# From Models of Firm Behavior to The Analysis of Market Outcomes: Empirical Industrial Organization.

The Jean-Jacques Laffont Lecture

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# What is Industrial Organization?

- Industrial Organization is the study of market responses to environmental and/or policy changes.
- I will regard a market as a collection of firms that produce competing products or services and sell them either to consumers or to other firms.
- The firms are "self-interested". The actions they take are modeled as attempts to maximize their value.
- The complication is that the outcome from a firm's actions depends on the actions of the competing firms.
- A change induces each firm to adjust its behavior. .Whether the outcome is satisfactory depends on the actions of competitors. If it is not, we assume the firm makes a further adjustment.

- This process continues until we reach a "rest point"; a situation where each firm perceives that it is doing the best it can given the actions of the other firms; so no firm has an incentive to change its behavior (to "deviate").
- A rest point for prices: when a firm increases its price it earns an extra Euro from all those who stay, but it loses the "markup" (price minus marginal cost) on those who leave. This continues until the two changes in profits offset each other:.
- It has become common place to analyze the effect of the environmental and policy change in terms of such a "rest point".
- Most of this lecture will focus on examples of what we have been able to accomplish using this assumption; but I would also like to give some indication on what we are missing.
- Nobody believes the market will get to a rest point instantaneously,

- We use the rest point assumption because
  - we think firms will not stop adjusting until the condition is met, and
  - we know very little about what an appropriate adjustment model looks like (for an initial attempt to look at this empirically see Doraszelski, Lewis, and Pakes).
- It is obvious that having an adjustment model, would let us investigate "transition dynamics"
  - how long does it take to get to the new rest point, and
  - how desirable is the transition path
- But the need for a model of adjustment is deeper than that.
- In models with interacting agents, like our models of markets, there may be several "rest points" with quite different properties.
- A reasonably accurate empirical model of how firms' learn to adapt to a change would be one way of choosing between the alternatives when computing the likely result of a policy option.

# Brief Recent History of the Field.

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- We quickly discarded the notion of perfectly competitive markets – markets where firms are “price-takers” and in equilibrium price equaled marginal cost for two reasons.
  1. Logical: it takes time and resources to start a firm, and if those inputs are not remunerated no firm will ever be established, and
  2. Empirical. The only markets that looked anything like that description were some agricultural markets – and they failed (the government to come in with various subsidies)..
- During the 1980’s theorists took up the challenge of analyzing responses to changes in market institutions in “oligopolistic” markets (where each firm actions affected all firms’ payoffs) and what followed was a revolution in the way market were analyzed.
- The models carefully laid out the assumptions their results relied on. These were quite detailed, but the results were very useful in opening up our eyes to what could happen in oligopolistic markets.
- The problem with using them was that often it was not clear which assumptions were appropriate for any given situation.

# Enter Empirical Industrial Organization.

- General Goal; build frameworks that let the data tie down the assumptions needed in order to use the theory to generate market responses in different situations.
- Earlier attempts to merge empirical work with theory (e.g. Houthakker, 1955, for production and Gorman, unpublished circa 1960 on demand systems) were difficult to generalize in a usable way, and it was the generality that enabled us to go to data to sort out assumptions.
- What changed? The computer revolution; and the data, econometric techniques, and computational abilities that accompanied it.
- Question:: how could we use these new instruments to mitigate the gap between the empirical work available on markets and what theory had been teaching us.
- Two related literatures developed in response to these developments.

- One part of the literature, closely associated with Jean-Jacques and the Toulouse school more broadly, studied the interaction between firms and regulators in regulated industries and auctions.
- These are situations where differences in the information available to different agents are central to explaining the phenomena being analyzed.
- A second literature, the part I was associated with, dealt with, the interaction among competing firms in a given product market.
- Here the focus was on the development, pricing, profitability and welfare implications of the products brought to market.
- Interestingly in my mind the most important early conference on empirical Industrial Organization was organized by Jean Jacques, included both strands of the literature, and occurred here in Toulouse in 1992.
- To keep things manageable I will focus on the part of the literature that deals with competition among a known set of products with known cost functions.
- Dynamic models of investment and product development are more complicated. I will briefly sketch were we are with them at the end of the lecture.

# What did we need to analyze these markets?

1. A model for how much of these products would be purchased at various prices (a "demand" system)
2. A model for how much does it cost to produce those products (a "cost" or "production" function).
3. A model for how firms determine prices given demand and cost
   - retail markets where there are take it or leave it offers and a Nash equilibrium.
   - markets with a few agents on each side who bargain with one another over prices.

# Primitives: The demand systems.

Problems with the prior product space models.

1. The "too many parameter problem".
2. Predicting demand for new goods.

We changed to characteristic space i.e.

- Products are defined as bundles of characteristics.
- Individual preferences determined by the interaction of product characteristics with the individual's characteristics.

Berry, Levinsohn and Pakes (1995, 2004); or BLP and fellow travelers.

This generated two computational problems.

- Aggregation. To figure out aggregate demand we had to sum up over the demands of many different individuals This is where computers and simulation techniques came in. (Prediction: McFadden and Travilte (1979); Estimation: Pakes, 1986)
- At least for retail products we need to allow for characteristics we could not condition on, and we had to be able to separate their effects from price effects (BLP).

# How have we done with our demand and pricing assumptions?

- At least in retail markets the framework can easily be checked.
- This because of the logic of equilibrium pricing we reviewed above. I.e. if we rely on
  - our demand system
  - our equilibrium or "rest point" assumption
- Price should equal cost plus a markup.
- The markup can be obtained separately from the estimates of the demand system and should have a coefficient of one in the pricing equation.

**The Wollmann Exercise**

- Have a separately estimated demand system for trucks.
- Regress price on the determinants of costs and the predicted markup.
- Then look at
  - fit
  - coefficient of markup
  - how well we fit changes in a products price over time.

As you can see we do pretty well. Accordingly the framework is used

- in much of economic research that deals with demand, supply, or equilibrium in market settings
- by government agencies when predicting likely outcomes from different policies
- used by many consultancies, and some firms in their planning

**Table 1: Wollmann & Pricing Equilibrium.**

| | Price | (S.E.) | Price | (S.E.) |
|---|---|---|---|---|
| Gross Weight | .36 | (0.01) | .36 | (.003) |
| Cab-over | .13 | (0.01) | .13 | (0.01) |
| Compact front | -.19 | (0.04) | 0.21 | (0.03) |
| long cab | -.01 | (0.04) | 0.03 | (0.03) |
| Wage | .08 | (.003) | 0.08 | (.003) |
| $\hat{Markup}$ | .92 | (0.31) | 1.12 | (0.22) |
| Time dummies? | No | n.r. | Yes | n.r. |
| $R^2$ | 0.86 | n.r. | 0.94 | n.r. |

**Note.** There are 1,777 observations; 16 firms over the period 1992-2012. S.E.=Standard error.

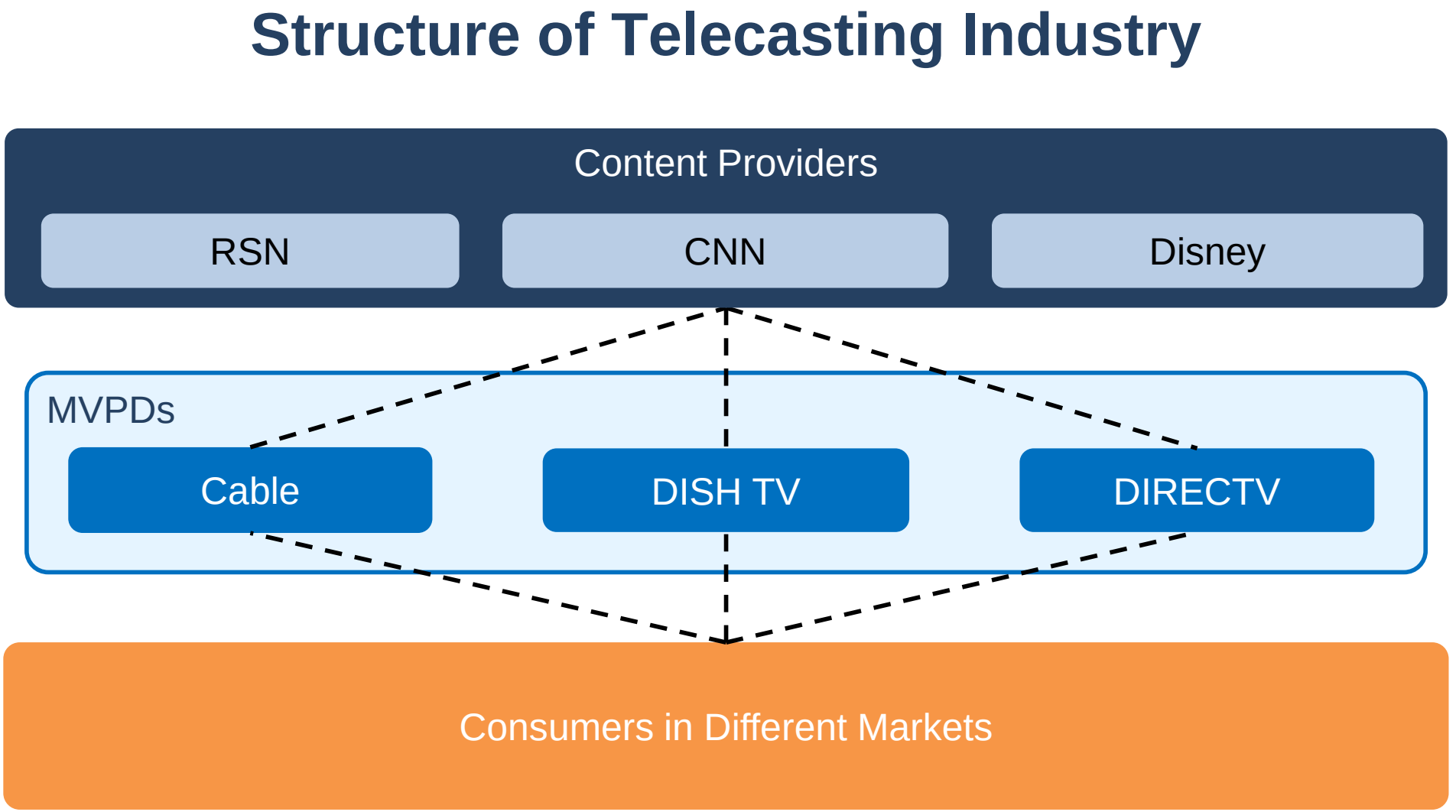
# Vertical Markets.

Examples; Broadcast television, health insurers, large retailers and manufacturers. Work starts with Crawford and Yurukoglu, (2012); Ho and Lee, (2017a and 2017b).

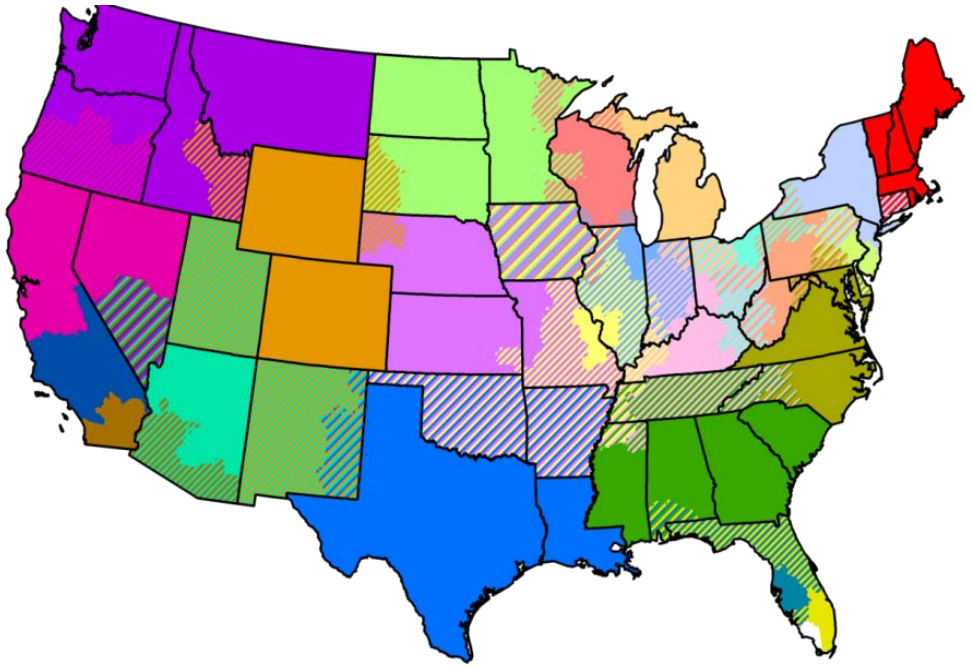
Structure

- "Upstream" market: Producers of goods or services that sell to an intermediary.
- The intermediary is typically a firm which buys from several different firms and re-markets bundles of these goods to consumers.
- The intermediary sets "take it or leave it" prices to consumers .
- If both the upstream firms and the intermediary are large they bargain for the price the intermediary pays the upstream firm for its goods or services.
- The total profits from the industry are the revenues the downstream firm generates minus the costs of production of the upstream firm.
- The bargaining generates a contract which splits those profits between the intermediary and the producer of the good.

# Example: what happens when you ignore the Intermediary.



# MLB Home Television Territories



- League defines each team's "home television territory."
- In-market telecast rights are assigned to the teams.
- Out-of-market ("OOM") telecast rights are held by the League.
- OOM telecasts can only be sold as part of an OOM Bundle ("OMB").

# Dr. Noll's Assumptions Ignore the MPVDs

| | Dr. Noll's Assumptions | Market Reality |
|---|---|---|
| **Marketer** | RSN: Each RSN sets the price to consumers for its own product | MVPDs: They contract with RSNs and set consumer prices for all RSN's they market. |
| **Cost to Marketer** | Only telecast costs | RSN/MVPD negotiation sets MVPD cost<br><br>Cost = telecast cost + RSN markup |
| **Pricing Incentives** | Each RSN sets its price independently to maximize its own revenue minus the telecast cost | An MVPD sets prices to maximize revenue from all products it markets minus the sum of their fees |

# Assumptions vs. Likely Reality

- Dr. Noll's BFW pricing assumptions.
  - MVPDs face higher cost than Dr. Noll assumes.
  - MVPDs prices multiple products, but Dr. Noll assumes RSNs set prices "independently."

  ***Implication: Consumers face higher prices than Dr. Noll's model predicts.***

- Dr. Noll did not check equilibrium conditions.
  - Dr. Noll assumes there still exists an OMB including all teams. However, the Yankees would make more money if they drop out and increase price.

  ***Implication: Both Yankee and OMB consumers lose.***

# Cost Functions.

- Cost data are often proprietary. If they are unavailable and we believe the theory, we can often back out marginal costs from the pricing assumption.
- Relies on the pricing assumption, but our pricing functions often do pretty well.
- In regulated industries there often is a regulatory requirement to submit data on costs.
- Opened up research in several fields, especially on health insurance (a major set of policy issues in the U.S.)
- Required empirical work to operationalize different parts of the theory literature.
  - adverse selection and moral hazard (early work; Einav, Finkelstein and Cullen, 2010)
  - incentive schemes for health care providers (the quality/cost tradeoff)
- The results on the adverse selection and moral hazard that emanated from choices among existing contracts, were that if we could design a mechanism which rid ourselves of these phenomena in health care we would save money, but the amount saved would only be a tiny part of health care costs.

- This because the vast majority of the costs came from treatment of the patients who required and always got treatment (obstetrics, cancer, end of life care ...), and neither adverse selection nor moral hazard had much of an impact on these costs.
- Question: can we alter incentives to providers to provide this care more efficiently.? E.g. Fee for service vs. capitation systems and the cost/quality tradeoff.
- The results we have thus far on incentive schemes are quite consistent; providers who face cost saving incentives seem not to sacrifice the quality of care, just the convenience of the patient. Ho and Pakes, 2014, on doctors; Einav, Finkelstein, and Mahoney, 2017, on Long-Term Care Hospitals.
- Recall that our society treats a minimum level of health insurance as a right. Entitlement programs like this should be evaluated by "Contractarian" not "Utilitarian" objective functions.
- So, though patients might have less utility as a result of the loss in convenience; that's not really the concern of an entitlement program. What we are trying to do is provide a given level of healthcare at minimal cost.

# Production Functions and Productivity

Productivity is defined as the ratio of outputs to inputs. Industrial Organization's interest in productivity

- analyzing the efficiency of the output allocation among firms; all else equal we would like to allocate output to firms in a way that minimizes costs (i.e. inputs), and
- for analyzing the impact of infrastructure, scientific advancements, spillovers from knowledge producing activities .., impact on our ability to produce output from a fixed set of inputs.

For productivity analysis we can suffice with data on the quantity of outputs and the quantities of inputs used in various plants and census offices opened up with such data.

However we need to estimate the index of inputs; determined by the "production function" (the description of how inputs are transformed into output).

# Example and the Problems that Arise.

Usually interested in measuring the productivity impacts of a major event in an industry; tariff reform, deregulation, major infrastructure projects, ....

Example: The breakup of A.T. & T (1982-84)

- Had been a monopolist in telephone services, and only purchased equipment from its wholly owned subsidiary, Western Electric.
- De-monopolization of the equipment industry starts with the registration and certification program in 1978.
- Judge Green's monopolization case.
  - Breaks it into 7 Regional Bell Operating Companies.
  - Makes it illegal for any of them to operate an equipment manufacturer.
- Result: huge changes in the industry; A.T.&T loses ground to entrants (Ericson, Northern Telecom, Hitachi,...). Data: 1972-87
  - 60% of plants (70% of firms) existed in 1972 exit by 1987
  - 80% of plants (87% of firms) were active in 1987 did not exist in 1972.
  - Firms who exit were negatively effected, and continuing establishment have very divergent growth rates (entrants grow from nothing).

# Production Function: Estimation Issues.

Estimation issues.

- Don't want to use a "balanced panel"; Exits are disproportionately those that were affected negatively by change. Need a model of relationship of exit to productivity.
- Want to analyze productivity change conditional on inputs, and firms that the change affected positively grew disproportionately. Need a model of inputs relationship to productivity.
- Economic theory provides models of input demand and exit decisions (Maskin and Tirole, 1987; Ericson and Pakes, 1995).
- Use the implications of the theory to correct for the relationship between productivity and i) input demands, ii) exit (Olley and Pakes 1996).

Table VI
Alternative Estimates of Production Function Parameters[a]
(Standard Errors in Parentheses)

| Sample: | Balanced Panel | | Full Sample[c,d] | | | |
|---|---|---|---|---|---|---|
| | | | | | | Nonparametric $F_\omega$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Estimation Procedure | Total | Within | Total | Within | OLS | Kernal |
| Labor | .851 | .728 | .693 | .629 | .628 | .608 |
| | (.039) | (.049) | (.019) | (.026) | (.020) | (.027) |
| Capital | .173 | .067 | .304 | .150 | .219 | .355 |
| | (.034) | (.049) | (.018) | (.026) | (.018) | (.058) |
| Age | .002 | -.006 | -.0046 | -.008 | -.001 | .010 |
| | (.003) | (.016) | (.0026) | (.017) | (.002) | (.013) |
| Time | .024 | .042 | .016 | .026 | .012 | .020 |
| | (.006) | (.017) | (.004) | (.017) | (.004) | (.046) |
| Investment | — | — | — | — | .13 | — |
| | | | | | (.01) | — |
| Other Variables | — | — | — | — | — | Kernel in $P$ and $h$ |
| # Obs.[b] | 896 | 896 | 2592 | 2592 | 2592 | 1758 |

**a.** The dependent variable is the log of value added.

# Results

*Production function estimates* (Table 6).

- Note the difference between the balanced panel estimates and the full sample. in
  - sample size
  - capital and labor coefficients
- full sample Total and Kernel which corrects for the input and exit decisions.

*Aggregate productivity* (Table 9).

- Productivity improvements greatly exaggerated in balanced panel
- In the period when they are adjusting to the change, productivity falls
- This is telecommunications so over the whole period productivity does go up at a decent rate; more so after 1984.

Table IX

Industry Productivity Grow Rates[a]

| Time Period | (1) Full Sample | (2) Balanced Panel |
|---|---|---|
| 1975-1977 | .020 | -.015 |
| 1978-1980 | .146 | .102 |
| 1981-1983 | -.087 | -.038 |
| 1984-1987 | .041 | .069 |
| 1975-1987 | .032 | .036 |
| 1978-1987 | .034 | .047 |

[a] The numbers in Table IX are annual averages over the various subperiods.

# Decomposing Productivity Growth

If $p_{i,t}$ is measured productivity $p_t$ is aggregate productivity for the industry, $s_{i,t}$ is the share of the plant in industry sales, and $\overline{p}_t$ is the (unweighted) average productivity among plants

$$p_{i,t} = \sum_i s_{i,t} p_{i,t} \quad \Rightarrow \quad p_t = \overline{p}_t + \sum_i \Delta s_{i,t} \Delta p_{i,t},$$

where $\Delta p_{i,t} = p_{i,t} - \overline{p}_t$, etc.

- Divide productivity changes into
  1. allocation of output effect,
  2. general productivity improvement.
- The productivity improvements we see after 1984 are totally in the distribution of output among plants (Table 11)
- What is clear is that the covariance of capital and productivity is improving. Under regulation the capital allocation seems inefficient and deregulation improves it.

Table XI
Decomposition of Productivity[a]
(Equation (16))

| Year | $p_i$ | $\overline{p}_i$ | $\Sigma_i \Delta s_{it} \Delta p_{it}$ | $\rho(p_t, k_t)$ |
|---|---|---|---|---|
| 1975 | 0.72 | 0.66 | 0.06 | -0.11 |
| 1976 | 0.77 | 0.69 | 0.07 | -0.12 |
| 1977 | 0.75 | 0.72 | 0.03 | -0.09 |
| 1978 | 0.92 | 0.80 | 0.12 | -0.05 |
| 1979 | 0.95 | 0.84 | 0.12 | -0.05 |
| 1980 | 1.12 | 0.84 | 0.28 | -0.02 |
| 1981 | 1.11 | 0.76 | 0.35 | 0.02 |
| 1982 | 1.08 | 0.77 | 0.31 | -0.01 |
| 1983 | 0.84 | 0.76 | 0.08 | -0.07 |
| 1984 | 0.90 | 0.83 | 0.07 | -0.09 |
| 1985 | 0.99 | 0.72 | 0.26 | 0.02 |
| 1986 | 0.92 | 0.72 | 0.20 | 0.03 |
| 1987 | 0.97 | 0.66 | 0.32 | 0.10 |

[a] See text for details.

# Generalizations and Caveats.

- Subsequent research replicates the problem of a misallocation of capital in regulated industries.
- There is a question of what happened to R&D and subsequent innovation. All indications are both increased.
- Most data sets (including this one) have revenue, but not quantity.. For many issues it will be important to separate them out.
- E.g. in our paper, it may be that the low average productivity is because the introduction of competition decreased prices (though this should not effect the analysis of the allocation of output).
- New work by De Loecker and co-authors (E.g. De Loecker, Goldberg, Khanderwal, Pavnick 2015): makes quite a bit of progress in separating revenue from output productivity.

# A Start on Product Development: Product Repositioning and Merger Analysis.

*Background: Merger analysis.*

- Focuses on predicting price changes resulting from the merger holding the set of products and their characteristics constant, largely using the framework above.
- Price logic: same as before but now when the firm loses a customer when it increases its price the customer may go the other product it owns, and it gains the markup on that.
- If their are no cost changes due to the merger, this will increase price.

*Product repositioning*: a change in the characteristics of the products marketed by an incumbent firm. Recent work:

- a number of industries in which firms already in the market can change the characteristics of their products as easily as they can change prices, and
- shows that static analysis that does not take repositioning into account is likely to be misleading, even in the very short run.

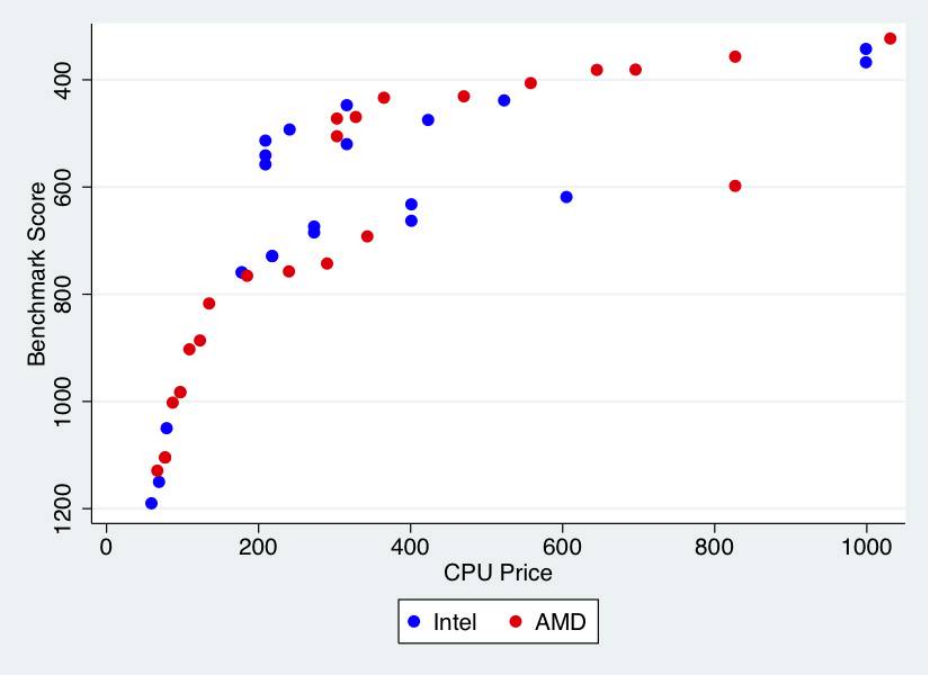
*The product repositioning literature*

- Employs different empirical tools than the dynamic literature, and given demand systems and pricing assumptions, the tools are easy to use.
- Need to estimate fixed cost of marketing a new variant and of taking out a product variant.
- Use the new literature on profit inequalities (Pakes, Porter, Ho, and Ishii, 2012)
  - The incremental profits a firm makes from marketing a product are expected to be greater than the fixed cost (otherwise why would the new product be marketed).
  - Since we can calculate what profits would be earned with and without the new product, this gives us a lower bound on those fixed costs.
  - Similarly if a firm could have marketed a product but decided not to, the change in profits that it expected to earn from marketing the new product must be less than the fixed costs. This gives us an upper bound.

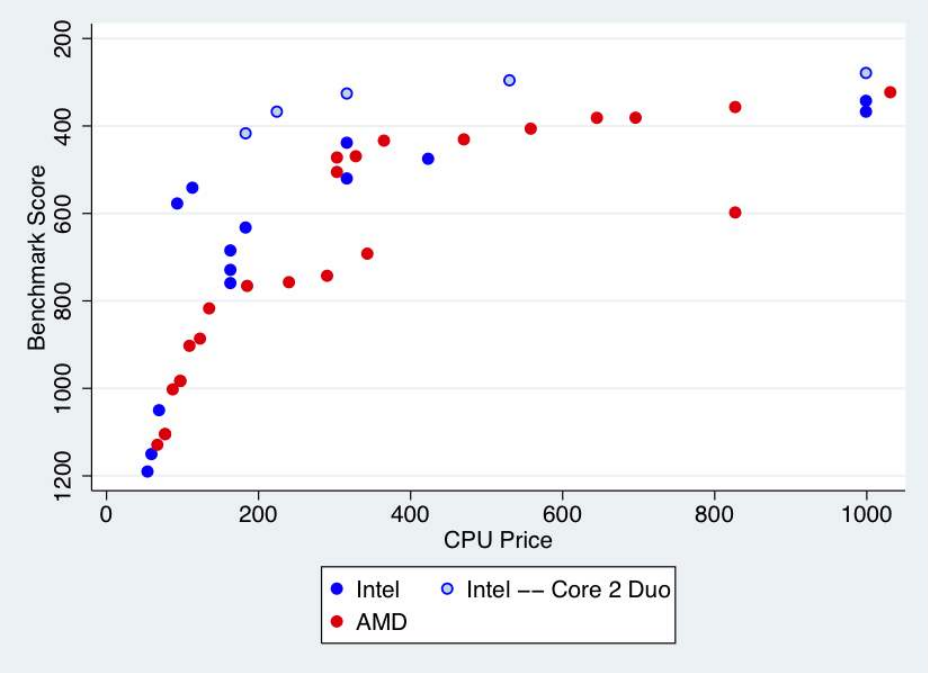
# Example: Nosko: Intels' Introduction of The Core 2 Duo Generation in Desktops.

Figures: benchmark scores and prices for the products offered at different times.

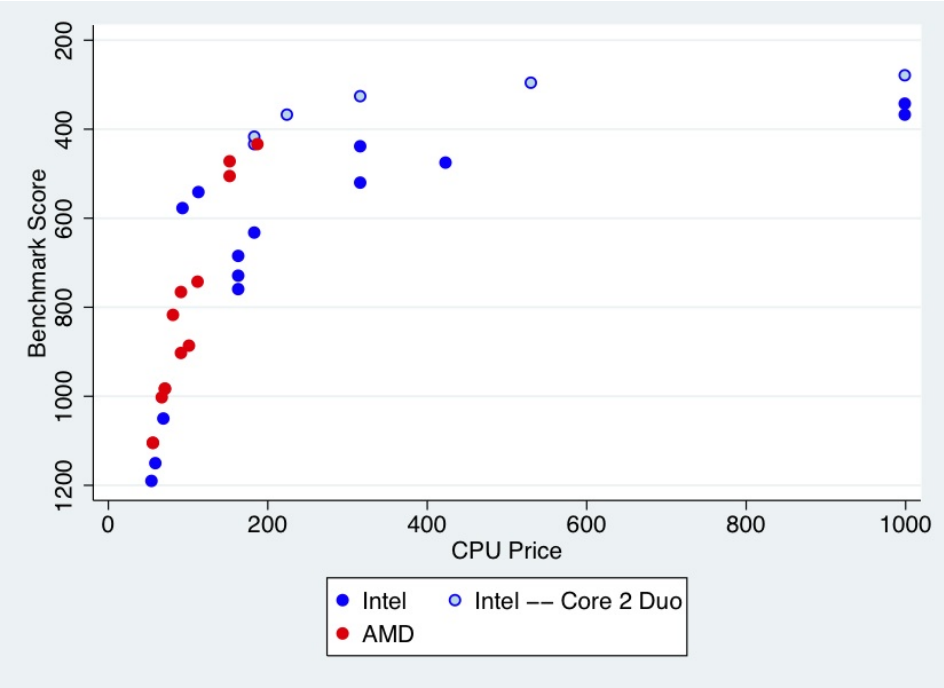
- June 2006: just prior to the introduction of the Core 2 Duo. The red and blue dots represent AMD's and Intel's offerings. Intense competition for high performance chips with AMD selling the highest priced product at just over $1000: seven sold at prices between $1000 and $600.
- Core 2 Duo introduced in July. By October; (i) AMD no longer markets any high priced chips (ii) there are no chips offered between $1000 and $600 dollars.
- November 2006: Only Core 2 Duo's at the high end.
- Nosko goes on to explain
  - that the returns from the research that went into the Core 2 Duo came primarily from the markups Intel was able to earn as a result of emptying out the space of middle priced chips and dominating the high priced end of the spectrum.
  - how a similar phenomena would likely occur if AMD were to merge with Intel. So one would get the wrong results if one ignored product repositioning in analyzing the potential merger.



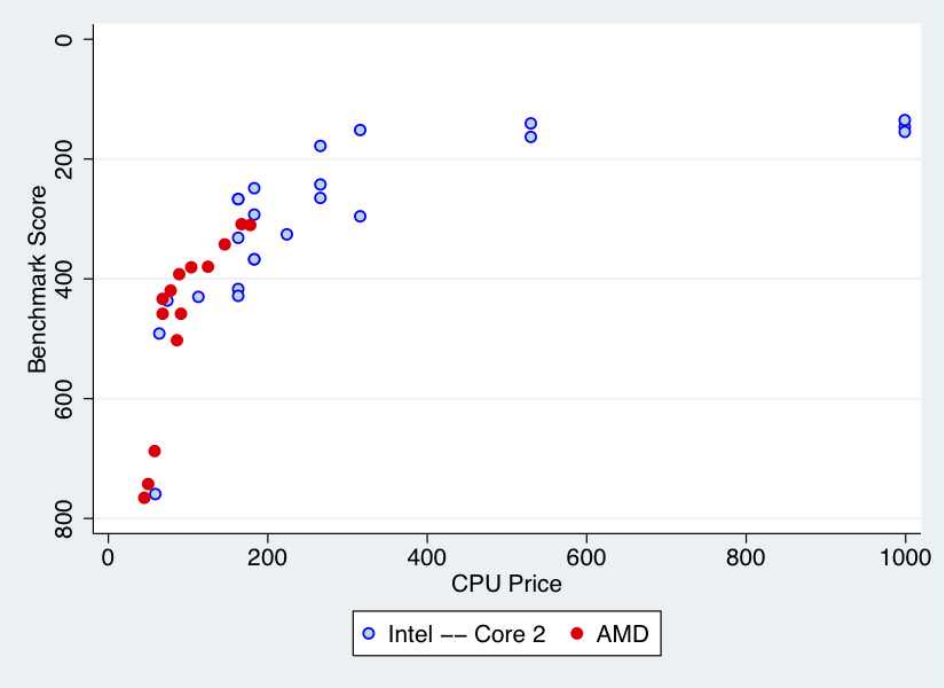

Price/Performance – June 2006




Price/Performance – July 2006




Price/Performance – Oct 2006




Price/Performance – January 2008

# Calculation of Counterfactuals.

Not enough to estimate fixed cost, must compute likely counterfactual equilibrium after merger. Use a two period perfect model (backward induction)

- product offerings set in the first stage and
- prices set in the second.

*The Multiplicity Problem.*

- When there are interacting agents there may be more than one rest point.
- If one firm produces product A, the other firm might be induced to produce product B; but if the first firm produced B, the second firm is unlikely to do so.
- That is what is profitable for me to do, depends on what my competitors do, and vice versa. So this leaves open room for many rest points.
- We need a way of choosing between them if we are to do counterfactuals.

*Back to Learning Theory.*

- One way to chose between the equilibria is to investigate how firms adapt to changes in their environment.
- If we knew this, and assumed they would keep changing until they reach a rest point, we could simulate what is likely to happen, and therefore which rest points are likely to be reached.
- This goes back to the beginning of the lecture. There we said we would need a learning model to analyze the time period between the equilibrium before the change and the new equilibrium induced by the change.
- Now we need a model of learning to know which new equilibrium we get to.

*Dynamics more generally..* Using the standard dynamic equilibrium frameworks (Maskin Tirole, 1987, Ericson Pakes, 1995) the models become extremely complex. The challenge becomes producing a framework which

- May actually better approximate firm behavior better through eliminating some of the complexities
- Enables us to analyze an assortment of industries with the data and tools we currently have available.

*Attempts to minimize the complexity.* Two related frameworks have been suggested

- "Oblivious Equilibrium" (introduced as an approximation technique by Benkard, Weintraub, and Van Roy, 2008).
- "Experience Based Equilibrium" (introduced as a behavioral model with asymmetric information) by Fershtman and Pakes, 2012).
- If one assumes the appropriate information sets (the basis functions for the approximations), they are the same.
- Equilibrium still requires a lot of information, and there is still a question of how firms behave whilst trying to accumulate it.

**Many thanks for being selected for this honor, and for your attention during my talk.**