

Pass-through, profits & the political economy of regulation

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

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

- **Application:**

- Political economy of regulation: Lobbying & market power
- Grossman-Helpman 1994 meets Buchanan 1969

Statement of the problem

- Suppose firm i experiences marginal cost shock ΔMC_i
- 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 (ΔMC_{-i}), their strategies, degree of competitiveness
- We try to radically simplify the problem, by remaining agnostic about most of the above
- 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: $p_i = \alpha - \beta x_i - \delta(X - x_i)$
 - Marginal cost: $MC_i = c_i + \tau$
 - FOC: Linear supply schedule $x_i = (1/\beta)(p_i - c_i - \tau)$
 - 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 $(dp_i/d\tau)/(dMC_i/d\tau)$
 - 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 (α, β, δ) or c_i

- **Cost pass-through**

- **Empirics:** e.g. De Loecker, Goldberg, Khandelwal & Pavcnik 2016 ($< 100\%$); Fabra & Reguant 2014 ($= 100\%$); Miller, Osborne & Sheu 2017 ($> 100\%$)
- **Pass-through as a tool:** Weyl & Fabinger 2013; Atkin & Donaldson 2015; Bergquist 2017; Miller, Osborne & Sheu 2017; Ganapati, Shapiro & Walker 2017
- **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
- **This paper:** Shift away from electricity & heavy industry, highlight firm-level heterogeneity in profit impacts and larger industry-wide profit loss for airlines

- **Airline competition**

- Brander & Zhang 1990; Kim & Sengal 1993; Goolsbee & Syverson 2008; Ciliberto & Tamer 2009; Berry & Jia 2010
- **This paper:** New results on political economy of low-cost vs legacy carriers, special role of Southwest also in terms of pass-through

Theory: Generalized linear model (GLM)

- Firm i sells quantity x_i at price p_i
- Emissions e_i viewed as input to production technology
- Emissions price τ on each unit of i 's emissions e_i
- Profits $\Pi_i = p_i x_i - C_i(x_i, e_i) - \tau e_i$
- 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 $\tau \geq 0$:

A1. *Emissions price-taking:* i takes input prices, including the emissions price τ , as given

A2. *Cost-minimizing emissions:* i chooses inputs, including emissions e_i , to minimize its costs of producing output x_i

A3. *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 $k_i(\tau) = c_i(\tau) + \tau z_i(\tau)$

- $z_i(\tau) \equiv e_i(\tau)/x_i$ is its emissions intensity

A4. *Linear product market behaviour:* i 's supply satisfies the linear schedule $x_i(\tau) = \psi_i[p_i(\tau) - k_i(\tau)]$

- $[p_i(\tau) - k_i(\tau)] > 0$ is its profit margin, $\psi_i > 0$ is a constant

Key features of the GLM

- Weaker assumptions than many standard oligopoly models
- No assumptions on technology or behaviour of i 's rivals
- No assumptions on demand system or nature of consumer behaviour
 - 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

Special cases with the GLM structure

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
- Bertrand & Cournot with horizontally and/or vertically differentiated products
- 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)
- Common ownership of firms (O'Brien & Salop 2000)

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 $\bar{\rho}_i(\tau) \equiv \frac{1}{\tau} \int_{s=0}^{\tau} \rho_i(s) ds$.

Proposition (1)

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

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

(b) in general, $\gamma_i(\tau) \leq \max\{2[1 - \bar{\rho}_i(\tau)], 0\}$

Background on aviation and climate policy

- **Global aviation:**

- CO₂ emissions are 2.5% of total – but 5% by impact
- Set to rise to 25% in 2050 without new policies

- **Policy problem:**

- Aviation is growing fast but hard to decarbonise

- **Policy so far:**

- 2012 inclusion of aviation in EU ETS – politically fraught...
- Chinese regional ETSs
- 2016 ICAO agreement – emissions offset system
- 2018 Swedish carbon tax on aviation

- **US aviation:**

- World's largest market, with 30% of global aviation emissions
- 2014: 172 million tCO₂, value \$8.6 billion at \$50/tCO₂

Empirical question & strategy

- **Research question:** What is the impact of a \$50/tCO₂ carbon price on US airlines' profits?
- Product: a flight on carrier i on route j
- 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

The data

- We use data from the Bureau of Transportation Statistics
- Time period: 2002Q1 to 2014Q4
- 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
- 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)
- 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

Fuel costs and ticket prices

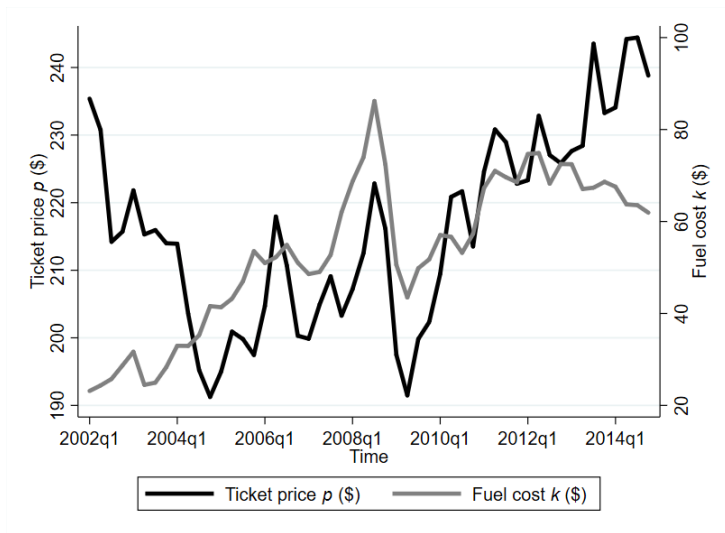


Figure: Ticket prices (left axis), and per-passenger fuel and non-fuel costs (right axis).

Baseline regression specification

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

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

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

Estimation approach

- 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
- Endogeneity: k_{ijt} constructed by dividing whole plane's fuel consumption by number of filled seats, which depends on p_{ijt}
- 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)

Main empirical results

- Repeat 2SLS estimation for $N = 615$ carrier-routes, calculate weighted average pass-through and profit impact

	Southwest	Legacy	All
Pass through	1.48 (0.04)	0.55 (0.06)	0.78 (0.05)
Profit impact (% revenue)	2.95 (0.22)	-3.56 (0.51)	-1.59 (0.36)
Profit neutral permit allocation	-0.96 (0.07)	0.90 (0.13)	0.43 (0.10)
<i>No. routes</i>	<i>212</i>	<i>403</i>	<i>615</i>
<i>No. obs.</i>	<i>11,024</i>	<i>20,956</i>	<i>31,980</i>

Estimated profit impacts of carbon pricing

- 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

What explains differences in pass-through?

	Southwest			Legacy		
	All weighted	All un-weighted	Common un-weighted	All weighted	All un-weighted	Common un-weighted
Pass through	1.48 (0.04)	1.72 (0.04)	1.61 (0.09)	0.55 (0.06)	0.69 (0.06)	0.98 (0.18)
<i>No. routes</i>	<i>212</i>	<i>212</i>	<i>49</i>	<i>403</i>	<i>403</i>	<i>49</i>

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:
 - Fuel cost: $k_{Southwest} = \$26$ and $k_{Legacy} = \$31$
 - If products are homogenous, then $\frac{\rho_i}{\rho_j} = \frac{\Delta k_j}{\Delta k_i}$
 - 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

Robustness checks and further results

- 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
- Asymmetric cost pass-through: Rockets and feathers
- Fixed effects estimation
- Log specification: Pass-through elasticity
- Competition from Southwest
 - Dummy for actual Southwest presence vs *potential* entry
- Bankruptcy of legacy carriers
- Input price volatility
 - Implications for emissions trading vs carbon tax

Application: Political economy of regulation

- 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)
- 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)
- 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 $\eta \equiv [dE(\tau)/E(\tau)] / [d\tau/\tau] < 0$ is the carbon price elasticity of industry-level emissions.

Political equilibrium carbon price for US airlines

Social cost of carbon \$50/tCO₂

Lobbying influence (λ)	Carbon price elasticity of emissions (η)		
	-0.06	-0.16	-0.26
0	\$10.71 (100%)	\$21.05 (100%)	\$27.08 (100%)
0.1	\$9.26 (96%)	\$18.87 (93%)	\$24.81 (91%)
0.2	\$8.15 (94%)	\$17.09 (88%)	\$22.89 (85%)
0.5	\$6.00 (89%)	\$13.33 (79%)	\$18.57 (73%)

Conclusion

- Understanding the profit impact of regulation is important for regulated firms, policymakers and investors
- 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

Thank you

Appendix: Southwest, PHX-SAT

Pass through	1.38*** (0.32)
No. firms	2.05 (3.26)
No. potential entrants	-2.11 (2.03)
Labour & maintenance cost index	166.81 (99.12)
GDP growth	537.72* (281.76)
Quarter 1	-3.87 (7.87)
Quarter 2	5.55 (4.54)
Quarter 3	15.81*** (5.58)
Constant	113.99*** (17.20)

No. of observations	52
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Standard errors in parentheses

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

Appendix: Full Mean Group Estimates

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

Standard errors in parentheses

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

Appendix: Descriptive statistics by carrier

	WN	AA	AS	DL	HA	UA	US
Price (\$)	157.31	226.29	205.46	230.86	166.68	245.56	240.44
Fuel cost (\$)	29.22	54.52	43.36	47.20	41.54	55.32	42.15
Distance (miles)	688	1,163	726	1,041	1,110	1,277	957
Emissions (tCO ₂)	0.13	0.24	0.18	0.19	0.17	0.22	0.18
Emissions cost (\$)	6.70	12.04	9.13	9.39	8.33	11.15	9.06
Passengers (000s)	195	159	158	155	331	141	127
No. firms	3.28	3.79	2.57	3.35	2.78	4.65	3.05
Fraction seats filled	0.72	0.79	0.70	0.81	0.81	0.81	0.79
Revenue (\$ million)	24.76	31.46	24.82	29.36	35.12	29.46	24.19
Revenue in sample	0.42	0.39	0.41	0.26	0.40	0.45	0.27
No. routes	212	111	35	90	10	101	56
No. observations	11,024	5,772	1,820	4,680	520	5,252	2,912

Appendix: Pass-through estimates by carrier

	WN	AA	AS	DL	HA	UA	US
Pass through	1.48 (0.04)	0.90 (0.08)	0.21 (0.09)	0.79 (0.14)	0.92 (0.18)	-0.09 (0.09)	0.69 (0.40)
Profit impact (%)	2.95 (0.22)	-0.80 (0.69)	-6.41 (0.70)	-1.39 (0.94)	-0.54 (1.31)	-9.58 (0.76)	-2.31 (2.93)
<i>No. routes</i>	<i>212</i>	<i>111</i>	<i>35</i>	<i>90</i>	<i>10</i>	<i>101</i>	<i>56</i>
<i>No. observations</i>	<i>11,024</i>	<i>5,772</i>	<i>1,820</i>	<i>4,680</i>	<i>520</i>	<i>5,252</i>	<i>2,912</i>

Appendix: Further pass-through results

	Southwest	Legacy
(a) Baseline (2SLS)	1.48 (0.03) <i>212</i>	0.55 (0.06) <i>403</i>
(b) OLS	1.34 (0.03) <i>212</i>	0.43 (0.04) <i>403</i>
(c) Late period: 2005-2014 only	1.50 (0.06) <i>229</i>	0.62 (0.06) <i>413</i>
(d) n -interaction	1.45 (0.04) <i>212</i>	0.64 (0.07) <i>403</i>
(e) Baseline with $\Delta n = 0$	1.54 (0.12) <i>24</i>	0.66 (0.19) <i>17</i>
(f) Baseline with $\Delta n \leq 1$	1.63 (0.08) <i>50</i>	0.82 (0.12) <i>57</i>
(g) Fixed effects specification	1.31 (0.05) <i>212</i>	0.57 (0.06) <i>403</i>
(h) Log specification	0.21 (0.01) <i>212</i>	0.15 (0.01) <i>403</i>

Appendix: Interaction coefficients

	Southwest	Legacy
(a) No. firms n	0.00 (1.45) <i>183</i>	-0.01 (0.21) <i>379</i>
(b) Volatility	-0.018 (0.001) <i>212</i>	-0.010 (0.001) <i>403</i>
(c) Bankruptcy dummy	- - -	0.15 (0.03) <i>358</i>
(d) Southwest present dummy	- - -	-0.24 (0.08) <i>209</i>
(e) Southwest present dummy	- - -	0.05 (0.20) <i>108</i>
Southwest potential	- - -	-0.91 (0.36) <i>108</i>

Standard errors in parentheses, number of routes in italics.