Online Appendix for "Access Pricing Regulation in the U.S. Domestic Aviation Industry"

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A Data Restrictions

First, raw DB1B data is restricted to only those tickets which involve the chosen subsample of airports, are roundtrip and consist of no more than 1 connection in each direction. Next, any products with a reported fare that is deemed questionable (a dollarcred value of 0) are dropped. Any products involving fares greater than \$1500 or less than \$20 are dropped as these are likely the result of key punch errors or the use of frequent flier miles. Passenger facility charges are not assessed on products purchased with frequent flier miles.[1] Any tickets involving ticketing carriers other than $AA, AS, B6, CO, DL, F9, G4, HP, N7, NJ, NK, NW, SY, TW, TZ, UA$, US or WN are excluded. Code sharing or the use of regional airlines may result in the carrier who operates a flight (the operating carrier) differing from the carrier who issues the ticket (ticketing carrier). I attribute ownership of products to the ticketing carrier. I drop any tickets involving multiple ticketing carriers. Next, I collapse tickets to the carrier-itinerary level, taking the average price and summing the passengers. Lastly, any products which are not purchased by at least 100 passengers (10 DB1B passengers) are dropped as they do not represent a competitive presence in the market.

Table 1 presents summary statistics at the product level. The airline industry experienced tremendous change over the chosen time period. A merger wave lead to significant consolidation. Ultra low cost carriers emerged and grew between 2000 and 2018.

In 2018, the average round trip fare was \$422.6 (2018 dollars). In 2000, the average fare is \$488 (2018 dollars). Fares have declined, despite consolidation, primarily due to lower fuel costs and the emergence of ultra low cost carriers (Spirit Airlines (NK), Frontier Airlines ($F9$), Allegiant Airlines ($G4$) and Sun Country Airlines (SY)). This fare includes the passenger facility charge collected, as well as other taxes. The total passenger facility charge collected on a product had an average of \$15 in 2018 (2018 dollars) and \$9 in 2000 (2000 dollars) which corresponds to \$12.97 in 2018 dollars. This increase is primarily due to

[1] Federal Code 14 C.F.R. §158.9 2007

Table 1: Summary Statistics

Variable	Description	2000	2018
Number of Passengers	Number of DB1B passengers	121.82	172.17
Price	average itinerary fare ($100s) (includes PFC)	4.876	4.226
Num. Dest. Origin	Number of destinations served from the origin airport by carrier (100s)	0.118	0.223
Nonstop	an indicator for nonstop products	0.196	0.312
Itinerary Distance	distance flown (1000s mi.)	1.415	1.306
Nonstop Distance	great circle distance between origin and destination (1000s mi.)	1.302	1.216
Distance Ratio	ratio of itinerary distance to nonstop distance	1.109	1.093
Total PFC	total PFC charged by airports on a product (nominal)	9.174	14.83
Market Size	Geometric mean of the population of the origin MSA and destination MSA (100000s)	29.017	34.136
LCC	indicator if carrier is low cost carrier	0.144	0.407
Number of products	The number of products in a market	10.965	8.155
N	Number of products/observations	23934	18649

the price cap increase implemented in 2001. The importance of low cost carriers has grown substantially over the time period. In 2018, low cost carriers offered about 41% of products, but only 14% of products in 2000. Coinciding with the rise of low cost carriers and the disappearance of network carriers, the number of nonstop products has risen. About 30% of products are nonstop were 2018, but only 20% were nonstop in 2000. Industry consolidation caused a decrease in the number of products in a market. There are on average 8.155 products in each market in 2018 compared to 10.965 in 2000. Recall that this could include products by different carriers, different connecting airports, different origin airports and different destination airports. As the industry has consolidated and fares have fallen, the average number of passengers per product has increased from 121.82 DB1B passengers in 2000 to 172.17 in 2018.

B Background on Passenger Facility Charges

Airports in the United States are publicly owned, usually by local governments, airport authorities or port authorities. Airports obtain funds to improve and expand from two primary sources: government grants[2] and charges for airport access and services (both aeronautical and non-aeronautical). Aside from some optional,

[2]Mostly airport improvement grants (AIPs)

small or uncommon charges, airports collect a two part charge from airlines for the usage of airport facilities. This charge takes the form of $A(m)f + wq$ where m is the weight[3] of the aircraft flown, f is the frequency of service (number of flights operated in a given period), A is a function of weight, w is a per passenger access price and q is the number of passengers boarded by the airline at the airport. $A(m)f$ is referred to as a landing fee. The focus of this article is w, the per passenger access charge which is known as a "passenger facility charge" (PFC). Each part of the charge serves a distinct purpose. Landing fees are intended to cover operational and capital costs of existing airfield facilities and services. Revenue from landing fees (in addition to other airport charges, but excluding PFCs) should not, generally, exceed these costs.[4] PFCs serve a different purpose. PFC revenue is designated for airport expansion and improvement.

Since their introduction in 1992, PFCs have been subject to a price cap. This cap had been raised previously to support infrastructure improvements and increased operations. Since 2001, when the price cap was raised in the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century, PFCs have remained capped at \$4.50, despite requests for an increase from airport operators and some politicians. PFCs have not been adjusted to account for inflation over this time period. Airports need the approval of the FAA before charging a PFC and not all commercial airports have been granted approval to charge the maximum price. After the creation of PFCs in 1992, airports began rapidly acquiring approval to charge the then maximum cap of \$3.00. By 2001, when the price cap was raised, more than three fourths of U.S. commercial airports where charging the maximum allowable PFC. As was the case with the introduction of PFCs in 1992, airports again quickly began acquiring approval to charge the new maximum of \$4.50. By 2020, almost all major U.S. commercial airports charge the maximum allowable PFC. Passenger facility charges are restricted to take on values of 0,1,2,3,4 and 4.50 per boarded passenger, with most airports charging no PFC, a PFC of \$3 or a PFC of \$4.50. Figure 1 (in the main text) shows the evolution of PFC levels over time at U.S. commercial airports.

The revenue from PFCs can be used only for eligible projects. An eligible project must enhance or preserve safety, decrease noise from the airport or enhance carrier competition.[5] Crucially, PFCs, as they are more certain than alternative sources of airport revenue such as concessions, are often used to back the loans necessary for airport expansion.

PFCs are collected each time a passenger boards a plane, but no more than 4 PFCs can be collected on any passenger trip. The total PFC collected for a given itinerary depends not only on the origin and destination airports involved in the ticket, but also the location of any connections. An increase in the

[3]Depending on the airport, this is measured in terms of maximum takeoff weight (MTOW) or maximum gross landing weight (MGLW).
[4]Federal Register. Vol. 78, No. 175. September 10, 2013. Notices.
[5]Federal Code 14 C.F.R. §158.9 2007

PFC at an airport changes the competitive landscape of the downstream market[6] as different products[7] face differing cost increases. Suppose the PFC increases at an airport A. All products involving airport A face what is equivalent to an increase in marginal cost. However, competing products which utilize an alternative airport in the city do not face such an increase in marginal cost. Among products between airports B and C, in a different city pair, direct products are unaffected by an increase in the PFC at airport A, while products that connect through A are affected. The effects of an increase in access charge are thus more complex than an equal increase in all firms' marginal cost.

Air carriers have two reasons to oppose passenger facility charge increases. First, a PFC increase is essentially an increase in the cost of a necessary input good, raising the marginal cost of the final product. Second, additional funds at airports could, in the long run, lead to additional downstream competition. With additional PFC revenue, airports can expand airport facilities, such as gates or runways. In fact, the use of PFC revenue collected by airports is restricted to a limited set of uses, one of which being airport expansion that encourages competition and the entrance of new carriers.[8] Naturally, dominant carriers oppose the entrance of new competitors or the expansion of other carriers facilities, especially at their dominant hub airports where they benefit from what is known as the hub premium.[9] See Snider and Williams (2015) for evidence of the pro-competitive effect of airport expansion and improved access to gate facilities.

B.1 Proposed Price Cap Changes

A recent bill introduced in the U.S. House of Representatives in 2017, and again in 2019, proposes the elimination of the PFC price cap.[10] The proposal was intended to decrease the reliance of airports on federal grant funding and raise funds for infrastructure projects such as terminal construction. Airports Council International, a global trade organization for airports, expressed support for the "pro-market" proposal.[11] The major trade association and lobbying group representing U.S. airlines, Airlines for America, strongly opposes any increase in the maximum passenger facility charge.[12] Carriers, through Airlines for America, argue that revenue from PFC collections have reached an all time high of $3.5 billion and that airport infrastructure expansion needs are already adequately met.[13]

Other proposals have suggested an increase in the cap rather than an elimination of the federal cap on passenger facility charges. President Obama's 2011 budget proposed an increase in the maximum allowed

[6] A market is defined as a directional city pair.

[7] A product is defined as a airline-route pair.

[8] Federal Code 14 C.F.R. §158.9 2007

[9] Ciliberto and Williams (2010) find that control of airport gates is a crucial determinant of the hub premium.

[10] Investing in America: Rebuilding America's Airport Infrastructure Act, H.R. 1265, 115th Congress. 2017. and Investing in America: Rebuilding America's Airport Infrastructure Act, H.R. 3791, 116th Congress. 2019.

[11] https://massie.house.gov/news/documentsingle.aspx?DocumentID=395240

[12] https://www.airlines.org/news/five-more-reasons-to-oppose-an-increase-to-the-passenger-facility-charge/

[13] https://www.stopairtaxnow.com/resources/pfc-5-reasons/

passenger facility charge to \$7.[14] While this increase was not approved, his administration again suggested an increase, this time to \$8, in 2014.[15] More recently, an early version of the FY2018 senate appropriations bill for the Departments of Transportation, and Housing and Urban Development[16] included a \$4 increase of the maximum allowable PFC, at the origin airport only. A RAND Corporation report (Miller et al., 2020), commissioned by Congress, proposes that the price cap is raised to approximately \$7.50, indexed to inflation and charged only to originating passengers.

B.2 PFC Application Process

To apply for the right to charge PFCs and collect PFC funds, airports must submit an application to the FAA. This application must include a list of projects which will be funded with PFC revenue and the level of the PFC (\$3, \$4.50 etc.). Air carriers are notified of the PFC application and are allowed to comment. Within 120 days from the FAA's receipt of a PFC application, the application is approved or disapproved by the Associate Administrator for Airports or Regional Airports Division Director. PFC applications, whether approved or disapproved, are published in the federal register. The majority of PFC applications published in the federal register are approved. For instance, the December 2014 edition of the Federal Register listed 10 PFC applications. One application was withdrawn and 9 applications were either approved or partially approved. Example projects include "signage improvements", "construct parallel taxiway D", "Runway 24 centerline/touchdown zone/runway guard lights", "Acquire airfield deicing vehicle", "Purchase and install jet bridge", "Terminal improvements", and "Terminal roof replacement."

C Robustness

C.1 Robustness: Changing Preference for Airlines

In this section, I consider how my findings are affected by changes in regulatory preference for airlines (γ) between 2000 and 2018. Recall that, because the preference weight on consumer surplus is normalized to 1, α represents regulatory preference for airports relative to consumers and $\frac{\alpha}{\gamma}$ represents regulatory preference for airports relative to airlines.

First, I consider regulatory preference for airports relative to consumers (α). Figure 1 plots $\hat{\alpha}$ for 2000 (blue) and 2018 (red) as a function of regulatory preference for airlines (γ) in that year.[17] To illustrate,

[14]https://www.huffpost.com/entry/passenger-facility-charges_n_6177984
[15]https://www.huffpost.com/entry/passenger-facility-charges_n_6177984
[16]FY2018 Transportation, Housing and Urban Development, and Related Agencies Appropriations Act, S. 1655, 115th Congress. 2017.
[17]These figures are very similar for other values of γ. I restrict attention to γ values between .8 and 1.2 for readability.

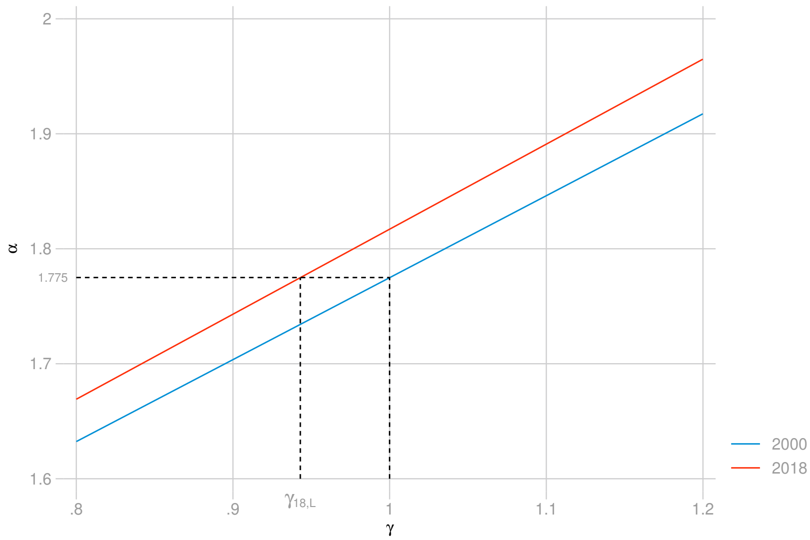

Figure 1: Regulatory Preference for Airports Relative to Consumers

suppose $\gamma = 1$ in 2000. Figure 1 shows that regulatory preference for airports relative to consumers in 2000 is 1.775 when $\gamma = 1$ (the point on the blue line above $\gamma = 1$) which is consistent with Table 2. Next, suppose regulatory preference for airlines γ is 1.1 in 2018 (an increase in preference relative to 2000). Figure 1 shows that the implied regulatory preference for airports relative to consumers in 2018 is therefore 1.89 (the point on the red line above $\gamma = 1.1$). Generally, Figure 1 shows that the finding that regulatory preference for airports relative to consumers has increased between 2000 and 2018 is robust to increases in γ. Additionally, an increase in γ strengthens this result (i.e., increases in γ increase the size of the increase in implied regulatory preference for airports (relative to consumers) α between 2000 and 2018). This finding is also robust to moderate reductions in γ. To illustrate, suppose $\gamma = 1$ in 2000 and regulatory preference for airlines declines between 2000 and 2018. Figure 1 shows that if $\gamma > \gamma_{18,L} = 0.944$ in 2018, then α increases between 2000 and 2018. In summary, the finding that regulatory preference for airports relative to consumers has increased between 2000 and 2018 is robust to increases in γ and moderate reductions in γ over this time period.

Next, I consider regulatory preference for airports relative to airlines ($\frac{\hat{\alpha}}{\gamma}$). Figure 2 plots $\frac{\alpha}{\gamma}$ for 2000 (blue) and 2018 (red) as a function of regulatory preference for airlines (γ) in that year. Figure 2 shows that whenever γ declines between 2000 and 2018, implied regulatory preference for airports relative to airlines increases. Thus, the finding that regulatory preference for airports relative to airlines increased over this period is robust to reductions in γ. This result is also robust to moderate increases in γ. To illustrate, suppose $\gamma = 1$ in 2000 and regulatory preference for airlines has increased between 2000 and 2018. Figure

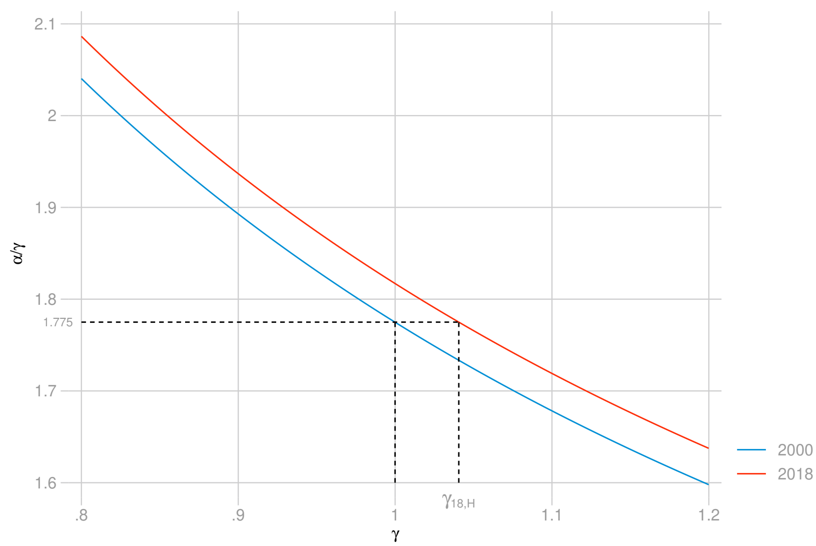

Figure 2: Regulatory Preference for Airports Relative to Airlines

2 shows that if $\gamma < \gamma_{18,H} = 1.040$, then $\frac{\alpha}{\gamma}$ increases between 2000 and 2018. In summary, the finding that regulatory preference for airports relative to airlines has increased between 2000 and 2018 is robust to decreases in γ and moderate increases in γ over this time period.

This subsection has shown that the result that regulatory preference for airports relative to both airlines and consumers has increased between 2000 and 2018 is robust to moderate changes in γ. For example, if $\gamma = 1$ in 2000, this result holds if $\gamma \in (\gamma_{18,L}, \gamma_{18,H})$ in 2018. For more drastic changes in γ, a weaker result holds: Either regulatory preference for airports relative to consumers (α) has increased over this period or regulatory preference for airports relative to airlines ($\frac{\alpha}{\gamma}$) has increased over this period. Note that there exist no changes in γ such that both the implied regulatory preference for airports relative to consumers (α) and regulatory preference for airports relative to airlines ($\frac{\alpha}{\gamma}$) declines.

Table 2 presents the interval $(\gamma_{18,L}, \gamma_{18,H})$ for a range of potential increases in price coordination κ (see Subsection C.4 for details). $(\gamma_{18,L}, \gamma_{18,H})$ denotes the set of γ values in 2018 such that, when $\gamma = 1$ in 2000, regulatory preference for airports relative to both consumers and airlines increases between 2000 and 2018. Note the interval $(\gamma_{18,L}, \gamma_{18,H})$ expands as κ increases. Thus, the interval $(\gamma_{18,L}, \gamma_{18,H})$ is significantly larger when, as prior literature suggests,[18] price coordination between airlines increases between 2000 and 2018. Additionally, Appendix D suggests that accounting for other sources of airport revenue is likely to increase the range of γ values for which the regulator's preference for airports relative to both consumers and airlines

[18] Recent research has found evidence of price coordination or collusion in the airline industry (Ciliberto et al., 2019; Aryal et al., 2021), particularly towards the end of the 2000-2018 period. The Department of Justice investigated the industry for potential collusion in 2015 (https://www.washingtonpost.com/business/economy/doj-investigating-potential-airline-collusion/2015/07/01/42d99102-201c-11e5-aeb9-a411a84c9d55_story.html).

increases.

Table 2: Regulator's Problem- Price Coordination/Changes in Gamma Robustness Check

κ	$\gamma_{18,L}$	$\gamma_{18,H}$
0	0.944	1.040
.25	0.876	1.110
.5	0.808	1.184
.75	0.738	1.306
1	0.669	1.501

C.2 Robustness: Binding Cap in 2000

In the main text, I assume that the price cap binds at any airport that charges the maximum PFC of $3 in quarter 3 of 2000.[19] In other words, I assume every airport charging a PFC of $3 in quarter 3 of 2000 will increase its PFC to the new price cap of $4.50.[20]

In this section, I relax this assumption and explore the robustness of my results. I assume that some airports charging a PFC of $3 in quarter 3 of 2000 will instead maintain the cap of $3 and not raise their PFC to the new maximum of $4.50. Specifically, I recalculate implied regulatory preference for airports in 2000 under the assumption that the cap is not binding at any airport that increased its PFC to $3 within x years prior to quarter 3 of 2000. I consider a range of values for x. Intuitively, the price cap is less likely to be binding at airports which only recently increased their PFC to the maximum.

I make three additional assumptions in this section. First, I assume $\gamma = 1$ for concreteness. Results are qualitatively unchanged for other γ values. Second, I assume, as in the main text, that the cap is binding for all airports charging a PFC of $4.50 in 2018. As Figure 1 shows, almost all airports were charging the maximum PFC of $4.50 in 2018 and had been charging this PFC for 5+ years. Thus, its likely that the cap was binding for many or all airports in 2018. Third, for consistency, I assume any airport charging a PFC below the cap (in either 2000 or 2018) will not change their PFC level after the cap is raised.[21]

Table 3 presents my findings under these conditions. The first column denotes x, the number of years prior to quarter 3 of 2000 for which the cap is assumed not to bind for any airport that increased its PFC to $3 within these years. For example, if $x = 3$, then the PFC is assumed to bind only at airports that 1)

[19]Recall that the price cap was raised in 2001, but 2000 quarter 3 data is used due to the September 11th attacks and their impact on the industry in quarter 3 of 2001.

[20]In practice, there is likely a delay between when the price cap is raised and when airports begin charging a higher PFC level due to the PFC application process, the FAA's review of PFC applications/proposals and other administrative delays. Thus, airports gradually increased their PFC levels after the cap was raised in 2001.

[21]Note that this assumption also differs from the main text. In the main text, I assumed airports that charged a PFC below the maximum increased their PFC by the amount of the price cap increase. Results are not driven by this assumption.

Table 3: Regulator's Problem-Robustness Checks: Binding in 2000

Years Previous to 2000 (x)	Per. Bind. (for 2000)	$\hat{\alpha}$ (2000)	$\hat{\alpha}$ (2018)
0/1/2	80.9%	1.775	1.814
3	77.6%	1.775	1.814
4	65.9%	1.767	1.814
5	60.6%	1.765	1.814
6	52.1%	1.764	1.814

charge the maximum PFC of $3 and 2) increased to this PFC level prior to quarter 4 of 1997. The second column denotes the percentage of airports in the sample for which the cap is assumed to be binding. No airport in the sample increased its PFC to $3 in the two years prior to quarter 3 of 2000. Thus, results are identical for $x = 0, 1$ or 2. The third column presents the implied regulatory preference in 2000 and the fourth column presents the implied regulatory preference in 2018 for comparison. For all values of x, the main finding holds: Regulatory preference for airports increased between 2000 and 2018.

C.3 Robustness: 2001 Quarter 2

Table 4 presents demand results for quarter 2 of 2001. Table 5 presents implied regulatory preference in quarter 2 of 2001 when $\gamma = 1$. Results are consistent with an increase in regulatory preference for airports.

Table 4: Demand Results

	2001Q2 Nested Logit (NL)		2018Q3 Nested Logit (NL)	
Variable	Mean	SE	Mean	SE
Intercept	-5.783***	(0.074)	-5.192***	(0.157)
Prices	-0.284***	(0.011)	-0.599***	(0.034)
Nonstop	1.184***	(0.019)	1.127***	(0.037)
Nonstop Distance	-0.249***	(0.037)	-0.069	(0.052)
Nonstop Distance Squared	0.026**	(0.012)	0.069***	(0.017)
Number of Dest. Origin	0.835***	(0.039)	0.795***	(0.043)
Distance Ratio	-0.479***	(0.029)	-0.178***	(0.038)
Continental	-0.133***	(0.02)		
Northwest	-0.106***	(0.018)		
US Airways	-0.198***	(0.019)		
American West	0.12***	(0.025)		
Transworld	-0.045**	(0.02)		
Delta	0.086***	(0.017)	0.366***	(0.018)
United	0.212***	(0.019)	-0.009	(0.02)
Southwest	-0.06***	(0.021)	-0.29***	(0.028)
Other LCC	0.168***	(0.023)	-1.45***	(0.087)
Alaskan	0.548***	(0.061)	0.261***	(0.043)
ρ	0.424***	(0.005)	0.457***	(0.009)

Notes: This table presents nested logit demand estimates in 2001Q3 and 2018Q3. Standard errors are heteroskedasticity robust. *** p<.01, ** p<.05, *p<.1.

Table 5: Regulator's Problem- 2001 Robustness Check

CS	γ	$\hat{\alpha}$ (2001 Q2)	$\hat{\alpha}$ (2018 Q3)
YES	1	1.801	1.816

C.4 Robustness: Increased Price Coordination

In this section, I explore the robustness of results to the possibility of an increase in price coordination in the airline industry between 2000 and 2018. Recent research has found evidence of price coordination or collusion in the airline industry (Ciliberto et al., 2019; Aryal et al., 2021), particularly towards the end of the 2000-2018 period, and the Department of Justice investigated the industry for potential collusion in 2015.[22] This suggests that airlines may be coordinating pricing decisions in 2018 and not engaging in Bertrand Nash competition. To examine this possibility, I recompute 2018 estimates of regulatory preference while relaxing the assumption that airlines engage in Bertrand Nash competition in 2018.

Let c_{jm} denote the marginal cost of product j in market m. Let $\mathcal{J}_{fm}$ denote the set of products owned by airline f in market m and let $\mathcal{F}_m$ denote the set of firms in market m. pfc_{jm} denotes the observed per passenger facility charge for this product. Airline f chooses prices to maximize

$$\sum_{g\in\mathcal{F}_m} \kappa(f,g) \sum_{j'\in\mathcal{J}_{gm}} s_{j'm}\left(p_{j'm} - c_{j'm}\right) \tag{1}$$

where $\kappa(f,g)$ is referred to as the coordination parameter between firm f and firm g. I assume

$$\kappa(f,g) = \begin{cases} 1 & \text{if } f = g \\ \kappa & \text{if } f \neq g \end{cases}.$$

κ represents the extent that a firm considers its rivals' profits when choosing its prices. If $\kappa = 1$, firm f and g price as if they were a single firm and entirely consider the rival firms' profits when setting prices. If $\kappa = 0$, firm f and g price competitively as in the main text. In this section I consider four alternative values for κ in 2018: .25, .5, .75 and 1. Table 6 presents the results with the regulatory preference parameter for 2000 included for comparison. In all specifications, regulatory preference for airports in 2018 exceeds the regulatory preference for airports in 2000.

Table 6: Regulator's Problem- Price Coordination Robustness Check

Period	κ	$\hat{\alpha}$
2000	0	1.775
2018	0	1.816
2018	.25	1.870
2018	.5	1.940
2018	.75	2.025
2018	1	2.13

[22] https://www.washingtonpost.com/business/economy/doj-investigating-potential-airline-collusion/2015/07/01/42d99102-201c-11e5-aeb9-a411a84c9d55_story.html

D Airport Surplus

In this section, I discuss how the consideration of alternative sources of airport revenue affects results.[23] In addition to PFC funds, airports also generate revenue from aeronautical and non-aeronautical services. Aeronautical revenue is revenue derived directly from air services including revenue from airline terminal fees and rents, landing fees, fuel sales, cargo and hangar rentals.[24] Non-aeronautical revenue is revenue generated from other services such as parking and ground transportation, retail stores, food and beverage concessions and rental cars.[25] Airport costs include labor costs, the cost of materials, insurance, administration costs and utilities. Aeronautical costs are airport costs resulting directly from aeronautical services (e.g., maintenance of terminals, gates and runways). Non-aeronautical costs are airport costs not directly related to aeronautical operations.

Next, I will consider how including aeronautical and non-aeronautical revenue/costs in the airport surplus function would impact the main results of this study. Let airport surplus $S(\bar{w})$ equal

$$S(\bar{w}) = \Pi_A(\bar{w}) + \Pi_{NA}(\bar{w}) + R_{PFC}(\bar{w}) \tag{2}$$

where $\bar{w}$ denotes the PFC cap. $\Pi_A(\bar{w}) = \sum_a \pi_A^a(\bar{w})$ represents aggregate airport profit from aeronautical services (i.e., aeronautical revenues generated in excess of aeronautical operating costs).[26] $\pi_A^a(\bar{w})$ denotes aeronautical profit at airport a. $\Pi_{NA}(\bar{w}) = \sum_a \pi_{NA}^a(\bar{w})$ represents aggregate airport profit from non-aeronautical activities (i.e., non-aeronautical revenues generated in excess of non-aeronautical operating costs). $\pi_{NA}^a(\bar{w})$ denotes non-aeronautical profit at airport a.

$R_{PFC}(\bar{w})$ denotes total PFC revenue.[27] PFC revenue is separated from other sources of aeronautical profit because PFC revenue cannot be used for covering operating costs and must be allocated toward airport expansion/improvement projects (as discussed in the main text).[28] Other aeronautical charges such as landing fees are intended to recover airport operating costs.

The amount of profit an airport generates from aeronautical services ($\pi_A^a(\bar{w})$) depends on the rates/prices it charges airlines to use the airport (e.g., landing fees or terminal rental fees). These rates are known as

[23] I thank an anonymous referee for the suggestion to include this analysis.

[24] For the purposes of this analysis, PFC revenue is not classified as an aeronautical revenue source. This reflects the fact that PFC revenue, as it is intended to finance airport expansion and improvement, is treated differently than other types of aeronautical revenue and is not regulated in the same way.

[25] Note that airports typically contract with downstream firms (i.e., restaurants, retailers and car rental companies) that provide non-aeronautical services. Non-aeronautical revenue refers to the revenue earned by the airport though leasing agreements and contracts with these firms.

[26] Airport profit refers to revenues generated in excess of operating costs. These profits are usually applied toward cash reserves or airport improvement/expansion. As will be discussed, airports in the U.S. are not permitted to generate excessive surpluses and may be investigated by the FAA if they do accumulate large surpluses.

[27] This quantity is denoted $R(\mathbf{p}, \mathbf{w})$ in the main text.

[28] Federal Code 14 C.F.R. §158.9 2007

aeronautical rates. Similarly, the amount of profit airports generate from non-aeronautical services ($\pi^a_{NA}(\bar{w})$) depends on the rates/prices airports charge for services such as parking and the rates airports charge third parties such as concession operators for the right to operate within the airport. These rates are known as non-aeronautical rates.

The specifics of how each airport determines its rates depend on a variety of factors such as whether the airport uses a residual or compensatory rate-setting methodology, airline use and lease agreements, majority in interest clauses with airlines and the size of the airport (Miller et al., 2020; Faulhaber et al., 2010; Wu, 2017; Starostina and Wu, 2018). At some airports, aeronautical rates are set such that revenues do not exceed the operating cost of providing aeronautical access and services. Thus, in these cases, aeronautical rates are set such that $\pi^a_A(\bar{w}) = 0$. However, these airports may set non-aeronautical rates such that positive non-aeronautical profits can be generated (i.e., $\pi^a_{NA}(\bar{w}) > 0$). At other airports, non-aeronautical profits are used to subsidize aeronautical operations and airlines pay any operating costs not covered by profits from non-aeronautical services. In these cases, rates are set such that $\pi^a_A(\bar{w}) + \pi^a_{NA}(\bar{w}) = 0$. In other cases, airports are permitted to generate profit/excess revenue from aeronautical[29] and non-aeronautical services in order to, for example, fund expansion/improvement projects. In summary, $\pi^a_A(\bar{w})$ and $\pi^a_{NA}(\bar{w})$ vary considerably across airports. $\pi^a_A(\bar{w})$ and $\pi^a_{NA}(\bar{w})$ may be 0 at some airports while they may be positive at others.

For the remainder of this section, let $\Pi^t_O(\bar{w}) = \Pi^t_A(\bar{w}) + \Pi^t_{NA}(\bar{w})$ denote aggregate airport profit from sources other than PFCs in period $t \in \{2000, 2018\}$. Additionally, let CS^t, Π^t_D, and R^t_{PFC} denote consumer surplus, airline profit and PFC revenue, respectively, in year t (i.e., CS^{2000} denotes consumer surplus in the year 2000). The regulator's problem is therefore

$$\text{argmax}_{\bar{w}} \quad CS^t(\bar{w}) + \gamma \Pi^t_D(\bar{w}) + \alpha \left(\Pi^t_O(\bar{w}) + R^t_{PFC}(\bar{w}) \right)$$

and implied regulatory preference in period t is

$$\hat{\alpha}^t = -\frac{\frac{\partial CS^t}{\partial \bar{w}} + \gamma \frac{\partial \Pi^t_D}{\partial \bar{w}}}{\frac{\partial R^t_{PFC}}{\partial \bar{w}} + \frac{\partial \Pi^t_O}{\partial \bar{w}}}. \tag{3}$$

The denominator of Equation (3) differs from the expression for regulatory preference from the main text (see Equation (3) in the main text) because it includes an additional term $\frac{\partial \Pi^t_O}{\partial \bar{w}}$. This term captures the change in airport profit (from non-PFC sources) from an increase in the price cap.

Ideally, $\Pi^t_O(\bar{w})$ would be estimated empirically. This would allow for the computation of $\frac{\partial \Pi^t_O}{\partial \bar{w}}$ and regulatory preference as given in Equation (3). Unfortunately, the estimation of non-aeronautical airport profit

[29] This may require the agreement of airlines operating at the airport.

would require knowledge of airports leasing agreements with entities providing non-aeronautical services (concessions, rental car companies etc.), estimates of consumer demand for each non-aeronautical service (e.g., concessions, rental cars and parking)[30] and a model of competition between non-aeronautical service providers. Additionally, the estimation of aeronautical airport profit would require knowledge of airline leasing agreements which are generally confidential. Thus, the estimation of $\Pi_O^t(\bar{w})$ is beyond the scope of the current study. However, I will argue that the omission of $\frac{\partial \Pi_O^t}{\partial \bar{w}}$ from the expression for regulatory preference from the main text is likely to underestimate the change in regulatory preference for airports. Thus, the primary result of this study, that regulatory preference for airports increased between 2000 and 2018, is likely to be strengthened if other airport profit sources were to be included in airport surplus.

With a slight abuse of notation, note that the impact of an increase in the PFC cap on $\Pi_O^t(\bar{w})$ can be decomposed as

$$\frac{\partial \Pi_O^t}{\partial \bar{w}} = \underbrace{\frac{\partial \Pi_O^t}{\partial D^t(\bar{w})}}_{>0} \underbrace{\frac{\partial D^t(\bar{w})}{\partial \bar{w}}}_{<0}. \tag{4}$$

$\frac{\partial \Pi_O^t}{\partial D^t(\bar{w})}$ denotes the change in non-PFC airport profits when the number of passengers increases. $\frac{\partial \Pi_O^t}{\partial D^t(\bar{w})} > 0$ as airports are likely to earn larger aeronautical and non-aeronautical profits when more passengers use the airport (e.g., a larger number of passengers implies more customers will purchase parking from the airport). $\frac{\partial D^t(\bar{w})}{\partial \bar{w}}$ denotes the change in the number of passengers as the PFC cap increases. $\frac{\partial D^t(\bar{w})}{\partial \bar{w}} < 0$ as an increase in PFCs raises airline prices and, as a result, reduces demand. As Equation (4) shows, this implies other sources of airport profit Π_O^t are decreasing in the PFC cap. This is captured in the following assumption.

Assumption 1. $\frac{\partial \Pi_O^t(\bar{w})}{\partial \bar{w}} < 0$ *for* $t \in \{2000, 2018\}$.

Next, I argue that $\left|\frac{\partial \Pi_O^t}{\partial \bar{w}}\right|$ is likely to be larger in 2018 than in 2000 (i.e., $\left|\frac{\partial \Pi_O^{2018}}{\partial \bar{w}}\right| > \left|\frac{\partial \Pi_O^{2000}}{\partial \bar{w}}\right|$). This is the case for two reasons. First, as demand estimates from the main text show, demand for air travel became more price sensitive in 2018. This implies that $\left|\frac{\partial D^{2018}(\bar{w})}{\partial \bar{w}}\right| > \left|\frac{\partial D^{2000}(\bar{w})}{\partial \bar{w}}\right|$ which, by equation (4), suggests $\left|\frac{\partial \Pi_O^{2018}}{\partial \bar{w}}\right| > \left|\frac{\partial \Pi_O^{2000}}{\partial \bar{w}}\right|$. Second, prior literature suggests that aeronautical and and non-aeronautical revenues have grown in importance relative to PFC revenue other this period (Miller et al., 2020). This suggests that Π_O^t is larger in 2018 and, as a result, $\frac{\partial \Pi_O^t}{\partial D^t(\bar{w})}$ may also be larger in 2018.[31] Thus, I assume the following inequality.

Assumption 2. $\left|\frac{\partial \Pi_O^{2000}}{\partial \bar{w}}\right| < \left|\frac{\partial \Pi_O^{2018}}{\partial \bar{w}}\right|$

Next, note that $\frac{\partial R_{PFC}^{2018}}{\partial \bar{w}} < \frac{\partial R_{PFC}^{2000}}{\partial \bar{w}}$ holds because demand is more sensitive to price in 2018 (as discussed

[30] These estimates would also need to take into account options available to consumers outside the airport.

[31] This would occur if, for example, airports extract a greater amount of non-aeronautical profit from each passenger in 2018 than in 2000 (perhaps because the airport offers a greater number of non-aeronautical services/products). Thus, an additional passenger results in a larger increase in Π_O^t.

in the text). Thus, a marginal increase in the PFC cap results in a smaller increase in PFC revenue in 2018. This is reflected in the below assumption.[32]

Assumption 3. $\frac{\partial R_{PFC}^{2018}}{\partial \bar{w}} < \frac{\partial R_{PFC}^{2000}}{\partial \bar{w}}$

Lastly, I assume $\frac{\partial R_{PFC}^{t}}{\partial \bar{w}} + \frac{\partial \Pi_{O}^{t}}{\partial \bar{w}} > 0$ which states that an increase in the price cap increases airport surplus. Airports' continued appeals for a price cap increase suggest this assumption is realistic.

Assumption 4. $\frac{\partial R_{PFC}^{t}}{\partial \bar{w}} + \frac{\partial \Pi_{O}^{t}}{\partial \bar{w}} > 0$ *for* $t \in \{2000, 2018\}$.

The following proposition demonstrates that, under assumptions 1-4, including other sources of airport profit in the airport surplus function is likely to strengthen the magnitude of the result from the main text (i.e., strengthens the magnitude of the increase in regulatory preference for airports). Note that $\hat{\alpha}_{Text}^{2018} - \hat{\alpha}_{Text}^{2000}$, represents the change in regulatory preference for airports in the main text.[33] Recall that $\hat{\alpha}^t$ (defined in equation (3)) is implied regulatory preference when other sources of airport profit are included in the airport surplus function.

Proposition 1. *Suppose* $\hat{\alpha}_{Text}^{2018} > \hat{\alpha}_{Text}^{2000}$ *and assumption 1-4 hold. Then,* $\hat{\alpha}_{Text}^{2018} - \hat{\alpha}_{Text}^{2000} < \hat{\alpha}^{2018} - \hat{\alpha}^{2000}$.

Proof. Note that

$$\begin{aligned}
\hat{\alpha}^t &= -\frac{\frac{\partial CS^t}{\partial \bar{w}} + \gamma \frac{\partial \Pi_D^t}{\partial \bar{w}}}{\frac{\partial R_{PFC}^t}{\partial \bar{w}} + \frac{\partial \Pi_O^t}{\partial \bar{w}}} \\
&= -\frac{\frac{\partial CS^t}{\partial \bar{w}} + \gamma \frac{\partial \Pi_D^t}{\partial \bar{w}}}{\frac{\partial R_{PFC}^t}{\partial \bar{w}}} \frac{\frac{\partial R_{PFC}^t}{\partial \bar{w}}}{\frac{\partial R_{PFC}^t}{\partial \bar{w}} + \frac{\partial \Pi_O^t}{\partial \bar{w}}} \\
&= \hat{\alpha}_{Text}^t \frac{\frac{\partial R_{PFC}^t}{\partial \bar{w}}}{\frac{\partial R_{PFC}^t}{\partial \bar{w}} + \frac{\partial \Pi_O^t}{\partial \bar{w}}}. \qquad (5)
\end{aligned}$$

Thus,

[32] I write $\frac{\partial R_{PFC}^{2018}}{\partial \bar{w}} < \frac{\partial R_{PFC}^{2000}}{\partial \bar{w}}$ as an assumption for consistency, but I have verified that this inequality holds by examining the derivatives involved in calculating implied regulatory preference from the main text.

[33] $\hat{\alpha}_{Text}^{2018} - \hat{\alpha}_{Text}^{2000}$ denotes the change in regulatory preference for airports relative to consumers. An analogous theorem holds for the change in regulatory preference for airports relative to airlines ($\frac{\hat{\alpha}_{Text}^{2018}}{\gamma} - \frac{\hat{\alpha}_{Text}^{2000}}{\gamma}$).

$$\begin{aligned}
\hat{\alpha}^{2018}_{Text} - \hat{\alpha}^{2000}_{Text} < \hat{\alpha}^{2018} - \hat{\alpha}^{2000} & \iff \\
\hat{\alpha}^{2018}_{Text} - \hat{\alpha}^{2018} < \hat{\alpha}^{2000}_{Text} - \hat{\alpha}^{2000} & \iff \text{by Equation (5)} \\
\hat{\alpha}^{2018}_{Text}\left(1 - \frac{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}}}{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} + \frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}}\right) < \hat{\alpha}^{2000}_{Text}\left(1 - \frac{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}}}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} + \frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}}\right) & \iff \\
\hat{\alpha}^{2018}_{Text}\left(\frac{\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}}{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} + \frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}}\right) < \hat{\alpha}^{2000}_{Text}\left(\frac{\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} + \frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}}\right) & \iff \text{by Assumption 1} \\
\hat{\alpha}^{2018}_{Text}\left(\frac{-\left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}\right) < \hat{\alpha}^{2000}_{Text}\left(\frac{-\left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}\right) & \iff \\
\hat{\alpha}^{2018}_{Text}\left(\frac{\left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}\right) > \hat{\alpha}^{2000}_{Text}\left(\frac{\left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}\right) & \iff \text{by Assumption 4} \\
\frac{\hat{\alpha}^{2018}_{Text}}{\hat{\alpha}^{2000}_{Text}} > \frac{\left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|} \frac{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}{\left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|} &
\end{aligned}$$

which holds by

$$\frac{\hat{\alpha}^{2018}_{Text}}{\hat{\alpha}^{2000}_{Text}} > 1 > \frac{\left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|}{\frac{\partial R^{2000}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2000}_{O}}{\partial \bar{w}}\right|} \frac{\frac{\partial R^{2018}_{PFC}}{\partial \bar{w}} - \left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}{\left|\frac{\partial \Pi^{2018}_{O}}{\partial \bar{w}}\right|}$$

where the second to last inequality holds by $\hat{\alpha}^{2018}_{Text} > \hat{\alpha}^{2000}_{Text}$ and the last inequality holds by Assumptions 2 and 3. □

To understand this result, recall that the regulator balances the benefit of PFCs (i.e., increased airport surplus) with the cost of PFCs (i.e., losses in consumer surplus and airline profit) when setting the price cap. Introducing alternative sources of airport profit into the airport surplus function reduces the marginal benefit of a price cap increase (i.e., the marginal increase in airport surplus). This is the case because an increase in PFCs raises airline prices, reduces passenger numbers (the number of people using the airport) and, as a result, reduces airport profit from alternative sources (e.g., non-aeronautical services such as parking). Thus, the inclusion of airport profit from alternative sources reduces the marginal benefit of a price cap increase (while not affecting the marginal cost). Reflecting this, a regulator with the same preferences sets a lower PFC when airport profit from alternative sources is included in the airport surplus function. Conversely, setting a particular PFC level implies a higher level of regulatory preference for airports when airport profits from alternative sources are included. As the marginal benefit of PFCs for airports is lower (and the marginal cost is unchanged) when airport profits from alternative sources are included, a regulator must place a larger weight on airports to rationalize a particular PFC level. Thus, $\hat{\alpha}^i > \hat{\alpha}^i_{Text}$ for both $i \in \{2000, 2018\}$ which is shown formally in Equation (5). In other words, excluding airport profit from alternative sources from the airport surplus results in an underestimation of regulatory preference for airports (i.e., $\hat{\alpha}$ is biased downwards by excluding these alternative sources of profit).

Proposition 1 shows that the magnitude of this bias is larger in 2018 than in 2000 (i.e., $\hat{\alpha}^{2018} - \hat{\alpha}^{2018}_{Text} > \hat{\alpha}^{2000} - \hat{\alpha}^{2000}_{Text}$) which implies that the finding from the main text is strengthened by the inclusion of alternative airport profit sources (i.e., $\hat{\alpha}^{2018}_{Text} - \hat{\alpha}^{2000}_{Text} < \hat{\alpha}^{2018} - \hat{\alpha}^{2000}$). To understand this result, note that an increase in PFCs is likely to cause a larger drop in passenger numbers due to the higher price-elasticity of demand in 2018. As a result, losses in airport profits from alternative sources from a PFC increase are likely to be greater in 2018 than in 2000. This implies that the reduction in the marginal benefit of a PFC increase in 2018 is greater than that of 2000. Therefore, the downward bias in $\hat{\alpha}$ from excluding airport profits from alternative sources is larger in 2018 than in 2000, as stated in Proposition 1.

In summary, while accounting for other sources of airport revenues and costs affects estimates of regulatory preference, the main result– that regulatory preference for airports increased between 2000 and 2018– seems likely to hold, and potentially be strengthened, if these other components were to be included in airport surplus.

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