Pass Through

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Leuven Lectures

Pass-Through: What is it?

Lots of cases in economics where we want to know how prices respond to changes in costs:

- Response to cost shocks (oil shock, commodity prices)
- Response to tax changes (incidence/efficiency of taxes)
- Transmission of Exchange Rate Shocks
- Transmission of Monetary Policy
- Price effects of Mergers
- Double Marginalization

Hot take

Pass-through is the simplest thing in economics that nobody understands

- Often we are talking about different things
  - IO: mostly $\rho = \frac{\partial p_j}{\partial mc_j}$ or the matrix $\frac{\partial \mathbf{p}}{\partial \mathbf{mc}}$
  - Macro/Trade: mostly $\frac{\partial \log p_j}{\partial \log mc_j}$
- One thing we know for sure: constant marginal costs, perfect competition:

$$p = mc \rightarrow \frac{\partial \mathbf{p}}{\partial \mathbf{mc}} = 1$$

- Everything else depends on:
  - Curvature of demand
  - Nature of competition

How bad is it?: International Trade Edition

Theory of International Trade

- Most models assume CES and monopolistic competition
- Implied PT in exchange rate shocks (zero if in local currency, 100% if in foreign currency).

Empirical Results International Trade:

- Gopinath, Ithshoki Rigobon (2010): 25% if priced in dollars; 95% if not.
- Goldberg Hellerstein (2013): around 25% of exchange rate shocks show up in retail beer prices
- Nakamura Zerom: around 30% of commodity price shocks for coffee show up in retail prices.

How bad is it?: Public Finance Edition

- Tobacco: Harding et al. (2012) $\rho < 1$, while DeCicca et al. (2013) $\rho \approx 1$.
- Gasoline: Taxes are fully passed through to consumers except when supply is inelastic or inventories were high (Marion and Muehlegger, 2011) but tax holidays $\rho << 1$ (Doyle Jr. and Samphantharak, 2008)
- Sales Taxes: Poterba (1996) found that retail prices of clothing and personal care items $\rho \approx 1$ Besley and Rosen (1999) could not reject $\rho \approx 1$, but found evidence of $\rho > 1$ half of the goods.
- Alcohol: Young and Bielinska-Kwapisz (2002) $\rho = (1.6, 2.1)$ Kenkel (2005) $\rho = (1.47, 2.1)$

Many studies of "price elasticity" for gasoline, cigarettes, tobacco, etc assume that $\rho = 1$ and regress prices on tax changes to get elasticities: $\frac{\partial \log p}{\partial \log t} = \frac{\partial \log p}{\partial \log c}$ (!)

Example Merger/UPP

Consider Bertrand FOC's for multi-product firm j:

$$\rightarrow p_j = q_j(\mathbf{p})\left[-\frac{\partial q_j}{\partial P_j}(\mathbf{p})\right]^{-1} + c_j + \sum_{k\in\mathcal{J}_f\setminus j}(p_k - c_k)\underbrace{\frac{\partial q_k}{\partial P_j}(\mathbf{p})\left[-\frac{\partial q_j}{\partial P_j}(\mathbf{p})\right]^{-1}}_{D_{jk}(\mathbf{p})}$$

$$p_j(p_{-j}) = \underbrace{\frac{1}{1+1/\epsilon_{jj}(\mathbf{p})}}_{\text{Markup}}\left[c_j + \sum_{k\in\mathcal{J}_f\setminus j}(p_k - c_k)\cdot D_{jk}(\mathbf{p})\right].$$

Mult-product pricing raises the opportunity cost of selling j.

Upward Pricing Pressure

Agencies often calculate Upward Pricing Pressure or UPP asks how merger changes the opportunity cost:

$$\left[c_j + \sum_{k \in \mathcal{J}_f \setminus j} (p_k - c_k) \cdot D_{jk}(\mathbf{p}) \right]$$

$$UPP_j = \Delta c_j + \sum_{k \in \mathcal{J}_g} (p_k - c_k) \cdot D_{jk}(\mathbf{p})$$

- How does the merger change the opportunity cost for j?
- If the opportunity cost change is positive we say there is upward pricing pressure
- But how much do we expect prices to rise?

Jaffe Weyl (2013)

- If we knew the pass-through rate $\rho = \frac{\partial p_j}{\partial mc_j}$ we could convert Δmc_j to Δp_j.
- But we would have to know the matrix $\frac{\partial \mathbf{p}}{\partial \mathbf{mc}}$, which is fine except it is $J \times J$ parameters (again).
- We can place restrictions on this matrix (maybe diagonal, or maybe just $\frac{\partial \mathbf{p}}{\partial \mathbf{mc}} = 0.8$, etc.).
- Miller, Ryan, Remer Sheu (2012/2016) did just that: simulate some mergers
  - Calculate UPP
  - What if we had whole $\frac{\partial \mathbf{p}}{\partial \mathbf{mc}}$ matrix? just the diagonal? just the average diagonal?
- some approximations are easier than others (depends on curvature of demand)

Miller, Ryan, Remer Sheu

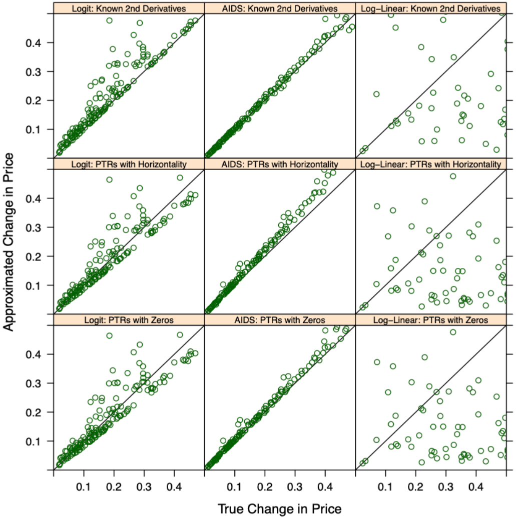


Figure 2: Prediction Error with Complete Information.
Notes: The figure provides scatter-plots of approximation against the true price effect for logit demand, the AIDS and log-linear demand. The case of linear demand is omitted because approximation is exact in that setting. Approximations are calculated alternately based on full knowledge of the second-order properties of demand in neighborhood of pre-merger equilibrium ("Known 2nd Derivatives"); based on full knowledge of pre-merger cost pass-through and the horizontality assumption

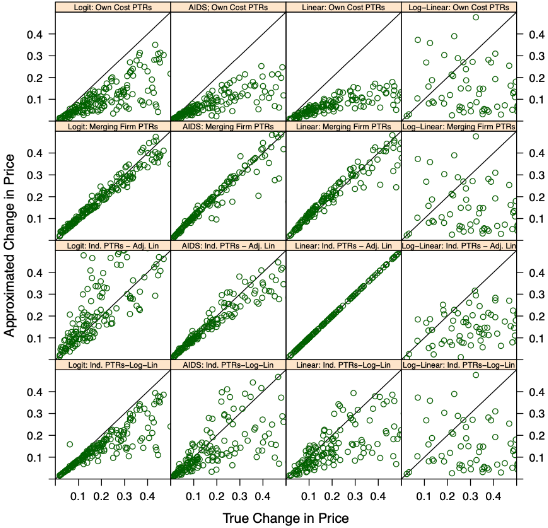


Figure 3: Prediction Error with Incomplete Information
Notes: The figure provides scatter-plots of approximation against the true price effect for logit demand, the AIDS, linear demand and log-linear demand. Four informational scenarios are considered: pre-merger cost pass-through that is available

Perfect Competition: Jenkin (1872), Alfred Marshall (1890)

$$D(p) = S(p - t)$$
$$\rho = \frac{dp}{dt} = \frac{1}{1 + \frac{\varepsilon_d}{\varepsilon_s}}$$

- Where ε_d is demand elasticity and ε_s is supply elasticity respectively.
- $\rho \in [0, 1]$ as long demand slopes down and supply slopes up!
- Constant MC implies that $\varepsilon_s \to \infty$ and $\rho \to 1$
- $I = \frac{\frac{d\,CS}{d\,t}}{\frac{d\,PS}{d\,t}} = \frac{\rho}{1-\rho}$ (higher pass-through more borne by consumers)

So far so good.

Monopoly (Fabinger Weyl JPE)

Start with $MR = MC$:

$$mr(q) = p(q) + p'(q)q = mc(q) + t$$

$$mr'\frac{dq}{dt} = mc'\frac{dq}{dt} + 1 \Rightarrow \frac{dq}{dt} = \frac{1}{mr' - mc'}$$

$$\Rightarrow \rho = \frac{dp}{dt} = p'\frac{dq}{dt} = \frac{p'}{mr' - mc'}$$

Define monopoly distortion or $ms(q) = p'(q)q$ and

$$\rho = \frac{1}{\frac{p'-ms'}{p'} - \frac{mc'}{p'}} = \frac{1}{1 - \frac{ms'\,q\cdot p}{q\cdot ms\cdot p'}\frac{q\cdot ms}{q\cdot p} - \frac{mc'\,q\cdot p}{p'\,q\cdot mc}\frac{q\cdot mc}{q\cdot p}}$$

$$= \frac{1}{1 + \frac{\epsilon_D}{\epsilon_{ms}}\frac{ms}{p} + \frac{\epsilon_D}{\epsilon_S}\frac{mc}{p}},$$

Simple right?

Monopoly: Continued (Fabinger Weyl JPE)

Use that $\frac{ms}{p} = -\frac{p' q}{p} = \frac{1}{\epsilon_D}$
and Lerner index $\frac{p-mc}{p} = \frac{1}{\epsilon_D} \Rightarrow \frac{mc}{p} = \frac{\epsilon_D - 1}{\epsilon_D}$:

$$\rho = \frac{1}{1 + \frac{\epsilon_D - 1}{\epsilon_S} + \frac{1}{\epsilon_{ms}}}$$

- $\epsilon_D > 1$ for Monopoly (except for my MBA students).
- $1/\epsilon_{MS} > 0$ log-concave (> 1 concave)
- $1/\epsilon_{MS} < 0$ log-convex (< 1 convex)

$$\frac{1}{\epsilon_{ms}} = \frac{ms' q}{ms} = \frac{(p'' q + p') q}{p' q} = 1 + \frac{p'' q}{p'}$$

Fabinger Weyl: Symmetric Imperfect Competition

Can generalize both cases for a conduct parameter $\theta = 0$ (PC); $\theta = 1$ (Monopoly).

$$\rho = \frac{1}{1 + \frac{\theta}{\epsilon_\theta} + \frac{\epsilon_D - \theta}{\epsilon_S} + \frac{\theta}{\epsilon_{ms}}}$$

Not sure how I feel about revival of conduct parameter...

A key feature is log curvature of demand (second-derivatives)

$$(\log D)' = \frac{D'}{D} = \frac{1}{p'\,q} = -\frac{1}{ms}$$
$$(\log D)'' = \frac{ms'}{ms^2}\frac{1}{p'} = -\frac{1}{\epsilon_{ms}}\frac{1}{ms}\left(-\frac{1}{p'\,q}\right) = -\frac{1}{\epsilon_{ms}}\frac{1}{ms^2}.$$

What if we wrote everything in terms of inverse demand?

Mrázová Neary (2017)

Just to make things complicated we could express the same ideas using the inverse demand $p(q)$ instead of Marshallian demand $q(p)$

$$\varepsilon(x) \equiv -\frac{p(x)}{xp'(x)} > 0 \quad \text{and} \quad \rho(x) \equiv -\frac{xp''(x)}{p'(x)}$$

$$\frac{dp}{dc} = \frac{1}{2-\rho} > 0 \Rightarrow \frac{dp}{dc} - 1 = \frac{\rho - 1}{2-\rho} \gtrless 0.$$

- To be extra-confusing here ρ denotes the curvature of demand, while before it was the pass-through rate.
- Under monopoly $2p' + xp'' < 0 \Rightarrow \rho < 2$ and $\varepsilon \geqslant 1$
- To get $PT > 1$ we need that $\rho > 1$

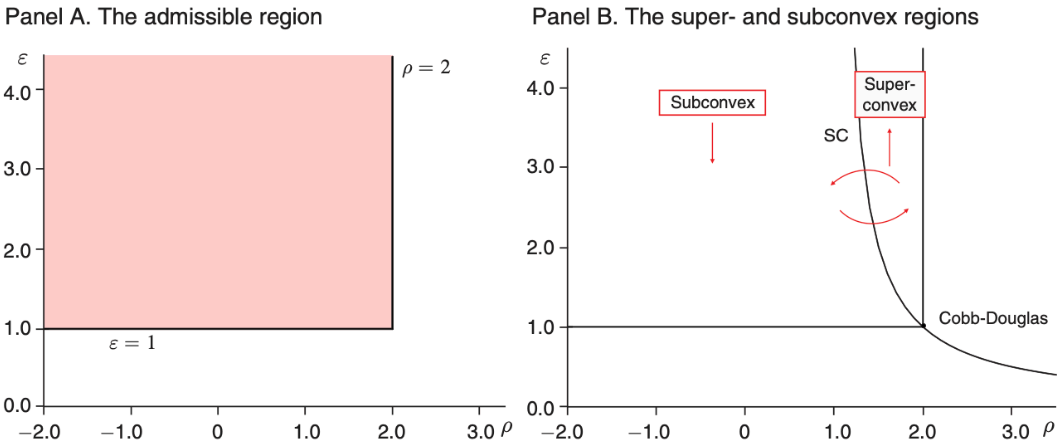


FIGURE 1. THE SPACE OF ELASTICITY AND CONVEXITY

Mrázová Neary (2017)

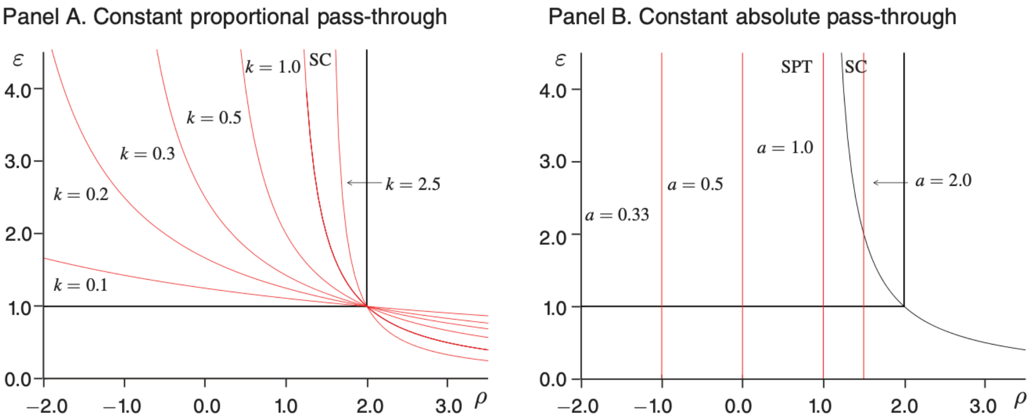


FIGURE 2. LOCI OF CONSTANT PASS-THROUGH

Multiproduct Pass-Through

Multiproduct Pass-Through

- Most firms sell multiple products.
- How does that affect what we know about pass-through?
- Let's start with the case of double marginalization.

Villas Boas (ReStud 2007)/ Miller Weinberg (2017)

Retailer and Wholesaler FOC given by:

$$\mathbf{p^r} = \underbrace{\mathbf{p^w} + \mathbf{c^r}}_{\mathbf{mc^r}} - (\mathcal{H}_r \odot \Delta_r(\mathbf{p^r}))^{-1}\mathbf{s}(\mathbf{p^r})$$

$$\mathbf{p^w} = \mathbf{mc^w} + \left(\mathcal{H}_w \odot \left(\frac{\partial \mathbf{p^r}}{\partial \mathbf{p^w}} \cdot \Delta_r(\mathbf{p^r})\right)\right)^{-1} \mathbf{s}(\mathbf{p^r})$$

- Δ_r is matrix of (retail) demand derivatives $\frac{\partial \mathbf{s}}{\partial \mathbf{p}}$.
- $\mathcal{H}_r, \mathcal{H}_w$ ownership matrix $(j, k) = 1$ if both products sold by same retailer/wholesaler.
- $\frac{\partial \mathbf{p^r}}{\partial \mathbf{p^w}}$ is the pass-through matrix (NEW!)

Challenge: We want $\mathbf{p^r}(\mathbf{p^w})$ and $\mathbf{mc^w}$ but we only have implicit solution for retailer FOC.

How do we get pass-through?

The pass-through matrix $\frac{\partial \mathbf{p^r}}{\partial \mathbf{p^w}}$ can be obtained in one of two ways:

1. Numerically: perturbing the retailer's marginal costs for each possible choice of k and solving

$$\mathbf{p^r} = \mathbf{mc^r} + e_k - (\mathcal{H}_r \odot \Delta_r(\mathbf{p^r}))^{-1}\mathbf{s}(\mathbf{p^r})$$

   (Use Morrow Skerlos (2011) formulation and solve for every (j, k) pair).

2. Analytic: Use the retailer's FOC and apply the implicit function theorem.

$$f(\mathbf{p^r}, \mathbf{mc^r}) \equiv \mathbf{p^r} - \mathbf{mc^r} - (\mathcal{H}_r \odot \Delta(\mathbf{p^r}))^{-1}\,\mathbf{s}(\mathbf{p^r}) = 0 \qquad \text{(retailer FOC)}$$

   See Jaffe Weyl (AEJM 2013) or Miller Weinberg (2017 Appendix E) or Conlon Rao (2023).
   This is what PyBLP does with `results.compute_passthrough` (very slowly).

The multivariate IFT says that for some system of J nonlinear equations

$$f(\mathbf{p^r}, \mathbf{p^w}) \equiv [F_1(\mathbf{p^r}, \mathbf{p^w}), \ldots, F_J(\mathbf{p^r}, \mathbf{p^w})] = [0, \ldots, 0]$$

with J endogenous variables $\mathbf{p^r}$ and J exogenous parameters $\mathbf{p^w}$.

$$\frac{\partial \mathbf{p^r}}{\partial \mathbf{p^w}} = -\begin{pmatrix} \frac{\partial F_1}{\partial p_1^r} & \ldots & \frac{\partial F_1}{\partial p_J^r} \\ \ldots & \ldots & \ldots \\ \frac{\partial F_J}{\partial p_1^r} & \ldots & \frac{\partial F_J}{\partial p_J^r} \end{pmatrix}^{-1} \cdot \underbrace{\begin{pmatrix} \frac{\partial F_1}{\partial p_k^w} \\ \ldots \\ \frac{\partial F_J}{\partial p_k^w} \end{pmatrix}}_{=-\mathbb{I}_J} \tag{PTR}$$

Because the system of equations is additive in $\mathbf{mc^r} = \mathbf{c^r} + \mathbf{p^w}$ this simplifies dramatically.

Multivariate IFT: Hard Part

Use the substitution $\Omega(\mathbf{p^r}) \equiv \mathcal{H}_r \odot \Delta_r(\mathbf{p^r})$, and differentiate the wholesalers' system of FOC's with respect to p_l, to get the $J \times J$ matrix with columns l given by:

$$\frac{\partial f(\mathbf{p^r}, \mathbf{p^w})}{\partial p_l^r} \equiv e_l - \Omega^{-1}(\mathbf{p^r}) \left[\mathcal{H}_r \odot \frac{\partial\, \Delta(\mathbf{p^r})}{\partial\, p_l^r} \right] \Omega^{-1}(\mathbf{p^r})\, \mathbf{s}(\mathbf{p^r}) - \Omega^{-1}(\mathbf{p^r})\, \frac{\partial \mathbf{s}(\mathbf{p^r})}{\partial p_l^r}. \tag{1}$$

The complicated piece is the demand Hessian: a $J \times J \times J$ tensor with elements (j, k, l), $\frac{\partial^2 s_j}{\partial p_k^r \partial p_l^r} = \frac{\partial^2 \mathbf{s}}{\partial \mathbf{p^r} \partial p_l^r} = \frac{\partial\, \Delta(\mathbf{p^r})}{\partial\, p_l^r}$.

This also shows a key relationship between pass through and demand curvature (2nd derivatives).

What's the point?

Why do we care about pass-through in vertical settings?

- When PT is high, we think that downstream firms have siginficant market power
- This also means the scope for elimination of double marginalization is large.
  - Higher pass-through should be associated with more efficient vertical mergers? (Not sure this has been tested)

What's the point?

- Because second-derivatives of plain logit are pinned down by price coefficient and shares, we don't have any flexibility in curvature.
- Mixed logit is less restricted but how much less? (See Miravete Seim Thurk 2023 at CEPR)
- Probably these models are under-parametrized....but
- A huge class of models adds an extra parameter between wholesale and retail prices...2

Estimating Pass Through: Conlon Rao (AEJP: 2020)

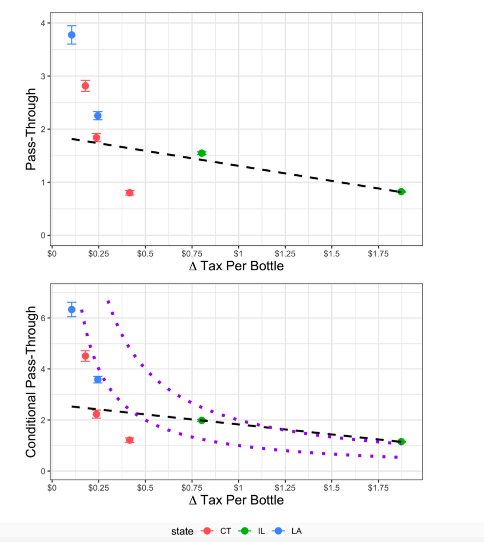
A simple empirical exercise

- US states tax distilled spirits by volume
- We see tax changes in three states (Connecticut, Louisianna, Illinois)
- Three popular bottle sizes (750mL, 1L, 1.75L)
- Run a regression at a 3 month difference product by product

$$\Delta p_{jst} = \rho_{jst}(\mathbf{X}, \Delta\tau) \cdot \Delta\tau_{jt} + \beta\Delta x_{jst} + \gamma_j + \gamma_t + \epsilon_{jst}$$

- Only innovation: allow $\rho_{jst}(\mathbf{X}, \Delta\tau)$ to vary by size of tax increase.

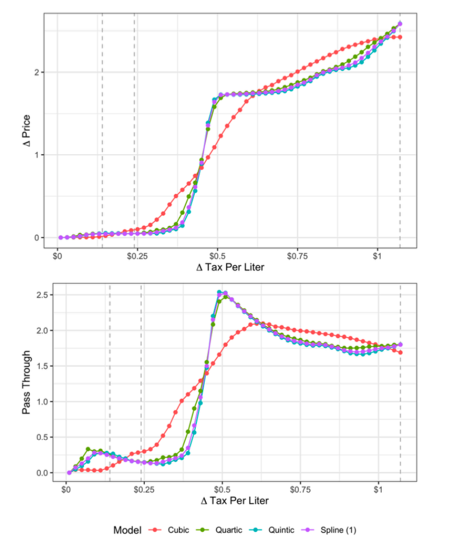
Goes horribly wrong



- Regression coefficients are huge > 1 and all over the map
- Conditional on a price change even larger > 3
- Seem to coincide with the purple line

Is PT a structural parameter?

- Price points are a big problem here
- Estimated an ordered probit with flexible $\beta(\Delta\tau)$
- Pass-through depends on where you are; not stable at all (!)
- Maybe structural interpretations of pass-through parameter are a bad idea!



Some challenges

- Pless and Van Bentham (AEJA: 2019)
  Use pass-through > 1 as a test for market power? (Is this true?)
- Chetty Looney Croft (AER 2016)

$$\log q\left(p, \tau^{S}\right) = \alpha + \beta \log p + \theta_{\tau} \beta \log\left(1 + \tau^{S}\right)$$

$$\theta_{\tau} = \frac{\partial \log q}{\partial \log\left(1 + \tau^{S}\right)} \Big/ \frac{\partial \log q}{\partial \log p} = \frac{\varepsilon_{q, 1+\tau^{s}}}{\varepsilon_{q, p}}$$

- Use θ as evidence of "tax salience" (is it?)
- Can we identify markups... ?!?