Introduction to Industrial Organization

Entry Deterrence

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December 5, 2019

Outline

- Theoretical Model
- Empirical Evidence: Airline Industries
  - Price Response to the Threat of Entry and the Actual Entry
    - Goolsbee and Syverson (2008, QJE)
  - Non-Price Response
    - Prince and Simon (2015, MS)

Theoretical Model

Entry Deterrence

- The incumbent modifies its behavior, such as lowering price or expanding capacity, to deter entry.
- Start with the example in Spence (1977):
  - Consider a two-period leader-follower game (similar to Stackelberg model), two firms decide how much capacity (or capital) to accumulate (invest).
  - In period 1, firm 1 has to choose its capacity-output investment, $k_1 \in [0, \infty)$; in period 2, firm 2 chooses whether to enter (choosing $k_2 > 0$) or to stay out ($k_2 = 0$).
  - There is an entry cost F for firm 2 to enter.
  - Profits:

$$\pi_1(k_1, k_2) \equiv k_1(1 - k_1 - k_2)$$

$$\pi_2(k_1, k_2) \equiv \begin{cases} k_2(1 - k_1 - k_2) - F & \text{if entry occurs} \\ 0 & \text{otherwise} \end{cases}$$

Entry Deterrence

- Consider the case without entry cost ($F = 0$)
- For firm 2, given k_1 decided by firm 1, the profits maximization problem:

$$\max_{k_2} k_2(1 - k_1 - k_2)$$

- First-order condition:

$$1 - k_1 - 2k_2 = 0, \ \Rightarrow \ k_2 = \frac{1 - k_1}{2} \equiv BR_2(k_1)$$

- For firm 1, the profits maximization problem:

$$\max_{k_1} k_1(1 - k_1 - \frac{1 - k_1}{2})$$

Entry Deterrence

- First-order condition:

$$1 - 2k_1 - \frac{1}{2} + k_1 = 0, \ \Rightarrow \ k_1^* = \frac{1}{2}, \text{ and } k_2^* = \frac{1}{4}.$$

- Subgame Perfect Nash Equilibrium (SPNE): $k_1 = \frac{1}{2}$, and $k_2 = \frac{1}{4}$.
- The profits for firm 1: $\pi_1 = \frac{1}{8}$; the profits for firm 2: $\pi_2 = \frac{1}{16}$.
- Because $\pi_1 > \pi_2$, firm 1 has first mover's advantage!
- However, firm 2 always has the incentive to enter into the market because $\pi_2 > 0$.

Entry Deterrence

- Consider the case with positive entry cost $(F > 0)$
- For firm 2, given k_1 decided by firm 1, the profits maximization problem:

$$\max_{k_2} k_2(1 - k_1 - k_2) - F$$

- First-order condition:

$$1 - k_1 - 2k_2 = 0, \ \Rightarrow \ k_2 = \frac{1 - k_1}{2} \equiv BR_2(k_1)$$

- The best response function $k_2 = \frac{1-k_1}{2}$ holds only if $\pi_2 > 0$, where

$$\pi_2 = \left(\frac{1 - k_1}{2}\right)\left(1 - k_1 - \frac{1 - k_1}{2}\right) - F = \frac{(1 - k_1)^2}{4} - F.$$

Entry Deterrence

- Therefore,

$$\pi_2 > 0 \;\Rightarrow\; \frac{(1-k_1)^2}{4} - F > 0 \;\Rightarrow\; k_1 < 1 - 2\sqrt{F}.$$

- Example:
  - Given $k_1 = \frac{1}{2}$, and entry cost $F = \frac{1}{64}$:

$$k_1 < 1 - 2\sqrt{F}, \text{ so } \pi_2 = \frac{3}{64} > 0, \text{ then } k_2 = \frac{1-k_1}{2} = \frac{1}{4}.$$

  - Given $k_1 = \frac{1}{2}$, and entry cost $F = \frac{1}{4}$:

$$k_1 > 1 - 2\sqrt{F}, \text{ so } \pi_2 = -\frac{3}{16} < 0, \text{ then } k_2 = 0.$$

Entry Deterrence

- The best response function $BR_2(k_1)$ should be

$$BR_2(k_1) = \begin{cases} \frac{1-k_1}{2} & \text{if } k_1 < k_1^b \\ 0 & \text{if } k_1 \geq k_1^b, \end{cases}$$

  where $k_1^b = 1 - 2\sqrt{F}$.

- For firm 1, the profits maximization problem:

$$\max_{k_1} \begin{cases} k_1(1 - k_1 - \frac{1-k_1}{2}) & \text{if } k_1 < k_1^b \\ k_1(1 - k_1 - 0) & \text{if } k_1 \geq k_1^b \end{cases}$$

- Let's separate two cases to discuss the optimal decision k_1 for firm 1.

Entry Deterrence

- If $k_1 < 1 - 2\sqrt{F}$, first-order condition:

$$1 - 2k_1 - \frac{1}{2} + k_1 = 0 \;\Rightarrow\; k_1 = \frac{1}{2},\; \pi_1 = \frac{1}{8}.$$

- If $k_1 \geq 1 - 2\sqrt{F}$, first-order condition:

$$1 - 2k_1 = 0 \;\Rightarrow\; k_1 = \frac{1}{2},\; \pi_1 = \frac{1}{4}.$$

- What's the threshold for F? $\frac{1}{2} < 1 - 2\sqrt{F} \;\Rightarrow\; F < \frac{1}{16}$.
- Therefore, if $F << \frac{1}{16}$, the optimal decision by firm 1 is $k_1 = \frac{1}{2}$. The best response for firm 2 is $k_2 = \frac{1}{4}$. Profits: $\pi_1 = \frac{1}{8}$, and $\pi_2 = \frac{1}{16} - F$.
- If $F \geq \frac{1}{16}$, the optimal decision by firm 1 is $k_1 = \frac{1}{2}$. The best response for firm 2 is $k_2 = 0$. Profits: $\pi_1 = \frac{1}{4}$.

Entry Deterrence

- If $F = \frac{1}{16} - \epsilon < \frac{1}{16}$ $(k_1 < 1 - 2\sqrt{F})$, the firm 1 can either choose $k_1 = \frac{1}{2}$ to get $\pi_1 = \frac{1}{8}$, or choose $k_1 = \frac{1}{2} + \delta$ to get $\pi_1 = \frac{1}{4}$ because $k_1 \geq 1 - 2\sqrt{F}$ holds if δ is large enough.
- Increasing the capital investment a little bit can deter the entry of firm 2 and enjoy the monopoly profits.
- To sum up:
  - For F close to $\frac{1}{16}$, firm 1 can increase its profit by deterring entry.
  - For $F << \frac{1}{16}$, firm 1 prefers to accommodate the entry.
  - For $F \geq \frac{1}{16}$, firm 1 can block the entry simply by choosing monopoly level k_1.

Empirical Evidence

Response to the Threat of Entry

- This is the example from Goolsbee and Syverson (2008).
- The challenge is to separately identify the threat of entry from the actual entry.
- They focus on the airline industry in the United States.
- Southwest Airlines is the most famous potential competitor during the data period.
- They look at situations where Southwest begins or even announces it will begin operating in the second endpoint airport of a route, but before it starts flying the route itself.
- They find that incumbents cut fares significantly when threatened by Southwest's entry.

Data

- U.S. Department of Transportation's DB1A file.
- Period: 1993Q1- 2004Q4
- 10% sample of all domestic tickets in each quarter
- Focus on the major incumbents: American, Continental, Delta, Northwest, TWA, United, and US Airways.
- Threat of entry from Southwest
- For each route in their sample, they look at the 25-quarter window (3 years before to 3 years after)
- Average logged ticket prices and the logged total number of passengers within each route-carrier-quarter combination are constructed.

How to Identify a Threat?

- Before 2006, Southwest had operated at Cleveland (CLE).
- On October 5, 2006, Southwest began operations at Dulles (IAD).
- However, one route Southwest did not offer service on immediately upon entering Dulles was IAD-CLE.

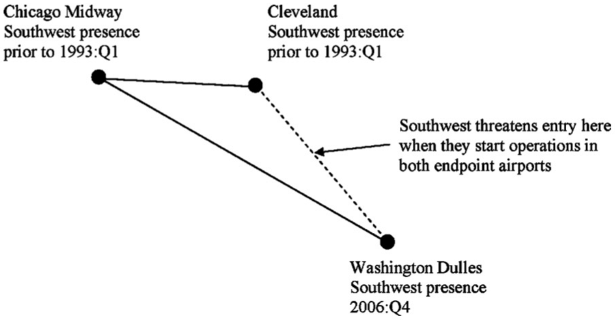


FIGURE I
Identifying a Threatened Incumbent Route

Probability of Southwest's Entry

- A probit regression of whether Southwest starts flying a route in a given quarter, conditional on the number of endpoints at which Southwest is already operating in the previous quarter.
- Having a presence in both airports raises the probability of entry to 18.5% per quarter.

TABLE I

PROBABILITY OF SOUTHWEST'S ENTRY INTO A ROUTE

Southwest operates in one endpoint airport in the previous quarter	0.0025
(single presence)	(0.0002)
Southwest operates in both endpoint airports in the previous quarter	0.1851
(dual presence)	(0.0203)
N	163,952

Notes. The table shows marginal effects estimates from a probit estimation for Southwest's entry into a route in a particular quarter, conditional on the number of the route's endpoint airports served by Southwest in the previous quarter. The excluded category includes observations where Southwest does not serve either endpoint airport in the previous quarter. Quarter fixed effects are included. Standard errors are in parentheses.

Empirical Specification

- The empirical model:

$$y_{ri,t} = \gamma_{ri} + \mu_{it} + \sum_{\tau=-8}^{3+} \beta_\tau (\text{SW\_in\_both\_airports})_{r,t_0+\tau}$$
$$+ \sum_{\tau=0}^{3+} \beta_\tau (\text{SW\_flying\_route})_{r,t_e+\tau} + X_{ri,t}\alpha + \epsilon_{ri,t},$$

  where $y_{ri,t}$ is the outcome of interest (e.g., mean logged fares) for incumbent carrier i flying route r in quarter t.
- SW_in_both_airports$_{r,t_0+\tau}$: time dummies surrounding the period when Southwest establishes a presence in both endpoints of a route but without flying the route.
- SW_flying_route$_{r,t_e+\tau}$: time dummies that commence in the period when Southwest actually starts flying the route

Main Results

TABLE II
INCUMBENT RESPONSES TO THE THREAT OF ENTRY

	(1) $\ln(P)$	(2) $\ln(Q)$	(3) Cost controls
Southwest in both airports (no flights)	-0.030	-0.177^{**}	-0.025
$t_0 - 8$	(0.024)	(0.088)	(0.024)
Southwest in both airports (no flights)	-0.071^{**}	-0.155	-0.053^{*}
$t_0 - 7$	(0.030)	(0.110)	(0.029)
Southwest in both airports (no flights)	-0.065^{*}	0.013	-0.059
$t_0 - 6$	(0.035)	(0.103)	(0.037)
Southwest in both airports (no flights)	-0.079^{*}	0.083	-0.072
$t_0 - 5$	(0.044)	(0.119)	(0.046)
Southwest in both airports (no flights)	-0.100^{*}	0.068	-0.093^{*}
$t_0 - 4$	(0.049)	(0.134)	(0.051)
Southwest in both airports (no flights)	-0.142^{**}	0.097	-0.137^{**}
$t_0 - 3$	(0.056)	(0.146)	(0.059)
Southwest in both airports (no flights)	-0.132^{**}	0.072	-0.123^{**}
$t_0 - 2$	(0.056)	(0.159)	(0.061)
Southwest in both airports (no flights)	-0.135^{**}	0.165	-0.125^{*}
$t_0 - 1$	(0.065)	(0.193)	(0.071)
Southwest in both airports (no flights)	-0.186^{**}	0.196	-0.162^{**}
t_0	(0.073)	(0.201)	(0.079)

Main Results (Continued)

Southwest in both airports (no flights)	−0.186**	0.196	−0.162**
t_0	(0.073)	(0.201)	(0.079)
Southwest in both airports (no flights)	−0.215**	0.240	−0.185**
t_0+1	(0.073)	(0.217)	(0.080)
Southwest in both airports (no flights)	−0.228**	0.123	−0.201**
t_0+2	(0.075)	(0.223)	(0.082)
Southwest in both airports (no flights)	−0.277**	0.167	−0.243**
t_0+3 to t_0+12	(0.079)	(0.224)	(0.085)
Southwest flying route	−0.237**	0.267	−0.211**
t_e	(0.082)	(0.239)	(0.091)
Southwest flying route	−0.288**	0.224	−0.260**
t_e+1 to t_e+2	(0.087)	(0.232)	(0.095)
Southwest flying route	−0.344**	0.329	−0.316**
t_e+3 to t_e+12	(0.113)	(0.271)	(0.117)
Operating cost control,			0.106
endpoint airport 1			(0.065)
Operating cost control,			0.158**
endpoint airport 2			(0.048)
N	19,414	19,414	18,176

Notes. The dependent variable in columns (1) and (3) is the passenger-weighted average logged fares. In column (2) it is logged total passengers. Standard errors are in parentheses and are clustered by route-carrier. The sample includes all routes where Southwest threatens entry, as defined in the text. The "Southwest in both airports" dummies denote Southwest having flights involving airports on both ends of a route previous to actually flying the route. The "Southwest flying route" dummies denote Southwest actually operating flights on the route. *Denotes significance at a 10% level. **Denotes significance at a 5% level.

Summary of Main Results

- Incumbent fares drop significantly before Southwest begins flying the route.
- By the time Southwest starts operating on both sides of the route (period t_0), prices are 17% lower ($\exp(0.186) = 0.830$) than in the excluded period.
- As time passes without Southwest entering, prices fall further.
- Prices are also lower in quarters before t_0 than in the excluded period.
- It is not surprising that prices begin to fall before t_0 since Southwest could start to advertise, sell tickets, and hire workers before t_0.
- For instance, Southwest's entry into Washington Dulles was publicly announced six months before the first day of operations.

Summary of Main Results

- Once Southwest actually enters the route at time t_e, prices fall 21% below the baseline and then continue falling to over 29% by the end of the period.
- In addition, passenger traffic rises (not significant) on threatened routes in the period before and around when Southwest enters the second endpoint airport.

Non-Price Response to the Threat of Entry

- This is the example from Prince and Simon (2015), "Do Incumbents Improve Service Quality in Response to Entry? Evidence from Airlines' On-Time Performance".
- One question of particular interest to academics and practitioners is how firm entry into a market impacts quality provision.
- We may expect that firms will want to improve the quality of their product or service when facing greater competition.
- This paper attempts to show how incumbent airlines adjust their on-time performance (OTP) in response to entry and entry threats by a particularly active (potential) entrant, Southwest Airlines.
- Data on airline on-time performance provide a good measure of product quality.

Data

- U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS) On-Time Performance data set.
- Period: 1993-2004.
- Since the OTP data is by flight, they define a route as an origin-destination pair. (O'Hare-Dulles and Dulles-O'Hare are two separate routes.)
- The data are aggregated at the carrier-route-quarter level.
- Their general approach to measuring entry and entry threats follows that of Goolsbee and Syverson (2008).

Dependent variables: On-Time Performance (OTP)

- The proportion of carrier i's flights on route j in quarter t that arrives at least 15/30 minutes late.
- The average number of minutes late that carrier is flights on route j in quarter t arrive at the gate, relative to its scheduled arrival time.
- Scheduled time and travel time.

Table 2 Descriptive Statistics

Variable	Mean	Std. dev.
Fraction of flights arriving at least 15 minutes late	0.180	0.119
Fraction of flights arriving at least 30 minutes late	0.083	0.078
Arrival delay (minutes)	4.113	6.689
Scheduled flight time	138.783	68.606
Travel time	144.384	68.941
Load factor	0.613	0.164
Carrier's flights on the route	243.947	170.285
Flights arriving at destination airport	18,313.61	12,021.35
Flights departing from origination airport	18,258.12	12,006.78

Main Results

- The variable T^0 indicates the quarter in which Southwest actually enters the second endpoint airport, threatening the route.

Table 3 Incumbents' On-Time Performance Response to Entry and Entry Threats by Southwest

	1	2	3	4	5
	Fraction of flights arriving at least 15 minutes late	Fraction of flights arriving at least 30 minutes late	Arrival delay (minutes)	Scheduled flight time	Travel time
8 quarters prethreat (T^{-8})	0.015 (0.006)*	0.007 (0.004)†	1.083 (0.366)**	−0.820 (0.275)**	0.666 (0.439)
7 quarters prethreat (T^{-7})	0.013 (0.006)*	0.004 (0.003)	0.970 (0.371)**	−0.971 (0.321)**	0.511 (0.429)
6 quarters prethreat (T^{-6})	0.006 (0.007)	0.000 (0.004)	0.775 (0.376)*	−0.808 (0.350)*	0.394 (0.337)
5 quarters prethreat (T^{-5})	0.002 (0.006)	−0.000 (0.004)	0.370 (0.364)	−0.795 (0.371)*	0.194 (0.465)
4 quarters prethreat (T^{-4})	0.012 (0.007)†	0.001 (0.003)	0.604 (0.416)	−0.537 (0.372)	0.755 (0.496)
3 quarters prethreat (T^{-3})	0.016 (0.008)*	0.007 (0.004)†	1.002 (0.494)*	−0.398 (0.403)	1.384 (0.582)*
2 quarters prethreat (T^{-2})	0.024 (0.008)**	0.012 (0.004)**	1.174 (0.527)*	−0.319 (0.491)	1.564 (0.632)*
1 quarter prethreat (T^{-1})	0.024 (0.008)**	0.012 (0.004)**	1.201 (0.549)*	−0.758 (0.484)	1.159 (0.641)†
Southwest threatens route (T^{0})	0.022 (0.009)*	0.009 (0.005)†	1.299 (0.609)*	−0.471 (0.499)	1.737 (0.716)*

Main Results (Continued)

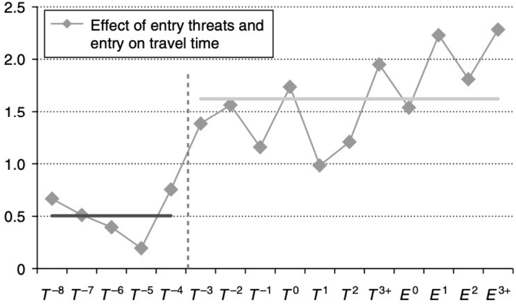
1 quarter postthreat (no flights) (T^1)	0.010	0.006	0.356	−0.193	0.985
	(0.011)	(0.005)	(0.624)	(0.514)	(0.744)
2 quarters postthreat (no flights) (T^2)	0.013	0.006	0.352	0.101	1.209
	(0.011)	(0.005)	(0.640)	(0.540)	(0.793)
3–12 quarters postthreat (no flights) (T^{3+})	0.023	0.010	1.148	−0.027	1.951
	(0.010)*	(0.005)†	(0.703)	(0.602)	(0.839)*
Southwest begins flying route (E^0)	0.023	0.011	1.113	−0.498	1.539
	(0.011)*	(0.006)*	(0.701)	(0.552)	(0.799)†
1 quarter postentry (E^1)	0.031	0.016	1.756	−0.610	2.231
	(0.011)**	(0.005)**	(0.730)*	(0.626)	(0.870)*
2 quarters postentry (E^2)	0.026	0.012	1.369	−0.490	1.810
	(0.012)*	(0.006)*	(0.798)†	(0.636)	(0.931)†
3–12 quarters postentry (E^{3+})	0.032	0.018	1.646	−0.502	2.284
	(0.013)*	(0.006)**	(0.831)*	(0.719)	(1.004)*
Load factor	0.126	0.043	7.150	−5.048	2.404
	(0.024)**	(0.014)**	(1.290)**	(2.746)†	(3.116)
Carrier's flights on the route	−0.004	−0.002	−0.224	−0.649	−1.017
	(0.006)	(0.003)	(0.310)	(0.605)	(0.705)
Ln(flights arriving at destination airport)	−0.000	−0.007	0.196	−0.565	−0.106
	(0.013)	(0.007)	(0.703)	(1.007)	(1.024)
Ln(flights departing from origination airport)	0.030	0.012	2.017	−3.466	−1.206
	(0.013)*	(0.007)†	(0.675)	(0.825)**	(0.932)
Wald test: (T^{-3} to E^{3+})–(T^{-8} to T^{-4})					1.119*
Wald test: (T^{-5} to T^{-4})–(T^{-8} to T^{-6})					−0.050
Wald test: (T^{-3} to T^{-2})–(T^{-8} to T^{-6})					0.950*
N	4,822	4,822	4,822	4,822	4,822

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects. Standard errors clustered by carrier-route-pair are reported in parentheses. Excluded category is quarters 9–12 prethreat. Models 1 and 2 are marginal effects from fractional logit models.
†$p < 0.10$; *$p < 0.05$; **$p < 0.01$.

Summary of Main Results

- the fraction of the incumbent's flights that arrive at least 15 (30) minutes late were about 3.2 (1.8) percentage points higher than the baseline when three or more quarters have passed since entry.
- 2.3 (1.0) percentage points higher when three or more quarters have passed since an entry threat emerged (but no entry occurred).

Figure 1 Effect of Entry Threats and Entry on Incumbent Travel Time



Possible Reasons

- Why might quality worsen in response to entry and entry threats?
  - Cost and price cutting:
    - During that period, Southwest is the predominant low-cost carrier in the United States.
    - Incumbents cut costs by reducing OTP to aggressively cut prices, with the intent both to deter entry by Southwest and to fight Southwest postentry.
  - Product differentiation:
    - Southwest is consistently a top performer in OTP during that period.
    - Incumbents respond to Southwest entry by moving away from Southwest on the OTP performance dimension
- However, any of them are not supported by the data.
- The phenomenon of worsening OTP can only be observed when the potential entrant is a low-cost carrier, such as Southwest, Jet Blue, and AirTran.

Homework 10

- Pick up an industry (not the airline industry), and define the markets in this industry.
- Who are the potential entrants? If possible, explain how you define the threat of entry.
- What kinds of strategies can the incumbents deter the potential entrants? (both price and non-price responses)
- Do incumbents have the same response to the threat of entry and the actual entry?