ECON-L1300 - Empirical Industrial Organization, PhD I: Static models

Lecture 8

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About today's lecture

- We discuss Dubois, P. & Lasio, L. (2018). Identifying industry marging with price constraints: Structural estimation on pharmaceuticals. *American Economic Review*, *108*(12), 3685–3724:

  1. What is the research question?
  2. Why would we care?
  3. Institutional setting
  4. Data
  5. Reduced form evidence
  6. Structural model
  7. Empirical implementation: specification
  8. Empirical implementation: instruments
  9. Empirical implementation: estimation results
  10. Empirical implementation: price constraint - results
  11. Empirical implementation: counterfactuals
  12. Overall assessment

What is the research question?

- Pharmaceutical prices regulated in many countries.
- May different types of regulation.
- Do these work?

Why would we care?

- Lots on money and health at stake.
- Notice also what is not done:
  1. innovation
  2. entry

Aside: Structure of intro

1. First para: motivation
2. 2nd - 4th para: what is done
3. 5th para: what is found
4. 6th - para: comparison to existing literature; what is new, how do results compare

Institutional setting

- Consumption of pharmaceuticals high in France.
- Public campaigns for use of generics.
- Financial incentives for pharmacists for generic substitution.
- Guidelines for physicians to prescribe drugs for which generics available.
- review of reimbursed drugs re therapeutic value.

Institutional setting

- 2003 maximum reimbursement rule introduced (TFR) as a function of generic price — low generic market share.
- Prices proposed by firms but approved by regulator:
  - prices of comparable drugs
  - therapeutic improvement
  - anticipated sales volume
- 2004 external reference pricing introduced (Italy, Germany, UK, Spain).
- 2006 regulator declared a price cut on all drugs in markets where generics available.

Institutional setting

TABLE 1—REGULATORY CHANGES AFFECTING THE ANTI-ULCER MARKET IN FRANCE SINCE 2003

Date	Description
Panel A. Regulatory changes affecting the demand side	
September 2003	Introduction of maximum reimbursement price (TFR) for Cimetidine (Tagamet) and Ranitidine (Zantac and Raniplex)
January 2006	Introduction of TFR on Famotidine (Pepcidine)
Panel B. Regulatory changes affecting the supply side	
January 2006	Price cut of all drugs in a class if generics entered or have been available for 24 months—Omeprazole (Losec) and Lansoprazole (Takepron, Lanzor)
January 2008	Price cut for branded drugs if enough sales of generics of the same or close substitute molecules—Esomeprazole (Nexium)
January 2009	Revision of the price cut rule (18 months instead of 24) for Omeprazole, Lansoprazole, and Pantoprazole (Pantozol)
January 2012	Revision of the price cut rule at generic entry for Omeprazole, Lansoprazole, Pantoprazole, and Rabeprazole (Pariet)

Note: Price cuts in 2006, 2009, 2012 are of different percentages.

Institutional setting

- Paper concentrates on price cuts.
- ERP studied in the counterfactual.

Institutional setting: Anti-ulcer drugs

- Anti-ulcer drugs (ATC class A02B): one of top-selling therapeutic classes world-wide.
- Potential substitution within this class, but not with drugs in other ATC-4 classes.
- 3 types of drugs:
  1. histamine antagonists (H2)
  2. proton-pump inhibitors (PPI)
  3. Prostaglandins
- Patent expiration for major drugs in the early 2000s, leading to generic entry.

Data

- IMS Health (data vendor): observation unit drug-country-year (name, manufacturer, molecule, therapeutic form, brand).
- Quantity and price.
- Advertising by drug/media/country (# detailing units).
- France, Germany, US; also avg wholesale prices in Italy, Spain, UK (instruments).
- French regulator: side effects, indications, medicat benefits, introduction and level of TFR.

Data

- 2003 - 2013; 103 different drugs; 29 firms (13 branded).
- 77 drugs in PPI; 24 in H2.
- Reimbursement rate usually 65%; for some older drugs 35% (from 2007).
- France, Germany, US; also avg wholesale prices in Italy, Spain, UK (instruments).
- French regulator: side effects, indications, medical benefits, introduction and level of TFR.

Data

TABLE 2—SUMMARY STATISTICS FOR FRANCE

Year	Number of drugs			Quantity	Market share (%)		Wholesale Price/std unit		Firm revenue
	All	Branded	Generics	(1,000 std units)	Branded	Generics	(US$)	(€)	(1,000 US$)
2003	25	12	13	1,131,140	98	2	0.75	0.55	1,414,127
2004	39	12	27	1,233,735	86	14	0.78	0.57	1,455,683
2005	40	12	28	1,334,331	77	23	0.70	0.51	1,423,278
2006	42	12	30	1,444,926	73	27	0.63	0.46	1,404,320
2007	51	12	39	1,508,936	70	30	0.60	0.44	1,364,369
2008	49	12	37	1,535,426	61	39	0.56	0.41	1,240,799
2009	59	12	47	1,596,513	55	45	0.52	0.38	1,183,251
2010	62	12	50	1,669,252	50	50	0.46	0.33	1,069,219
2011	74	12	62	1,732,595	39	61	0.43	0.31	974,594
2012	86	12	74	1,820,351	29	71	0.39	0.28	853,985
2013	94	11	83	1,890,575	18	82	0.32	0.23	619,035

Notes: Price is the average price per standard unit in US$ or in € (constant exchange rate for 2014:II: €/US$ = 1.3772). Expenses is the total manufacturer-level revenue of the class. Wholesale prices are at the manufacturer level. Here, the market shares are relative to the total sales of anti-ulcer drugs (no outside good as in the model).

Reduced form evidence

- "Triple-difference" estimation.
- Dependent variable: log price.
- Explanatory variables:
  1. drug characteristics
  2. drug group dummies (TFR, Price Cut)
  3. interaction between group dummies and post-dummy
  4. interaction between France-dummy and the above interaction
  5. year, country, molecule FE

Reduced form evidence

Drug group dummies after				
TFR × after	0.341	0.324	0.639	0.468
	(0.558)	(0.622)	(0.690)	(0.724)
Price Cut × after	0.232	0.290	0.113	0.659
	(0.233)	(0.188)	(0.186)	(0.354)
Reimbursement rule change in France				
TFR × after × France	−0.770	−0.814	−1.656	−1.627
	(0.541)	(0.542)	(0.694)	(0.772)
Price regulation in France				
Price Cut × after × France	−0.773	−0.737	−0.293	−0.328
	(0.353)	(0.338)	(0.291)	(0.384)
Country fixed effects	Yes			
Molecule fixed effects	Yes	Yes		
Year fixed effects	Yes			
Country year fixed effects		Yes	Yes	
Country-molecule fixed effects			Yes	
Country-molecule-year fixed effects				Yes
Observations	2,614	2,614	2,614	2,614
R^2	0.507	0.525	0.599	0.670

Structural model: firms

- pp. 3695: *In France, the prices of drugs must be agreed upon by the regulator (CEPS) and are not determined under fully binding regulatory rules. Thus, it is possible that pharmaceutical companies obtain prices that maximize profits.*

Profit function

$$\Pi_{ft} = \sum_{j \in F_f} (p_{jt} - c_{jt})\, q_{jt}(\mathbf{p}_t, \mathbf{a}_t) - a_{jt}\,, \tag{1}$$

where p_{jt} is the price of drug j, a_{jt} is the detailing expense for drug j, c_{jt} is the constant marginal cost of product j, and $q_{jt}(\mathbf{p}_t, \mathbf{a}_t)$ is the quantity of drug j demanded given the vector $\mathbf{p}_t$ of all drug prices and the vector of detailing expenditures $\mathbf{a}_t$ for all J products.

As assumptions on firms' detailing choices are not necessary to identify marginal costs, we only consider the firms' profit-maximizing conditions in prices and assume that they compete in price à la Bertrand. Assuming that a pure-strategy Bertrand-Nash equilibrium in prices exists, the price of any product j sold by firm f must satisfy the first-order condition

$$q_{jt} + \sum_{k \in F_f} (p_{kt} - c_{kt}) \frac{\partial q_{kt}(\mathbf{p}_t, \mathbf{a}_t)}{\partial p_{jt}} = 0. \tag{2}$$

PCM

Then, with $\mathbf{1}_{\{j \in F_f\}} = 1$ if $j \in F_f$ and 0 otherwise, denoting by D_f the $J \times J$ diagonal matrix whose row ith element is $\mathbf{1}_{\{i \in F_f\}}$, by Q_{p_t} the $J \times J$ matrix whose row i column j element is $\partial q_{jt}(\mathbf{p}_t, \mathbf{a}_t)/\partial p_{it}$ and $\mathbf{q}_t = (q_{1t}, \ldots, q_{Jt})'$, $\mathbf{c}_t = (c_{1t}, \ldots, c_{Jt})'$, we obtain the usual formula valid for all firms f:

$$D_f(\mathbf{p}_t - \mathbf{c}_t) = -\left[D_f Q_{p_t} D_f\right]^{-1} D_f \mathbf{q}_t. \tag{3}$$

Constrained profit function

For branded drugs in France, some price ceiling $\overline{p}_{jt}$ for drug j may be imposed by the regulator when the drug is first authorized and revised over time, in which case $\mathbf{\Omega}_{jt} = [0, \overline{p}_{jt}]$. For generic drugs, French regulation also imposes a price ceiling that is a specific proportion of the price of the branded version. If for a generic drug j we denote by $b(j)$ the index of the branded version of the same molecule, the price constraint can then be written as $p_{jt} \leq \tau_{b(j)t} p_{b(j)t}$, where $\tau_{b(j)t}$ is a year-specific (and sometimes molecule-specific) factor set by the regulator; then, $\mathbf{\Omega}_{jt} = [0, \tau_{b(j)t} p_{b(j)t}]$. Until 2005, it was 55 percent at the time of generic entry, then reduced to 50 percent in 2006, 45 percent in 2009, and 40 percent in 2012. This percentage may be higher in exceptional cases approved by the regulator (high production costs, late entry for generic manufacturers, low price of the branded drug) but reducing to less than 10 percent the difference between the brand-name and the generic price.

Then, removing detailing arguments ($\mathbf{a}_t$) from demand to simplify notation, firm f's constrained price maximization, given other firms' pricing strategies, is

$$\max_{\{p_{jt}\}_{j \in F_f}} \Pi_{ft} = \sum_{j \in F_f} (p_{jt} - c_{jt})\, q_{jt}(\mathbf{p}_t) \quad \text{subject to} \quad p_{jt} \in \mathbf{\Omega}_{jt}. \tag{4}$$

Constrained PCM

Assuming that a pure-strategy Bertrand-Nash equilibrium in prices exists, the necessary first-order conditions of the problem above are[5]

$$q_{jt} + \sum_{k \in F_f} (p_{kt} - c_{kt}) \frac{\partial q_{kt}(\mathbf{p}_t)}{\partial p_{jt}} = \lambda_{jt} \quad \forall j \in F_f, \forall f. \tag{5}$$

In the current regulatory framework in France, denoting by $\tilde{\lambda}_{jt}$ the Lagrange multiplier of the price cap constraint that may implicitly or explicitly be imposed by the regulator on branded drugs ($p_{jt} \leq \overline{p}_{jt}$) and on generic drugs ($p_{jt} \leq \tau_{b(j)t} p_{b(j)t}$), λ_{jt} is equal to the "true" Lagrange multiplier $\tilde{\lambda}_{jt}$, except in the case in which the manufacturer owns both the branded and generic drug version, in which case for the branded drug j, $\lambda_{jt} = \tilde{\lambda}_{jt} - \tau_{jt} \tilde{\lambda}_{g(j)}$, where $g(j)$ denotes the generic version of j.[6]

Identification problem

In the case of a Bertrand-Nash equilibrium in prices, the first-order conditions of firm f can be written in matrix form as

$$D_f(\mathbf{p}_t - \mathbf{c}_t) = -\left[D_f Q_p(\mathbf{p}_t) D_f\right]^{-1} D_f(\mathbf{q}_t - \lambda_t), \tag{7}$$

where the elements of $\boldsymbol{\lambda}_t = (\lambda_{1t}, \ldots, \lambda_{Jt})$ are unknown (J_t allows the total number of products to vary with t).

Thus, with $\boldsymbol{\lambda}_t$ being unknown, even with known demand and prices, one cannot identify price-cost margins without further assumptions. Theoretically, the net effects of regulation on prices are ambiguous and will depend on all own- and cross-price elasticities of demand. A price reduction for one drug can affect other drugs that are not constrained because of cross-price elasticities of demand. Using first-order conditions, for each vector $\boldsymbol{\lambda}_t$, we have price-cost margins or marginal cost $c_{jt}(\boldsymbol{\lambda}_t)$ as a known function of $\boldsymbol{\lambda}_t$ (depending on demand and prices). Using the superscript f for the vector in which the elements corresponding to products not belonging to firm f are replaced by zeros, the first-order conditions can also be written as

$$\mathbf{c}_t^f(\boldsymbol{\lambda}_t^f) = \mathbf{p}_t^f + Q_p^f(\mathbf{p}_t)^{-1}(\mathbf{q}_t^f - \boldsymbol{\lambda}_t^f). \tag{8}$$

Identification solution #1

Thus, we cannot identify marginal costs without restrictions on λ_t^f. Moreover, price constraints have spillover effects across drugs because the marginal cost of product i of firm f depends on the constraint of price j of firm f through λ_{jt}^f according to

$$\frac{\partial c_{it}^f(\lambda_t^f)}{\partial \lambda_{jt}^f} = -\left[Q_p^f(\mathbf{p}_t)^{-1}\right]_{i,j} \quad \text{for } i,j \in F_f, \tag{9}$$

where $[\cdot]_{i,j}$ stands for the row i, column j term of the matrix in the brackets.

However, adding some cost restrictions may allow identification. Our approach is similar to that of Goldberg (1995), who uses observations not subject to quotas in the car market to identify the effect of quantity constraints on exports.

Let us first assume that some unconstrained markets S are observed, such that

$$\lambda_t = 0 \quad \text{for any } t \in S. \tag{10}$$

Identification solution #1

that for any $t \in S$, there exists a vector of observed variables $\mathbf{z}$ such that, for all $t_0 \notin S$, the marginal costs satisfy for all j:

$$c_{jt} - c_{jt_0} = \left(\mathbf{z}_{jt} - \mathbf{z}_{jt_0}\right)'\delta + \omega_{jt} \quad \text{with} \quad E\left(\omega_{jt} \middle| \mathbf{z}_{jt} - \mathbf{z}_{jt_0}\right) = 0. \tag{11}$$

Identification solution #1

PROPOSITION 1: *With Assumptions* (10) *and* (11) *and a market* $t_0 \notin S$, *marginal costs* $\mathbf{c}_{t_0}$ *are*

$$\mathbf{c}_{t_0} = \mathbf{p}_{t_0} + Q_p^f(\mathbf{p}_{t_0})^{-1}(\mathbf{q}_{t_0} - \boldsymbol{\lambda}_{t_0}), \tag{12}$$

where $\boldsymbol{\lambda}_{t_0}$ *is identified using the following moment condition:*

$$E\left(\boldsymbol{\omega}_t\left(\delta, \boldsymbol{\lambda}_{t_0}\right)\right) = 0 \tag{13}$$

with vector $\boldsymbol{\omega}_t\left(\delta, \boldsymbol{\lambda}_{t_0}\right)$ *defined by*

$$\begin{aligned}\boldsymbol{\omega}_t\left(\delta, \boldsymbol{\lambda}_{t_0}\right) = &\left[\mathbf{p}_t - \mathbf{p}_{t_0} + Q_p(\mathbf{p}_t)^{-1}\mathbf{q}_t - Q_p(\mathbf{p}_{t_0})^{-1}\mathbf{q}_{t_0}\right] \\ &+ Q_p(\mathbf{p}_{t_0})^{-1}\boldsymbol{\lambda}_{t_0} - \left(\mathbf{z}_t - \mathbf{z}_{t_0}\right)'\delta\end{aligned} \tag{14}$$

provided that the matrix $E\left[\left(\mathbf{z}_t - \mathbf{z}_{t_0}\right)', Q_p(\mathbf{p}_{t_0})^{-1}\right]$ *has full rank.*

Demand

With these caveats in mind, we specify a random utility for each drug $j \in \{1, \ldots, J_t\}$ for patient i in period t as

$$u_{ijt} = \sum_k \alpha_i^k x_{jt}^k - \beta_i^0 p_{jt} \mathbf{1}_{\{p_{jt} \leq \overline{p}_{jt}^{tfr}\}} - \beta_i^1 p_{jt} \mathbf{1}_{\{p_{jt} > \overline{p}_{jt}^{tfr}\}} + \zeta_{jt} + \varepsilon_{ijt}, \tag{16}$$

where x_{jt}^k are k drug characteristics including detailing a_{jt}, p_{jt} is the price of the drug, $\overline{p}_{jt}^{tfr}$ is the maximum reimbursement price of the drug (coming from the TFR rule), which by convention will be equal to $+\infty$ for drugs that are not subject to TFR reimbursement rules, ζ_{jt} are drug-period-specific effects, and ε_{ijt} is consumer i's deviation from the mean utility of taking drug j in period t. The preference param-

Demand

- Note that the authors interpret the structural model as a "reduced form" encapsulating the decisions/actions of the physician, pharmacist & patient.
- In France, pharmacists have a monetary incentive to offer cheaper (generic) drugs.
- Outside good: estimating it using the Huang and Rojas 2013 approach.

Outside good

$$\ln q_{it} - \ln q_{i't} = \sum \alpha^k (x_{it}^k - x_{i't}^k) - \beta(p_{it} - p_{i't}) + \zeta_{it} - \zeta_{i't}$$

which does not depend on any market size assumption and allows to identify α^k, β, by two stage least squares with the usual instrumental variables. In a second stage we estimate the market sizes M_t that minimize

$$\min_{M_t} \sum_t \left(\sum_k \left[\hat{\alpha}^k(M_t) - \hat{\alpha}^k\right]^2 + \left[\hat{\beta}(M_t) - \hat{\beta}\right]^2 \right)$$

where $\hat{\alpha}^k(M_t)$ and $\hat{\beta}(M_t)$ are the 2SLS coefficient estimates of the following equation:

$$\ln q_{jt} - \ln\left(M_t - \sum_{k=1}^{J} q_{kt}\right) = \sum_k \alpha^k x_{jt}^k + \beta p_{jt} + \zeta_{jt}.$$

Empirical implementation: specification

Product characteristics:

- branded dummy
- molecule dummies
- # side effects
- # formats
- dummies for main indications
- i-a branded & # format, # side effects
- detailing expenses (drug-year)

Instruments

1. Hausman style instruments: **hospital** prices in French, German, Italian, Spanish, British and American hospitals. These regressed on
    1. molecule dummies
    2. country dummies
    3. year FE
2. use **residuals** of this regression as instruments.
3. **predictions** from regression of prices on i-a of firm FE and exchange rate (note: not clear from text which prices).
4. industry price indices (=all pharmaceuticals for FRA, antispasmodics for US, pharmaceutical preparations for GER) and wages (manuf for FRA, pharma manuf for US & GER) in each country.
5. (detailing) avg price of detailing / drug + square.
6. use approximation of optimal instruments.

Outside good

$$\ln q_{it} - \ln q_{i't} = \sum \alpha^k (x_{it}^k - x_{i't}^k) - \beta(p_{it} - p_{i't}) + \zeta_{it} - \zeta_{i't}$$

which does not depend on any market size assumption and allows to identify α^k, β, by two stage least squares with the usual instrumental variables. In a second stage we estimate the market sizes M_t that minimize

$$\min_{M_t} \sum_t \left(\sum_k \left[\hat{\alpha}^k(M_t) - \hat{\alpha}^k\right]^2 + \left[\hat{\beta}(M_t) - \hat{\beta}\right]^2 \right)$$

where $\hat{\alpha}^k(M_t)$ and $\hat{\beta}(M_t)$ are the 2SLS coefficient estimates of the following equation:

$$\ln q_{jt} - \ln\left(M_t - \sum_{k=1}^{J} q_{kt}\right) = \sum_k \alpha^k x_{jt}^k + \beta p_{jt} + \zeta_{jt}.$$

Demand estimation results

TABLE 4—ESTIMATION RESULTS OF RANDOM COEFFICIENT LOGIT MODEL

	France		Germany		US	
	Mean	Sigma	Mean	Sigma	Mean	Sigma
Price			−5.50	3.00	−4.06	2.97
			(1.50)	(1.87)	(1.36)	(1.52)
Price below TFR $(p_{jt} \times \mathbf{1}_{\{p_{jt} \leq \overline{p}_{jt}^{tfr}\}})$	−6.95	6.62				
	(2.70)	(3.25)				
Price above TFR $(p_{jt} \times \mathbf{1}_{\{p_{jt} > \overline{p}_{jt}^{tfr}\}})$	−18.73	6.83				
	(6.24)	(1.38)				
Detailing	0.27		0.17		0.05	
	(0.11)		(0.04)		(0.14)	
Branded	2.44	1.07	2.81	0.27	6.31	3.10
	(1.37)	(3.17)	(1.39)	(0.80)	(4.91)	(1.55)

Demand estimation results

TABLE 5—OWN- AND CROSS-PRICE ELASTICITIES FOR MAIN DRUGS, 2009 (*France*)

	Branded						Generic	
Subclass	H2	H2	PPI	PPI	PPI	Prost.	H2	PPI
Company	Aptalis	Glaxo	AstraZ	AstraZ	Takeda	Pfizer	Mylan	Mylan
Molecule	Cimet.	Ranit.	Omep.	Esom.	Lanso.	Miso.	Ranit.	Omep.
Drug name	Tagamet	Zantac	Losec	Nexium	Takepron	Cytotec		
Tagamet	−6.96	2.84	0.003	0.23	0.05	0.01	0.02	0.14
Zantac	0.71	−5.62	0.002	0.19	0.04	0.01	0.02	0.13
Losec	0.00	0.00	−5.48	1.64	0.16	0.00	0.003	0.05
Nexium	0.00	0.00	0.19	−3.90	0.25	0.005	0.01	0.14
Takepron	0.00	0.00	0.13	1.73	−5.24	0.01	0.01	0.16
Cytotec	0.002	0.01	0.01	0.81	0.17	−2.45	0.02	0.16
Ranit. Mylan	0.001	0.003	0.02	0.68	0.13	0.01	−3.00	0.23
Omep. Mylan	0.001	0.002	0.04	0.91	0.16	0.01	0.03	−3.68

Notes: Each column is the price elasticity of demand for the drug in the first row with respect to the drug named in the first column. Company names: Glaxo is GlaxoSmithKline. AstraZ is AstraZeneca. Molecules: Ranit. is Ranitidine; Omep. is Omeprazole; Esom. is Esomeprazole; Lanso. is Lansoprazole; Miso. is Misoprostol.

Price elasticities

TABLE 5—OWN- AND CROSS-PRICE ELASTICITIES FOR MAIN DRUGS, 2009 (*France*)

	Branded						Generic	
Subclass	H2	H2	PPI	PPI	PPI	Prost.	H2	PPI
Company	Aptalis	Glaxo	AstraZ	AstraZ	Takeda	Pfizer	Mylan	Mylan
Molecule	Cimet.	Ranit.	Omep.	Esom.	Lanso.	Miso.	Ranit.	Omep.
Drug name	Tagamet	Zantac	Losec	Nexium	Takepron	Cytotec		
Tagamet	−6.96	2.84	0.003	0.23	0.05	0.01	0.02	0.14
Zantac	0.71	−5.62	0.002	0.19	0.04	0.01	0.02	0.13
Losec	0.00	0.00	−5.48	1.64	0.16	0.00	0.003	0.05
Nexium	0.00	0.00	0.19	−3.90	0.25	0.005	0.01	0.14
Takepron	0.00	0.00	0.13	1.73	−5.24	0.01	0.01	0.16
Cytotec	0.002	0.01	0.01	0.81	0.17	−2.45	0.02	0.16
Ranit. Mylan	0.001	0.003	0.02	0.68	0.13	0.01	−3.00	0.23
Omep. Mylan	0.001	0.002	0.04	0.91	0.16	0.01	0.03	−3.68

Notes: Each column is the price elasticity of demand for the drug in the first row with respect to the drug named in the first column. Company names: Glaxo is GlaxoSmithKline. AstraZ is AstraZeneca. Molecules: Ranit. is Ranitidine; Omep. is Omeprazole; Esom. is Esomeprazole; Lanso. is Lansoprazole; Miso. is Misoprostol.

Estimation of French MC

$$\boldsymbol{\lambda}_t = \arg\min_{\boldsymbol{\lambda} \geq \mathbf{0}} \sum_{j=1}^{J} \omega_{jt}(\boldsymbol{\lambda})^2, \tag{20}$$

where $\omega_{jt}(\boldsymbol{\lambda}_t)$ is the residual of the linear regression

$$\ln c_{jt}(\boldsymbol{\lambda}_t) = \rho_j + \rho_{US} \ln c_{jt}^{US} + \rho_{GR} \ln c_{jt}^{GR} + \omega_{jt}(\boldsymbol{\lambda}_t). \tag{21}$$

Estimation of French MC

TABLE 6—NLLS ESTIMATES OF λ_{jt} (*Normalized by Market Size*)

	All products		Products with λ_{jt} significantly positive				
	Number of products		Number of products		λ_{jt}	s_{jt}	$\sum_j s_{jt}$
Year	Branded	Generics	Branded	Generics	Mean	Mean	Mean
2003	12	11	1	5	0.00026	0.00105	0.00628
2004	12	27	1	9	0.00029	0.00183	0.01826
2005	12	28	1	3	0.00027	0.00084	0.00334
2006	12	30	2	5	0.00023	0.01168	0.08176
2007	12	37	3	10	0.00033	0.00904	0.11756
2008	12	36	1	6	0.00030	0.00127	0.00891
2009	12	47	0	11	0.00031	0.00138	0.01519
2010	12	50	1	11	0.00083	0.00318	0.03816
2011	12	62	2	26	0.00152	0.00634	0.17764
2012	12	74	4	36	0.00210	0.00626	0.25034
2013	11	83	3	47	0.00288	0.00858	0.42907

Estimation of French PCM

Table B2: Average price-cost margins by year (France)

Year	Not accounting for Price Regulation			Accounting for Price Regulation		
	All Drugs	Branded	Generic	All Drugs	Branded	Generic
2003	27 percent	21 percent	33 percent	21 percent	16 percent	26 percent
2004	28 percent	23 percent	30 percent	20 percent	16 percent	21 percent
2005	27 percent	23 percent	28 percent	20 percent	16 percent	22 percent
2006	30 percent	21 percent	33 percent	22 percent	15 percent	24 percent
2007	27 percent	21 percent	28 percent	21 percent	16 percent	23 percent
2008	29 percent	20 percent	32 percent	23 percent	15 percent	26 percent
2009	31 percent	22 percent	33 percent	24 percent	16 percent	26 percent
2010	38 percent	20 percent	42 percent	28 percent	15 percent	31 percent
2011	40 percent	22 percent	43 percent	30 percent	16 percent	33 percent
2012	44 percent	21 percent	47 percent	33 percent	17 percent	35 percent
2013	53 percent	29 percent	56 percent	38 percent	21 percent	40 percent

Note: When not taking into account price regulation, we infer price cost margins as if firms were free to choose price. Margins as a percentage of price.

Counterfactual

1. Allow free pricing of branded drugs in France, maintain current regulations for generics.
2. Allow free pricing of all drugs (no numbers reported).
3. Introduction of ERP: $p_{jt} \leq \bar{p}_{jt}^{ref} = min(p_{jt-1}^{FR}, p_{jt-1}^{GER}, p_{jt-1}^{ITA}, p_{jt-1}^{ESP}, p_{jt-1}^{UK})$

Counterfactual #1: Free brand drug prices, regulated generic prices

TABLE 8—COUNTERFACTUAL SAVINGS AND SURPLUS FROM FREE PRICING

		2003	2006	2009	2012	2003–2013
Subclass	Molecule					
H2	Cimetidine	−913	−239	−28	−83	−2,120
	Ranitidine	−894	−578	−384	1133	−4,007
	Famotidine	−37	8	18	42	134
	Nizatidine	−4	1	3	6	5
PPI	Omeprazole	−469	1,916	2,111	13,091	59,149
	Lansoprazole	666	616	−468	3,853	9,973
	Pantoprazole	82	333	1,710	1,203	17,495
	Esomeprazole	1,672	−1,067	1,095	4,488	44,213
	Rabeprazole	407	389	−832	28,273	27,918
Prost.	Misoprostol	−277	−239	−181	−145	−2,375
Combi.	Bismuth/ Antibiotic					53
Total		234	1,140	3,044	51,860	150,439
Subtotal	Branded	382	1,903	4,107	30,389	88,242
	Generics	−148	−763	−1,064	21,471	62,197
Consumer surplus change		+1.1%	+1.3%	+2.6%	+10.2%	+15.4%

Notes: Savings are in 1,000 US$. Negative numbers indicate increased expenditures compared to observed. Surplus

Counterfactual #2: Free drug prices

- Allow free pricing of all drugs (no numbers reported).
- Generic prices increase; branded drug prices only slightly (recall, these are substitutes).
- As a result, demand for branded drugs increases.

Counterfactual #3: ERP

TABLE 9—COUNTERFACTUAL SAVINGS AND SURPLUS WITH EXTERNAL REFERENCE CAPS

		2004	2006	2009	2012	2004–2013
Subclass	Molecule					
H2	Cimetidine	−608	−365	−103	675	−652
	Ranitidine	−339	−1,323	−951	4,534	2,525
	Famotidine	83	−114	−78	95	−61
	Nizatidine	−4	−15	21	31	38
Subtotal H2						
PPI	Omeprazole	−6,241	−17,175	−6,751	43,880	34,593
	Lansoprazole	−292	4,997	−2,596	25,622	81,427
	Pantoprazole	4,985	8,565	4,663	20,743	109,294
	Esomeprazole	1,210	851	5,180	9,162	68,689
	Rabeprazole	1,531	4,340	3,995	21,829	99,573
Subtotal PPI						
Prost.	Misoprostol	45	−363	−153	637	−113
Combi.	Bismuth/ Antibiotic					382
Total		371	−601	3,226	127,209	395,695
Subtotal	Branded	7,594	20,025	24,687	27,216	267,745
	Generics	−7,222	−20,626	−21,462	99,993	127,950
Consumer surplus change		+6%	+9%	+24%	+30%	+39%

Notes: Savings are in 1,000 US$. Negative numbers indicate increased expenditures relative to observed. Surplus change is as a percentage of the counterfactual estimated surplus.

Counterfactual #3: ERP

- Effects heterogeneous depending on the ERP prices (naturally).
- Old H2 and Prostaglandin prices decrease substantially.
- Prices decrease by up to $> 50\%$.
- Demand goes up (recall pretty high elasticities).
- Generic sales increase substantially.
- As demand increases, expenditure does not change that much, but consumer welfare does.

Overall assessment

Example of a paper that

- asks an important question
- takes standard discrete choice demand + supply modeling as the starting point.
- displays good understanding of the institutional environment
- tailors the methods to fit the institutional details
- uses both data and "tweaked" methods to solve a technical challenge
- delivers interesting and important results.