Online Appendix to Accompany:

Market Power in the U.S. Airline Industry, 1990-2019

Germán Bet*

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A Carriers in Production Data Sample

Table OA.1 below lists, by airline type (i.e., regional and major), the carrier names of the airlines that enter the production data sample.

*Department of Economics, University of Florida. 224 Matherly Hall, P.O. Box 117140, Gainesville, FL 32611-7140. e-mail: cgerman.bet@ufl.edu

Table OA.1: List of Carriers in Sample (Production Data)

Regional Airlines	**Major Airlines**
Air South Inc.	ATA Airlines d/b/a ATA
Air Wisconsin Airlines Corp	AirTran Airways Corporation
Aloha Airlines Inc.	Alaska Airlines Inc.
Aspen Airways Inc.	Allegiant Air
Business Express	America West Airlines Inc.
Carnival Air Lines Inc.	American Airlines Inc.
Chautauqua Airlines Inc.	Continental Air Lines Inc.
Colgan Air	Delta Air Lines Inc.
Comair Inc.	Frontier Airlines Inc.
Compass Airlines	JetBlue Airways
Endeavor Air Inc.	Mesa Airlines Inc.
Envoy Air	Midway Airlines Inc.
Executive Airlines	Northwest Airlines Inc.
ExpressJet Airlines Inc.	Pan American World Airways
ExpressJet Airlines LLC	Republic Airline
Freedom Airlines d/b/a HP Expr	Southwest Airlines Co.
GoJet Airlines LLC d/b/a United Express	Spirit Air Lines
Hawaiian Airlines Inc.	Sun Country Airlines d/b/a MN Airlines
Horizon Air	Trans World Airways LLC
Independence Air	US Airways Inc.
Island Air Hawaii	United Air Lines Inc.
Kiwi International	Virgin America
Lynx Aviation d/b/a Frontier Airlines	
Markair Inc.	
Mesaba Airlines	
Midway Airlines Inc.	
Midwest Airline, Inc.	
Morris Air Corporation	
PSA Airlines Inc.	
Pan American Airways Corp.	
Reeve Aleutian Airways Inc.	
Reno Air Inc.	
Shuttle America Corp.	
SkyWest Airlines Inc.	
Trans States Airlines	
UFS Inc.	
USA 3000 Airlines	
USAir Shuttle	
Valujet Airlines Inc.	
Vanguard Airlines Inc.	
Westair Airlines Inc.	
Western Pacific Airlines	

B Revenue and Costs per Output

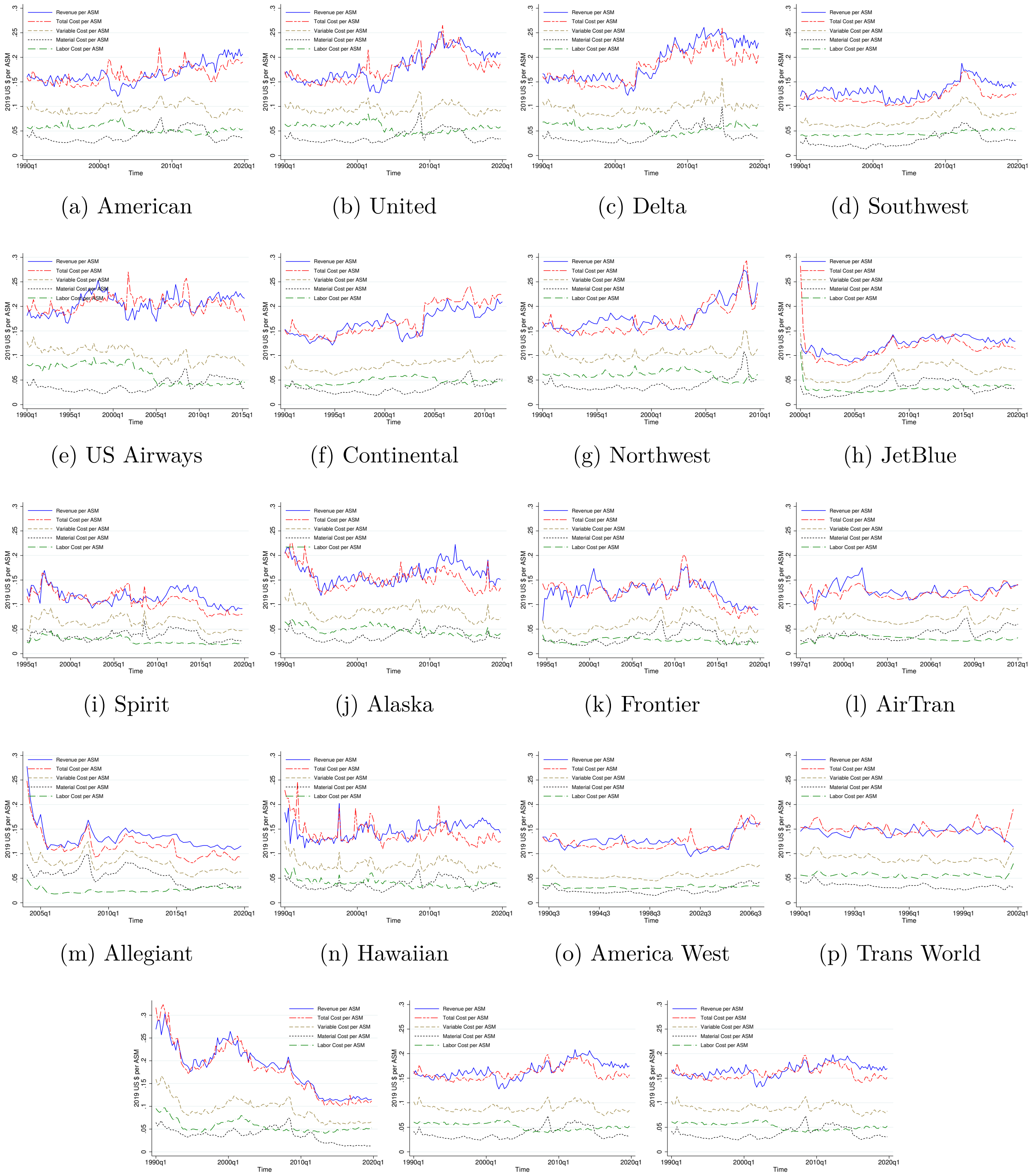
Table OA.2 reports the mean and standard deviation of various cost measures per available seat mile (ASM), along with a measure of revenue per ASM, categorized by airline and airline type. Figure OA.1 illustrates the evolution of these variables across airlines and airline types. Similarly, Table OA.3 and Figure OA.2 provide an equivalent analysis, where revenue and cost measures are normalized by revenue passenger mile (RPM) instead of ASM. Finally, Figure OA.3 depicts the evolution of the revenue-to-total-cost ratio and the revenue-to-material-and-labor-cost ratio, also disaggregated by airline and airline type.

The data for the variables reported in this section are sourced from the Air Carrier Financial Reports (Form 41 Financial Data) database. Revenue is measured as total operating revenue, while total cost corresponds to the reported total operating expenses. Labor cost includes total salaries and related fringe benefits. Material cost reflects the total reported expenditure on materials, encompassing aircraft fuel and oil, maintenance materials, passenger food, and other materials. Variable cost is defined as the sum of labor and material costs. All monetary variables are deflated using the GDP price deflator from the U.S. Bureau of Economic Analysis.

Table OA.2: Revenue and Costs per Available Seat Mile - Summary Statistics

	Total Cost per ASM	Variable Cost per ASM	Material Cost per ASM	Labor Cost per ASM	Revenue per ASM
American	0.164	0.095	0.055	0.041	0.166
	(0.017)	(0.010)	(0.008)	(0.013)	(0.021)
Continental	0.173	0.081	0.048	0.033	0.165
	(0.033)	(0.011)	(0.007)	(0.011)	(0.026)
Delta	0.180	0.097	0.056	0.041	0.191
	(0.031)	(0.012)	(0.009)	(0.014)	(0.039)
Northwest	0.173	0.102	0.061	0.041	0.180
	(0.032)	(0.012)	(0.009)	(0.014)	(0.030)
United	0.180	0.095	0.057	0.038	0.182
	(0.029)	(0.010)	(0.009)	(0.012)	(0.032)
US Airways	0.205	0.103	0.064	0.039	0.205
	(0.016)	(0.014)	(0.020)	(0.012)	(0.020)
Trans World	0.151	0.090	0.056	0.034	0.144
	(0.012)	(0.008)	(0.005)	(0.006)	(0.009)
Southwest	0.119	0.075	0.045	0.030	0.134
	(0.016)	(0.016)	(0.005)	(0.013)	(0.017)
Jet Blue	0.114	0.068	0.033	0.035	0.121
	(0.026)	(0.017)	(0.010)	(0.013)	(0.017)
Frontier	0.125	0.059	0.027	0.033	0.127
	(0.025)	(0.016)	(0.005)	(0.014)	(0.021)
Airtran	0.123	0.071	0.031	0.040	0.128
	(0.012)	(0.011)	(0.005)	(0.011)	(0.014)
Spirit	0.108	0.063	0.026	0.037	0.115
	(0.020)	(0.013)	(0.007)	(0.010)	(0.017)
Major Airlines	0.161	0.089	0.052	0.038	0.167
	(0.037)	(0.017)	(0.013)	(0.013)	(0.037)
Regional Airlines	0.159	0.087	0.052	0.035	0.167
	(0.070)	(0.038)	(0.022)	(0.026)	(0.072)
Industry	0.161	0.089	0.052	0.037	0.167
	(0.040)	(0.020)	(0.014)	(0.015)	(0.041)

Note: This table reports the mean for the variables specified in the column headings by carrier or carrier type (i.e., major and regional airlines). Standard deviations are reported in parentheses below their means. All variables are measured in 2019 U.S. dollars per available seat mile (ASM). The last three rows (i.e., Major Airlines, Regional Airlines, and Industry) report statistics weighted by ASM.



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

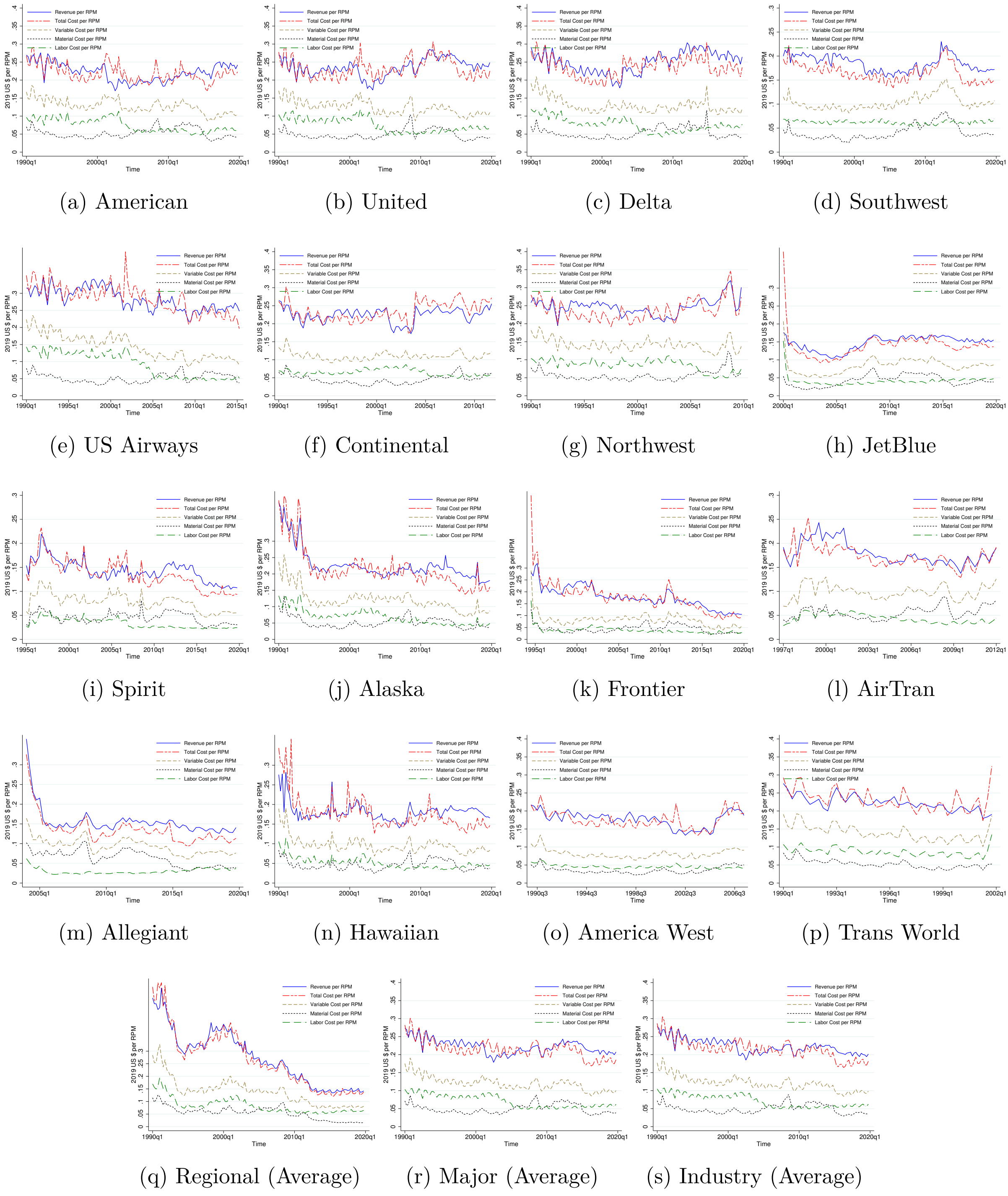
(q) Regional (Average) (r) Major (Average) (s) Industry (Average)

Figure OA.1: Costs and Revenue per Available Seat Mile. This figure shows the evolution of costs and revenue per available seat mile (ASM) for selected airlines. Panels (q), (r), and (s) plot the evolution of average (output-weighted) costs and revenue per available seat mile for regional carriers, major carriers, and all carriers, respectively.

Table OA.3: Revenue and Costs per Revenue Passenger Mile - Summary Statistics

	Total Cost per RPM	Variable Cost per RPM	Material Cost per RPM	Labor Cost per RPM	Revenue per RPM
American	0.219	0.128	0.075	0.053	0.222
	(0.025)	(0.019)	(0.018)	(0.014)	(0.024)
Continental	0.235	0.110	0.065	0.045	0.224
	(0.026)	(0.011)	(0.009)	(0.013)	(0.020)
Delta	0.237	0.130	0.076	0.054	0.250
	(0.028)	(0.021)	(0.019)	(0.015)	(0.029)
Northwest	0.238	0.142	0.085	0.057	0.247
	(0.030)	(0.017)	(0.016)	(0.015)	(0.023)
United	0.233	0.124	0.075	0.049	0.235
	(0.027)	(0.020)	(0.020)	(0.013)	(0.024)
US Airways	0.285	0.145	0.092	0.053	0.283
	(0.042)	(0.036)	(0.038)	(0.013)	(0.032)
Trans World	0.233	0.140	0.087	0.053	0.222
	(0.031)	(0.022)	(0.013)	(0.012)	(0.021)
Southwest	0.165	0.104	0.062	0.041	0.185
	(0.019)	(0.015)	(0.004)	(0.015)	(0.017)
Jet Blue	0.139	0.083	0.041	0.042	0.147
	(0.038)	(0.022)	(0.014)	(0.016)	(0.019)
Frontier	0.178	0.082	0.039	0.044	0.177
	(0.069)	(0.029)	(0.016)	(0.017)	(0.046)
Airtran	0.173	0.099	0.044	0.056	0.180
	(0.023)	(0.015)	(0.009)	(0.013)	(0.024)
Spirit	0.135	0.078	0.033	0.045	0.143
	(0.030)	(0.018)	(0.010)	(0.012)	(0.022)
Major Airlines	0.211	0.117	0.068	0.049	0.220
	(0.048)	(0.027)	(0.022)	(0.015)	(0.044)
Regional Airlines	0.213	0.116	0.069	0.047	0.223
	(0.122)	(0.062)	(0.037)	(0.037)	(0.124)
Industry	0.211	0.117	0.068	0.049	0.220
	(0.058)	(0.031)	(0.024)	(0.018)	(0.055)

Note: This table reports the mean for the variables specified in the column headings by carrier or carrier type (i.e., major and regional airlines). Standard deviations are reported in parentheses below their means. All variables are measured in 2019 U.S. dollars per revenue passenger mile (RPM). The last three rows (i.e., Major Airlines, Regional Airlines, and Industry) report statistics weighted by RPM.



(a) American (b) United (c) Delta (d) Southwest

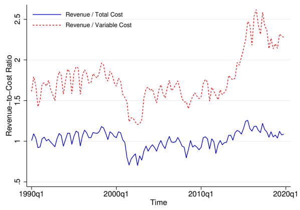
(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

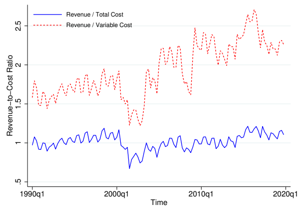
(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average) (r) Major (Average) (s) Industry (Average)

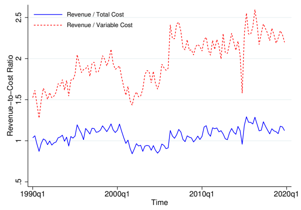
Figure OA.2: Costs and Revenue per Revenue Passenger Mile. This figure shows the evolution of costs and revenue per revenue passenger mile (RPM) for selected airlines. Panels (q), (r), and (s) plot the evolution of average (output-weighted) costs and revenue per revenue passenger mile for regional carriers, major carriers, and all carriers, respectively.



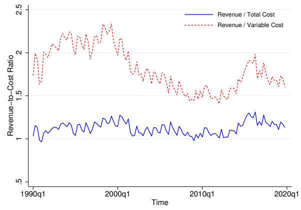
(a) American



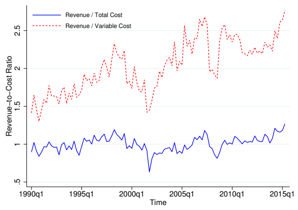
(b) United



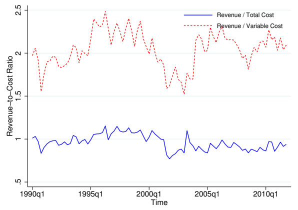
(c) Delta



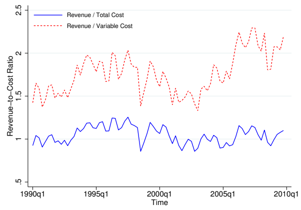
(d) Southwest



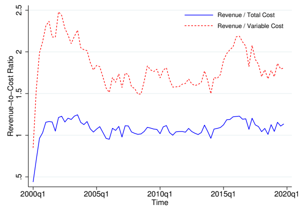
(e) US Airways



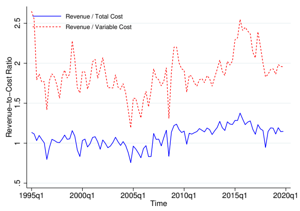
(f) Continental



(g) Northwest

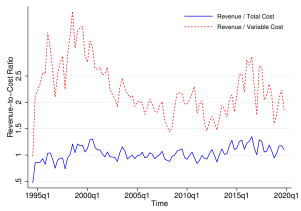


(h) JetBlue



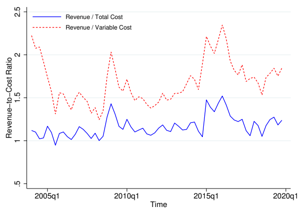
(i) Spirit

(j) Alaska

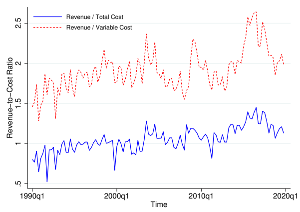


(k) Frontier

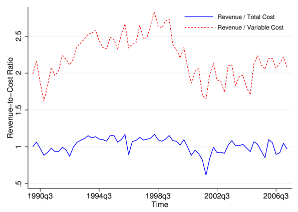
(l) AirTran



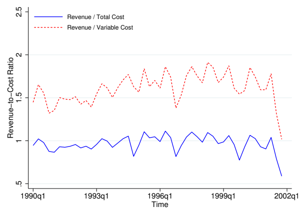
(m) Allegiant



(n) Hawaiian

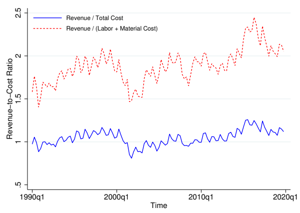


(o) America West

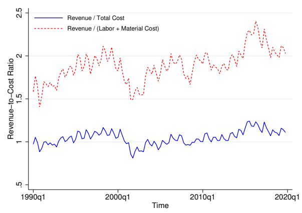


(p) Trans World

(q) Regional (Average)



(r) Major (Average)



(s) Industry (Average)

Figure OA.3: Revenue-to-Cost Ratio. This figure shows the evolution of various revenue-to-cost measures for selected airlines, including operating revenue relative to total operating costs and operating revenue relative to labor and material costs (denoted as variable costs). Panels (q), (r), and (s) depict the output-weighted average trends of these variables for regional carriers, major carriers, and all carriers, respectively.

C Aircraft Utilization

This appendix provides evidence relevant for the timing and flexibility assumptions applied to aircraft inputs in Section 3.1.2, and helps motivate the interpretation of the production-side marginal-cost object discussed in the text. To this end, this section conducts two complementary exercises: (i) an analysis of aircraft utilization rates, and (ii) an analysis of how the stock of aircraft and their utilization rates vary with changes in demand.

In the empirical application, aircraft inputs are measured through the *flow* of services they provide. Formally, the service flow from aircraft inputs can be expressed as:

$$S = uX$$

where X denotes the stock of aircraft, u is the utilization rate, and S is the resulting service flow from aircraft inputs.

S is measured by the number of seats-minutes used in production. The data also contain information on the stock of aircraft inputs, X, measured as the number of aircraft-days assigned to production.[1] Because data on seat capacity by airline-aircraft type are readily available, the stock measure can be converted into seat-days assigned to production. Both X and S are available at the airline, aircraft-type, quarter level. Given this, average utilization (in minutes per day) at the airline-aircraft type-quarter level can be calculated as S/X, providing a consistent metric to explore variation in service intensity across time, airlines, and equipment types.

Figure OA.4 plots the logged aircraft utilization rate—measured as the ratio of block hours to aircraft days—against the logged stock of aircraft inputs—measured as the number of seats-days available for production. Each observation represents an airline-aircraft type-period combination. The figure reveals substantial variation in utilization rates conditional on the stock of aircraft inputs.

Much of this variation in utilization rates can be attributed to differences in network characteristics across carriers and the type of routes they operate. For instance, longer-haul routes typically result in higher utilization rates because aircraft spend more time in the air relative to time on the ground. While turnaround times for long-haul flights might be longer, they do not scale proportionally with flight distance, leading to greater effective utilization. A simple regression of utilization rates on airline-aircraft type fixed effects explains approximately half of the observed variation, highlighting the importance

[1] This variable is defined as the number of days that aircraft owned or acquired through rental or lease are in the possession of the reporting air carrier and are available for service. This includes days in overhaul, or temporarily out of service due to schedule cancellations. The variable excludes days that newly acquired aircraft are on hand but not available for productive use, days the aircraft are dry-leased or rented to others, and days the aircraft are in the carrier's possession but have been formally withdrawn from air transportation service.

of carrier-specific and route-specific operational factors.

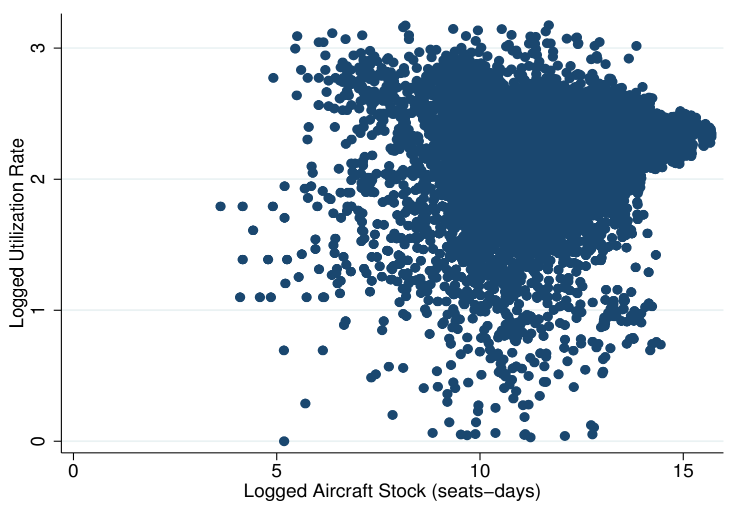


Figure OA.4: Aircraft Utilization Rate and Stock. This figure plots the log of aircraft utilization, measured as block hours per aircraft day, against the log of aircraft inputs, measured as available seat-days. Each observation corresponds to an airline-aircraft type-period combination.

While airlines have strong incentives to keep aircraft in the air, as idle aircraft generate no revenue, in practice other operational considerations—such as facilitating passenger connections or scheduling departures at desirable times—can lengthen turnaround times (i.e., the time aircraft spend on the ground), thereby affecting utilization rates. Demand conditions also play a central role in shaping utilization patterns, as documented by Belobaba (2016, Chapter 6), for example.

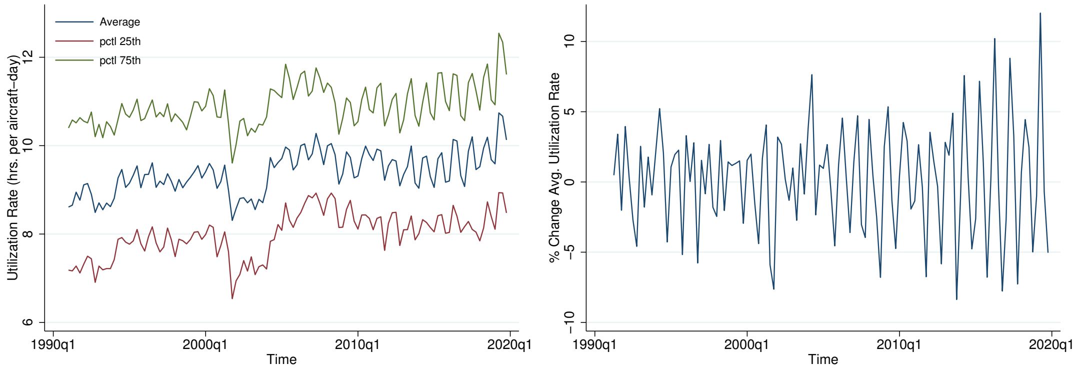
Figure OA.5 provides supporting evidence by plotting the evolution of the average aircraft utilization rate and its percentage change over time for the airlines in my sample. The figure shows that utilization rates decline during periods of reduced demand for air travel (e.g., following the 9/11 attacks or during the 2008 financial crisis) and increase as demand recovers. In addition, the figure highlights substantial time-series variation in average utilization rates. As shown below, not only do utilization rates respond to shifts in demand, but so does the stock of aircraft deployed.

To inform the appropriate modeling assumption for aircraft inputs, I begin by assessing how the stock and utilization of aircraft adjust to changes in demand. To this end, I construct a measure of aggregate demand volatility by estimating a time-varying demand shifter from a constant elasticity demand specification:

$$Q_t = A_t P_t^{\eta}$$

where Q_t denotes observed quantities (measured as total revenue passenger miles),[2] P_t

[2]Revenue passenger miles are defined as the product of the number of paying passengers and the



(a) Aircraft Utilization Rate

(b) Percentage Change in Avg. Aircraft Utilization Rate

Figure OA.5: Aircraft Utilization Rate. Panel (a) plots the evolution of average aircraft utilization rate (blue solid line) along with the evolution of the 75th and 25th percentiles of the distribution of aircraft utilization rate (green and red solid lines, respectively). Panel (b) plots the percentage change in average aircraft utilization rate over time.

is observed average price (measured as real average revenue per revenue passenger mile), η is the demand elasticity, and A_t is a time-varying demand shifter. Setting η=-3, a standard value in the literature (see, e.g., Borenstein and Rose 2013), allows me to back out a series for A_t.

While caution is warranted in interpreting this series—since, for example, the specification imposes a fixed elasticity and may omit other evolving demand-side factors—period-to-period changes in A_t can be interpreted as the magnitude of demand shifts necessary to rationalize observed price-quantity pairs under the assumed demand curve. This measure serves as a useful proxy for demand volatility in the subsequent analysis.

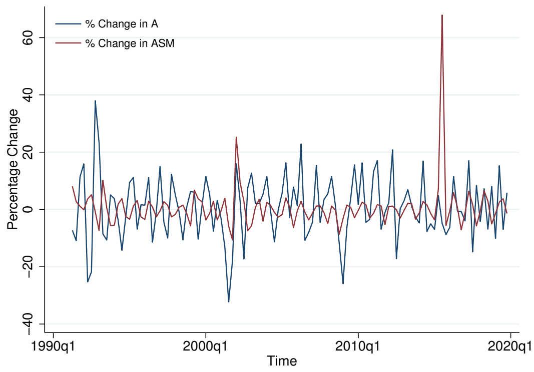
Figure OA.6 plots period-to-period percentage changes in implied aggregate demand alongside changes in capacity (measured by available seat miles) for four major carriers: American, United, Delta, and Southwest. Two key takeaways emerge from this figure. First, the estimated demand fluctuations are sizable, reinforcing the notion that air travel demand is highly volatile. Second, capacity adjustments tend to track changes in aggregate demand closely, suggesting that airlines respond to evolving demand conditions. This co-movement is particularly pronounced in the post-2001 period.[3] Similar patterns hold for the remaining carriers in the sample (not shown in the figure).

Figure OA.7 illustrates the extent to which capacity adjustments are driven by changes in both the stock of aircraft inputs and their utilization rates. Specifically, the figure plots period-to-period percentage changes in capacity (measured by available seat miles) alongside percent changes in aircraft stock and average utilization rates for four major

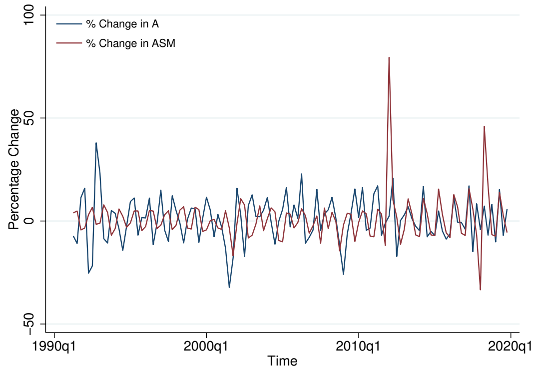
distance traveled.

[3]Factors other than aggregate demand—such as supply-side shocks, idiosyncratic demand shocks, or strategic considerations—are also expected to affect capacity decisions.

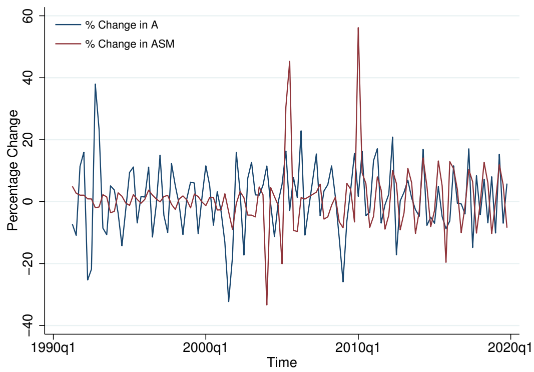
airlines: American, United, Delta, and Southwest. The results indicate that airlines adjust capacity not only by varying utilization rates, but also—though to a lesser extent—by changing the stock of aircraft inputs. Similar patterns are observed for the remaining airlines in the sample (not shown in the figure).



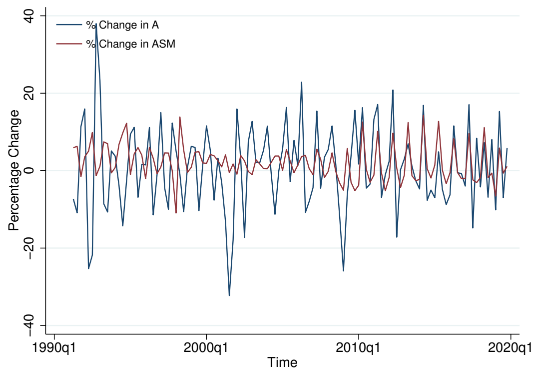
(a) American



(b) United



(c) Delta

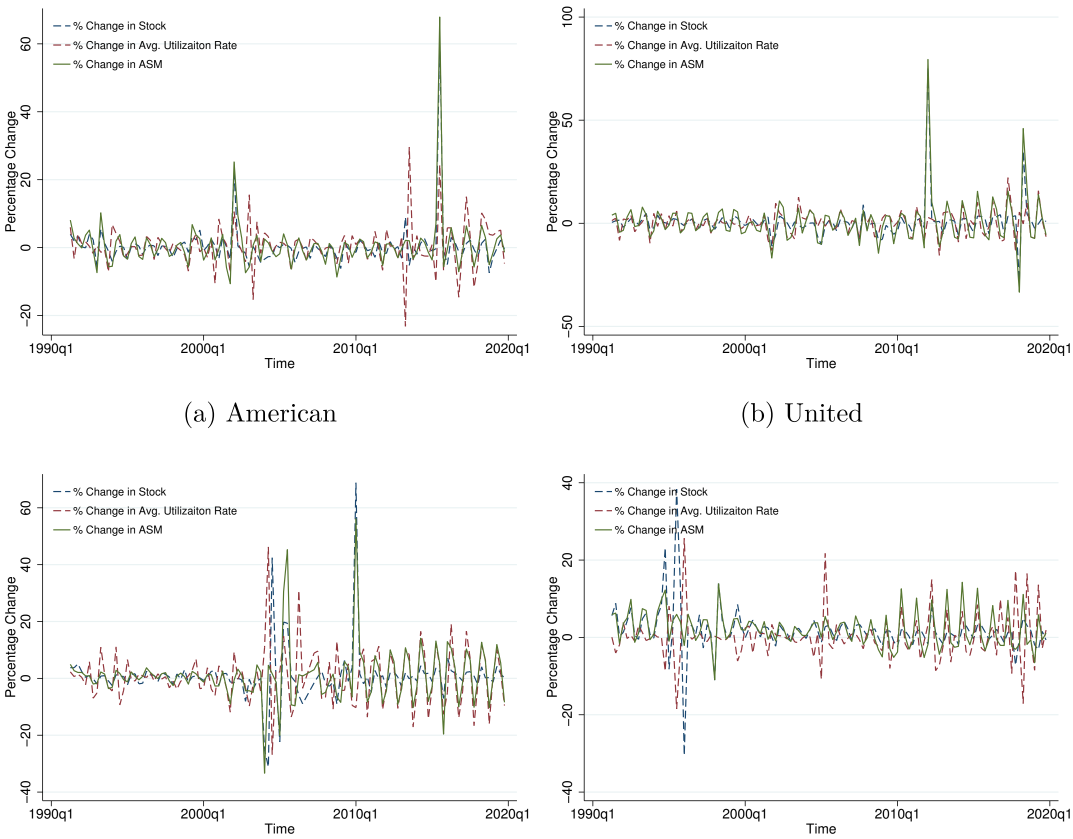


(d) Southwest

Figure OA.6: Changes in Capacity and Implied Aggregate Demand. This figure shows the evolution of implied changes in demand and available seat miles (ASM) over time for selected airlines. Panel (a) plots the evolution of percentage changes in implied aggregate demand and ASM for American; Panels (b) through (d) report the corresponding series for United, Delta, and Southwest.

There are two possible interpretations for the observed co-movement between aggregate demand and capacity, and the corresponding adjustment in aircraft inputs required to meet these capacity changes. One possibility is that airlines make production decisions within each period (i.e., year-quarter combination) after observing demand conditions. In this view, both the stock and utilization of aircraft are adjusted in response to current demand—providing support for the assumption that aircraft are flexible inputs.

An alternative interpretation is that airlines cannot adjust aircraft inputs contemporaneously but are able to forecast demand conditions with sufficient accuracy. In this case, capacity and input decisions are made in advance, in anticipation of future demand



(a) American (b) United

(c) Delta (d) Southwest

Figure OA.7: Changes in Capacity, Stock of Aircraft Inputs, and Average Utilization Rate. This figure shows the evolution of changes in available seat miles (ASM), stock of aircraft inputs, and their average utilization rate over time for selected airlines. Panel (a) plots the evolution of percentage changes in stock of aircraft inputs, average utilization rate, and ASM for American; Panels (b) through (d) report the corresponding series for United, Delta, and Southwest.

shifts. This would still be consistent with the high correlation observed between capacity and demand changes. Importantly, even under this scenario, it may be reasonable to treat aircraft inputs as flexible in the model. This is because timing assumptions are fundamentally assumptions about the information set available to producers when making input decisions.

This observation suggests that a model in which producers choose inputs at time t based on an information set $\mathcal{I}_{it}$ available at time t is observationally equivalent—in terms of its predictions—to a model in which producers choose inputs at $t-1$ in order to supply at t, provided that firms already possess the same information set $\mathcal{I}_{it}$ at that earlier time. A similar insight applies from the perspective of econometric identification, as noted by Ackerberg (2023).[4] Thus, if the information available to firms when choosing aircraft

[4] Ackerberg (2023), p. 651, notes that what matters is not the absolute timing of input choice, but the *difference* between when the input is chosen and when structural shocks or variables relevant to the

inputs does not change markedly from one quarter to the next, treating aircraft inputs *as if* they are flexible remains a reasonable approximation—even if, in practice, these inputs are determined prior to the period in which production occurs.

While these two interpretations are not mutually exclusive—namely, that airlines either adjust aircraft inputs within the quarter or accurately anticipate future conditions—the former appears more consistent with industry practices. As discussed in the main text, airlines' ability to forecast demand improves significantly closer to departure, and they have access to a range of tools to flexibly adjust aircraft services in the short run.

input decision enter the firm's information set.

D Markups

I estimate markups using the production approach to markup estimation, building on the work of De Loecker and Warzynski (2012). I assume airlines minimize costs subject to their network and the technological constraint provided by equation (2) of the paper. These assumptions provide the following static cost minimization problem:

$$\min_{\{L_{ist},K_{ist},\mathbb{X}_{ist}\}_{s\in\mathcal{S}_{it}}} \quad \sum_{s\in\mathcal{S}_{it}} \left(W^L_{ist}L_{ist} + W^K_{ist}K_{ist} + \sum_{X\in\mathbb{X}} W^X_{ist}X_{ist} \right)$$
$$\textit{subject to}: \; \min\{F_{\psi,t}(K_{ist}, L_{ist};\beta)e^{\omega_{it}}, [\gamma^x_{ist}X_{ist}]_{X\in\mathbb{X}}\} \geq \hat{Q}_{ist} \;\forall\, s \in \mathcal{S}_{it}$$
$$\sum_{s\in\mathcal{S}_{it}} K_{ist} = K_{it}$$

where $\hat{Q}_{ist}$ denotes planned output by airline i in segment s at time t, and $(W^L_{ist}, W^K_{ist}, W^X_{ist})$ denotes the input prices for inputs L_{ist}, K_{ist}, and $X_{ist} \in \mathbb{X}_{ist}$, respectively.

Because labor and the vector of fixed-proportion inputs $\mathbb{X}_{ist}$ are assumed to be variable, and the latter enters linearly in the production function, the Leontief first-order condition $F_{\psi,t}(K_{ist}, L_{ist};\beta)e^{\omega_{it}} = \gamma^x_{ist}X_{ist}$ will hold for any $X_{ist} \in \mathbb{X}_{ist}$ at any solution to the conditional cost minimization problem with $\hat{Q}_{ist} > 0$. Then, the fixed-proportion inputs must satisfy $X_{ist} = \frac{\hat{Q}_{ist}}{\gamma^x_{ist}}$. Consequently, the conditional cost minimization problem can be written as:

$$\min_{\{L_{ist},K_{ist}\}_{s\in\mathcal{S}_{it}}} \quad \sum_{s\in\mathcal{S}_{it}} \left(W^L_{ist}L_{ist} + W^K_{ist}K_{ist} + \sum_{X\in\mathbb{X}} W^X_{ist}\frac{\hat{Q}_{ist}}{\gamma^x_{ist}} \right) \tag{OA.1}$$
$$\textit{subject to}: \; F_{\psi,t}(K_{ist}, L_{ist};\beta)e^{\omega_{it}} \geq \hat{Q}_{ist} \;\forall\, s \in \mathcal{S}_{it} \tag{OA.2}$$
$$\sum_{s\in\mathcal{S}_{it}} K_{ist} = K_{it} \tag{OA.3}$$

By the envelope theorem, the marginal cost of supplying an additional unit of output in segment s is:

$$mc_{ist} = \lambda_{ist} + \sum_{X\in\mathbb{X}} \frac{W^X_{ist}}{\gamma^x_{ist}} \tag{OA.4}$$
$$mc_{ist} = \lambda_{ist} + \sum_{X\in\mathbb{X}} \frac{W^X_{ist}X_{ist}}{\hat{Q}_{ist}} \tag{OA.5}$$
$$mc_{ist} = \frac{W^L_{ist}L_{ist}}{\theta^L_{it}\hat{Q}_{ist}} + \sum_{X\in\mathbb{X}} \frac{W^X_{ist}X_{ist}}{\hat{Q}_{ist}} \tag{OA.6}$$

where λ_{ist} is the Lagrange multiplier associated to the technological constraint (OA.2). Equation (OA.5) follows from the Leontief first-order condition, i.e., $X_{ist} = \frac{\hat{Q}_{ist}}{\gamma^x_{ist}}$ for any $X_{ist} \in \mathbb{X}_{ist}$. The final line (i.e., equation (OA.6)) relies on the first-order condition for labor (L_{ist}), which provides $\lambda_{ist} = \frac{W^L_{ist} L_{ist}}{\theta^L_{it} \hat{Q}_{ist}}$, where the output elasticity of labor, θ^L_{it}, does not vary across segments under the maintained assumptions that $F_{\psi,t}(.)$ does not depend on s, is homogeneous of degree $\phi_\psi > 0$, and that inputs are allocated neutrally.

Let $\hat{Q}_{it} = \sum_{s\in\mathcal{S}_{it}} \hat{Q}_{ist}$ define total planned output for airline i at time t. Then, multiplying both sides of equation (OA.6) by $\hat{Q}_{ist}/\hat{Q}_{it}$ and summing across s provides:

$$\mathcal{MC}_{it} = \sum_{s\in\mathcal{S}_{it}} mc_{ist} \frac{\hat{Q}_{ist}}{\hat{Q}_{it}} \quad = \quad \frac{E^L_{it}}{\theta^L_{it}\hat{Q}_{it}} + \sum_{X\in\mathbb{X}} \frac{E^X_{it}}{\hat{Q}_{it}} \tag{OA.7}$$

where $E^L_{it} = \sum_{s\in\mathcal{S}_{it}} W^L_{ist} L_{ist}$ is aggregate labor expenditure and $E^X_{it} = \sum_{s\in\mathcal{S}_{it}} W^X_{ist} X_{ist}$ is aggregate expenditure on input X. The right-hand side of equation (OA.7) is the standard marginal cost equation obtained under the De Loecker and Warzynski (2012) approach and firm-level data. As equation (OA.7) indicates, this object is a weighted average of segment-level marginal costs, where the weights are given by the ratio of segment output to aggregate output.

The right-hand side of equation (OA.7) can also be interpreted as a weighted average of product-level marginal costs. To see this, note that the marginal cost of product j is provided by:

$$mc_{jmt} \quad = \quad \sum_{s\in\mathcal{S}_{ijt}} mc_{ist} = \sum_{s\in\mathcal{S}_{ijt}} \left(\frac{W^L_{ist} L_{ist}}{\theta^L_{it}\hat{Q}_{ist}} + \sum_{X\in\mathbb{X}} \frac{W^X_{ist} X_{ist}}{\hat{Q}_{ist}} \right) \tag{OA.8}$$

where $\mathcal{S}_{ijt}$ is the set of segments in the itinerary of product j belonging to firm i at time t. Let J_{it} be the set of products offered by airline i at time t. Multiplying both sides of equation (OA.8) by $\hat{q}_{jmt}/\hat{Q}_{it}$ and summing across $j \in J_{it}$ provides:

$$\sum_{j\in J_{it}} mc_{jmt} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \quad = \quad \sum_{j\in J_{it}} \sum_{s\in\mathcal{S}_{ijt}} \frac{W^L_{ist} L_{ist}}{\theta^L_{it}\hat{Q}_{ist}} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} + \sum_{j\in J_{it}} \sum_{s\in\mathcal{S}_{ijt}} \sum_{X\in\mathbb{X}} \frac{W^X_{ist} X_{ist}}{\hat{Q}_{ist}} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \tag{OA.9}$$

$$\sum_{j\in J_{it}} mc_{jmt} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \quad = \quad \sum_{s\in\mathcal{S}_{it}} \sum_{j\in\Lambda_{ist}} \frac{W^L_{ist} L_{ist}}{\theta^L_{it}\hat{Q}_{ist}} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} + \sum_{s\in\mathcal{S}_{it}} \sum_{j\in\Lambda_{ist}} \sum_{X\in\mathbb{X}} \frac{W^X_{ist} X_{ist}}{\hat{Q}_{ist}} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \tag{OA.10}$$

$$\sum_{j\in J_{it}} mc_{jmt} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \quad = \quad \sum_{s\in\mathcal{S}_{it}} \frac{W^L_{ist} L_{ist}}{\theta^L_{it}\hat{Q}_{it}} + \sum_{s\in\mathcal{S}_{it}} \sum_{X\in\mathbb{X}} \frac{W^X_{ist} X_{ist}}{\hat{Q}_{it}} \tag{OA.11}$$

$$\sum_{j\in J_{it}} mc_{jmt} \frac{\hat{q}_{jmt}}{\hat{Q}_{it}} \quad = \quad \frac{E^L_{it}}{\theta^L_{it}\hat{Q}_{it}} + \sum_{X\in\mathbb{X}} \frac{E^X_{it}}{\hat{Q}_{it}} \tag{OA.12}$$

where the second line, equation (OA.10), simply rearranges the summation terms (being $\mathcal{S}_{it}$ the set of segments served by airline i at time t, and Λ_{ist} the set of products belonging to firm i that contain segment s in their itinerary). Equation (OA.11) employs the fact that $\hat{Q}_{ist} = \sum_{j\in\Lambda_{ist}} \hat{q}_{jmt}$. Then, the right-hand side of equation (OA.12) can be interpreted as a weighted average of product-level marginal costs, where the weights are given by the ratio of product output to total output.

Similarly, the markup equation provided by De Loecker and Warzynski (2012) and defined in terms of firm-level information can be interpreted as a weighted average of firm-product level markups. Product level markups, μ_{jmt}, are defined as:

$$\mu_{jmt} = \frac{p_{jmt}}{mc_{jmt}} \quad = \quad \frac{p_{jmt}}{\sum_{s \in \mathcal{S}_{ijt}} \left(\frac{W^L_{ist} L_{ist}}{\theta^L_{it} \hat{Q}_{ist}} + \sum_{X \in \mathbb{X}} \frac{W^X_{ist} X_{ist}}{\hat{Q}_{ist}} \right)} \tag{OA.13}$$

Let $\varpi_{jmt} = \frac{mc_{jmt} \hat{q}_{jmt}}{\sum_{s \in \mathcal{S}_{it}} mc_{ist} \hat{Q}_{ist}}$. Multiplying equation (OA.13) by ϖ_{jmt} and summing across j provides:

$$\mathcal{M}_{it} = \sum_{j \in J_{it}} \frac{p_{jmt}}{mc_{jmt}} \varpi_{jmt} \quad = \quad \frac{\sum_{j \in J_{it}} p_{jmt} \hat{q}_{jmt}}{\sum_{s \in \mathcal{S}_{it}} mc_{ist} \hat{Q}_{ist}} = \frac{R_{it}}{\frac{E^L_{it}}{\theta^L_{it}} + \sum_{X \in \mathbb{X}} E^X_{it}} \tag{OA.14}$$

where the last equality relies on equation (OA.7) and $R_{it} = \sum_{j \in J_{it}} p_{jmt} \hat{q}_{jmt}$ is total revenue.

The right-hand side of equation (OA.14) represents the markup equation obtained under firm-level data and the approach developed by De Loecker and Warzynski (2012). As equation (OA.14) indicates, this object is a weighted average of firm product-level markups, where the weights, $\varpi_{jmt} = \frac{mc_{jmt} \hat{q}_{jmt}}{\sum_{s \in \mathcal{S}_{it}} mc_{ist} \hat{Q}_{ist}}$, are given by the share of total percentage change in firm cost when scaling up all products that can be attributed to product j (i.e., how costly it is to increase the output of product j within a multi-product firm). See Cairncross, Morrow, Orr and Rachapalli (2024) for alternative interpretations and additional details.

E Production Function Estimation: Estimating Equation

This section outlines the derivation of equation (11) in the main text, namely, the airline-level estimating equation obtained when segment-level production is aggregated under homogeneity and the neutral input-allocation rule described in the text. The airline-level composite output term that appears in the estimating equation should therefore be read as a model-implied object, not as an independent technological primitive. The derivation is based on the more general model in which segment centrality, denoted by D_{ist}, enters the function $F_{\psi,t}(\cdot)$. The baseline specification used for estimation corresponds to a special case of this model in which the coefficient on segment centrality, β_{d_ψ}, is set to zero.

Equation (2) from the manuscript and $\hat{Q}_{ist} = Q_{ist}/e^{\hat{\epsilon}_{ist}}$ provide:

$$\hat{Q}_{ist} = F_{\psi,t}(K_{ist}, L_{ist}, D_{ist}; \beta)e^{\omega_{it}} \tag{OA.15}$$

I assume that inputs are allocated across segments in a neutral way, such that $H_{ist} = a_{ist}H_{it}$, with $H = \{L, K\}$, $a_{ist} \in [0, 1]$, and $\sum_{s\in\mathcal{S}_{it}} a_{ist} = 1$. Summing output across segments s for airline i at time t provides:

$$\begin{aligned}
\hat{Q}_{it} = \sum_{s\in\mathcal{S}_{it}} \hat{Q}_{ist} &= \sum_{s\in\mathcal{S}_{it}} F_{\psi,t}(K_{ist}, L_{ist}, D_{ist}; \beta)e^{\omega_{it}} && \text{(OA.16)}\\
&= \sum_{s\in\mathcal{S}_{it}} L_{ist}^{\beta_{l_\psi}} K_{ist}^{\beta_{k_\psi}} \left[\frac{e^{log(L_{ist})log(K_{ist})}}{\sqrt{e^{log(L_{ist})^2} e^{log(K_{ist})^2}}}\right]^{\beta_{lk_\psi}} D_{ist}^{\beta_{d_\psi}} e^{\omega_{it}} && \text{(OA.17)}\\
&= e^{\omega_{it}} L_{it}^{\beta_{l_\psi}} K_{it}^{\beta_{k_\psi}} \left[\frac{e^{log(L_{it})log(K_{it})}}{\sqrt{e^{log(L_{it})^2} e^{log(K_{it})^2}}}\right]^{\beta_{lk_\psi}} \sum_{s\in\mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}} && \text{(OA.18)}
\end{aligned}$$

where equation (OA.17) employs the assumed functional for $F_{\psi,t}(.)$ and equation (OA.18) exploits the properties of $F_{\psi,t}(.)$ (i.e., homogeneity of degree $\phi_\psi = \beta_{l_\psi} + \beta_{k_\psi} > 0$).

Let $\hat{q}_{it} = \ln(\hat{Q}_{it})$. Logging both sides of equation (OA.18) provides:

$$\hat{q}_{it} = \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi}(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) + \ln\left(\sum_{s\in\mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}}\right) + \tau_{\psi t} + \omega_{it} \tag{OA.19}$$

where lower case variables denote the corresponding logged values, and $\tau_{\psi t}$ represents an airline type-time effect that accounts for variation in industry-level variables across time.

Equation (OA.19) not only depends on observable variables and unobserved (to the econometrician) productivity, but also on unobserved input allocations a_{ist}. To express equation (OA.19) only as a function of observables and unobserved productivity, note that equations (OA.15) and (OA.18) provide:

$$\frac{\hat{Q}_{ist}}{\hat{Q}_{it}} = \frac{a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}}}{\sum_{s \in \mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}}} \tag{OA.20}$$

Let sh_{ist} denote the ratio of segment output to total output (i.e., $sh_{ist} = \hat{Q}_{ist}/\hat{Q}_{it}$). Solving for a_{ist} from equation (OA.20) and summing across s provides:

$$\sum_{s \in \mathcal{S}_{it}} a_{ist} = \sum_{s \in \mathcal{S}_{it}} \left(\frac{sh_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \left(\sum_{s \in \mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}} \right)^{\frac{1}{\phi_\psi}} \tag{OA.21}$$

$$1 = \left(\sum_{s \in \mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}} \right)^{\frac{1}{\phi_\psi}} \sum_{s \in \mathcal{S}_{it}} \left(\frac{sh_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \tag{OA.22}$$

$$\ln(1) = \frac{1}{\phi_\psi} \ln \left(\sum_{s \in \mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}} \right) + \ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\frac{sh_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \right) \tag{OA.23}$$

$$\ln \left(\sum_{s \in \mathcal{S}_{it}} a_{ist}^{\phi_\psi} D_{ist}^{\beta_{d_\psi}} \right) = -\phi_\psi \ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\frac{sh_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \right) \tag{OA.24}$$

Equations (OA.19) and (OA.24) provide:

$$\hat{q}_{it} = \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi} (l_{it} k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) - \phi_\psi \ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\frac{sh_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \right) + \tau_{\psi t} + \omega_{it}$$

which corresponds to equation (11) in the paper.

F Firm-Level Markups: Baseline Specification

Figure OA.8 below shows individual markups for selected major airlines, alongside the evolution of the (output-weighted) average markup charged by regional carriers. The reported markups are based on the baseline specification described in the main text.

(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average)

Figure OA.8: Markups - Selected Airlines. This figure shows the evolution of markups over time under the baseline specification for selected airlines. Panel (q) plots the average (output-weighted) markup for regional carriers.

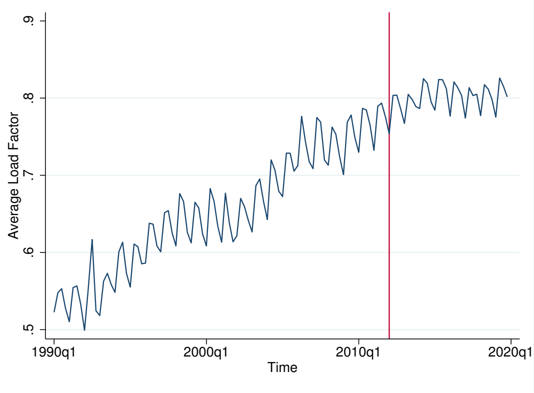
G Markup Estimates: ASM as Output Measure

This section presents results from a model in which output, for production function estimation, is measured using available seat miles (ASMs), rather than revenue passenger miles (RPMs). The markup equation derived in the text implicitly assumes that all output is sold—an unrealistic assumption when ASMs are used as output, as unsold seats are common. In practice, total revenue is used in computing markups, which effectively replaces ASMs with RPMs in the markup equation. While the Lagrange multiplier associated with the conditional cost minimization problem in this specification represents the incremental cost of an additional ASM, the fact that $RPM = ASM \times load\ factor$ (the fraction of ASMs sold) means that the marginal cost in the markup equation can be interpreted as an "effective" marginal cost of serving a passenger mile. This cost reflects the incremental cost of supplying an additional seat mile, adjusted for the fact that not all capacity is sold—that is, it accounts for the rate at which ASMs perish unused.

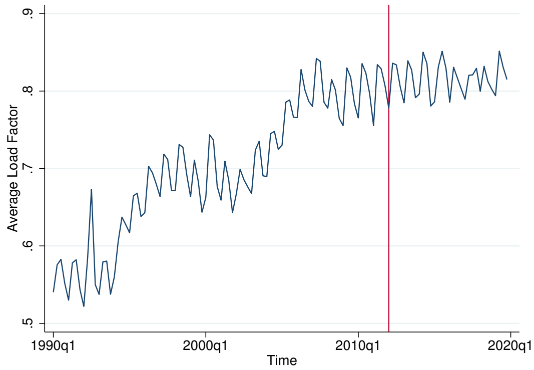
This effective marginal cost can also be derived from a slightly modified cost-minimization problem in which the firm minimizes costs subject to a constraint that output, measured in RPMs, cannot exceed planned capacity (ASMs) multiplied by the expected load factor. The Lagrange multiplier associated with this problem represents the incremental cost of serving an additional passenger mile, conditional on the expected load factor. This equivalence reinforces the interpretation of the effective marginal cost as the marginal cost of serving a passenger mile under expected capacity utilization.

This interpretation, however, also highlights an important caveat. The ASM and RPM specifications are equivalent only conditional on the load factor. Over the long run, average load factors in the airline industry rise substantially, so a larger share of capacity is sold in later years (see Figure OA.9). In the ASM-based specification, this secular change is not modeled explicitly; instead, it is absorbed through a lower effective marginal cost of serving a passenger mile. As a result, improvements in capacity utilization appear as declines in marginal cost per RPM and are therefore observationally similar to productivity growth. This is a limitation of the ASM-based approach. At the same time, load factors are comparatively stable over 2012–2019, the period used to infer conduct. This stability makes it less likely that changes in load factor are driving the within-period movements that are central to the conduct analysis.

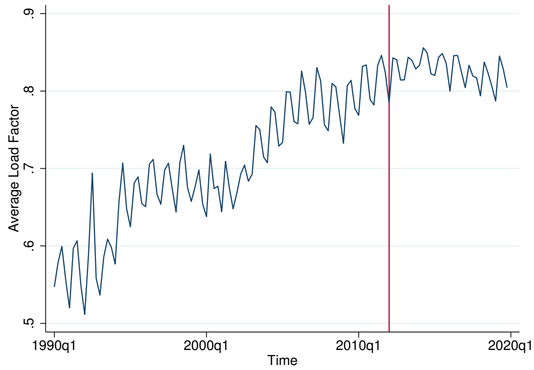
Table OA.4 reports average (unweighted) markups by carrier type—major and regional—and for selected airlines, across different time periods, using the ASM-based specification. Figure OA.10 below provides a more detailed view of markup estimates at the firm level, along with output-weighted averages by carrier type (regional and major) and at the industry level. In all cases, the main results and conclusions are consistent with those obtained under the baseline specification.



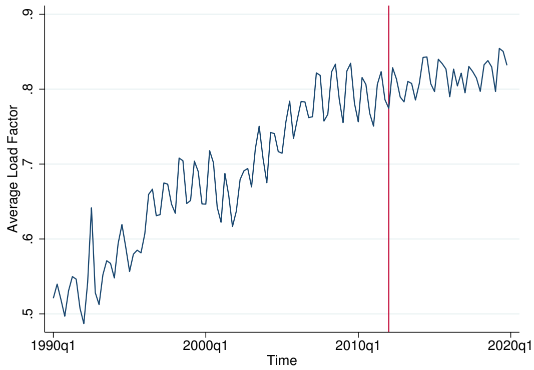
(a) Industry



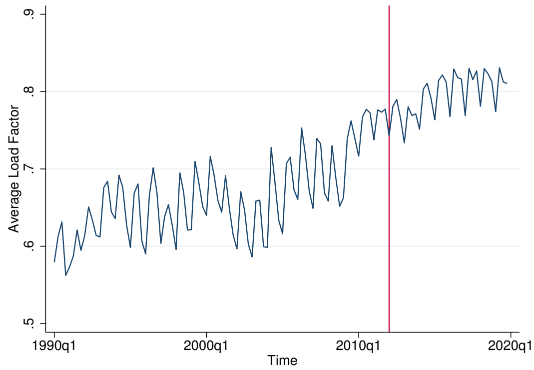
(b) American



(c) United



(d) Delta



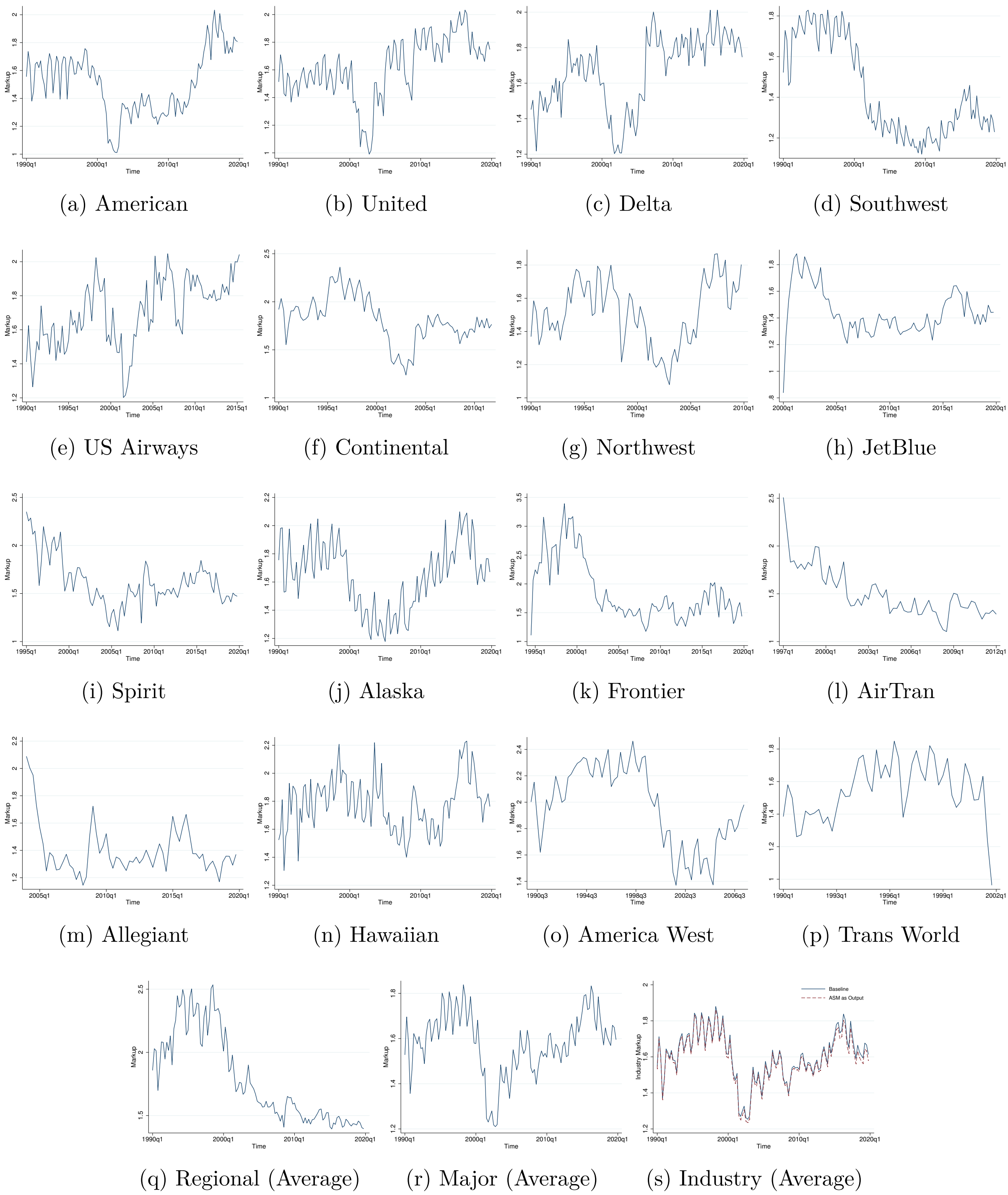
(e) Southwest

Figure OA.9: Average Load Factor. This figure shows the evolution of the average load factor, defined as RPM/ASM, over time. For each period, the average is computed across airline-route load factors. Panel (a) plots the industry average. A red vertical line marks $2012q_1$. Panels (b) through (e) report the corresponding series for American, United, Delta, and Southwest.

Table OA.4: Markup Estimates (ASM as Output Measure) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.585	1.606	1.223	1.331	1.517	1.835	1.508
	(0.117)	(0.084)	(0.136)	(0.071)	(0.197)	(0.102)	(0.226)
Continental	1.933	2.042	1.542	1.735	1.762		1.816
	(0.158)	(0.176)	(0.195)	(0.077)	(0.047)		(0.240)
Delta	1.533	1.661	1.358	1.805	1.827	1.857	1.663
	(0.131)	(0.100)	(0.113)	(0.112)	(0.076)	(0.068)	(0.206)
Northwest	1.538	1.557	1.289	1.714			1.516
	(0.136)	(0.151)	(0.116)	(0.100)			(0.194)
United	1.531	1.549	1.325	1.696	1.836	1.797	1.614
	(0.086)	(0.108)	(0.240)	(0.157)	(0.101)	(0.114)	(0.223)
US Airways	1.535	1.717	1.606	1.844	1.854		1.701
	(0.112)	(0.159)	(0.235)	(0.131)	(0.091)		(0.198)
Trans World	1.503	1.635	1.331				1.544
	(0.154)	(0.133)	(0.294)				(0.181)
Southwest	1.718	1.698	1.310	1.194	1.267	1.310	1.430
	(0.104)	(0.088)	(0.088)	(0.047)	(0.084)	(0.065)	(0.232)
Jet Blue		1.335	1.614	1.341	1.367	1.481	1.443
		(0.376)	(0.184)	(0.063)	(0.092)	(0.100)	(0.176)
Frontier	2.055	2.768	1.779	1.514	1.534	1.679	1.873
	(0.478)	(0.349)	(0.287)	(0.158)	(0.177)	(0.230)	(0.534)
Airtran		1.846	1.461	1.340	1.289		1.508
		(0.236)	(0.135)	(0.108)	(0.034)		(0.261)
Spirit	2.252	1.861	1.451	1.514	1.605	1.542	1.623
	(0.099)	(0.217)	(0.198)	(0.158)	(0.105)	(0.119)	(0.251)
Major Airlines	1.710	1.820	1.483	1.519	1.595	1.634	1.621
	(0.280)	(0.364)	(0.261)	(0.245)	(0.237)	(0.239)	(0.299)
Regional Airlines	2.208	2.220	1.696	1.618	1.513	1.368	1.822
	(0.517)	(0.529)	(0.328)	(0.323)	(0.342)	(0.281)	(0.525)
Industry	1.637	1.716	1.401	1.529	1.595	1.655	1.583
	(0.102)	(0.095)	(0.103)	(0.062)	(0.078)	(0.074)	(0.135)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means.



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average) (r) Major (Average) (s) Industry (Average)

Figure OA.10: Markups - Selected Airlines. This figure shows the evolution of markups over time under the ASM-based specification for selected airlines. Panels (q), (r), and (s) plot the average (output-weighted) markup for regional carriers, major carriers, and all carriers, respectively.

H Decomposition Analysis

This section provides additional details on the industry markup decomposition discussed in Section 4 of the manuscript. Specifically, Table OA.5 presents the results of this analysis, reporting for each year: the average industry markup, the average change in this industry markup, and the average of each of the terms included in equation (13) from the paper.

Table OA.5: Industry Markup Decomposition

	Markup	Δ Markup	Δ Within	Δ Market Share	Δ Cross Term	Net Entry
1990	1.559	-0.058	-0.060	0.000	0.001	-0.000
1991	1.585	0.056	0.052	-0.001	0.002	0.003
1992	1.578	-0.020	-0.021	0.000	0.001	-0.000
1993	1.679	0.030	0.025	0.002	0.001	0.002
1994	1.689	-0.001	-0.000	-0.001	0.001	-0.002
1995	1.758	0.013	0.010	0.000	0.001	0.001
1996	1.757	-0.007	-0.012	-0.001	0.005	0.000
1997	1.760	0.010	0.008	-0.000	0.001	0.001
1998	1.792	0.002	-0.001	-0.000	0.004	-0.000
1999	1.729	-0.019	-0.022	0.001	0.002	-0.000
2000	1.608	-0.030	-0.031	0.001	0.001	-0.000
2001	1.384	-0.058	-0.060	0.002	0.002	-0.001
2002	1.285	-0.004	-0.007	0.001	-0.000	0.002
2003	1.422	0.053	0.047	0.003	0.000	0.003
2004	1.452	-0.021	-0.024	0.000	0.001	0.002
2005	1.514	0.026	0.028	-0.000	-0.001	-0.001
2006	1.572	0.017	0.017	-0.001	0.000	0.000
2007	1.574	-0.017	-0.013	-0.001	-0.001	-0.002
2008	1.444	-0.005	0.001	-0.000	0.000	-0.005
2009	1.542	0.019	0.017	-0.002	0.000	0.003
2010	1.582	0.006	0.003	0.002	0.001	-0.001
2011	1.549	-0.008	-0.006	-0.001	0.000	-0.001
2012	1.543	-0.002	-0.004	0.004	-0.001	-0.001
2013	1.605	0.020	0.023	-0.001	0.001	-0.004
2014	1.634	0.017	0.014	-0.001	0.000	0.003
2015	1.756	0.015	0.016	0.002	0.003	-0.006
2016	1.770	-0.010	-0.011	-0.000	0.000	0.000
2017	1.705	-0.010	-0.011	0.001	0.000	-0.000
2018	1.623	-0.011	-0.012	0.000	0.000	0.002
2019	1.638	0.001	0.001	0.000	0.001	-0.001

Note: This table reports the results of the industry markup decomposition analysis (see Section 4 of the manuscript for details). This table reports, by year, the average (output-weighted) industry markup, the average change in the industry markup, and the average of each of the terms included in equation (13) of the paper. The term $\Delta Within$ measures the average change attributed to a change in markups, holding the market shares unchanged from the last period. The term Δ *Market Share* measures the change in industry markup attributed to an increase in the market share while holding the markup fixed. The term Δ *Cross Term* measures the joint change in markups and market share. Combined, these two last terms (i.e., Δ *Market Share* and Δ *Cross Term*) capture the average change due to changes in reallocation of economic activity. The term *Net Entry* captures the effect of entry and exit on the industry markup. See the text for additional details.

I Alternative Estimation Approaches

In this section, I assess the robustness of my results using alternative estimation methods. Section I.1 employs a control function approach, while Section I.2 applies dynamic panel techniques to estimate the production function. Finally, Section I.3 adopts a factor shares methodology based on input cost minimization assumptions.

I.1 Control Function

I estimate the production function using a control function approach to recover the output elasticity of a flexible input and corresponding markups. Unlike the baseline specification, which relies on a Leontief first-order condition to identify unexpected shocks to production, this method relaxes that requirement. Instead, it imposes alternative assumptions on the nature of these shocks and typically requires either additional data or structural restrictions to account for imperfect competition (see De Loecker and Syverson 2021). Specifically, the approach assumes $\epsilon_{ist} = 0$ for all i, s, and t, but permits untransmitted shocks to airline-level composite output (ϵ_{it}). This modifies the airline-level composite output index equation (Equation 12 in the paper) as follows:

$$\mathcal{Q}_{it}(\beta) = \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi}(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) + \tau_{\psi t} + \omega_{it} + \epsilon_{it} \tag{OA.25}$$

with $E_t[\epsilon_{it} \mid \mathcal{I}_{it}] = 0$ and $\mathcal{Q}_{it}(\beta)$, airline-level composite output, defined as:

$$\mathcal{Q}_{it}(\beta) = \ln \left(\sum_{s \in \mathcal{S}_{it}} Q_{ist}^{\frac{1}{\phi_\psi}} \right)^{\phi_\psi} \tag{OA.26}$$

The specification builds on Ackerberg, Caves and Frazer (2015), and proceeds by assuming that demand for some flexible input m_{it}, aircraft utilization in this case, is given by

$$m_{it} = m_\psi(\omega_{it}, k_{it}, l_{it}, z_{it}) \tag{OA.27}$$

where z_{it} is a vector of variables affecting variable input demand.

The inclusion of vector z_{it} in the variable input demand function is important to avoid the non-identification result of Gandhi, Navarro and Rivers (2020). As discussed by these authors, the identification of the production function can be aided by additional variation in the form of the inclusion of observed shifters that vary across firms entering in the flexible input demand $m_\psi(\cdot)$, but excluded from the production function.[5] In addition, in a context of imperfect competition, the variable input demand function must be modified to account for the effect of competitive interactions among producers (see De Loecker and Syverson 2021 for details).

[5] De Loecker and Warzynski (2012) and De Loecker and Scott (2016), for example, pursue this strategy.

In practice, the vector z_{it} includes airline-specific variable input prices (i.e., jet fuel price per gallon and wages), network characteristics (such as the number of airports and segments served, a measure of network centrality or degree, and indicators for expansions or contractions involving more than five destinations),[6] and the total revenue of competitors. As discussed by De Loecker and Ackerberg (2024), including this variable helps account for the effects of imperfect competition under certain conditions and across a range of imperfectly competitive models.

The variable input demand $m_\psi(\omega_{it}, k_{it}, l_{it}, z_{it})$ is assumed strictly monotone in a single unobservable ω_{it}. Then, the inverted variable input demand function (OA.27) provides

$$\omega_{it} = m_\psi^{-1}(m_{it}, k_{it}, l_{it}, z_{it}) \tag{OA.28}$$

which can be used to control for productivity. Equations (OA.25) and (OA.28) provide:

$$\begin{aligned} \mathcal{Q}_{it}(\beta) &= \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi}(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) + \tau_{\psi t} + m_\psi^{-1}(m_{it}, k_{it}, l_{it}, z_{it}) + \epsilon_{it} \\ &= \Phi_\psi(l_{it}, k_{it}, m_{it}, z_{it}) + \epsilon_{it} \end{aligned} \tag{OA.29}$$

Note that the preceding equation implies that productivity is defined as:

$$\omega_{it}(\beta) = \Phi_\psi(l_{it}, k_{it}, m_{it}, z_{it}) - \beta_{l_\psi} l_{it} - \beta_{k_\psi} k_{it} - \beta_{lk_\psi}(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) - \tau_{\psi t} \tag{OA.30}$$

Given the non-linearities in equation (OA.25), I implement a profile GMM estimator. For each value of $\phi_\psi = \beta_{l_\psi} + \beta_{k_\psi}$, I proceed in two stages. In the first stage, I non-parametrically estimate $\Phi_\psi(l_{it}, k_{it}, m_{it}, z_{it})$ by regressing the airline-level composite output index on $(l_{it}, k_{it}, m_{it}, z_{it})$, yielding estimates $\hat{\epsilon}_{it}$ (i.e., untransmitted shocks) and $\hat{\Phi}_\psi(l_{it}, k_{it}, m_{it}, z_{it})$.[7]

In the second stage, I estimate structural parameters relying on the estimate $\hat{\Phi}_\psi(l_{it}, k_{it}, m_{it}, z_{it})$, the parametric restrictions imposed by the production function (i.e., equation (OA.25)), the restriction $\phi_\psi = \beta_{l_\psi} + \beta_{k_\psi}$, and the law of motion for productivity, $g_\psi(\omega_{it}, \Delta\ \mathbf{nwk}_{it}, \mathbf{macq}_{it})$, defined in the paper. This provides the following moment condition:

$$\begin{aligned} E[\,\xi_{it}(\beta) \mid \mathcal{I}_{it-1}] &= E[\hat{\Phi}_\psi(l_{it}, k_{it}, m_{it}, z_{it}) - \beta_{l_\psi} l_{it} - \beta_{k_\psi} k_{it} - \beta_{lk_\psi}(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) - \tau_{\psi t} \\ &- \ g_\psi(\omega_{it-1}(\beta), \Delta\ \mathbf{nwk}_{it-1}, \mathbf{macq}_{it-1}) \mid \mathcal{I}_{it-1}\,] = 0 \end{aligned}$$

where $\omega_{it-1}(\beta)$ is constructed using equation (OA.30).

[6] As discussed in the manuscript, network decisions—such as which airports and routes to serve—are made well in advance to allow time for advertising, ticket sales, and hiring. As such, these variables are predetermined and should not be correlated with productivity innovations, but help explain variable input demand conditional on productivity.

[7] Time effects are also included when fitting $\Phi_\psi(\cdot)$.

In practice, the following moment condition is used to estimate the model:

$$E[\xi_{it}(\beta) \mid \quad \mathcal{Z}_{it}] = 0$$

where $\mathcal{Z}_{it}$ denotes the vector of instruments employed in the baseline specification (see manuscript). A GMM criterion function is then constructed over values of ϕ_{ψ}, and the estimate is obtained by minimizing this function.

Columns 1 and 2 of Table OA.6 report the average output elasticities with respect to each input—labor and capital—for regional and major carriers, respectively. The estimated elasticities for labor and capital are similar to those obtained under the baseline specification.

Table OA.6: Production Function Estimates

	Regional	Major
Variables	(1)	(2)
Labor	0.774	0.785
	(0.073)	(0.041)
Capital	0.082	0.075
	(0.073)	(0.041)
Observations	1710	1703

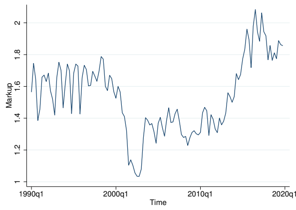
Note: This table reports the estimated average output elasticity with respect to each factor of production (labor and capital). Standard deviations of output elasticities are reported in parentheses below their means. Output is measured using revenue passenger miles (RPM).

Table OA.7 reports average (unweighted) markups by carrier type—major and regional—and for selected airlines, across different time periods, using the current specification. Figure OA.11 below provides a more detailed view of markup estimates at the firm level, alongside the evolution of the (output-weighted) average markup charged by regional carriers. In all cases, the main results and conclusions are consistent with those obtained under the baseline specification.

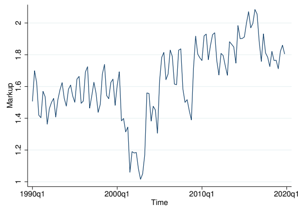
Table OA.7: Markup Estimates (Robustness - Control Function) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.608	1.637	1.252	1.356	1.546	1.882	1.538
	(0.120)	(0.085)	(0.139)	(0.075)	(0.202)	(0.104)	(0.232)
Continental	1.889	2.006	1.561	1.757	1.767		1.806
	(0.150)	(0.162)	(0.197)	(0.077)	(0.047)		(0.217)
Delta	1.543	1.690	1.399	1.832	1.863	1.914	1.694
	(0.138)	(0.096)	(0.115)	(0.112)	(0.082)	(0.069)	(0.211)
Northwest	1.546	1.567	1.314	1.743			1.532
	(0.137)	(0.151)	(0.122)	(0.100)			(0.194)
United	1.532	1.568	1.360	1.711	1.862	1.849	1.637
	(0.087)	(0.108)	(0.247)	(0.161)	(0.109)	(0.114)	(0.228)
US Airways	1.530	1.722	1.599	1.828	1.852		1.697
	(0.114)	(0.159)	(0.222)	(0.131)	(0.095)		(0.195)
Trans World	1.471	1.563	1.273				1.493
	(0.125)	(0.127)	(0.281)				(0.160)
Southwest	1.741	1.720	1.340	1.222	1.294	1.341	1.456
	(0.105)	(0.085)	(0.088)	(0.048)	(0.089)	(0.068)	(0.229)
Jet Blue		1.333	1.637	1.370	1.400	1.526	1.474
		(0.405)	(0.179)	(0.068)	(0.099)	(0.105)	(0.179)
Frontier	1.939	2.638	1.761	1.507	1.520	1.674	1.833
	(0.467)	(0.327)	(0.263)	(0.153)	(0.179)	(0.231)	(0.486)
Airtran		1.826	1.439	1.341	1.290		1.496
		(0.236)	(0.132)	(0.109)	(0.033)		(0.255)
Spirit	2.169	1.823	1.419	1.482	1.587	1.555	1.598
	(0.088)	(0.205)	(0.201)	(0.154)	(0.112)	(0.117)	(0.241)
Major Airlines	1.702	1.805	1.485	1.527	1.607	1.662	1.624
	(0.267)	(0.334)	(0.247)	(0.245)	(0.237)	(0.241)	(0.286)
Regional Airlines	1.975	2.012	1.550	1.498	1.388	1.248	1.657
	(0.490)	(0.494)	(0.322)	(0.283)	(0.327)	(0.250)	(0.478)
Industry	1.632	1.715	1.410	1.533	1.604	1.683	1.589
	(0.101)	(0.092)	(0.103)	(0.064)	(0.084)	(0.075)	(0.135)

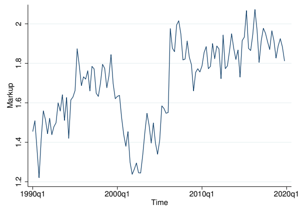
Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification described in Online Appendix I.1, which applies control function methods to estimate the production function.



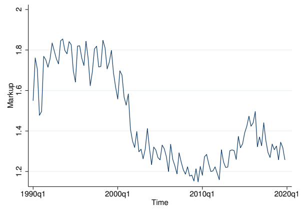
(a) American



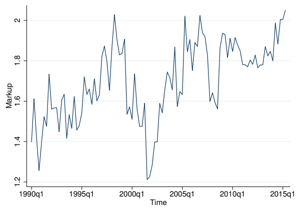
(b) United



(c) Delta

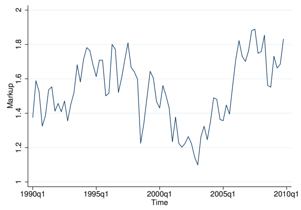


(d) Southwest

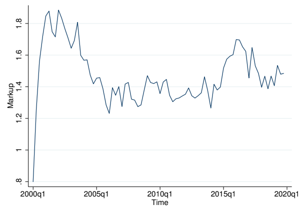


(e) US Airways

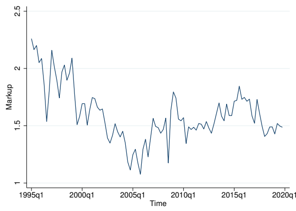
(f) Continental



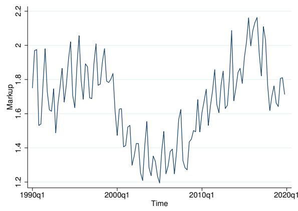
(g) Northwest



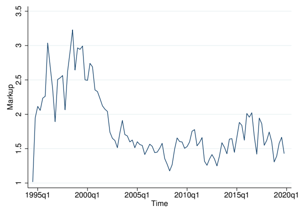
(h) JetBlue



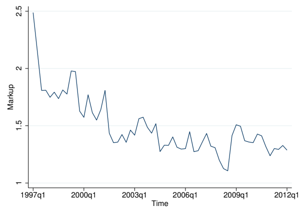
(i) Spirit



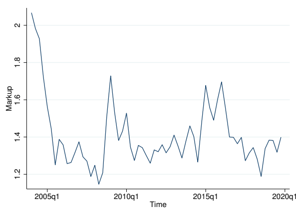
(j) Alaska



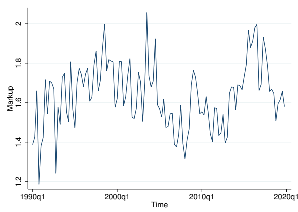
(k) Frontier



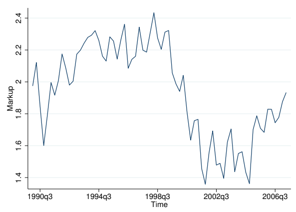
(l) AirTran



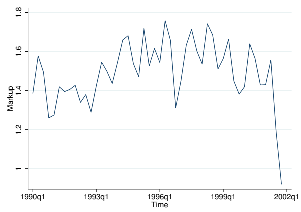
(m) Allegiant



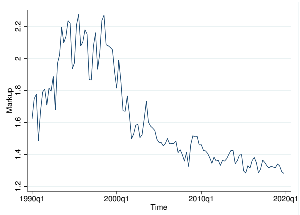
(n) Hawaiian



(o) America West



(p) Trans World



(q) Regional (Average)

Figure OA.11: Markups - Selected Airlines. This figure shows the evolution of markups over time for selected airlines under a control function specification. Panel (q) plots the average (output-weighted) markup for regional carriers.

I.2 Dynamic Panel

In this section, I estimate the production function using dynamic panel methods to recover the output elasticity of a flexible input and corresponding markups. Like the control function approach, this estimation strategy relaxes the reliance on a Leontief first-order condition to identify unexpected shocks to production. It does assume, however, that $\epsilon_{ist} = 0$ for all i, s, and t, while allowing for untransmitted shocks, ϵ_{it}, to airline-level composite output. The corresponding airline-level composite output index is given by equation (OA.25).

Unlike a control function approach, this method does not rely on the invertibility of input demand or investment policy functions. As such, it does not require the assumptions to guarantee those inversions (i.e., scalar unobservable assumption) and can easily accommodate imperfect competition. On the other hand, unlike proxy methods, it relies on productivity following a linear process. More specifically, productivity is assumed to follow a first-order Markov process given by:

$$\omega_{it} = \rho_\psi \omega_{it-1} + \mathbf{macq}_{it-1}\vartheta_\psi + \Delta\mathbf{nwk}_{it-1}\zeta_\psi + \xi_{it} \qquad \text{(OA.31)}$$

where $\mathbf{macq}_{it-1}$ and $\Delta\mathbf{nwk}_{it-1}$ are vectors defined in the manuscript. ρ_ψ captures persistence and ξ_{it} is an innovation term uncorrelated with past information.

Estimation proceeds by differentiating the model. Equations (OA.25) and (OA.31) provide the following moment condition after differentiating the model:

$$\begin{aligned} E[\xi_{it} + (\epsilon_{it} - \rho_\psi \epsilon_{it-1}) \mid \mathcal{I}_{it-1}] \;&=\; E[\Delta\mathcal{Q}_{it}(\beta) - \beta_{l_\psi}\Delta l_{it} - \beta_{k_\psi}\Delta k_{it} - \beta_{lk_\psi}\Delta(l_{it}k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) \\ &-\; (\rho_\psi - 1) \times (\mathcal{Q}_{it-1}(\beta) - \beta_{l_\psi} l_{it-1} - \beta_{k_\psi} k_{it-1} \\ &-\; \beta_{lk_\psi}(l_{it-1}k_{it-1} - \frac{1}{2}(l_{it-1}^2 + k_{it-1}^2))) - \tau_{\psi t} \\ &-\; \mathbf{macq}_{it-1}\vartheta_\psi - \Delta\mathbf{nwk}_{it-1}\zeta_\psi \mid \mathcal{I}_{it-1}] = 0 \end{aligned}$$

where Δ denotes the first-difference operator (e.g., $\Delta l_{it} = l_{it} - l_{it-1}$) and $\mathcal{Q}_{it}(\beta)$ is airline-level composite output (i.e., left-hand side of equation OA.25), defined as:

$$\mathcal{Q}_{it}(\beta) = \ln\left(\sum_{s\in\mathcal{S}_{it}} Q_{ist}^{\frac{1}{\phi_\psi}}\right)^{\phi_\psi} \qquad \text{(OA.32)}$$

I rely on the following moment condition to estimate the model:

$$E[\xi_{it} + \epsilon_{it} - \rho_\psi \epsilon_{it-1} \mid \; \mathcal{Z}_{it}] = 0$$

where $\mathcal{Z}_{it}$ denotes the vector of instruments employed in the baseline specification (see manuscript).

Columns 1 and 2 of Table OA.8 report the average output elasticities with respect to each input—labor and capital—for regional and major carriers, respectively. The estimated elasticities for labor and capital are broadly consistent with those obtained under the baseline specification.

Table OA.8: Production Function Estimates

	Regional	Major
Variables	(1)	(2)
Labor	0.844	0.797
	(0.027)	(0.024)
Capital	0.062	0.046
	(0.027)	(0.024)
Observations	1710	1703

Note: This table reports the estimated average output elasticity with respect to each factor of production (labor and capital). Standard deviations of output elasticities are reported in parentheses below their means. Output is measured using revenue passenger miles (RPM).

Table OA.9 reports average (unweighted) markups by carrier type—major and regional—and for selected airlines, across different time periods, using the current specification. Figure OA.12 below provides a more detailed view of markup estimates at the firm level, alongside the evolution of the (output-weighted) average markup charged by regional carriers. In all cases, the main results and conclusions are consistent with those obtained under the baseline specification.

Table OA.9: Markup Estimates (Robustness - Dynamic Panel) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.626	1.656	1.267	1.369	1.559	1.903	1.554
	(0.122)	(0.086)	(0.140)	(0.076)	(0.204)	(0.106)	(0.234)
Continental	1.887	2.008	1.576	1.771	1.776		1.812
	(0.149)	(0.158)	(0.198)	(0.078)	(0.047)		(0.212)
Delta	1.556	1.708	1.417	1.846	1.880	1.940	1.712
	(0.141)	(0.095)	(0.116)	(0.113)	(0.084)	(0.070)	(0.213)
Northwest	1.558	1.580	1.328	1.757			1.546
	(0.138)	(0.152)	(0.123)	(0.100)			(0.195)
United	1.544	1.584	1.377	1.723	1.878	1.873	1.652
	(0.088)	(0.109)	(0.249)	(0.163)	(0.112)	(0.115)	(0.230)
US Airways	1.540	1.736	1.606	1.831	1.859		1.705
	(0.116)	(0.160)	(0.219)	(0.132)	(0.096)		(0.194)
Trans World	1.472	1.552	1.265				1.488
	(0.119)	(0.126)	(0.279)				(0.156)
Southwest	1.757	1.736	1.355	1.234	1.306	1.355	1.470
	(0.106)	(0.086)	(0.089)	(0.049)	(0.090)	(0.068)	(0.231)
Jet Blue		1.341	1.651	1.382	1.413	1.543	1.487
		(0.414)	(0.180)	(0.069)	(0.101)	(0.108)	(0.181)
Frontier	1.909	2.608	1.764	1.510	1.519	1.675	1.826
	(0.465)	(0.322)	(0.259)	(0.152)	(0.179)	(0.232)	(0.475)
Airtran		1.828	1.437	1.344	1.293		1.498
		(0.237)	(0.132)	(0.109)	(0.032)		(0.255)
Spirit	2.152	1.821	1.415	1.475	1.583	1.562	1.595
	(0.084)	(0.203)	(0.204)	(0.154)	(0.115)	(0.116)	(0.240)
Major Airlines	1.710	1.810	1.493	1.533	1.615	1.675	1.632
	(0.265)	(0.326)	(0.244)	(0.247)	(0.239)	(0.244)	(0.285)
Regional Airlines	2.032	2.058	1.591	1.536	1.431	1.285	1.702
	(0.490)	(0.500)	(0.320)	(0.290)	(0.335)	(0.266)	(0.484)
Industry	1.644	1.730	1.426	1.546	1.620	1.704	1.604
	(0.103)	(0.092)	(0.104)	(0.065)	(0.086)	(0.076)	(0.136)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification described in Online Appendix I.2, which applies dynamic panel methods to estimate the production function.

(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average)

Figure OA.12: Markups - Selected Airlines. This figure shows the evolution of markups over time for selected airlines under a dynamic panel specification. Panel (q) plots the average (output-weighted) markup for regional carriers.

I.3 Factor Shares

In this section, I assess the robustness of my results by employing a factor share methodology to estimate the output elasticity of labor and corresponding markups.[8] This approach assumes producers minimize costs and are unable to influence input prices when making their input decisions. In the absence of input adjustment costs, this methodology provides a nonparametric first-order approximation to the output elasticities of a general production function. Specifically, for a cost-minimizing producer, the output elasticity of an input equals the product of the input's cost share and the scale elasticity:

$$\theta_{it}^{x} = cs_{it}^{x} \times \phi_{\psi t} \tag{OA.33}$$

where $\phi_{\psi t}$ represents the returns to scale of the production function $F_{\psi,t}(\cdot)$, and cs_{it}^{x} is the cost share of input x.[9]

The cost share of input $x = \{L, K\}$ for airline i at time t is defined as $cs_{it}^{x} = \frac{W_{it}^{x} x_{it}}{W_{it}^{L} L_{it} + W_{it}^{K} K_{it}}$, where L denotes labor, K denotes capital (i.e., ground property and equipment), and W_{it}^{x} represents the unit price of input x. Labor expenditures are directly observed in the data. Capital costs are constructed as the capital stock multiplied by the user cost of capital W_{it}^{K}, defined—within each technology type and time period—as the median across firms of depreciation expense over assets plus interest expense over total liabilities.[10]

Some remarks about the factor share approach merit emphasis. First, concerns about the presence of input adjustment costs can be partially alleviated by relying on the average or median of equation (OA.33) over producers, smoothing out adjustment cost-driven differences between actual and optimal input levels (see Syverson 2011; Collard-Wexler and De Loecker 2016; and De Loecker and Syverson 2021 for additional details). Second, an important strength of the factor share methodology is that, unlike production function techniques that rely on proxy methods (i.e., control function approaches), it can easily accommodate imperfect competition. The implementation of a control function approach under imperfect competition requires additional assumptions and data (see De Loecker

[8]See Syverson (2011) or De Loecker and Syverson (2021) for a discussion of this approach and Foster, Haltiwanger and Syverson (2008) and Raval (2023), for example, for applications.

[9]For a homothetic production function, the scale elasticity equals the returns to scale of the production function. Equation (OA.33) can be derived from the conditional cost minimization problem described by equations (OA.1)—(OA.3).

[10] More specifically, $W_{\psi t}^{K} = median_{i \in \psi}\{\frac{D_{it}}{A_{it}} + \frac{INT_{it}}{LIA_{it}}\}$, for $\psi \in \{M, R\}$, and where D_{it} represents depreciation expense, A_{it} total assets, INT_{it} interest expense, and LIA_{it} total liabilities. I have also experimented with a measure of the user cost of capital similar to the one employed by De Loecker, Eeckhout and Unger (2020), obtaining very similar results. In this case, the user cost of capital W_{it}^{K} is computed as the real interest rate plus a depreciation rate set at 12%. The real interest rate is calculated as the difference between the nominal interest rate, measured by the federal funds rate, and the inflation rate, measured by the investment price index from the NBER-CES Manufacturing Industry database. Results using this alternative measure of the user cost of capital are available from the author upon request.

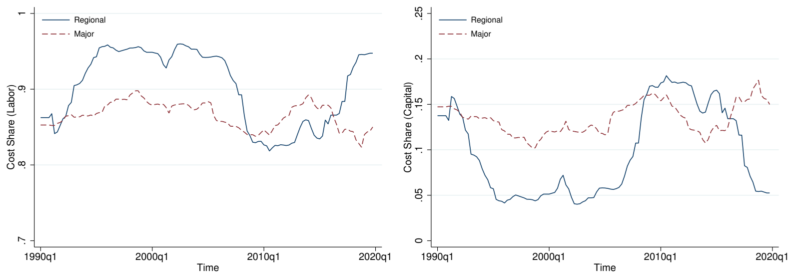
and Syverson 2021). Third, in contrast to structural production function estimation, this approach does not rely on comparable input and output quantity data, making it well-suited to settings with product differentiation—as long as the underlying production function is common across producers (De Loecker and Syverson 2021). A limitation of the factor share approach, however, is that it requires normalizing the returns to scale, whereas structural production function methods allow these to be estimated directly. In the results that follow, I assume constant returns to scale, i.e., $\phi_{\psi t} = 1$.

Table OA.10 reports summary statistics for the estimated output elasticities of labor and capital, disaggregated by carrier type. The elasticities are computed separately by technology type and year, using the median of the cost share distribution to capture technological changes over time and differences in production organization across airlines. Figure OA.13 complements the table by illustrating the evolution of output elasticities over time for each technology type. On average, the estimated labor output elasticity is 0.903 for regional carriers and 0.866 for major carriers.

Table OA.10: Output Elasticity Estimates - Summary Statistics

	Regional	Major
Cost Share of Labor	0.903	0.866
	(0.049)	(0.017)
Cost Share of Capital	0.097	0.134
	(0.049)	(0.017)

Note: This table reports, by carrier type, the estimated average (across years) cost share of labor and capital. Standard deviations are reported in parentheses below their means. Cost shares were obtained according to the specification described in Online Appendix I.3.



(a) Cost Share of Labor (b) Cost Share of Capital

Figure OA.13: Cost Shares. This figure shows the estimates of the cost share of labor and capital, for regional and major carriers. Panel (a) plots the estimates of the cost share of labor over time, for regional (blue solid line) and major (red dashed line) carriers. Panel (b) plots the estimates of the cost share of capital over time, for regional (blue solid line) and major (red dashed line) carriers.

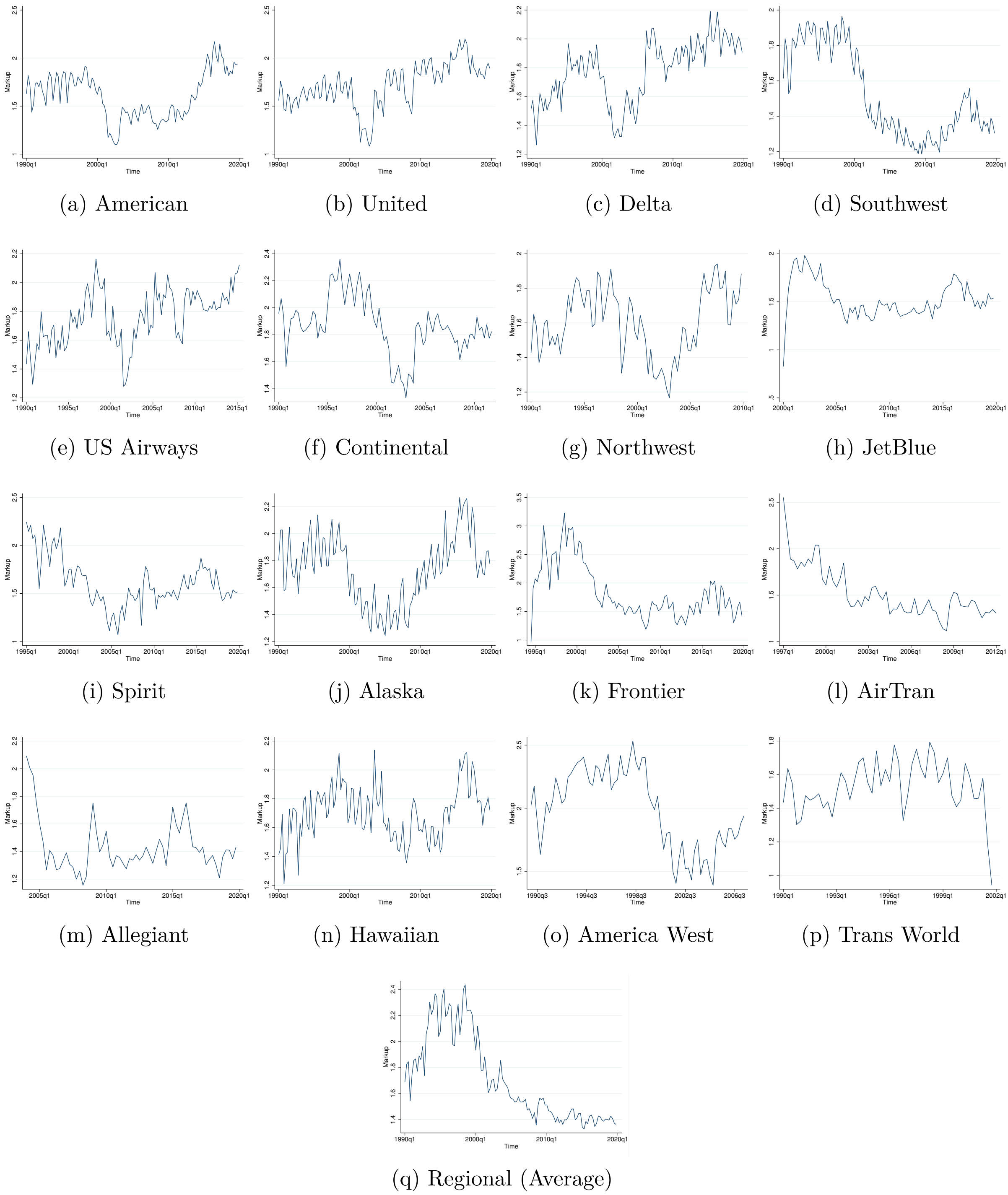
I.3.1 Markup Estimates

Table OA.11 reports, for different time periods, average (unweighted) markups by carrier type (i.e., major or regional), and for selected airlines. Figure OA.14 below complements this information showing a selection of major airlines' individual markups, along with the evolution of the (output-weighted) average markup charged by regional carriers. In all cases, the results and conclusions are similar to those obtained under the baseline specification.

Table OA.11: Markup Estimates (Factor Share Approach) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.696	1.747	1.324	1.402	1.606	1.954	1.613
	(0.129)	(0.093)	(0.141)	(0.081)	(0.213)	(0.111)	(0.243)
Continental	1.928	2.074	1.643	1.810	1.812		1.865
	(0.154)	(0.158)	(0.198)	(0.084)	(0.047)		(0.212)
Delta	1.613	1.794	1.479	1.885	1.943	2.001	1.773
	(0.150)	(0.099)	(0.115)	(0.116)	(0.096)	(0.079)	(0.215)
Northwest	1.613	1.657	1.387	1.795			1.604
	(0.145)	(0.157)	(0.124)	(0.105)			(0.195)
United	1.602	1.672	1.442	1.760	1.942	1.933	1.714
	(0.093)	(0.116)	(0.251)	(0.169)	(0.123)	(0.127)	(0.232)
US Airways	1.595	1.830	1.664	1.852	1.899		1.759
	(0.126)	(0.174)	(0.212)	(0.136)	(0.104)		(0.193)
Trans World	1.513	1.594	1.295				1.529
	(0.115)	(0.131)	(0.283)				(0.159)
Southwest	1.816	1.815	1.409	1.262	1.342	1.388	1.520
	(0.113)	(0.094)	(0.094)	(0.052)	(0.098)	(0.073)	(0.247)
Jet Blue		1.400	1.714	1.411	1.453	1.583	1.531
		(0.432)	(0.192)	(0.072)	(0.109)	(0.118)	(0.194)
Frontier	1.901	2.628	1.809	1.525	1.532	1.681	1.845
	(0.469)	(0.327)	(0.263)	(0.152)	(0.180)	(0.237)	(0.478)
Airtran		1.881	1.461	1.357	1.306		1.524
		(0.244)	(0.136)	(0.111)	(0.032)		(0.271)
Spirit	2.168	1.874	1.440	1.473	1.591	1.577	1.615
	(0.076)	(0.207)	(0.216)	(0.152)	(0.121)	(0.120)	(0.252)
Major Airlines	1.761	1.876	1.538	1.555	1.650	1.709	1.674
	(0.266)	(0.322)	(0.244)	(0.253)	(0.253)	(0.256)	(0.293)
Regional Airlines	2.078	2.137	1.643	1.547	1.434	1.313	1.740
	(0.502)	(0.514)	(0.322)	(0.288)	(0.339)	(0.274)	(0.503)
Industry	1.702	1.810	1.482	1.575	1.661	1.749	1.656
	(0.111)	(0.099)	(0.103)	(0.069)	(0.096)	(0.083)	(0.145)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups were estimated according to the specification described in Online Appendix I.3, in which the output elasticity of the flexible input is estimated under the factor share approach.



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average)

Figure OA.14: Markups - Selected Airlines. This figure shows the evolution of markups over time for selected airlines under a factor shares specification. Panel (q) plots the average (output-weighted) markup for regional carriers.

J Product Heterogeneity

J.1 Segment Centrality

This section evaluates the robustness of the main results by incorporating a measure of segment centrality, D_{ist}, into the production function—specifically, into the function $F_{\psi,t}(\cdot)$ defined in equation (4) of the paper. Segment centrality is defined as the geometric mean of the number of destinations served by the carrier from the origin and destination airports of segment s, normalized by the carrier's total number of airports served minus one. As discussed in the manuscript, including this variable allows me to account for network effects—namely, economies of density—whereby carriers serving a greater number of destinations from a given airport can transport more passengers per unit of non-flight labor (L_{ist}) and non-aircraft capital (K_{ist}). In addition, D_{ist} is also a measure of product differentiation, as it summarizes a carrier's presence at the segment's endpoint airports—a feature valued by consumers.

Under this extended specification, the first-stage estimation used to recover unexpected productivity shocks remains unchanged from the baseline. However, the second stage is modified to incorporate D_{ist}. Consistent with the discussion in the manuscript, the Leontief first-order condition continues to apply, implying:

$$Q_{ist} = \min\{F_{\psi,t}(K_{ist}, L_{ist}, D_{ist}; \beta)e^{\omega_{it}}, [\gamma^x_{ist} X_{ist}]_{X_{ist} \in \mathbb{X}_{ist}}\}e^{\epsilon_{ist}} = F_{\psi,t}(K_{ist}, L_{ist}, D_{ist}; \beta)e^{\omega_{it}+\epsilon_{ist}}$$

The above equation provides:

$$q_{ist} = f_{\psi,t}(k_{ist}, l_{ist}, d_{ist}; \beta) + \omega_{it} + \epsilon_{ist} \tag{OA.34}$$

where $(q_{ist}, l_{ist}, k_{ist}, d_{ist})$ denote the corresponding logged values of $(Q_{ist}, L_{ist}, K_{ist}, D_{ist})$ and $f_{\psi,t}(l_{ist}, k_{ist}, d_{ist}; \beta) = \ln F_{\psi,t}(L_{ist}, K_{ist}, D_{ist}; \beta)$. Similar to the baseline specification, I assume $f_{\psi,t}(.; \beta)$ is a translog production function, homogeneous of degree $\phi_\psi > 0$, and separable in d_{ist}:

$$f_{\psi,t}(l_{ist}, k_{ist}, d_{ist}; \beta) = \beta_{l_\psi} l_{ist} + \beta_{k_\psi} k_{ist} + \beta_{lk_\psi}(l_{ist}k_{ist} - \frac{1}{2}(l^2_{ist} + k^2_{ist})) + \beta_{d_\psi} d_{ist} + \tau_{\psi t} \tag{OA.35}$$

where $\tau_{\psi t}$ is an airline type-time effect that accounts for variation in industry-level variables across time.

Equation (OA.34) and the first-stage estimates provide:

$$\hat{Q}_{ist} = F_{\psi,t}(K_{ist}, L_{ist}, D_{ist}; \beta)e^{\omega_{it}} \tag{OA.36}$$

where $\hat{Q}_{ist} = Q_{ist}/e^{\hat{\epsilon}_{ist}}$.

As in the baseline specification, I assume that inputs are allocated across segments in a neutral way, such that $H_{ist} = a_{ist} H_{it}$, with $H = \{L, K\}$, $a_{ist} \in [0, 1]$, and $\sum_{s \in \mathcal{S}_{it}} a_{ist} = 1$. Summing output across segments s for airline i at time t provides (see Online Appendix E for details):

$$\ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\frac{\hat{Q}_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \right)^{\phi_\psi} = \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi} (l_{it} k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) + \tau_{\psi t} + \omega_{it} \quad \text{(OA.37)}$$

where $\phi_\psi = \beta_{l_\psi} + \beta_{k_\psi}$. While the right-hand side of equation (OA.37) resembles a standard production-function specification, the left-hand side is better viewed as a model-implied airline-level composite output index. It is constructed from segment-level planned outputs, with each segment scaled by $D_{ist}^{-\beta_{d_\psi}}$, where D_{ist} measures the connectivity or centrality of segment s in airline i's network. This index follows from the homogeneity of $F_{\psi,t}(.)$ together with the neutral input-allocation rule, rather than from an independent assumption about how airline output aggregates across segments. When $\beta_{d_\psi} > 0$, segment centrality acts as a segment-specific efficiency shifter: more central segments can produce a given level of output with less non-aircraft labor and capital, or equivalently generate more output from a given bundle of those inputs.

The law of motion for productivity is assumed to be identical to the one assumed in the baseline specification. Equation (OA.37) and the law of motion for productivity provide the following moment condition:

$$\begin{aligned} E[\xi_{it}(\beta) \mid \mathcal{I}_{it-1}] \quad = \quad & E[\ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\frac{\hat{Q}_{ist}}{D_{ist}^{\beta_{d_\psi}}} \right)^{\frac{1}{\phi_\psi}} \right)^{\phi_\psi} - \beta_{l_\psi} l_{it} - \beta_{k_\psi} k_{it} - \beta_{lk_\psi} (l_{it} k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) \\ & - g_\psi(\omega_{it-1}(\beta), \mathbf{\Delta nwk}_{it-1}, \mathbf{macq}_{it-1}) - \tau_{\psi t} \mid \mathcal{I}_{it-1}] = 0 \end{aligned}$$

where $\omega_{it-1}(\beta)$ is defined by (lagged) equation (OA.37).

I rely on the following moment condition to estimate the model:

$$E[\xi_{it}(\beta) \mid \mathcal{Z}'_{it}, \tau_{\psi t}, \mathbf{\Delta nwk}_{it-1}, \mathbf{macq}_{it-1}] = 0$$

where $\mathcal{Z}'_{it}$ is a vector of instruments, consisting of those used in the baseline specification (see manuscript), augmented with the lagged value of output concentration across segments in the carrier's network, measured by the Herfindahl-Hirschman Index (HHI).

Identification of the model follows the same logic as in the baseline specification (see manuscript). The inclusion of an additional instrument strengthens identification of the composite output index structure. Specifically, the structure of the composite output index implies that both the number of segments and the distribution of output across them (e.g., the degree of concentration) influence the composite output index's curvature. Conditional on labor and capital inputs, variation in segment count and concentration of production provides nonlinear variation in the composite output term that helps disentangle ϕ_ψ and β_{d_ψ} from productivity.

Timing assumptions are critical for instrument validity: the set of segments or routes to be served is assumed to be determined at least one period in advance, ensuring they are uncorrelated with contemporaneous productivity shocks. Conversely, because production responds to current productivity shocks, I use lagged segment-level output to construct the Herfindahl-Hirschman index as a measure of production concentration.

Columns 1 and 2 of Table OA.12 report the average output elasticities with respect to each input—labor and ground property and equipment—along with the estimated coefficient on segment centrality, for regional and major carriers, respectively. The estimated elasticities for labor and capital are broadly consistent with those obtained under the baseline specification.

Table OA.12: Production Function Estimates

	Regional	Major
Variables	(1)	(2)
Panel A: First Stage Estimates		
$\hat{\gamma}^{AU}$	0.621	1.096
	(0.993)	(1.614)
Observations	456875	892659
Out-of-Bag Score	0.813	
MSE	0.087	
R^2	0.974	
Panel B: Output Elasticities		
Labor	0.796	0.804
	(0.00002)	(0.053)
Capital	0.036	0.046
	(0.00002)	(0.053)
Segment Centrality	0.025	0.063
	(0.198)	(0.037)
Observations	1710	1703

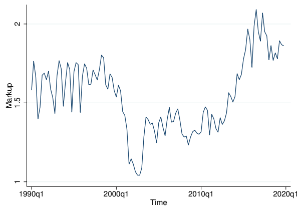
Note: Panel A of this table reports the estimated average Leontief coefficient for aircraft utilization (i.e., γ_{ist}^{AU}). Standard deviations are reported in parentheses below their means. Panel B reports the estimated average output elasticity with respect to each factor of production (labor and capital), along with the estimated coefficient on segment centrality. Standard deviations of output elasticities are reported in parentheses below their means. The estimate reported for Segment Centrality is a point estimate, and its standard error is reported below in parentheses. Output is measured using revenue passenger miles (RPM).

Table OA.13 reports average (unweighted) markups by carrier type—major and regional—and for selected airlines, across different time periods, using the current specification. Figure OA.15 below provides a more detailed view of markup estimates at the firm level, alongside the evolution of the (output-weighted) average markup charged by regional carriers. In all cases, the main results and conclusions are consistent with those obtained under the baseline specification.

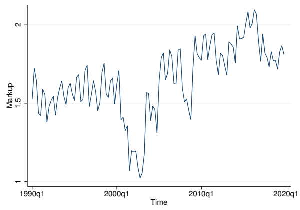
Table OA.13: Markup Estimates (Robustness - Seg. Centrality) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.623	1.650	1.259	1.362	1.551	1.889	1.547
	(0.121)	(0.086)	(0.138)	(0.075)	(0.202)	(0.105)	(0.233)
Continental	1.916	2.032	1.573	1.766	1.778		1.824
	(0.153)	(0.165)	(0.197)	(0.078)	(0.047)		(0.223)
Delta	1.558	1.702	1.404	1.839	1.870	1.921	1.704
	(0.138)	(0.097)	(0.115)	(0.113)	(0.082)	(0.070)	(0.211)
Northwest	1.561	1.582	1.322	1.749			1.544
	(0.138)	(0.152)	(0.120)	(0.101)			(0.195)
United	1.550	1.583	1.367	1.721	1.872	1.857	1.648
	(0.087)	(0.109)	(0.246)	(0.162)	(0.109)	(0.115)	(0.228)
US Airways	1.549	1.742	1.616	1.843	1.864		1.713
	(0.115)	(0.161)	(0.224)	(0.133)	(0.095)		(0.195)
Trans World	1.494	1.594	1.299				1.520
	(0.132)	(0.129)	(0.286)				(0.165)
Southwest	1.753	1.733	1.346	1.225	1.297	1.345	1.463
	(0.106)	(0.087)	(0.089)	(0.049)	(0.089)	(0.068)	(0.233)
Jet Blue		1.349	1.647	1.373	1.403	1.528	1.479
		(0.401)	(0.183)	(0.068)	(0.099)	(0.106)	(0.180)
Frontier	1.977	2.684	1.778	1.516	1.528	1.679	1.851
	(0.471)	(0.335)	(0.271)	(0.155)	(0.178)	(0.232)	(0.501)
Airtran		1.844	1.451	1.346	1.294		1.507
		(0.237)	(0.134)	(0.109)	(0.033)		(0.259)
Spirit	2.201	1.846	1.435	1.494	1.595	1.558	1.611
	(0.090)	(0.209)	(0.203)	(0.156)	(0.111)	(0.118)	(0.246)
Major Airlines	1.721	1.825	1.497	1.534	1.614	1.668	1.636
	(0.271)	(0.341)	(0.250)	(0.247)	(0.240)	(0.243)	(0.291)
Regional Airlines	1.978	2.004	1.561	1.517	1.415	1.266	1.668
	(0.476)	(0.490)	(0.317)	(0.282)	(0.338)	(0.270)	(0.470)
Industry	1.649	1.731	1.419	1.541	1.613	1.691	1.600
	(0.102)	(0.093)	(0.103)	(0.064)	(0.084)	(0.076)	(0.136)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification detailed in Online Appendix J.1, which incorporates a measure of segment centrality into the production function.



(a) American



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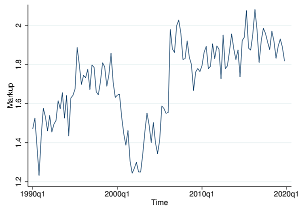
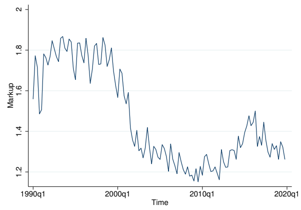
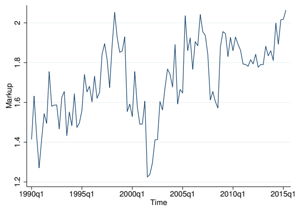


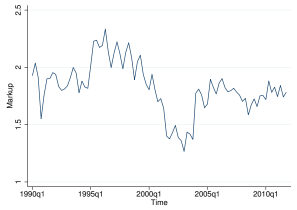
(c) Delta



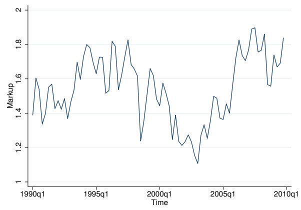
(d) Southwest



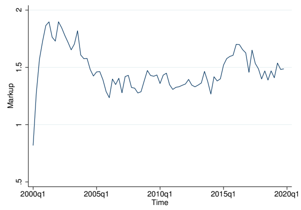
(e) US Airways



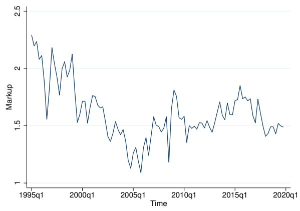
(f) Continental



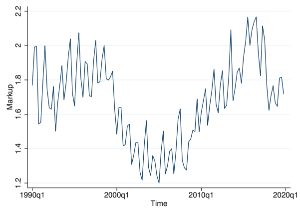
(g) Northwest



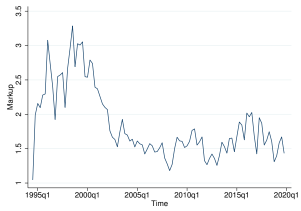
(h) JetBlue



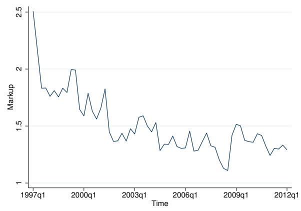
(i) Spirit



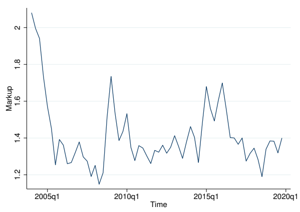
(j) Alaska



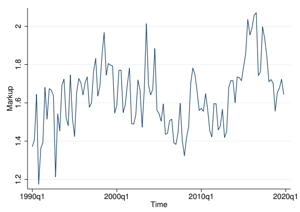
(k) Frontier



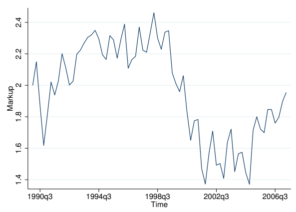
(l) AirTran



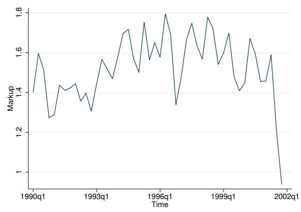
(m) Allegiant



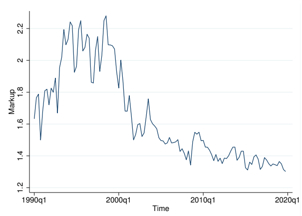
(n) Hawaiian



(o) America West



(p) Trans World



(q) Regional (Average)

Figure OA.15: Markups - Selected Airlines. This figure shows the evolution of markups over time for selected airlines under a specification that includes segment centrality in the production function. Panel (q) plots the average (output-weighted) markup for regional carriers.

J.2 Quality Control

This section assesses the robustness of the main results by incorporating a control for product quality, following the framework proposed by De Loecker, Goldberg, Khandelwal and Pavcnik (2016). Under this framework, the first-stage estimation used to recover unexpected productivity shocks remains identical to that of the baseline specification. However, the second stage is modified to account for quality differences across products. As discussed in the manuscript, the Leontief first-order condition continues to apply. The resulting estimating equation is:

$$\ln \left(\sum_{s \in \mathcal{S}_{it}} \left(\hat{Q}_{ist} \right)^{\frac{1}{\phi_\psi}} \right)^{\phi_\psi} = \beta_{l_\psi} l_{it} + \beta_{k_\psi} k_{it} + \beta_{lk_\psi} (l_{it} k_{it} - \frac{1}{2}(l_{it}^2 + k_{it}^2)) + \tau_{\psi t} + \nu(p_{it}, w_{it}^L) + \omega_{it}$$

where $\phi_\psi = \beta_{l_\psi} + \beta_{k_\psi}$, and $\nu(\cdot)$ denotes a function of logged average output prices and wages, assumed to be linear in these variables, as in Rubens (2023).

The law of motion for productivity is assumed to be the same as in the baseline specification. Identification of the model follows the discussion provided in the manuscript. Estimation relies on the following moment condition:

$$E[\xi_{it}(\beta) \mid \mathcal{Z}_{it}, p_{it-1}, w_{it-1}^L] = 0$$

where $\mathcal{Z}_{it}$ denotes the vector of instruments employed in the baseline specification. The set of instruments mirrors those used in the baseline specification, augmented with lagged average output prices and wages. These additional instruments aid in identifying the parameters that govern the extent of quality variation reflected in price differences.

Columns 1 and 2 of Table OA.14 report the average output elasticities with respect to each input—labor and capital—for regional and major carriers, respectively. The estimated elasticities for labor and capital are broadly consistent with those obtained under the baseline specification.

Table OA.14: Production Function Estimates

	Regional	Major
Variables	(1)	(2)
Panel A: First Stage Estimates		
$\hat{\gamma}^{AU}$	0.621	1.096
	(0.993)	(1.614)
Observations	456875	892659
Out-of-Bag Score	0.813	
MSE	0.087	
R^2	0.974	
Panel B: Output Elasticities		
Labor	0.875	0.823
	(0.027)	(0.057)
Capital	0.097	0.043
	(0.027)	(0.057)
Observations	1710	1703

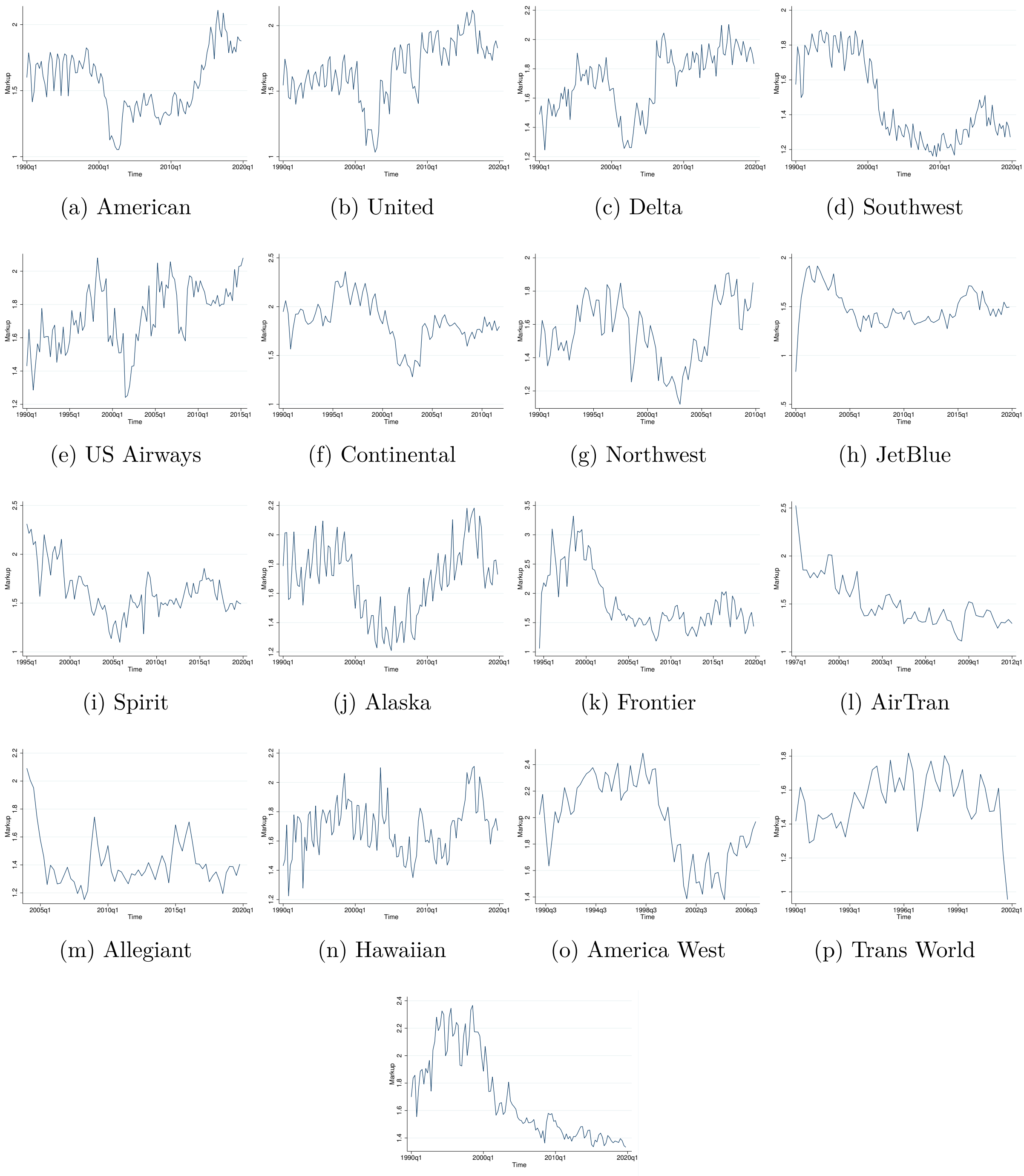
Note: Panel A of this table reports the estimated average Leontief coefficient for aircraft utilization (i.e., γ_{ist}^{AU}). Standard deviations are reported in parentheses below their means. Panel B reports the estimated average output elasticity with respect to each factor of production (labor and capital). Standard deviations of output elasticities are reported in parentheses below their means. Output is measured using revenue passenger miles (RPM).

Table OA.15 reports average (unweighted) markups by carrier type—major and regional—and for selected airlines, across different time periods, using the current specification. Figure OA.16 below provides a more detailed view of markup estimates at the firm level, alongside the evolution of the (output-weighted) average markup charged by regional carriers. In all cases, the main results and conclusions are consistent with those obtained under the baseline specification.

Table OA.15: Markup Estimates (Robustness - Quality Control) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.644	1.669	1.271	1.373	1.561	1.904	1.562
	(0.123)	(0.087)	(0.139)	(0.076)	(0.203)	(0.106)	(0.235)
Continental	1.938	2.054	1.590	1.780	1.791		1.843
	(0.155)	(0.167)	(0.197)	(0.079)	(0.047)		(0.225)
Delta	1.576	1.721	1.417	1.852	1.884	1.939	1.719
	(0.139)	(0.098)	(0.115)	(0.113)	(0.084)	(0.071)	(0.211)
Northwest	1.579	1.601	1.336	1.761			1.560
	(0.140)	(0.154)	(0.120)	(0.102)			(0.196)
United	1.571	1.603	1.381	1.735	1.888	1.875	1.665
	(0.089)	(0.111)	(0.246)	(0.164)	(0.111)	(0.117)	(0.229)
US Airways	1.569	1.765	1.634	1.856	1.876		1.731
	(0.117)	(0.163)	(0.224)	(0.134)	(0.096)		(0.194)
Trans World	1.515	1.616	1.317				1.540
	(0.134)	(0.131)	(0.290)				(0.168)
Southwest	1.771	1.750	1.358	1.232	1.304	1.355	1.476
	(0.107)	(0.089)	(0.091)	(0.049)	(0.090)	(0.068)	(0.238)
Jet Blue		1.366	1.662	1.381	1.410	1.538	1.489
		(0.402)	(0.187)	(0.068)	(0.100)	(0.107)	(0.183)
Frontier	1.997	2.710	1.794	1.524	1.534	1.683	1.864
	(0.474)	(0.339)	(0.276)	(0.156)	(0.178)	(0.233)	(0.509)
Airtran		1.860	1.461	1.352	1.299		1.517
		(0.239)	(0.136)	(0.110)	(0.033)		(0.264)
Spirit	2.221	1.865	1.447	1.501	1.600	1.562	1.622
	(0.090)	(0.211)	(0.205)	(0.156)	(0.111)	(0.118)	(0.250)
Major Airlines	1.741	1.844	1.510	1.543	1.623	1.678	1.649
	(0.272)	(0.344)	(0.252)	(0.249)	(0.243)	(0.247)	(0.295)
Regional Airlines	2.060	2.085	1.607	1.549	1.444	1.298	1.721
	(0.494)	(0.504)	(0.321)	(0.295)	(0.336)	(0.267)	(0.491)
Industry	1.671	1.753	1.435	1.554	1.625	1.705	1.617
	(0.104)	(0.095)	(0.103)	(0.065)	(0.085)	(0.077)	(0.139)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification detailed in Online Appendix J.2, which incorporates a control for quality as discussed in the text.



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

(q) Regional (Average)

Figure OA.16: Markups - Selected Airlines. This figure shows the evolution of markups over time for selected airlines under a specification that includes a control for quality in the production function. Panel (q) plots the average (output-weighted) markup for regional carriers.

K Efficient Bargaining

The baseline specification assumes that firms cannot influence wages when making labor decisions at time t. This assumption is motivated by institutional features of the U.S. airline industry, where labor markets are highly unionized and compensation is determined through multiyear collective bargaining agreements (see, e.g., Borenstein and Rose 2013). These long-term contracts fix wage rates in advance, so when firms decide how much labor to employ, wages are effectively predetermined. This setting aligns with a right-to-manage bargaining model, in which unions and firms first negotiate wages, and firms subsequently choose employment levels given those wages (see, e.g., Doraszelski and Jaumandreu 2019). Under this model, firms operate along a labor demand curve, with the marginal revenue product of labor equating to the fixed wage.

In this section, I examine the robustness of the main results using an alternative framework of efficient bargaining, in which wages and employment are jointly determined through negotiations between unions and firms. Under this framework, the outcome must lie on the efficient contract curve, and—under fairly general conditions—employment is set to the right of the standard labor demand curve.

Implementing this model requires additional structural assumptions. In particular, I assume that the firm chooses all variable inputs other than labor after wage negotiations with the union have concluded. In addition, it is necessary to specify preferences for the union, described by a utility function $U_i(W_{it}^L, L_{it}, \bar{W}_{it}^L)$, quasi-concave in its arguments, and where $\bar{W}_{it}^L$ represents a measure of outside wage opportunities. The union and firm are assumed to bargain over wages and employment to maximize a Nash product. More specifically, the bargaining problem solves:

$$(W_{it}^L, L_{it}) = \arg\max \ [U_i(W_{it}^L, L_{it}, \bar{W}_{it}^L)]^{\theta}[\Pi_{it}(W_{it}^L, L_{it}, K_{it}, \mathbb{X}_{it})]^{1-\theta} \tag{OA.38}$$

where θ represents the bargaining weight of the union. A Pareto efficient bargain requires that employment-wage combinations lie along the contract curve, defined by:

$$\frac{\frac{\partial U_i}{\partial L_{it}}}{\frac{\partial U_i}{\partial W_{it}^L}} = \frac{\frac{\partial \Pi_{it}}{\partial L_{it}}}{\frac{\partial \Pi_{it}}{\partial W_{it}^L}} \tag{OA.39}$$

Given the assumed technology of production, the contract curve can be rewritten as:

$$\frac{\frac{\partial U_i}{\partial L_{it}}}{\frac{\partial U_i}{\partial W_{it}^L}} = \frac{\frac{\partial Q_{it}}{\partial L_{it}}(P_{it} - \frac{\partial P_{it}}{\partial Q_{it}}Q_{it} - \sum_{X\in\mathbb{X}}\frac{W_{it}^X}{\gamma^x}) - W_{it}^L}{-L_{it}} \tag{OA.40}$$

Equation OA.40 can be rewritten to obtain a firm-level markup equation:

$$\mathcal{M}_{it} = \frac{R_{it}}{\frac{E^L_{it}(1-h_{it})}{\theta^L_{it}} + \sum_{X\in\mathbb{X}} E^X_{it}} \tag{OA.41}$$

where $h_{it} = \frac{\partial U_i/\partial L_{it}}{\partial U_i/\partial W^L_{it}} \frac{L_{it}}{W^L_{it}}$ represents the absolute value of the elasticity of wages with respect to employment along the union's indifference curve. Note that when $h_{it} = 0$, this markup equation corresponds to the one employed in the baseline specification, where firms optimize labor demand conditional on fixed wages (i.e., firms remain on their labor demand curves).

An estimate of $\mathcal{M}_{it}$ requires a value of h_{it}, which in turn depends on specifying a functional form for the union's utility function $U_i(W^L_{it}, L_{it}, \bar{W}^L_{it})$, as well as a measure of outside wage opportunities $\bar{W}^L_{it}$. Following Bughin (1993), I assume a conventional Stone-Geary union's utility function; $U_i(W^L_{it}, L_{it}, \bar{W}^L_{it}) = (W^L_{it} - \bar{W}^L_{it})^\sigma L_{it}$.

Under this specification, the term $(1 - h_{it})$ simplifies to:

$$(1 - h_{it}) = 1 - \frac{1}{\sigma} + \frac{1}{\sigma}\left(\frac{\bar{W}^L_{it}}{W^L_{it}}\right)$$

Note that when $\sigma = 1$, the union behaves as a pure rent maximizer—employment depends only on the outside wage, and the contract curve becomes vertical.

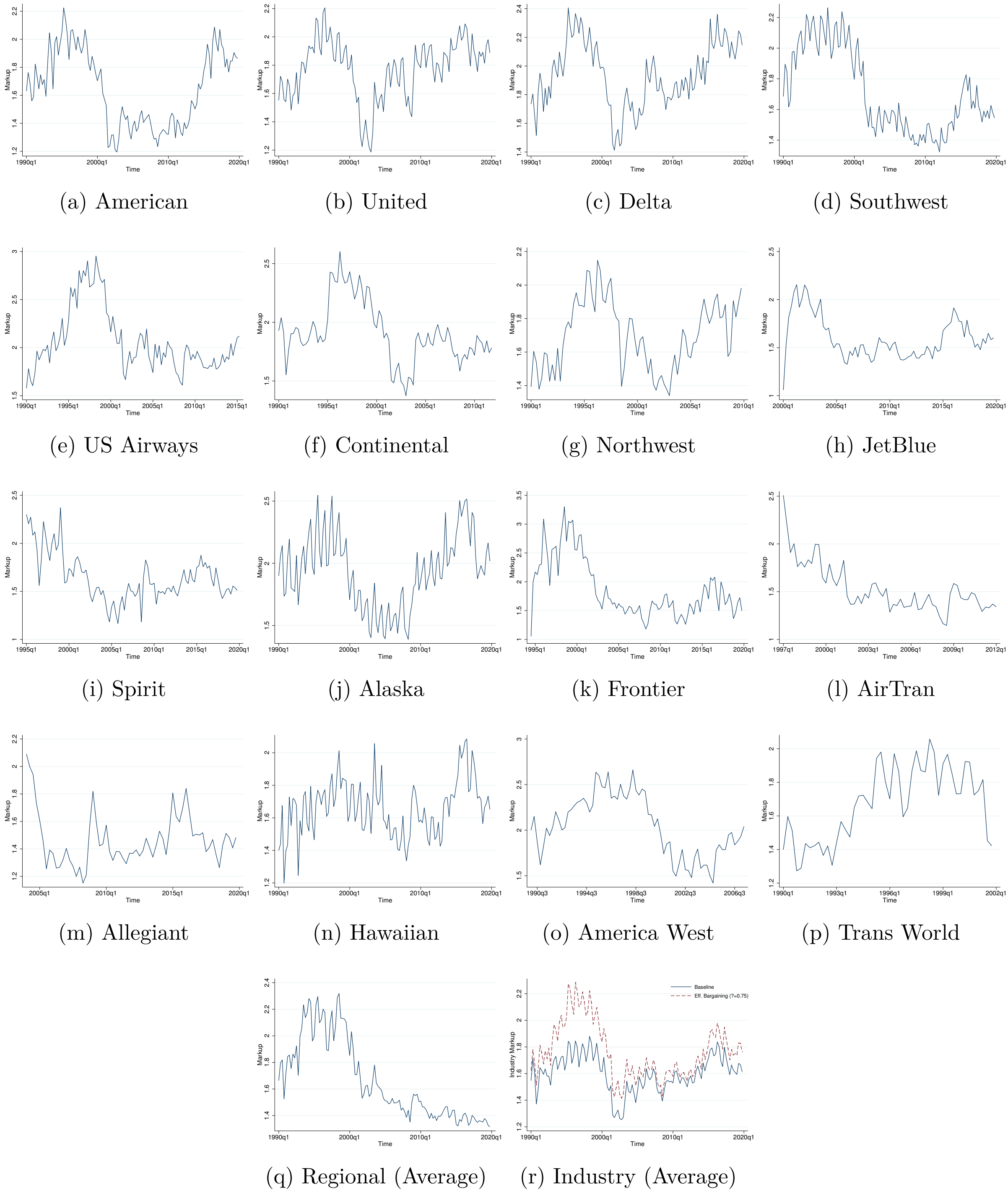
To operationalize $\bar{W}^L_{it}$, I proxy outside wage opportunities using the average wage rate of regional carriers. These carriers exhibit low unionization rates, and the literature supports the use of their wage rates as a reasonable approximation for the opportunity cost of labor for major carriers (see, for example, Hirsch 2007).

Tables OA.16—OA.18 and Figures OA.17—OA.19 report the estimated markups for major carriers under the efficient bargaining model, using three alternative values of σ: 0.75, 0.85, and 1. As expected, these specifications produce higher markup levels than the baseline. Nonetheless, the estimated markup trends under these alternatives closely mirror those of the baseline model. In all cases, the main conclusions remain unchanged.

Table OA.16: Markup Estimates (Eff. Bargaining—σ=0.75) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.830	1.886	1.365	1.379	1.548	1.901	1.649
	(0.193)	(0.129)	(0.110)	(0.074)	(0.202)	(0.100)	(0.269)
Continental	1.945	2.237	1.678	1.801	1.777		1.911
	(0.201)	(0.183)	(0.184)	(0.103)	(0.047)		(0.262)
Delta	1.928	2.128	1.630	1.861	1.961	2.175	1.939
	(0.208)	(0.158)	(0.126)	(0.102)	(0.139)	(0.079)	(0.226)
Northwest	1.685	1.787	1.527	1.831			1.700
	(0.222)	(0.197)	(0.122)	(0.111)			(0.206)
United	1.755	1.909	1.482	1.739	1.870	1.917	1.773
	(0.180)	(0.147)	(0.189)	(0.154)	(0.109)	(0.095)	(0.210)
US Airways	2.031	2.579	1.950	1.882	1.891		2.069
	(0.286)	(0.263)	(0.153)	(0.125)	(0.112)		(0.329)
Trans World	1.543	1.845	1.610				1.674
	(0.193)	(0.128)	(0.202)				(0.221)
Southwest	2.003	2.043	1.574	1.454	1.512	1.619	1.714
	(0.173)	(0.124)	(0.117)	(0.071)	(0.147)	(0.081)	(0.271)
Jet Blue		1.580	1.802	1.475	1.488	1.654	1.601
		(0.388)	(0.252)	(0.077)	(0.128)	(0.128)	(0.218)
Frontier	1.990	2.698	1.796	1.517	1.547	1.728	1.870
	(0.473)	(0.337)	(0.296)	(0.155)	(0.194)	(0.227)	(0.505)
Airtran		1.862	1.459	1.392	1.335		1.533
		(0.243)	(0.129)	(0.117)	(0.028)		(0.255)
Spirit	2.215	1.897	1.490	1.510	1.610	1.586	1.644
	(0.096)	(0.219)	(0.198)	(0.147)	(0.119)	(0.118)	(0.248)
Major Airlines	1.888	2.061	1.620	1.594	1.683	1.781	1.763
	(0.293)	(0.356)	(0.246)	(0.245)	(0.259)	(0.271)	(0.326)
Regional Airlines	2.016	2.042	1.582	1.531	1.427	1.280	1.692
	(0.485)	(0.496)	(0.319)	(0.288)	(0.336)	(0.267)	(0.480)
Industry	1.878	2.053	1.569	1.605	1.684	1.827	1.764
	(0.196)	(0.137)	(0.092)	(0.070)	(0.115)	(0.079)	(0.214)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification detailed in Online Appendix K, which incorporates a model of efficient bargaining (with σ=0.75).



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

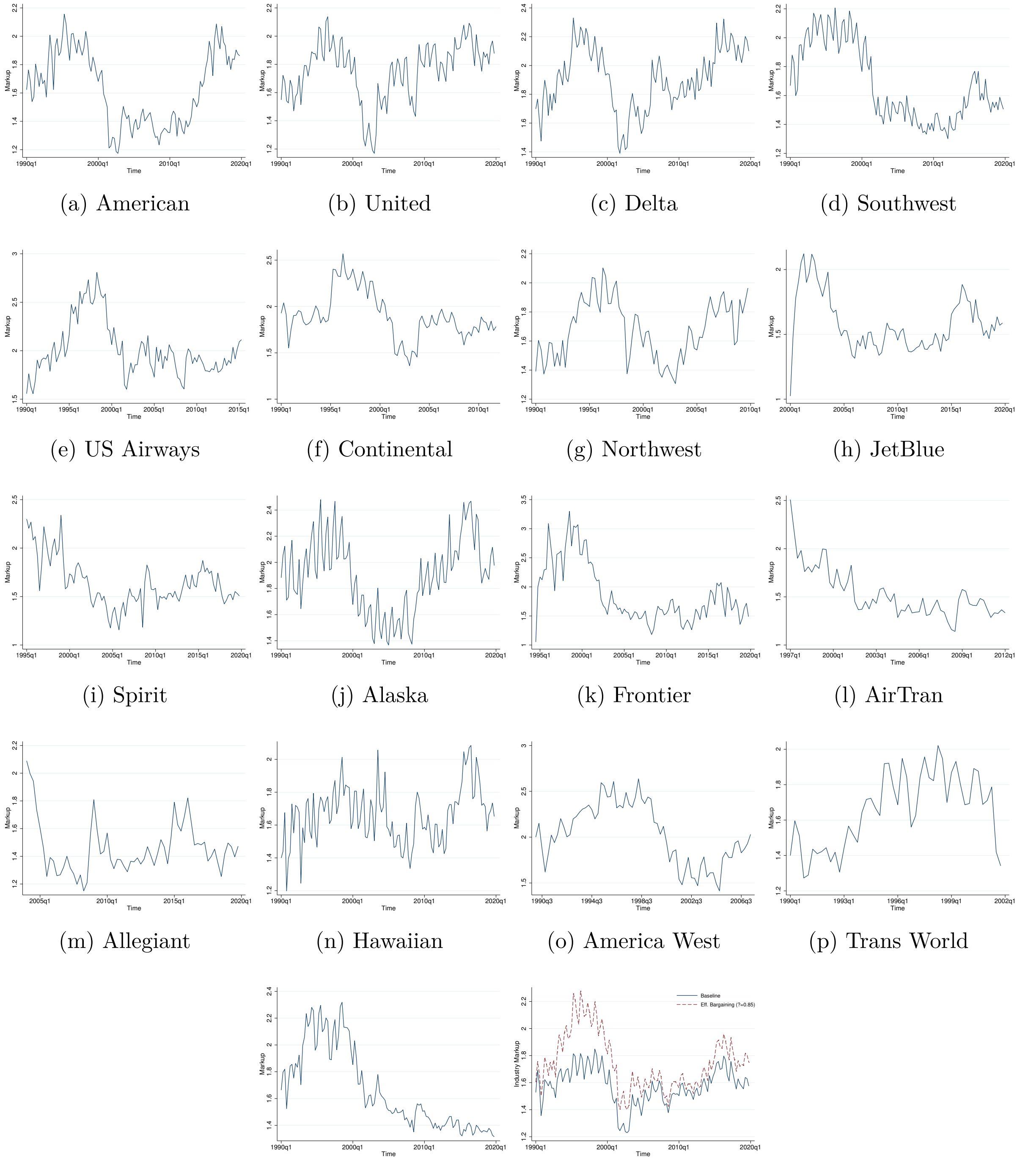
(q) Regional (Average) (r) Industry (Average)

Figure OA.17: Markups—Selected Airlines (Eff. Bargaining—σ=0.75). This figure shows the evolution of markups over time for selected airlines under an efficient bargaining model with $\sigma = 0.75$ (see text for details). Panels (q) and (r) plot the average (output-weighted) markup for regional carriers and all carriers, respectively.

Table OA.17: Markup Estimates (Eff. Bargaining—σ=0.85) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.801	1.854	1.351	1.377	1.548	1.899	1.635
	(0.174)	(0.122)	(0.111)	(0.074)	(0.202)	(0.101)	(0.260)
Continental	1.942	2.211	1.665	1.797	1.777		1.900
	(0.195)	(0.180)	(0.185)	(0.099)	(0.047)		(0.256)
Delta	1.875	2.066	1.599	1.858	1.949	2.141	1.906
	(0.196)	(0.146)	(0.121)	(0.103)	(0.130)	(0.076)	(0.216)
Northwest	1.668	1.760	1.499	1.820			1.679
	(0.208)	(0.189)	(0.122)	(0.108)			(0.202)
United	1.727	1.863	1.467	1.737	1.870	1.909	1.756
	(0.162)	(0.138)	(0.195)	(0.155)	(0.109)	(0.097)	(0.207)
US Airways	1.957	2.439	1.901	1.878	1.887		2.013
	(0.249)	(0.239)	(0.154)	(0.126)	(0.110)		(0.283)
Trans World	1.537	1.812	1.565				1.654
	(0.183)	(0.126)	(0.217)				(0.210)
Southwest	1.969	2.001	1.543	1.422	1.483	1.581	1.679
	(0.163)	(0.118)	(0.113)	(0.067)	(0.138)	(0.079)	(0.265)
Jet Blue		1.548	1.782	1.462	1.477	1.638	1.585
		(0.391)	(0.242)	(0.076)	(0.124)	(0.125)	(0.213)
Frontier	1.990	2.698	1.794	1.517	1.545	1.722	1.868
	(0.473)	(0.337)	(0.293)	(0.155)	(0.192)	(0.227)	(0.505)
Airtran		1.860	1.458	1.387	1.330		1.530
		(0.242)	(0.130)	(0.116)	(0.028)		(0.255)
Spirit	2.214	1.891	1.484	1.508	1.609	1.583	1.640
	(0.095)	(0.217)	(0.199)	(0.148)	(0.118)	(0.118)	(0.247)
Major Airlines	1.865	2.027	1.603	1.586	1.674	1.765	1.746
	(0.282)	(0.344)	(0.243)	(0.244)	(0.255)	(0.265)	(0.316)
Regional Airlines	2.016	2.042	1.582	1.531	1.427	1.280	1.692
	(0.485)	(0.496)	(0.319)	(0.288)	(0.336)	(0.267)	(0.480)
Industry	1.846	2.006	1.549	1.596	1.674	1.808	1.741
	(0.180)	(0.129)	(0.092)	(0.069)	(0.110)	(0.078)	(0.200)

Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification detailed in Online Appendix K, which incorporates a model of efficient bargaining (with σ=0.85).



(a) American (b) United (c) Delta (d) Southwest

(e) US Airways (f) Continental (g) Northwest (h) JetBlue

(i) Spirit (j) Alaska (k) Frontier (l) AirTran

(m) Allegiant (n) Hawaiian (o) America West (p) Trans World

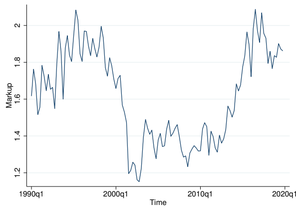
(q) Regional (Average) (r) Industry (Average)

Figure OA.18: Markups—Selected Airlines (Eff. Bargaining—σ=0.85). This figure shows the evolution of markups over time for selected airlines under an efficient bargaining model with $\sigma = 0.85$ (see text for details). Panels (q) and (r) plot the average (output-weighted) markup for regional carriers and all carriers, respectively.

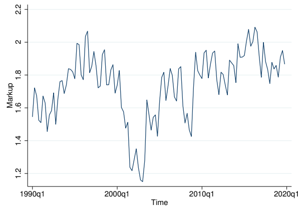
Table OA.18: Markup Estimates (Eff. Bargaining—σ=1) - Summary Statistics

	1992-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019	Total
American	1.770	1.819	1.335	1.374	1.548	1.897	1.620
	(0.156)	(0.114)	(0.114)	(0.073)	(0.202)	(0.101)	(0.252)
Continental	1.938	2.183	1.650	1.792	1.777		1.888
	(0.188)	(0.177)	(0.186)	(0.096)	(0.047)		(0.249)
Delta	1.819	2.001	1.565	1.855	1.936	2.104	1.870
	(0.183)	(0.134)	(0.118)	(0.103)	(0.120)	(0.073)	(0.208)
Northwest	1.650	1.730	1.469	1.809			1.657
	(0.194)	(0.181)	(0.121)	(0.105)			(0.199)
United	1.697	1.814	1.450	1.734	1.870	1.900	1.737
	(0.144)	(0.129)	(0.203)	(0.156)	(0.109)	(0.099)	(0.205)
US Airways	1.881	2.300	1.850	1.873	1.884		1.956
	(0.215)	(0.218)	(0.161)	(0.126)	(0.107)		(0.242)
Trans World	1.530	1.776	1.517				1.631
	(0.173)	(0.126)	(0.233)				(0.200)
Southwest	1.933	1.955	1.509	1.388	1.451	1.540	1.642
	(0.151)	(0.112)	(0.108)	(0.063)	(0.128)	(0.077)	(0.259)
Jet Blue		1.514	1.760	1.447	1.465	1.620	1.568
		(0.394)	(0.232)	(0.074)	(0.119)	(0.122)	(0.207)
Frontier	1.990	2.697	1.792	1.517	1.543	1.716	1.866
	(0.473)	(0.337)	(0.290)	(0.155)	(0.190)	(0.228)	(0.505)
Airtran		1.858	1.458	1.380	1.324		1.526
		(0.241)	(0.130)	(0.115)	(0.029)		(0.256)
Spirit	2.213	1.884	1.477	1.506	1.607	1.579	1.636
	(0.094)	(0.214)	(0.199)	(0.149)	(0.117)	(0.118)	(0.247)
Major Airlines	1.840	1.992	1.585	1.578	1.664	1.749	1.727
	(0.273)	(0.335)	(0.241)	(0.243)	(0.251)	(0.259)	(0.308)
Regional Airlines	2.016	2.042	1.582	1.531	1.427	1.280	1.692
	(0.485)	(0.496)	(0.319)	(0.288)	(0.336)	(0.267)	(0.480)
Industry	1.811	1.958	1.527	1.587	1.664	1.788	1.716
	(0.164)	(0.121)	(0.093)	(0.068)	(0.106)	(0.077)	(0.187)

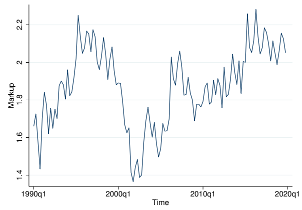
Note: This table reports, for different time periods, the estimated average markup by carrier or carrier type (i.e., major and regional airlines). The last row (i.e., Industry) reports the output-weighted average markup at the industry level. Standard deviations are reported in parentheses below their means. Markups are estimated using the specification detailed in Online Appendix K, which incorporates a model of efficient bargaining (with σ=1).



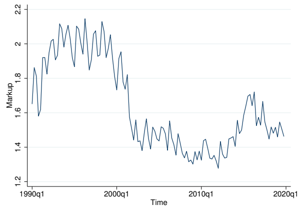
(a) American



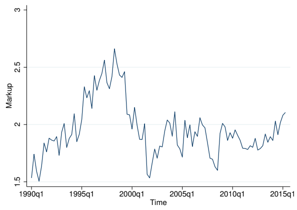
(b) United



(c) Delta

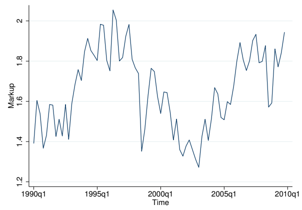


(d) Southwest

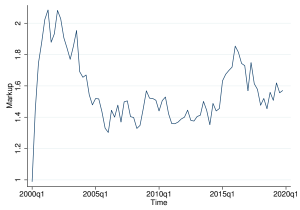


(e) US Airways

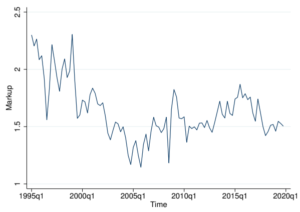
(f) Continental



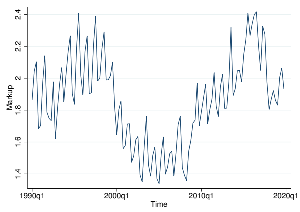
(g) Northwest



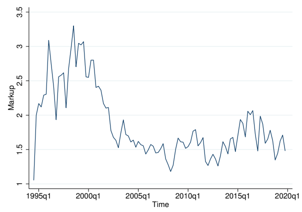
(h) JetBlue



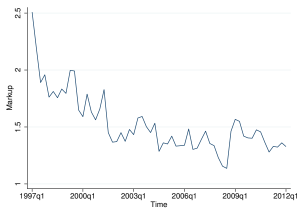
(i) Spirit



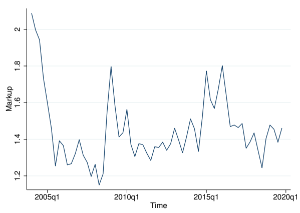
(j) Alaska



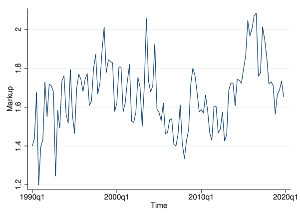
(k) Frontier



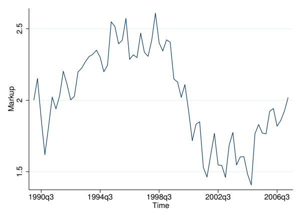
(l) AirTran



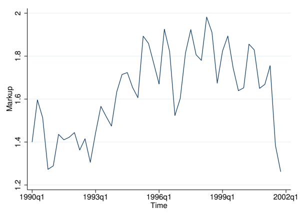
(m) Allegiant



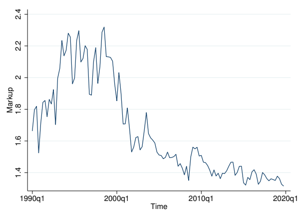
(n) Hawaiian



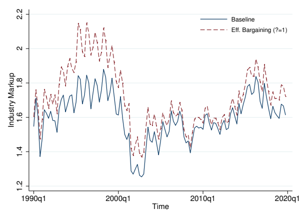
(o) America West



(p) Trans World



(q) Regional (Average)



(r) Industry (Average)

Figure OA.19: Markups—Selected Airlines (Eff. Bargaining—σ=1). This figure shows the evolution of markups over time for selected airlines under an efficient bargaining model with $\sigma = 1$ (see text for details). Panels (q) and (r) plot the average (output-weighted) markup for regional carriers and all carriers, respectively.

L Robustness: Supply-Side Estimates with Alternative Benchmarks

This section tests the robustness of the supply estimates reported in Section 5.2.4 to the assumption of Nash-Bertrand competition in the baseline period (i.e., $\kappa = 0$ in 2012). Specifically, I re-estimate the model imposing alternative nonzero values of κ in 2012 (0.1, 0.2, 0.3, 0.4, and 0.5) and obtain the corresponding post-2012 estimates. The results, reported in Table OA.19, show that for low-cost and smaller airlines the estimates remain close to the 2012 baseline values in most years, increasing only in 2015-2016, consistent with a mild softening of price competition in that period. For large carriers, the estimates are statistically different from the 2012 baseline values and follow the same pattern as in the baseline—gradually increasing until 2016 and declining thereafter—leading to rejection of the null of no change in conduct.

Table OA.20 reports a robustness check based on the level moment conditions—i.e., equation (22) in the paper. The results confirm the baseline pattern: small carriers show evidence of a temporary conduct change in 2015-2016, whereas large carriers consistently display high but varying degrees of internalization behavior, reaching a peak in 2016 before moderating thereafter. Table OA.21 reports, by carrier size and year for 2012-2019, average marginal cost estimates from the production model (columns 1 and 2), and compares them with the corresponding model-implied average marginal costs obtained under the estimated supply model based on level moment conditions (columns 3 and 4) and under a Nash-Bertrand pricing benchmark (columns 5 and 6). The results indicate that the estimated-conduct model tracks the level and path of the production-based marginal-cost series more closely than the Nash-Bertrand specification.

Table OA.19: Conduct Parameter Estimates under Alternative Benchmarks

	2012 Internalization: 0.1		**2012 Internalization: 0.2**		**2012 Internalization: 0.3**		**2012 Internalization: 0.4**		**2012 Internalization: 0.5**	
	Small Carriers	Large Carriers	Small Carriers	Large Carriers	Small Carriers	Large Carriers	Small Carriers	Large Carriers	Small Carriers	Large Carriers
Year	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
2013	0.061	0.002	0.163	0.108	0.266	0.223	0.368	0.337	0.473	0.450
	(0.035)	(0.042)	(0.031)	(0.035)	(0.027)	(0.029)	(0.023)	(0.025)	(0.020)	(0.020)
2014	0.046	0.371	0.125	0.437	0.209	0.506	0.296	0.578	0.387	0.653
	(0.034)	(0.027)	(0.031)	(0.025)	(0.029)	(0.023)	(0.026)	(0.020)	(0.024)	(0.018)
2015	0.152	0.651	0.212	0.688	0.279	0.728	0.356	0.771	0.440	0.816
	(0.040)	(0.020)	(0.039)	(0.019)	(0.038)	(0.018)	(0.036)	(0.016)	(0.034)	(0.014)
2016	0.299	0.844	0.370	0.874	0.445	0.907	0.530	0.942	0.611	0.981
	(0.057)	(0.026)	(0.052)	(0.024)	(0.045)	(0.022)	(0.037)	(0.020)	(0.029)	(0.018)
2017	0.008	0.811	0.076	0.846	0.162	0.882	0.287	0.916	0.412	0.953
	(0.089)	(0.041)	(0.086)	(0.039)	(0.083)	(0.036)	(0.076)	(0.034)	(0.064)	(0.031)
2018	1.1e-04	0.486	1.3e-04	0.549	1.7e-04	0.616	2.9e-04	0.687	0.003	0.763
	(0.088)	(0.064)	(0.074)	(0.059)	(0.062)	(0.054)	(0.054)	(0.048)	(0.053)	(0.043)
2019	1.5e-04	0.635	1.9e-04	0.687	3.0e-04	0.742	0.001	0.802	0.116	0.851
	(0.081)	(0.055)	(0.075)	(0.051)	(0.073)	(0.047)	(0.075)	(0.043)	(0.073)	(0.039)

Note: This table reports the estimates of the conduct parameters κ under alternative values imposed on conduct in 2012. Columns (1) and (2) report, by year, the parameter estimates for small and large carriers, respectively, when κ is set to 0.1 in 2012. Columns (3) and (4) report, by year, the parameter estimates for small and large carriers, respectively, when κ is set to 0.2 in 2012. Columns (5) and (6) report, by year, the parameter estimates for small and large carriers, respectively, when κ is set to 0.3 in 2012. Columns (7) and (8) report, by year, the parameter estimates for small and large carriers, respectively, when κ is set to 0.4 in 2012. Columns (9) and (10) report, by year, the parameter estimates for small and large carriers, respectively, when κ is set to 0.5 in 2012. Cluster-robust (firm-clustered) standard errors are reported in parentheses.

Table OA.20: Conduct Parameter Estimates

	Small Carriers	Large Carriers
Year	**(1)**	**(2)**
2012	0.145	0.466
	(0.044)	(0.097)
2013	0.029	0.417
	(0.052)	(0.111)
2014	0.006	0.661
	(0.046)	(0.078)
2015	0.137	0.821
	(0.068)	(0.054)
2016	0.254	0.957
	(0.092)	(0.036)
2017	0.001	0.945
	(0.114)	(0.038)
2018	8.5e-05	0.682
	(0.112)	(0.041)
2019	1.1e-04	0.808
	(0.112)	(0.043)

Note: This table reports the estimates of the conduct parameters κ using level moment conditions—i.e., equation (22) of the paper. Columns (1) and (2) report, by year, the parameter estimates for small and large carriers, respectively. See the text for additional details. Cluster-robust (firm-clustered) standard errors are reported in parentheses.

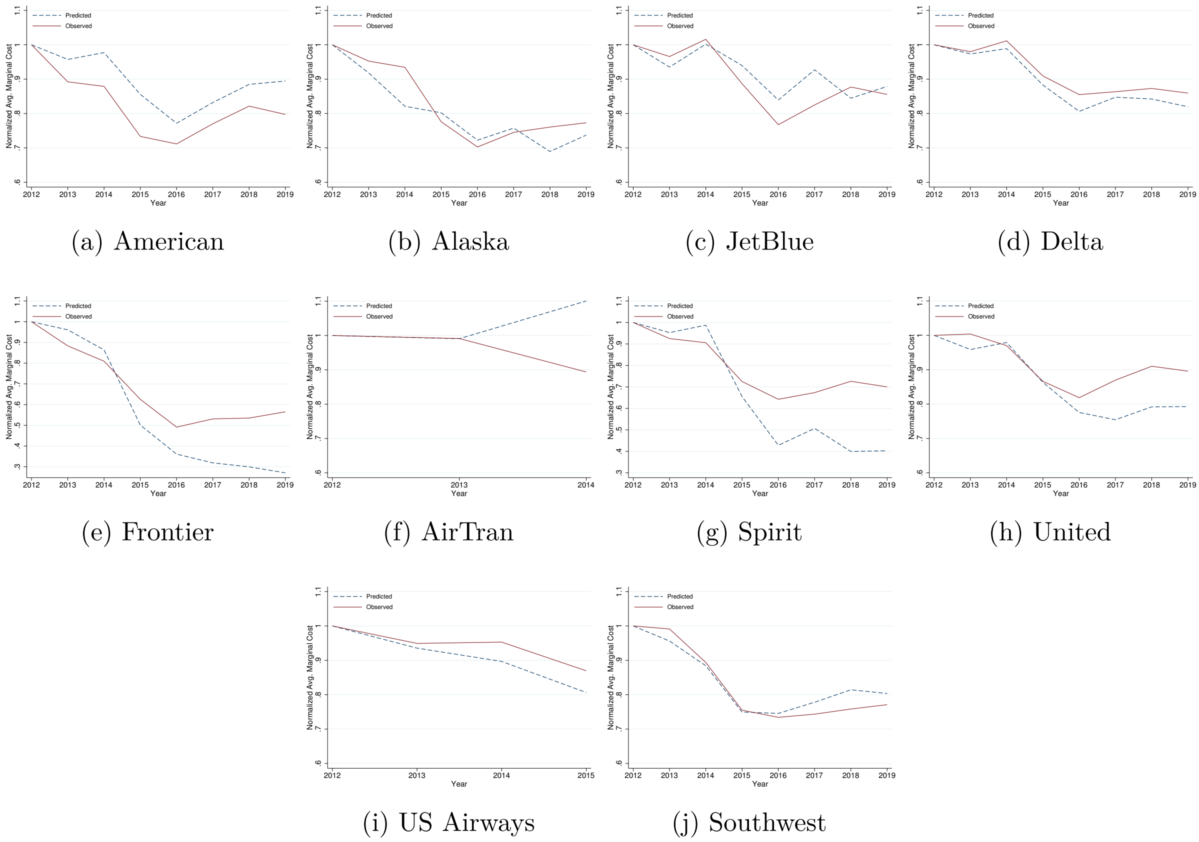
Table OA.21: Production-Based and Conduct-Implied Average Marginal Costs ($/RPM), 2012-2019

	Production Model		**Estimated Supply Model**		**Nash-Bertrand Competition**	
	Small Carriers	Large Carriers	Small Carriers	Large Carriers	Small Carriers	Large Carriers
Year	(1)	(2)	(3)	(4)	(5)	(6)
2012	0.119	0.159	0.114	0.156	0.119	0.168
	(0.011)	(0.011)	(0.028)	(0.025)	(0.027)	(0.024)
2013	0.111	0.153	0.111	0.151	0.112	0.162
	(0.012)	(0.013)	(0.024)	(0.022)	(0.024)	(0.021)
2014	0.109	0.148	0.108	0.149	0.108	0.171
	(0.015)	(0.008)	(0.021)	(0.021)	(0.021)	(0.017)
2015	0.090	0.129	0.085	0.137	0.090	0.166
	(0.016)	(0.009)	(0.034)	(0.018)	(0.033)	(0.017)
2016	0.077	0.124	0.071	0.126	0.079	0.157
	(0.017)	(0.008)	(0.037)	(0.014)	(0.037)	(0.012)
2017	0.083	0.129	0.076	0.130	0.076	0.159
	(0.018)	(0.005)	(0.042)	(0.016)	(0.042)	(0.013)
2018	0.086	0.134	0.069	0.135	0.069	0.153
	(0.019)	(0.004)	(0.039)	(0.013)	(0.039)	(0.011)
2019	0.086	0.132	0.070	0.133	0.070	0.157
	(0.018)	(0.003)	(0.043)	(0.013)	(0.043)	(0.010)

Note: This table reports, by year, average marginal cost estimates from the production model (columns 1 and 2), the estimated supply model based on level moment conditions (columns 3 and 4), and an alternative model that assumes Nash-Bertrand price competition (columns 5 and 6). Columns 1, 3, and 5 present results for small carriers, while columns 2, 4, and 6 present results for large carriers. In columns 1 and 2, values are yearly averages by carrier size. Averages in columns 3 through 6 are computed from firm-level objects, which are themselves obtained as weighted averages of product-level measures using the weights prescribed by the production model. Marginal costs are expressed in 2019 dollars per revenue passenger mile (RPM). Standard deviations are reported in parentheses.

M Model Fit: Supply Model

This section assesses the fit of the baseline supply model estimated in Section 5.2.4 using ticket data from 2012 to 2019, the period over which the demand and pricing models are estimated. In this specification, conduct is set to Nash-Bertrand competition in 2012 and κ is estimated for the post-2012 period. Figure OA.20 plots, for the airlines that enter the moment conditions, the evolution of the model-implied average marginal costs under the estimated baseline supply model ("Predicted") and the corresponding production-based firm-level average marginal costs ("Observed"). Both series are normalized to their 2012 values to facilitate comparison. The model exhibits a strong fit: in most cases, the predicted average marginal cost series closely matches the observed series over time.



(a) American (b) Alaska (c) JetBlue (d) Delta

(e) Frontier (f) AirTran (g) Spirit (h) United

(i) US Airways (j) Southwest

Figure OA.20: Model Fit. This figure shows, for airlines included in the moment conditions, the evolution of average marginal costs recovered from the estimated (baseline) supply model and ticket data ("Predicted") alongside the corresponding firm-level marginal costs recovered from production data ("Observed").

Table OA.22 complements Figure OA.20 by reporting, by carrier size and year for 2012-2019, average marginal cost estimates from the production model (columns 1 and 2), together with the corresponding model-implied average marginal costs under the baseline estimated supply model (columns 3 and 4) and under a Nash-Bertrand pricing benchmark (columns 5 and 6). Because the baseline identifies κ from changes relative to 2012 rather than from level moment conditions, this comparison in levels is descriptive. Even so, the estimated supply model tracks the production-based marginal-cost series more closely than the Nash-Bertrand benchmark, especially for large carriers. Online Appendix L reports the analogous comparison under the alternative supply specification estimated from level moment conditions.

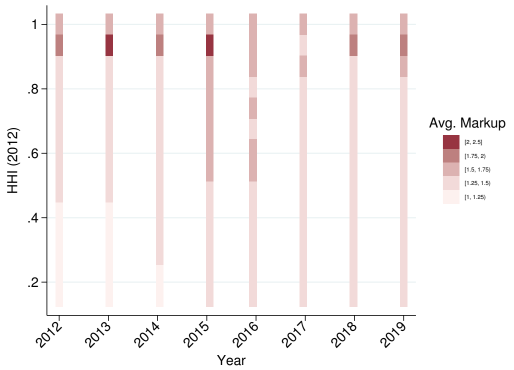
Table OA.22: Production-Based and Conduct-Implied Average Marginal Costs ($/RPM), 2012-2019

	Production Model		**Estimated Supply Model**		**Nash-Bertrand Competition**	
	Small Carriers	Large Carriers	Small Carriers	Large Carriers	Small Carriers	Large Carriers
Year	(1)	(2)	(3)	(4)	(5)	(6)
2012	0.119	0.159	0.119	0.168	0.119	0.168
	(0.011)	(0.011)	(0.027)	(0.024)	(0.027)	(0.024)
2013	0.111	0.153	0.112	0.162	0.112	0.162
	(0.012)	(0.013)	(0.024)	(0.021)	(0.024)	(0.021)
2014	0.109	0.148	0.108	0.163	0.108	0.171
	(0.015)	(0.008)	(0.021)	(0.019)	(0.021)	(0.017)
2015	0.090	0.129	0.087	0.147	0.090	0.166
	(0.016)	(0.009)	(0.034)	(0.018)	(0.033)	(0.017)
2016	0.077	0.124	0.072	0.133	0.079	0.157
	(0.017)	(0.008)	(0.037)	(0.013)	(0.037)	(0.012)
2017	0.083	0.129	0.076	0.138	0.076	0.159
	(0.018)	(0.005)	(0.042)	(0.015)	(0.042)	(0.013)
2018	0.086	0.134	0.069	0.143	0.069	0.153
	(0.019)	(0.004)	(0.039)	(0.012)	(0.039)	(0.011)
2019	0.086	0.132	0.070	0.142	0.070	0.157
	(0.018)	(0.003)	(0.043)	(0.012)	(0.043)	(0.010)

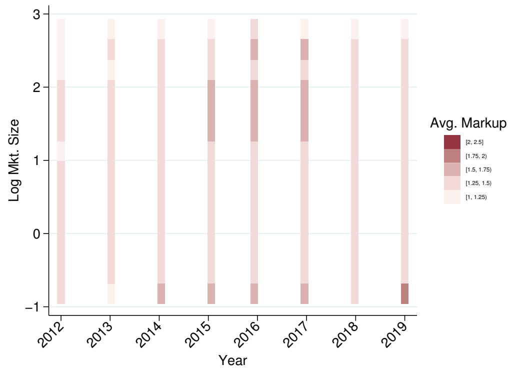
Note: This table reports, by year, average marginal cost estimates from the production model (columns 1 and 2), the estimated (baseline) supply model described in Section 5.2.2 (columns 3 and 4), and an alternative model that assumes Nash-Bertrand price competition (columns 5 and 6). The baseline κ parameters are identified from normalized changes relative to 2012; the level comparison reported here is therefore descriptive. Columns 1, 3, and 5 present results for small carriers, while columns 2, 4, and 6 present results for large carriers. In columns 1 and 2, values are yearly averages by carrier size. Averages in columns 3 through 6 are computed from firm-level objects, which are themselves obtained as weighted averages of product-level measures using the weights prescribed by the production model. Marginal costs are expressed in 2019 dollars per revenue passenger mile (RPM). Standard deviations are reported in parentheses.

N Average Markups by Market Characteristics

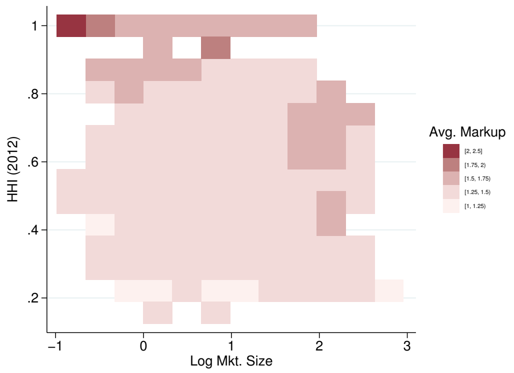
Figure OA.21 reports average markups from the estimated supply model (baseline estimates) across predetermined market characteristics. Panel (a) shows that markups are, on average, higher in markets with greater concentration (2012 HHI above 0.8), while most of the variation over time occurs in markets with 2012 HHI values between 0.3 and 0.7. Panel (b) indicates that average markups exhibit increases over time more pronounced in both larger and very small markets. The joint-distribution plots in panels (c) and (d) reveal that the highest markups occur in large markets, in markets combining high concentration with small size, and in short-haul markets.



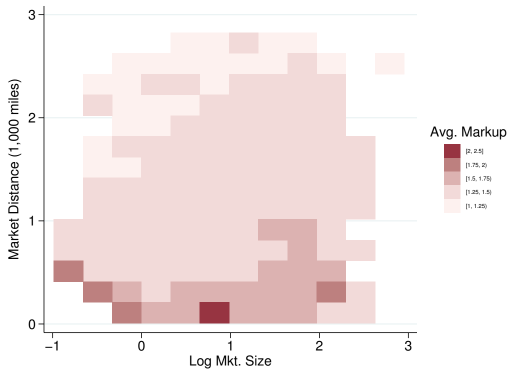
(a) Market Concentration



(b) Market Size



(c) Market Concentration and Size



(d) Market Distance and Size

Figure OA.21: Average Markups (baseline estimates). This figure shows average markups from the estimated supply model—baseline estimate—by predetermined (pre-period) market characteristics. Panels (a) and (b) plot the time path by the 2012 Herfindahl-Hirschman Index (HHI) and log market size (in hundreds of thousands), respectively. Panel (c) shows averages across joint bins of 2012 HHI and log market size, and panel (d) across joint bins of market distance (thousands of miles) and log market size.

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