Generalized Linear Competition: From Pass-through to Policy

Gaudin, Genakos, Grey and Ritz (2026)

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Policy evaluation under imperfect competition

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  - Standard approach: specify mode of competition and estimate demand system for all firms.
  - Complex, data demanding, time consuming and resource intensive.
- In the spirit of Sutton (2007): "*aim to build the theory in such a way as to focus attention on those predictions which are robust across a range of model specifications which are deemed 'reasonable'*."

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- GLC nests many IO models and makes no assumptions on tech or behaviour of rivals, consumer behaviour or equilibrium concept.
- **Empirical application**:
  - Carbon pricing for aviation: US domestic airline market.
  - Substantial pass-through heterogeneity: Winners & losers.
  - Extend GLC for consumer surplus and welfare analysis.

The Logic of Generalized Linear Competition

- Consider two single-product firms facing a per-unit tax of τ.
- Firms face elastic demands, zero costs of production, and move simultaneously.
- What is the effect of raising the industry tax rate on firm 1's profits?
- Firm 1's Nash equilibrium profits: $\Pi_1^*(\tau) = (p_1^* - \tau)\, x_1^*$, then the marginal impact of the tax on firm 1's profits is:

$$\frac{d\Pi_1^*(\tau)}{d\tau} = \underbrace{\frac{\partial \Pi_1^*(\tau)}{\partial \tau}}_{=-x_1^*} + \frac{dp_1^*}{d\tau} \underbrace{\frac{\partial \Pi_1^*(\tau)}{\partial p_1}}_{=0} + \underbrace{\frac{dp_2^*}{d\tau} \frac{\partial \Pi_1^*(\tau)}{\partial p_2}}_{\text{strategic effect}} \tag{1}$$

Goal: Understand how a cost shock affects a firm's profits without specifying rivals' behaviour.

Key assumption (GLC): Firm i's sales are proportional to its profit margin:

$$x_1^* = \psi\big(p_1^* - \tau\big), \quad \psi > 0.$$

Under GLC, profits: $\Pi_1^*(\tau) = (p_1^* - \tau)\, x_1^*$

- FOC:

$$\psi(p_1^* - \tau) = x_1^*$$

Rivals' responses (the strategic effect) matter only insofar as they change p_1^*, and this is exactly what pass-through $\frac{dp_1^*}{d\tau}$ captures.

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- Hence, effect of tax increase on profit:

$$\frac{d\Pi_1^*(\tau)}{d\tau} = 2\psi(p_1^* - \tau)(\frac{dp_1^*}{d\tau} - 1) = 2x_1^*(\frac{dp_1^*}{d\tau} - 1)$$

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Define firm-level cost pass-through:

$$\rho_1(\tau) = \frac{dp_1^*}{d\tau}.$$

Main result: Pass-through as a sufficient statistic

$$\frac{d\Pi_1^*(\tau)}{d\tau} = -2\big[1 - \rho_1(\tau)\big]\, x_1^*.$$

Profits fall if and only if

$$\rho_1(\tau) < 1,$$

rise if

$$\rho_1(\tau) > 1.$$

Strategic effect is fully summarised by the firm's own pass-through rate.

Setup and assumptions

Industry:

- N firms, possibly multiproduct, operating in M markets.
- Regulation (or cost shock) on an input e_{im} with per–unit price τ.

Key assumptions (only need to hold for the firm of interest):

1. Input price taking: firm i takes τ as given.
2. Cost–minimising choice of inputs.
3. Constant returns to scale: optimised total cost is linear in output,

$$C_i(x_i, e_i) + \tau e_i = \sum_{m \in M_i} k_{im}(\tau)\, x_{im}.$$

4. **Linear product–market behaviour (GLC defining assumption):**

$$x_{im}(\tau) = \psi_{im}\big(p_{im}(\tau) - k_{im}(\tau)\big), \quad \psi_{im} > 0.$$

Under A1–A4, the firm's sales are proportional to its profit margin.

Firm-level pass-through

For component m of firm i:

- Marginal cost pass-through:

$$\rho_{im}(\tau) = \frac{dp_{im}(\tau)/d\tau}{dk_{im}(\tau)/d\tau}.$$

- Firm–level multidimensional pass-through (weighted by use of the regulated factor):

$$\rho_i(\tau) = \sum_{m \in M_i} \omega_{im}(\tau)\, \rho_{im}(\tau), \quad \omega_{im}(\tau) = \frac{e_{im}(\tau)}{e_i(\tau)}.$$

Intuition:

- $\rho_i(\tau)$ summarises how the firm's *average* price responds to its own cost shift.
- Under GLC, this single number pins down the profit impact for firm i.

Main profit result

Proposition 1 (marginal change in regulation). If A1–A4 hold for firm i, then an infinitesimal increase in τ affects firm i's profits as:

$$\frac{d\Pi_i(\tau)}{d\tau} = -2\big[1 - \rho_i(\tau)\big]\, e_i(\tau).$$

Implications:

- If
$$\rho_i(\tau) < 1,$$
profits fall: margin shrinks and sales decline.
- If
$$\rho_i(\tau) > 1,$$
profits rise: regulation increases both margin and sales.
- Rivals' behaviour and market structure enter only via firm i's observed pass-through.

Consumer surplus and welfare

Assume demand comes from a representative consumer with utility $V(\cdot)$ and $S(\tau) = V(x_1, \ldots, x_N) - \sum_{i,m} p_{im} x_{im}$.

Define: $E(\tau) = \sum_i e_i(\tau), \quad \rho_e(\tau) = \sum_i \frac{e_i(\tau)}{E(\tau)} \rho_i(\tau)$.

Consumer surplus:

$$\frac{dS(\tau)}{d\tau} = -E(\tau)\, \rho_e(\tau).$$

Social welfare (including government revenue and external damage $D(E)$):
$W(\tau) = S(\tau) + \tau E(\tau) - D(E(\tau)) + \sum_i \Pi_i(\tau)$, so

$$\frac{dW(\tau)}{d\tau} = -\big[1 - \rho_e(\tau)\big] E(\tau) - \big[D'(E(\tau)) - \tau\big] \frac{dE(\tau)}{d\tau}.$$

GLC thus provides closed–form sufficient statistics for profit, surplus and welfare impacts.

Empirical setting

- Domestic US airline market, 2004Q1–2013Q4.
- Focus on five major carriers:
  - Four legacy carriers: American, Delta, United, US Airways.
  - One major low-cost carrier (LCC): Southwest.
- Product: a seat on a direct flight (carrier–route–quarter).
- Data:
  - Ticket prices p_{ijt} from DB1A.
  - Per-passenger fuel cost k_{ijt} from T-100 and Form 41.
  - Route characteristics, competition, macro controls.
- Carbon pricing: use fuel cost pass-through as a proxy for future carbon cost pass-through.

Step 1: Estimating pass-through

Baseline specification (panel 2SLS):

$$p_{ijt} = \rho_S k_{ijt} \cdot S_i + \rho_L k_{ijt} \cdot L_i + X'_{ijt}\beta + \lambda_t + \eta_{ij} + \varepsilon_{ijt},$$

- S_i and L_i are dummies for Southwest vs legacy carriers.
- Instrument k_{ijt} with spot jet fuel prices and their interaction with distance.
- Controls: GDP growth, non–fuel cost index, number of competitors, LCC competitors, carrier size, time and carrier–route fixed effects.

Key estimates (baseline 2SLS):

- Southwest: $\rho_S \approx 1.42 \quad (\rho_S > 1, \text{ statistically significant})$.
- Legacy carriers: $\rho_L \approx 0.66 \quad (\rho_L < 1, \text{ statistically significant})$.

Southwest more than fully passes fuel (and hence carbon) costs into prices; legacy carriers do not.

Step 2: Checking GLC assumptions in airlines

- A1 (input price-taking): airlines are price takers in global jet fuel and carbon markets.
- A2 (cost-minimising inputs): strong incentives to optimise fuel use; carbon treated similarly.
- A3 (constant returns to scale): standard in airline IO; evidence suggests only modest scale effects.
- A4 (linear product-market behaviour):
  - Monopoly routes: estimated pass-through ≈ 0.6, not different from 0.5 implied by linear demand.
  - Duopoly/triopoly routes: no significant non-linear own–price terms in demand.
- Conclusion: GLC assumptions appear empirically reasonable for US airlines.

Step 3: Profit impacts of a carbon price

Consider an exogenous carbon price of \$30 per tonne of CO_2.

- Using Corollary 1 and carrier-level pass-through:
  - Legacy carriers:
$$\Delta\Pi_L \approx -\$234 \text{ million} \quad (\approx -1.60\% \text{ of revenue}).$$
  - Southwest:
$$\Delta\Pi_S \approx +\$98 \text{ million} \quad (\approx +1.55\% \text{ of revenue}).$$
  - Industry overall:
$$\Delta\Pi_{\text{industry}} \approx -\$136 \text{ million} \quad (\approx -0.65\%).$$
- Interpretation:
  - Legacy carriers lose from carbon pricing; Southwest gains.
  - Heterogeneous pass-through generates winners and losers within the same sector.

Consumer surplus and welfare

- Industry-average pass-through: $\rho_e \approx 0.853$.
- Estimated elasticity of emissions with respect to the carbon price: $\eta \approx -0.253$.
- At \$30/tCO$_2$:
  - Consumer surplus falls by about

$$\Delta S \approx -\$395 \text{ million}.$$

  - Social welfare (including external benefits and government revenue) rises by

$$\Delta W \approx +\$49 \text{ million},$$

    though confidence intervals admit small welfare losses.

Carbon pricing in airlines is mildly welfare-improving once environmental gains are counted, but distributional effects across firms and consumers are non-trivial.

Main contributions

- **Conceptual:**
  - Defines GLC, a flexible class of imperfect competition models.
  - Shows that firm-level pass-through is a sufficient statistic for profit impacts.
  - Provides simple welfare formulas using pass-through and emissions elasticity.
- **Empirical:**
  - Estimates heterogeneous pass-through in US airlines: Southwest $> 100\%$, legacy carriers $< 100\%$.
  - Quantifies winners and losers from carbon pricing and overall welfare effects.
- **Methodological:**
  - Offers a roadmap for practitioners (regulators, consultants, firms) to conduct fast, robust ex ante policy evaluation without full demand estimation.