Pass-through, profits & the political economy of regulation

Felix Grey
Faculty of Economics & EPRG
Cambridge University

&

Robert A. Ritz
Judge Business School & EPRG
Cambridge University

September 2018
Research motivation

- **Research question:** What is the impact of cost-raising regulation on a firm’s profits?
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- Market-based environmental regulation
- Minimum wage legislation
- Bank capital adequacy regulation
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- **Why is this question important?**
  - Regulated firms
  - Policymakers and political economy of regulation
  - Institutional investors
Theory:

- New ’generalized linear model of competition’ (GLM)
- Cost pass-through as sufficient statistic for profit impact
Overview of this paper

- **Theory:**
  - New ‘generalized linear model of competition’ (GLM)
  - Cost pass-through as sufficient statistic for profit impact

- **Empirics:**
  - Carbon pricing for aviation: US domestic airline market
  - Substantial pass-through heterogeneity: Winners & losers
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- **Empirics:**
  - Carbon pricing for aviation: US domestic airline market
  - Substantial pass-through heterogeneity: Winners & losers

- **Application:**
  - Political economy of regulation: Lobbying & market power
Suppose firm $i$ experiences marginal cost shock $\Delta MC_i$
Statement of the problem

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- Profit impact $\Delta \Pi_i$, in general, depends on:
  - Technology of firm $i$
  - Demand for $i$’s (differentiated) product
  - Competitors: how many ($n$), their technologies, their cost shocks ($\Delta MC_{-i}$), their strategies, degree of competitiveness
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- 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’.”
The basic idea of the GLM

- Consider firm $i$ competing a la Cournot
  - Demand: $p_i = \alpha - \beta x_i - \delta(X - x_i)$
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  - Marginal cost: $MC_i = c_i + \tau$

No assumptions on rival’s technologies or behaviour...

Suppose regulation raises $i$’s marginal cost by $d\tau$

Define $i$’s rate of cost pass-through ($dp_i/d\tau$)/(d$MC_i$/d$\tau$)

By construction, pass-through captures margin impact

By linear supply schedule, sales impact is proportional to pass-through

$i$’s pass-through = sufficient statistic for $i$’s profit impact

No information needed on ($\alpha, \beta, \delta$) or $c_i$
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Comparison with structural empirical IO

- **Structural IO**
  - Consumer demand system (often logit structure)
  - Firms’ production technologies (often constant MC)
  - Mode of competition (often Bertrand-Nash)

- No estimation of consumer demand system
- No assumptions on mode of competition
- Departures from Nash and/or profit-maximization

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- Weaker assumptions & greater simplicity vs
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- **This paper**: Shift from market-wide to firm-specific pass-through, further simplification of incidence analysis
• **Marked-based environmental policy**
  
  - Bovenberg & Goulder 2005; Hepburn, Quah & Ritz 2013; Bushnell, Chyong & Mansur 2014; Fowlie, Reguant & Ryan 2016
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Firm $i$ sells quantity $x_i$ at price $p_i$
Theory: Generalized linear model (GLM)

- Firm $i$ sells quantity $x_i$ at price $p_i$
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- Regulation may apply to all, some or none of $i$’s rivals
Assumptions of the GLM

Four assumptions hold for firm $i$ for all relevant $\tau \geq 0$:

1. Emissions price-taking: $i$ takes input prices, including the emissions price $\tau$, as given.
2. Cost-minimizing emissions: $i$ chooses inputs, including emissions $e_i$, to minimize its costs of producing output $x_i$.
3. Constant returns to scale: $i$'s unit costs are linear in output $C_i(x_i, e_i) + \tau e_i = k_i(\tau)x_i$, with unit cost $k_i(\tau) = c_i(\tau) + \tau z_i(\tau)$ where $z_i(\tau) = e_i(\tau)/x_i$ is its emissions intensity.
4. Linear product market behaviour: $i$'s supply satisfies the linear schedule $x_i(\tau) = \psi_i[p_i(\tau) - k_i(\tau)] > 0$ is its profit margin, $\psi_i > 0$ is a constant.
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Key features of the GLM

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  - No assumptions on number of competing products, or extent to which these are substitutes or complements, or whether competition is in strategic substitutes or complements
- No equilibrium concept
  - Departures from Nash and/or profit-maximization
  - Rule of thumb behaviour
A4 is satisfied by a very wide range of IO models:

- Cournot-Nash with linear demand, including with firm-specific conjectural variations, and linear Stackelberg

Two-stage models with linear competition in 2nd stage, e.g.,
- Strategic forward contracting (Allaz & Vila 1993)
- Managerial delegation (Fershtman & Judd 1987)
- Supply function equilibrium (Klemperer & Meyer 1989)
- Behavioural biases (Al-Najjar, Baliga & Besanko 2008)
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Main result

- Define $i$’s marginal pass-through rate $\rho_i(\tau) \equiv \frac{dp_i(\tau)/d\tau}{dk_i(\tau)/d\tau}$, and let average pass-through $\bar{\rho}_i(\tau) \equiv \frac{1}{\tau} \int_{s=0}^{\tau} \rho_i(s)ds$. 
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Proposition (1)

In the GLM, the profit impact of emissions pricing $\tau$ on firm $i$ satisfies $\Delta \Pi_i(\tau) \equiv -\gamma_i(\tau) [\tau e_i(0)]$ where:

(a) if $\tau$ is small, $\gamma_i(\tau) \simeq 2[1 - \bar{\rho}_i(\tau)]$, where $\bar{\rho}_i(\tau) \simeq \rho_i(0)$

(b) in general, $\gamma_i(\tau) \leq \max\{2[1 - \bar{\rho}_i(\tau)], 0\}$
So $\rho_i$ is a sufficient statistic for $\Delta \Pi_i$, given $\tau$ & $e_i(0)$
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- $\rho_i$ contains *all* relevant information about $i$’s demand & supply conditions (incl. rivals’ technologies & behaviour)
- No extra information on conduct parameters & mark-ups
- No estimation of $\psi_i$: $\Delta \Pi_i$ & $e_i(0)$ both proportional to $\psi_i$
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Formula for $\gamma_i$ holds *approximately* even with modest departures from GLM (e.g. from A3 or A4)

- No *systematic* upward or downward bias in $\gamma_i$
To progress further, two possible approaches:
Next steps

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1. Choose specific theory of competition to determine $\rho_i$

2. Estimate $\rho_i$ empirically, e.g., next part of this talk on US airlines
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**Background on aviation and climate policy**

- **Global aviation:**
  - CO$_2$ emissions are 2.5% of total – but 5% by impact
  - Set to rise to 25% in 2050 without new policies
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  - 2012 inclusion of aviation in EU ETS – politically fraught...
  - Chinese regional ETSs
  - 2016 ICAO agreement – emissions offset system
  - 2018 Swedish carbon tax on aviation
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- **US aviation:**
  - World’s largest market, with 30% of global aviation emissions
  - 2014: 172 million tCO\(_2\), value $8.6 billion at $50/tCO\(_2\)
Research question: What is the impact of a $50/t\text{CO}_2$ carbon price on US airlines’ profits?
Empirical question & strategy

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- **GLM**: Aggregate profit impact on carrier $i$ across its $j$ routes:

$$
\Delta \Pi_i \simeq -2(1 - \rho_i) \tau e_i(0)
$$

where $\rho_i = \sum_j \frac{e_{ij}(0)}{e_i(0)} \rho_{ij}$ is weighted-average pass-through

Predict carbon cost pass-through by estimating fuel cost pass-through

Wide variation in fuel costs over time (factor of 5)

Airlines cannot influence fuel price
Empirical question & strategy

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- Predict carbon cost pass-through by estimating fuel cost pass-through
  - Wide variation in fuel costs over time (factor of 5)
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Empirical strategy

- Example route: Phoenix Sky Harbor International Airport, (PHX) to San Antonio International Airport (SAT)

Important heterogeneities across carrier-routes:
Product differentiation: leg room, service, refreshments, loyalty rewards, airports, etc

Cost structure
Routes flown (product mix)
Competitors on a given route: their identity, products, prices, costs, strategies
Empirical strategy

- Example route: Phoenix Sky Harbor International Airport, (PHX) to San Antonio International Airport (SAT)
- Example product: $i = \text{Southwest}, j = \text{PHX-SAT}$
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The data

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Average quarterly price $p_{ijt}$, from a 10% sample of all tickets (DB1A)

- One way (split returns), ignore direction
- Exclude: international, frequent fliers, non-economy, prices >5 times ‘standard’, some others
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- Per-passenger fuel cost $k_{ijt}$ constructed from fuel expenditure by aircraft (Form 41), and aircraft share by route (T-100)

The data

- Keep all carrier-routes which are:
  - direct flights (standard in airlines literature)
  - continuously operated (to enable regression)
Keep all carrier-routes which are:
- direct flights (standard in airlines literature)
- continuously operated (to enable regression)

Focus on 7 largest carriers:
- Legacy carriers: Alaska, American, Delta, Hawaiian, United, US Airways
- Low cost carrier: Southwest
The data

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  - direct flights (standard in airlines literature)
  - continuously operated (to enable regression)

- Focus on 7 largest carriers:
  - Legacy carriers: Alaska, American, Delta, Hawaiian, United, US Airways
  - Low cost carrier: Southwest

- Resulting sample is a balanced panel:
  - $N = 615$ carrier-routes over $T = 52$ quarters
  - 26% by revenue of all US aviation activity over the period
### Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Southwest</th>
<th>Legacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>s.d.</td>
</tr>
<tr>
<td>Price ($)</td>
<td>157.31</td>
<td>40.52</td>
</tr>
<tr>
<td>Fuel cost ($)</td>
<td>29.22</td>
<td>15.69</td>
</tr>
<tr>
<td>Distance (miles)</td>
<td>688</td>
<td>407</td>
</tr>
<tr>
<td>Emissions (tCO₂)</td>
<td>0.13</td>
<td>0.06</td>
</tr>
<tr>
<td>Emissions cost ($)</td>
<td>6.70</td>
<td>2.92</td>
</tr>
<tr>
<td>Passengers (000s)</td>
<td>195</td>
<td>172</td>
</tr>
<tr>
<td>No. firms</td>
<td>3.28</td>
<td>2.41</td>
</tr>
<tr>
<td>Fraction seats filled</td>
<td>0.72</td>
<td>0.10</td>
</tr>
<tr>
<td>Revenue ($ million)</td>
<td>24.76</td>
<td>18.78</td>
</tr>
<tr>
<td>Revenue in sample</td>
<td>0.42</td>
<td>–</td>
</tr>
<tr>
<td>No. routes</td>
<td>212</td>
<td>–</td>
</tr>
<tr>
<td>No. observations</td>
<td>11,024</td>
<td>–</td>
</tr>
</tbody>
</table>
Figure: Average per-passenger fuel cost $k_t$ and the spot price of jet fuel.
Fuel costs and ticket prices

Figure: Ticket prices (left axis), and per-passenger fuel and non-fuel costs (right axis).
Baseline regression specification

- Estimate cost pass-through at the carrier-route level:

\[ p_{ijt} = \rho_{ij}^m \sum_{m=0}^{3} k_{ij,t-m} + X'_{ijt} \beta_{ij} + \epsilon_{ijt} \] (1)

where:

- “Equilibrium” pass-through \( \rho_{ij} = \sum_{m=0}^{3} \rho_{ij}^m \)

- \( X_{ijt} \) is a vector of covariates:
  - GDP growth \( g_{jt} \), proxy for demand
  - Index of labour and maintenance costs \( c_{it} \)
  - Number of competitor firms \( n_{jt} \)
  - Number of potential entrants \( n_{jt}^p \)
  - Quarterly dummies \( q_t \)
We find Mean Group (Pesaran & Smith 1995) estimates for carrier pass-through rates:

- run a separate regression for each $ij$
- calculate emissions-weighted average for airline $i$
Estimation approach

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  - run a separate regression for each $ij$
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- Endogeneity: $k_{ijt}$ constructed by dividing whole plane’s fuel consumption by number of filled seats, which depends on $p_{ijt}$
Estimation approach

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- Hence, $k_{ijt}$ endogenous - use spot fuel price as an instrument. First stage regression:

$$k_{ij,t-m} = \sum_{q=0}^{7} \gamma_{ij,q} f_{t-q} + X_{ij,t} \beta_{ij}^m + \epsilon_{ijt}^m \quad \text{for each } m \in \{0, 1, 2, 3\}$$
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  - run a separate regression for each $ij$
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- Hence, $k_{ijt}$ endogenous - use spot fuel price as an instrument. First stage regression:

\[
    k_{ij,t-m} = \sum_{q=0}^{7} \gamma_{ij}^{m,q} f_{t-q} + X_{ijt}' \beta_{ij}^m + \epsilon_{ijt}^m \quad \text{for each } m \in \{0, 1, 2, 3\}
\]

- 2SLS estimate using $\hat{k}_{ijt}$ in Equation (1)
Illustration for Southwest on PHX-SAT
### Results

Pass through  
1.38  
(0.32)  

Profit impact (% of revenue)  
2.22  
(1.83)

### Descriptive statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price ($)</td>
<td>200.32</td>
</tr>
<tr>
<td>Fuel cost ($)</td>
<td>32.59</td>
</tr>
<tr>
<td>Number of firms</td>
<td>2.57</td>
</tr>
<tr>
<td>Number of potential entrants</td>
<td>8.10</td>
</tr>
<tr>
<td>Distance (miles)</td>
<td>843</td>
</tr>
<tr>
<td>Emissions (tCO₂)</td>
<td>0.13</td>
</tr>
<tr>
<td>Emissions cost ($)</td>
<td>6.40</td>
</tr>
<tr>
<td>Passengers, annual</td>
<td>76,014</td>
</tr>
<tr>
<td>Proportion of seats filled</td>
<td>0.73</td>
</tr>
<tr>
<td>Revenue in 2014 ($ million)</td>
<td>17.36</td>
</tr>
<tr>
<td>No. of observations</td>
<td>52</td>
</tr>
</tbody>
</table>
Main empirical results

- Repeat 2SLS estimation for $N = 615$ carrier-routes, calculate weighted average pass-through and profit impact.
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<table>
<thead>
<tr>
<th></th>
<th>Southwest</th>
<th>Legacy</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass through</td>
<td>1.48</td>
<td>0.55</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.06)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Profit impact (% revenue)</td>
<td>2.95</td>
<td>-3.56</td>
<td>-1.59</td>
</tr>
<tr>
<td></td>
<td>(0.22)</td>
<td>(0.51)</td>
<td>(0.36)</td>
</tr>
<tr>
<td>Profit neutral permit allocation</td>
<td>-0.96</td>
<td>0.90</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.13)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>No. routes</td>
<td>212</td>
<td>403</td>
<td>615</td>
</tr>
<tr>
<td>No. obs.</td>
<td>11,024</td>
<td>20,956</td>
<td>31,980</td>
</tr>
</tbody>
</table>
Pass-through heterogeneity

![Graph showing pass-through heterogeneity for Southwest and Legacy companies.](image-url)
Substantial heterogeneity of profit impact:
- Southwest +2.95% (± 0.44) of revenue
- Legacy –3.56% (± 1.02) of revenue

Assuming our routes are representative of all routes flown by the airlines, total profit impacts:
- Southwest +$0.51 (± 0.07) billion
- Legacy –$1.46 (± 0.41) billion

For comparison, reported 5-year average profits:
- Southwest $1.17 billion
- Legacy $4.26 billion
Estimated profit impacts of carbon pricing

- Substantial heterogeneity of profit impact:
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What explains differences in pass-through?

<table>
<thead>
<tr>
<th></th>
<th>Southwest</th>
<th>Legacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short distance ∈ [0, 570)</td>
<td>Medium distance ∈ [570, 1034)</td>
</tr>
<tr>
<td></td>
<td>Short distance ∈ [0, 570)</td>
<td>Medium distance ∈ [570, 1034)</td>
</tr>
<tr>
<td>Small</td>
<td>2.00 (0.10)</td>
<td>1.03 (0.07)</td>
</tr>
<tr>
<td>n ∈ [1, 2.3)</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>Medium</td>
<td>2.48 (0.10)</td>
<td>0.90 (0.09)</td>
</tr>
<tr>
<td>n ∈ [2.3, 4.3)</td>
<td>35</td>
<td>19</td>
</tr>
<tr>
<td>Large</td>
<td>2.55 (0.10)</td>
<td>0.87 (0.09)</td>
</tr>
<tr>
<td>n ∈ [4.3, 12.5]</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>All n</td>
<td>2.40 (0.56)</td>
<td>0.91 (0.38)</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>68</td>
</tr>
</tbody>
</table>

Standard errors in parentheses, number of routes in italics.
What explains differences in pass-through?

<table>
<thead>
<tr>
<th></th>
<th>Southwest</th>
<th>Legacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All weighted</td>
<td>All un-weighted</td>
</tr>
<tr>
<td>Pass through</td>
<td>1.48</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>No. routes</td>
<td>212</td>
<td>212</td>
</tr>
</tbody>
</table>

Standard errors in parentheses, number of routes in italics.
Decomposition of pass-through difference

(1) Southwest flies different routes:
- Pass-through on all routes vs on common routes
- Explains 62% of the original difference

(2) Southwest is more fuel efficient on like-for-like routes:

\[
\text{Fuel cost: } k_{\text{Southwest}} = \$26 \text{ and } k_{\text{Legacy}} = \$31
\]

If products are homogenous, then

\[
\rho_i \rho_j = \Delta k_j - \Delta k_i
\]

Explains 26% of original difference

(3) Residual: Southwest has a different demand profile on like-for-like routes:

Differentiated-product demand-side asymmetries
Pass-through heterogeneity even for a uniform cost shock
Decomposition of pass-through difference

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   - If products are homogenous, then \( \frac{\rho_i}{\rho_j} = \frac{\Delta k_j}{\Delta k_i} \)
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- Differentiated-product demand-side asymmetries
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Further results and robustness checks
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- Entry and exit
  - Allow $\rho_{ij}(n_{ijt})$ by including an interaction term in regression
  - Look at subset of routes where $n_{ijt}$ is stable over time

Competition from Southwest

Dummy for Southwest presence and potential entry

Input price volatility

Implications for emissions trading vs carbon tax

Asymmetric cost pass-through: Rockets and feathers

Bankruptcy of legacy carriers

Fixed effects estimation

Log specification: Pass-through elasticity
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GLM brings together two strands of literature:

- Second-best emissions tax with market power (Buchanan 1969; Requate 2006; Fowlie, Reguant & Ryan 2016)
- Political contributions to lobby government ”for sale” (Grossman & Helpman 1994; Goldberg & Maggi 1999; Bombardini 2008)
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Government payoff: $U_{\text{gov}}(\tau) = W(\tau) + \lambda \sum_{i=1}^{n} K_i(\tau)$
- $K_i$ is $i$’s political contribution (in eqm, linear in profit)
Application: Political economy of regulation

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- Now assume GLM (A1–A4) holds for each \( i \)
  - Constant emissions intensity for each \( i \)
  - Utility-maximizing consumers (differentiated products)
  - Emissions damages function \( D(E) \)
The political equilibrium carbon price

Proposition (2)

At an interior solution:

\[ \tau^\star(\lambda) = \left[ \frac{D'(E(\tau))}{1 - \frac{1 + 2\lambda}{\eta(\tau)} \sum_{i=1}^{n} \frac{e_i(\tau)}{E(\tau)}[1 - \rho_i(\tau)]} \right]_{\tau = \tau^\star(\lambda)} \]

where \( \eta \equiv \frac{dE(\tau)/E(\tau)}{d\tau/\tau} < 0 \) is the carbon price elasticity of industry-level emissions.
Political equilibrium carbon price for US airlines

Social cost of carbon $50/tCO₂

<table>
<thead>
<tr>
<th>Lobbying influence (λ)</th>
<th>Carbon price elasticity of emissions (η)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.06</td>
</tr>
<tr>
<td>0</td>
<td>$10.71</td>
</tr>
<tr>
<td></td>
<td>(100%)</td>
</tr>
<tr>
<td>0.1</td>
<td>$9.26</td>
</tr>
<tr>
<td></td>
<td>(96%)</td>
</tr>
<tr>
<td>0.2</td>
<td>$8.15</td>
</tr>
<tr>
<td></td>
<td>(94%)</td>
</tr>
<tr>
<td>0.5</td>
<td>$6.00</td>
</tr>
<tr>
<td></td>
<td>(89%)</td>
</tr>
</tbody>
</table>
Conclusion

Understanding the profit impact of regulation is important for regulated firms, policymakers and investors.
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- We introduce a new, simple, flexible theoretical framework allowing large-scale estimation based on pass-through as a sufficient statistic

For US airlines, we find large heterogeneities in carbon cost pass-through between Southwest and legacy carriers

We hope the GLM will also be useful in other contexts in IO, public economics, international trade and networks

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- We hope the GLM will also be useful in other contexts in IO, public economics, international trade and networks.

Thank you.
### Appendix: Southwest, PHX-SAT

<table>
<thead>
<tr>
<th>Description</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass through</td>
<td>1.38***</td>
<td>(0.32)</td>
</tr>
<tr>
<td>No. firms</td>
<td>2.05</td>
<td>(3.26)</td>
</tr>
<tr>
<td>No. potential entrants</td>
<td>-2.11</td>
<td>(2.03)</td>
</tr>
<tr>
<td>Labour &amp; maintenance cost index</td>
<td>166.81</td>
<td>(99.12)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>537.72*</td>
<td>(281.76)</td>
</tr>
<tr>
<td>Quarter 1</td>
<td>-3.87</td>
<td>(7.87)</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>5.55</td>
<td>(4.54)</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>15.81***</td>
<td>(5.58)</td>
</tr>
<tr>
<td>Constant</td>
<td>113.99***</td>
<td>(17.20)</td>
</tr>
</tbody>
</table>

| No. of observations                 | 52          |

Standard errors in parentheses:
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
## Appendix: Full Mean Group Estimates

<table>
<thead>
<tr>
<th></th>
<th>Southwest</th>
<th>Legacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass-through</td>
<td>1.48***</td>
<td>0.55***</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>173.85***</td>
<td>93.21*</td>
</tr>
<tr>
<td></td>
<td>(18.44)</td>
<td>(53.27)</td>
</tr>
<tr>
<td>No. firms</td>
<td>-1.91***</td>
<td>-7.08***</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.84)</td>
</tr>
<tr>
<td>No. potential entrants</td>
<td>-1.13***</td>
<td>-1.13**</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.42)</td>
</tr>
<tr>
<td>Labour and maintenance cost index</td>
<td>122.66***</td>
<td>97.88***</td>
</tr>
<tr>
<td></td>
<td>(8.69)</td>
<td>(6.53)</td>
</tr>
<tr>
<td>Quarter 1</td>
<td>-5.75***</td>
<td>-7.97***</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(1.69)</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>4.32***</td>
<td>10.94***</td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td>(1.23)</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>-1.71***</td>
<td>12.77***</td>
</tr>
<tr>
<td></td>
<td>(0.50)</td>
<td>(1.47)</td>
</tr>
<tr>
<td>No. routes</td>
<td>212</td>
<td>403</td>
</tr>
<tr>
<td>No. obs.</td>
<td>11,024</td>
<td>20,956</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
## Appendix: Descriptive statistics by carrier

<table>
<thead>
<tr>
<th></th>
<th>WN</th>
<th>AA</th>
<th>AS</th>
<th>DL</th>
<th>HA</th>
<th>UA</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price ($)</strong></td>
<td>157.31</td>
<td>226.29</td>
<td>205.46</td>
<td>230.86</td>
<td>166.68</td>
<td>245.56</td>
<td>240.44</td>
</tr>
<tr>
<td><strong>Fuel cost ($)</strong></td>
<td>29.22</td>
<td>54.52</td>
<td>43.36</td>
<td>47.20</td>
<td>41.54</td>
<td>55.32</td>
<td>42.15</td>
</tr>
<tr>
<td><strong>Distance (miles)</strong></td>
<td>688</td>
<td>1,163</td>
<td>726</td>
<td>1,041</td>
<td>1,110</td>
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<td><strong>Emissions (tCO₂)</strong></td>
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<td>0.24</td>
<td>0.18</td>
<td>0.19</td>
<td>0.17</td>
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<td>0.18</td>
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<tr>
<td><strong>Passengers (000s)</strong></td>
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<td>158</td>
<td>155</td>
<td>331</td>
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<tr>
<td><strong>No. firms</strong></td>
<td>3.28</td>
<td>3.79</td>
<td>2.57</td>
<td>3.35</td>
<td>2.78</td>
<td>4.65</td>
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<td><strong>Fraction seats filled</strong></td>
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<td>0.79</td>
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<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.79</td>
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<tr>
<td><strong>Revenue ($ million)</strong></td>
<td>24.76</td>
<td>31.46</td>
<td>24.82</td>
<td>29.36</td>
<td>35.12</td>
<td>29.46</td>
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<td><strong>Revenue in sample</strong></td>
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<td>0.39</td>
<td>0.41</td>
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<td>35</td>
<td>90</td>
<td>10</td>
<td>101</td>
<td>56</td>
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<tr>
<td><strong>No. observations</strong></td>
<td>11,024</td>
<td>5,772</td>
<td>1,820</td>
<td>4,680</td>
<td>520</td>
<td>5,252</td>
<td>2,912</td>
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## Appendix: Pass-through estimates by carrier

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<td><strong>Pass through</strong></td>
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<td>0.92</td>
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<td>0.69</td>
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<tr>
<td>(0.04)</td>
<td>(0.08)</td>
<td>(0.09)</td>
<td>(0.14)</td>
<td>(0.18)</td>
<td>(0.09)</td>
<td>(0.40)</td>
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<tr>
<td><strong>Profit impact (%)</strong></td>
<td>2.95</td>
<td>-0.80</td>
<td>-6.41</td>
<td>-1.39</td>
<td>-0.54</td>
<td>-9.58</td>
<td>-2.31</td>
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<tr>
<td>(0.22)</td>
<td>(0.69)</td>
<td>(0.70)</td>
<td>(0.94)</td>
<td>(1.31)</td>
<td>(0.76)</td>
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<tbody>
<tr>
<td><strong>No. routes</strong></td>
<td>212</td>
<td>111</td>
<td>35</td>
<td>90</td>
<td>10</td>
<td>101</td>
<td>56</td>
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<tr>
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<td>5,772</td>
<td>1,820</td>
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<td>5,252</td>
<td>2,912</td>
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Appendix: Further pass-through results

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<tr>
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<th>Legacy</th>
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<td>(a) Baseline (2SLS)</td>
<td>1.48</td>
<td>0.55</td>
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<tr>
<td></td>
<td>(0.03)</td>
<td>(0.06)</td>
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<td>403</td>
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<tr>
<td>(b) OLS</td>
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<td>0.43</td>
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<tr>
<td></td>
<td>(0.03)</td>
<td>(0.04)</td>
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<tr>
<td></td>
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<td>403</td>
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<tr>
<td>(c) Late period: 2005-2014 only</td>
<td>1.50</td>
<td>0.62</td>
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<tr>
<td></td>
<td>(0.06)</td>
<td>(0.06)</td>
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<tr>
<td></td>
<td>229</td>
<td>413</td>
</tr>
<tr>
<td>(d) (n)-interaction</td>
<td>1.45</td>
<td>0.64</td>
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<tr>
<td></td>
<td>(0.04)</td>
<td>(0.07)</td>
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<td></td>
<td>212</td>
<td>403</td>
</tr>
<tr>
<td>(e) Baseline with (\Delta n = 0)</td>
<td>1.54</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.19)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>(f) Baseline with (\Delta n \leq 1)</td>
<td>1.63</td>
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<td>(0.08)</td>
<td>(0.12)</td>
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<td>57</td>
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<td>(g) Fixed effects specification</td>
<td>1.31</td>
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<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
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<td>403</td>
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<tr>
<td>(h) Log specification</td>
<td>0.21</td>
<td>0.15</td>
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<td></td>
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<td>(0.01)</td>
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### Appendix: Interaction coefficients

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<th>Southwest</th>
<th>Legacy</th>
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<td>(a) No. firms $n$</td>
<td>0.00</td>
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<td>(1.45)</td>
<td>(0.21)</td>
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<td>379</td>
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<td>(b) Volatility</td>
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<td>-0.010</td>
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<td>(0.001)</td>
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<td>403</td>
</tr>
<tr>
<td>(c) Bankruptcy dummy</td>
<td>–</td>
<td>0.15</td>
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</tr>
<tr>
<td></td>
<td>–</td>
<td>358</td>
</tr>
<tr>
<td>(d) Southwest present dummy</td>
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<td>-0.24</td>
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<tr>
<td></td>
<td>–</td>
<td>(0.08)</td>
</tr>
<tr>
<td></td>
<td>–</td>
<td>209</td>
</tr>
<tr>
<td>(e) Southwest present dummy</td>
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<td>0.05</td>
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<td>Southwest potential</td>
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<td>-0.91</td>
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<tr>
<td></td>
<td>–</td>
<td>(0.36)</td>
</tr>
<tr>
<td></td>
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</table>

Standard errors in parentheses, number of routes in italics.
### Appendix: Emissions elasticity estimation

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<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
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<tbody>
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<td>Fuel price elasticity</td>
<td>-0.16***</td>
<td>(0.04)</td>
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<tr>
<td>No. firms</td>
<td>-0.05</td>
<td>(0.04)</td>
</tr>
<tr>
<td>No. potential entrants</td>
<td>0.02</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Labour &amp; maintenance cost index</td>
<td>-0.67**</td>
<td>(0.25)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>-0.79</td>
<td>(0.84)</td>
</tr>
<tr>
<td>Quarter 1</td>
<td>-0.02</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>-0.02</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>-0.05***</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Constant</td>
<td>15.73***</td>
<td>(0.34)</td>
</tr>
</tbody>
</table>

No. observations: 52

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$