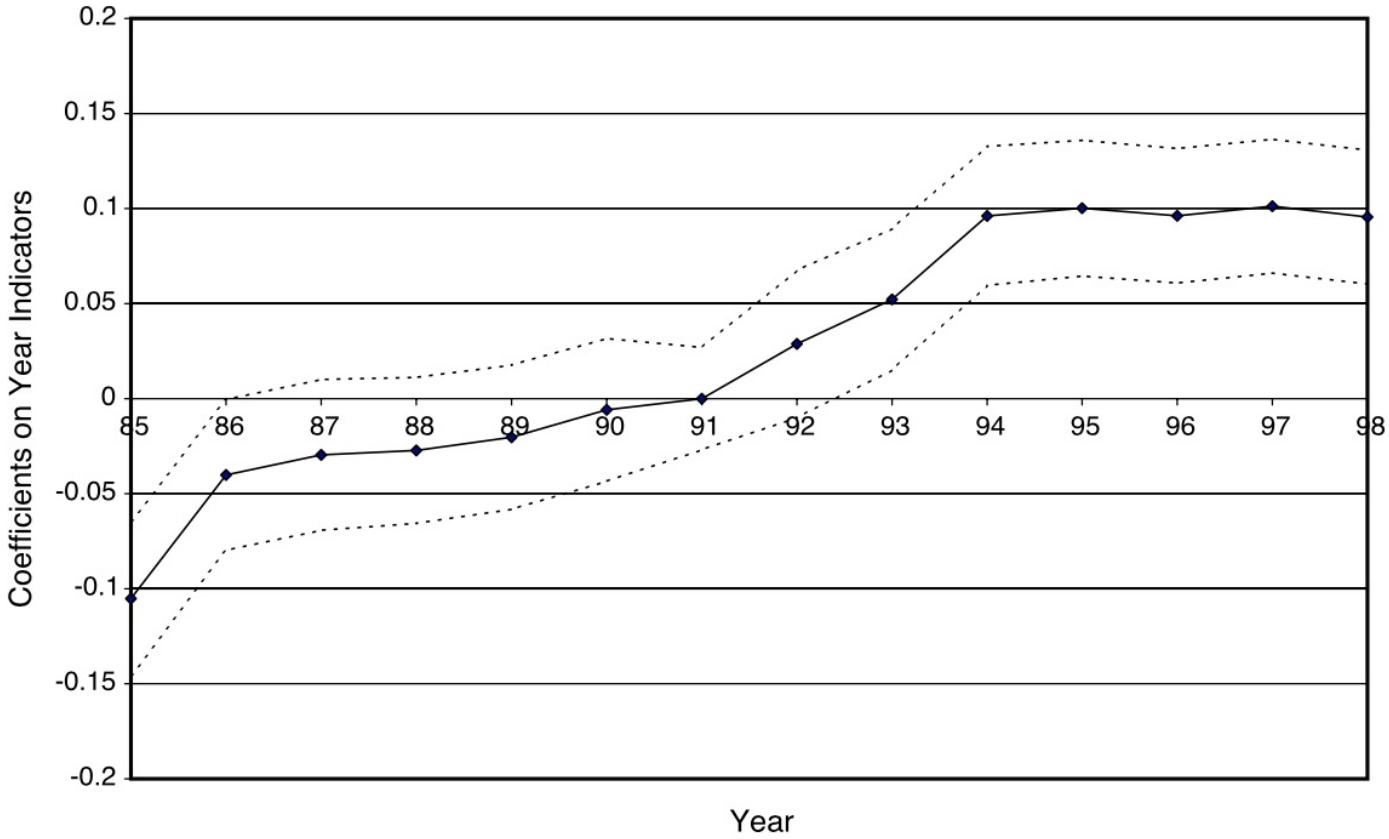
Policy Evaluation

Policy Evaluation

- This example is from Irwin and Pavcnik (2004), "Airbus versus Boeing revisited: international competition in the aircraft market".
- Industry: aircraft market
- Background:
  - In 1992, the United States and European Community reached a bilateral agreement on trade in civil aircraft.
  - The agreement establishes limits on the direct and indirect (military) subsidies used to finance the development of new aircraft.
  - The maximum allowed direct subsidy is 33% of development costs.
  - The agreement has several provisions that affect the variable production cost of aircraft and might thus affect pricing in the aircraft market.
  - ... (many details about subsidies)
- Question: Did the 1992 bilateral agreement have any impact on pricing in the aircraft market?

Impact of the 1992 Agreement

- To compare the aircraft prices before and after the agreement, they regress aircraft prices (in logs) on dummies for each year and other time-varying factors which can affect the aircraft prices.



Quantify the Change of Marginal Costs

- They simulate the case that firms' marginal cost increases ranging from 5% to 20%.
- The table suggests that the observed average 3.77.5% price rise corresponds to about 510% increase in the marginal costs of firms.

Table 5b
The stimulated effect of the 1992 trade agreement on prices

Marginal cost increase	No change	5%	7.5%	10%	12.5%	15%	17.5%	20%
Durable demand								
Average price	89.6	93.3	95.1	97.0	98.8	100.7	102.5	104.4
S.D.	(27.1)	(28.3)	(28.9)	(29.5)	(30.1)	(30.7)	(31.3)	(31.9)
Average % change in price	n.a.	4.09	6.14	8.19	10.24	12.30	14.36	16.42
S.D.	n.a.	(0.25)	(0.37)	(0.50)	(0.63)	(0.75)	(0.88)	(1.01)

Simulations are based on demand parameter from Table 2, column 2 and the assumption of multi-product Bertrand pricing. Simulations use aircraft characteristics and marginal cost estimates from 1992. The prices are expressed in million 1995 US Dollars.

Alternative Way to Evaluate the Policy

- If we know the policy rule precisely, then we can directly use the new marginal costs to simulate the new equilibrium.
- For instance, if the trade agreement affects the import tax rates for some of the products, then the new marginal costs for those products should be directly adjusted based on the new tax rates. Then we can solve the new prices for all the products.

Summary

- After the demand estimation, we can set up the model to fit the supply side problem.
- Based on the supply side problem, we can solve some cost parameters for the firms, such as marginal costs.
- We can use the counterfactual exercise to investigate the merger effect, welfare gain from the new products, and the policy evaluation.
- We can also apply this framework to study many interesting questions.