DOI: 10.1111/fire.12293

ORIGINAL ARTICLE

The Financial Review WILEY

Price asymmetries in the US airline industry

Yi Jiang[1] | Tingting Que[2] | Miaomiao Yu[3]

[1]Mihaylo College of Business and Economics, California State University, Fullerton, Fullerton, California, USA

[2]Faculty of Business Administration, University of Macau, Macau, China

[3]EJ Ourso College of Business, Louisiana State University, Baton Rouge, Louisiana, USA

Correspondence
Faculty of Business Administration, University of Macau, Macau, China.
Email: tingtingque@um.edu.mo

Abstract

We document price asymmetries in the US airline industry. We find evidence that the average airfare increases in response to rising fuel cost but does not decrease in response to declining fuel cost. In searching for the cause of price asymmetries, we find that common ownership, measured by overlapping institutional investors, is associated with greater price asymmetry in the airline industry. To mitigate endogeneity concerns, we exploit the variation in common ownership induced by the financial institution mergers and conduct a difference-in-differences test to establish the causal effects of common ownership on price asymmetry in the airline industry. In addition, airlines in highly concentrated markets exhibit more price asymmetries than those in low concentration markets. Our results support focal price tacit collusion as an important determinant of asymmetric pricing. Furthermore, first-class airfares are shown to decrease more slowly than economy-class airfares in response to fuel cost decreases, which supports consumer search as the mechanism driving asymmetric pricing.

KEYWORDS
common ownership, consumer search, focal price tacit collusion, price asymmetry

JEL CLASSIFICATION
G30, L11, L13, L93

1 INTRODUCTION

We document asymmetric airline ticket price adjustment to fuel cost changes in the US airline industry between 2001 and 2016, that is, airfares increase in response to a rise in fuel cost but do not decrease in response to a decline in fuel cost. Such asymmetric pricing to fluctuations in fuel cost is important for airlines, consumers, and policy makers to understand. Jet fuel cost represents a major cost for airlines (Koopmans and Lieshout, 2016), and volatility in fuel cost levels imposes significant risk to the airline industry (Borenstein, 2011).[1] However, consumers and policy makers have expressed concerns about possible anticompetitive dynamics during the US Department of Justice's investigation of potential airline price collusion, in which major US airlines were accused of having saved billions of dollars on their fuel expenses without passing on even a portion of these savings to passengers (Harwell et al., 2015).

In search of the cause of price asymmetries, we document two important determinants of asymmetric pricing: focal price tacit collusion and consumer search. Focal price tacit collusion refers to the practice of firms using past prices as a focal point to collude, that is, if the cost drops then the previous price is sustained until a firm breaks the agreement and triggers a price war; conversely, if cost increases then firms raise their price to maintain a positive margin in accordance with the collusive agreement (Borenstein et al., 1997; Lewis, 2011).

Common ownership (competing firms with overlapping ownership) has been shown to be associated with increases in the likelihood of collusion (Azar et al., 2018a, 2018b, 2018c; Azar et al., 2019; He & Huang, 2017; Pawliczek et al., 2019; Levenstein & Suslow, 2006; Stigler, 1964). If competing firms with common owners have reduced incentive to temper collusive selling price behavior, then we expect that asymmetric pricing is more pronounced when firms have common ownership, measured by overlapping institutional investors (institutional investors of a firm that also own shares of peer firms).[2]

Common ownership refers to the investment practice of investors holding investment positions in more than one company competing in the same sector. Financial investors often have overlapping ownership interests in a substantial fraction of the equity of rival firms in the airline industry. For example, Vanguard owns 6.12% of the equity in Southwest Airlines, and 5.4% of the equity in United Airlines, a rival company. Common ownership between airlines facilitates such practices as signing anti-competitive agreements or passing sensitive information between commonly owned competitors, thereby nullifying direct competition, which in turn results in higher profits for all involved. If investors holding financial stakes in multiple airlines have reduced incentive to foster competition among those airlines, we would expect the likelihood of tacit collusion to increase in common ownership, which is associated with a greater price asymmetry effect in the airline industry. To test this hypothesis, we construct a measure of common ownership (*Common institutional holdings*) from 13F filings using Thomson-Reuters institutional holdings data, which is similar to those from Cohen and Frazzini (2008) and Jiang et al. (2016). We compute this as the number of institutional investors reporting holdings in an airline company as well as of any "same-market" peers in the year, divided by the number of institutional investors of the airline company. This measure is based on the idea that competing firms with common owners may lack the incentive to temper collusive selling price behavior in response to fluctuations in fuel cost. We predict that asymmetric price adjustment is more severe in firms with more overlapping investors. The empirical evidence is consistent with our prediction: price asymmetry is more pronounced in airlines with more overlapping institutional investors.[3]

[1] In 2014, fuel cost composed around 20–50% of airlines' total costs.

[2] A large body of literature has studied the potential influence of institutional investors on firm value, mutual fund performance and stock returns (e.g., Riley, 2021; Tosun, 2019; Jiang and Yüksel, 2019; and Jiang et al., 2021).

[3] For robustness, we also examine two other measures of common ownership: common mutual fund holdings and common analyst coverage. Common mutual fund holdings is the number of actively-managed equity mutual funds reporting holdings on an airline company as well as on any of the "same-market" peers in the year, divided by the number of actively-managed equity mutual funds with holdings in the airline company. The data are from Thomson-Reuters mutual fund holdings. Common analyst coverage is the number of analysts providing EPS forecasts for an airline company as well as on any of the "same-market" peers in the year, divided by the number of analysts covering the airline company. The analyst data are retrieved from the IBES Detailed History File. The results are robust: the price asymmetry effect is more pronounced in firms with more common mutual fund holdings and more overlapping analysts. These results are available from the authors upon request.

To mitigate endogeneity concerns of common ownership, we run a difference-in-differences test based on the quasi-natural experiment of financial institution mergers following He and Huang (2017). Since financial institutions are unlikely to merge for reasons related to any individual firm's performance and characteristics in their portfolio (He and Huang (2017)) and airline stocks typically constitute only a small fraction of these institutions' portfolios (Azar, Schmalz & Tecu, 2018a, 2018b, 2018c; Sun et al., 2021), these financial institutions' mergers exert an arguably exogenous shock to the common ownership of the merging institutions' portfolios. We exploit the variation in common ownership generated by these mergers to establish the causal effects of common ownership on price asymmetry in the airline industry. Our results suggest that the price asymmetry is more pronounced in firms that experience an increase in common ownership induced by these mergers. The empirical evidence further corroborates the previous result that common ownership by institutional blockholders is associated with greater price asymmetry in the airline industry.

The likelihood of collusion also increases with market concentration measured by the Herfindahl-Hirschman Index (HHI), which captures the number of firms and their relative share within the market. HHI is calculated as the sum of squared market share of each firm competing in the same market, where market share is the percentage of each firm's sales over total market sales. We expect pricing asymmetry to be more pronounced in a high concentration market than in a low concentration market. We find evidence consistent with our hypothesis.

Overall, the two factors we document (common ownership and market concentration) support focal price tacit collusion as an explanation for asymmetric pricing. Our findings suggest firms with common ownership and/or in high concentration market may lack the incentive to temper collusive selling price behavior.

In addition to the focal price tacit collusion explanation, formal models of consumer search driving asymmetric pricing have been developed. Yang and Ye (2008), Tappata (2009), and Lewis (2011) all show that consumer search can lead to equilibrium asymmetric pricing if consumers are more likely to search following a cost increase than a cost decrease. The models in Yang and Ye (2008) and Tappata (2009) both suggest that higher search cost leads to less search (i.e., as search cost increases, a given consumer searches less). Thus, firms will have little incentive to lower their prices in response to a negative cost shock if their consumers are not actively searching. As a result, the prices will decline more gradually for higher search cost consumers than for lower search cost consumers. An additional implication of Yang and Ye (2008) is that if the proportion of zero search cost shoppers decreases, then prices will adjust downward more slowly in response to a negative cost shock. Given that consumers who purchase first-class tickets generally earn higher incomes, and are less price sensitive than those who purchase economy-class tickets, it is reasonable to assume that first-class customers are typified by higher search cost and are less likely to shop around for the lowest possible price. If asymmetric pricing is a consequence of consumer search, then first-class airfares should fall more slowly than economy-class airfares in response to fuel cost decreases. Our results support this hypothesis.

A variety of studies involving gasoline (Karrenbrock, 1991; Borenstein, Cameron and Gilbert, 1997), bank deposit rates (Neumark and Sharpe, 1992; Jackson, 1997), and municipal bonds (Green et al., 2010) all find that output prices respond faster to input price increases than to decreases. We add to the literature by establishing the presence of price asymmetry in the airline industry in a comprehensive sample of all US airlines between 2001Q1 and 2016Q4. We also improve the test by matching average airfare per mile flown with the actual jet fuel cost normalized by revenue-passenger miles, which are hand-collected from TranStats Database of the Bureau of Transportation Statistics (BTS).

Since Borenstein, Cameron and Gilbert (1997) proposed focal price tacit collusion as a critical determinant of asymmetric pricing, Verlinda (2008) and Lewis (2011) both provide supporting empirical evidence in the retail gasoline industry. We contribute to the literature by showing that airlines in high concentration markets (measured by HHI) exhibit more price asymmetry than those in low concentration markets, which supports the focal price tacit collusion explanation.

Azar, Schmalz & Tecu (2018a, 2018b, 2018c) show common ownership motivates anti-competitive practices and leads to higher prices in the airline industry. Azar, Raina and Schmalz (2019) report similar findings for the banking industry. Dennis et al. (2021) revisit the anti-competitive pricing effect and argue that the prior evidence could be explained by the market share component of their common ownership measure in prior literature. Our paper focuses on the airline industry and examines the specific pricing practice of asymmetric pricing. We contribute to this growing body of work by showing that competing firms with common owners have reduced incentive to temper collusive selling price behavior, which leads to price asymmetries in response to changing fuel cost. We focus on focal price tacit collusion as an important determinant of asymmetric pricing, and our paper speaks to an ongoing debate among policy makers regarding how to best promote competition in the airline industry.

Besides single-industry studies, a growing body of work investigates the relationship between common ownership and product market competition (He & Huang, 2017; Koch et al., 2021; Lewellen & Lowry, 2021; Lopez & Vives, 2019; Gilje et al., 2020; Abdoh & Liu, 2021). He and Huang (2017) examine the impact of institutional common ownership on product market behavior and performance and find that common-held firms experience significantly higher market share growth than control firms. Koch, Panayides and Thomas (2021) construct a common ownership concentration measure which combines a firm's market share, common institutional ownership, and voting controls of the firm. Lewellen and Lowry (2021) also modify the empirical measure of common ownership. The latter two studies find little robust evidence that common ownership affects firm behavior or its outcome in the product market. Our work complements these studies by examining a strategic asymmetric pricing behavior in the product market. Our findings indicate when firms within the same industry have overlapping institutional investors, common ownership may induce focal price tacit collusions.

Lewis (2011), Hastings and Shapiro (2013), and Remer (2015) have provided empirical evidence in support of consumer search in the retail gasoline industry. Consumer search theories predict that product prices of higher search cost consumers will decline more gradually in response to a cost decrease. We add to the literature by finding that first-class airfares, consumers of which have higher search cost than those of economy-class airfares, decline more slowly than economy-class airfares in response to fuel cost decreases. Our results support consumer search as an important determinant of price asymmetry in the US airline industry. To the best of our knowledge, we are the first to use the difference between first-class and economy-class airfares to test whether consumer search drives asymmetric pricing.

The remainder of the paper is organized as follows: Section 2 reviews the related literature and develops our hypotheses. Section 3 describes the methodology and data used. The empirical results are presented in Section 4 and Section 5 discusses our conclusions.

2 | RELATED LITERATURE AND HYPOTHESES DEVELOPMENT

Numerous studies have found that output prices respond faster to input price increases than to decreases. To generalize, Peltzman (2000) employs large samples of diverse products—77 consumer and 165 producer goods—and finds price asymmetry occurs as frequently in producer goods markets as in consumer goods markets. This pattern is also known as "rockets and feathers" and has sometimes been used interchangeably with the term "asymmetric pricing".

2.1 | Tacit collusion hypotheses

Informal models of focal price tacit collusion were initially offered as an explanation for price asymmetry. For example, Borenstein, Cameron and Gilbert (1997) offered a stylized version of the tacit collusion model based on Green and Porter (1984) as a motivation for price asymmetry: firms use the previous period's price as a focal point for tacit collusion. If costs drop then the previous period's price is maintained until a firm cheats on the agreement and triggers a price war. Conversely, if costs increase then the firms raise their price to maintain a positive margin, which is not viewed as cheating on the collusive agreement. As a result, market prices adjust more slowly to cost decreases than increases. Verlinda (2008) and Lewis (2011) both provide supporting empirical evidence.

Common ownership has been shown to be associated with increases in the likelihood of tacit collusion. For example, Azar, Schmalz & Tecu (2018a, 2018b, 2018c) find that common ownership by institutional investors results in distorted competition in airline ticket prices. Azar, Raina, and Schmalz (2019) report similar findings for the banking industry. He and Huang (2017) show common ownership could facilitate product market collaboration. Pawliczek, Skinner and Zechman (2019) show commonly owned firms use public disclosure to aid in coordinating and monitoring compliance with anti-competitive strategies. Levenstein and Suslow (2006) and Stigler (1964) find that communication can facilitate both coordinating anti-competitive behavior and monitoring defection from the common strategy. If competing firms with common owners have reduced incentive to temper collusive selling price behavior then we posit:

Hypothesis (I): Price asymmetry effect is more pronounced in firms with more overlapping sets of investors.

In general, the ability to maintain tacit collusion decreases as the number of firms entered in the agreement increases. Market concentration measured by the Herfindahl-Hirschman Index (HHI) captures the number of firms and their relative share within the market. We calculate HHI as the sum of squared market share of each firm competing in the same market, where market share is the percentage of each firm's sales over total market sales.[4] Kim and Singal (1993) show a positive relationship between changes in concentration and changes in fares for the airline industry. Azar, Schmalz & Tecu (2018a, 2018b, 2018c) also examine the airline industry and find HHI has a positive impact on average fares. If asymmetric price adjustments are a consequence of tacit collusion, we posit:

Hypothesis (II): Airlines in high concentration markets will exhibit more price asymmetry than those in low concentration markets.

2.2 | Consumer search hypotheses

More recently, formal models of consumer search as an explanation for asymmetric pricing have been developed. Yang and Ye (2008), Tappata (2009), and Lewis (2011) all show that consumer search can lead to equilibrium asymmetric pricing if consumers are more likely to search following a cost increase than a decrease.

In Yang and Ye (2008), the learning asymmetry between searchers and non-searchers is the main driving force of asymmetric price adjustment. When there is a positive cost shock, firms are economically incentivized to reveal the cost increase by raising prices. As a result, searchers infer that a price increase indicates an increase in input costs. Consequently, searchers spend less time searching when they observe a price increase and the upward price adjustment is completed quickly. On the other hand, when the input cost goes down, firms have no incentive to reveal the cost decrease by lowering prices. Those non-searchers who observe the high price do not learn the true state of input cost and remain as non-searchers, whereas only those non-searchers who observe the lower input cost through means other than selling price reduction begin to search and become searchers. With the downward selling price pressure applied by searchers, firms slowly adjust their prices downward. Asymmetric price adjustment thus arises naturally. In Tappata (2009), price asymmetry emerges under persistent cost realization. If the current fuel cost is high, then consumers expect it to remain high, so they search very little because they don't expect much price dispersion. If it turns out that the marginal fuel cost unexpectedly decreases, firms have little incentive to lower their price because their consumers are not searching intensively. Conversely, if current fuel cost is low, consumers expect it to stay low and will search more intensively because they expect high price dispersion.[5]

[4] HHI approaches zero when a market is occupied by a large number of firms of relatively equal size (i.e., a low concentration market). The HHI increases both as the number of firms in the market decreases and as the disparity in size between those firms increases (i.e., a high concentration market).

[5] To validate Tappata's assumption that price dispersion is higher in low-cost periods than in high-cost periods, we measure price dispersion using the standard deviation of the air ticket price following Lewis (2011), and then split the sample into fuel cost increasing versus decreasing periods. The untabulated results show that price dispersions in cost increasing and decreasing periods are 0.246 and 0.251, respectively, and the difference is significant at 1%. This confirms that the price dispersion assumption is satisfied.

Lewis (2011) develops a consumer search model in which consumers form expectations about the price distribution based on a reference price, which is the average price level from the previous period. If input cost increases, firms are economically incentivized to raise prices. Consumers' expectation of the price (based on the previous period's prices) will tend to be low relative to the actual price, causing them to search more. Consumers quickly find out that a price increase indicates an increase in input costs and stop searching. Consequently, the upward price adjustment is completed quickly. Conversely, when costs are falling, consumers' expectation of the price will be high relative to the actual price, therefore they tend to be satisfied and search less. Firms then only have the incentive to lower prices just enough to discourage consumers from searching, generating a slower downward price adjustment. As a result, asymmetric pricing arises.

Among empirical studies, Hastings and Shapiro (2013) study the purchasing behavior of retail gasoline consumers and find empirical evidence for a behavioral model wherein consumers are more price sensitive when prices increase. Remer (2015) relies upon the differences in consumers who purchase regular versus premium gasoline to empirically examine the sources of search-based price asymmetry. He argues purchasers of premium gasoline have a higher search cost than regular gas purchasers and shows premium gasoline prices fall more slowly than regular gasoline prices, which supports consumer search as the underlying cause of asymmetric pricing.

Given that consumers who purchase first-class airline tickets generally earn higher incomes, are less price sensitive, and possibly are less informed than consumers who purchase economy-class, it is reasonable to assume that first-class passengers are (i) typified by higher search cost, and (ii) less likely to be a "shopper" for the lowest possible price.[6] The models in Yang and Ye (2008) and Tappata (2009) both imply that if consumers of a product have higher search costs then the price will fall more slowly. Lewis (2011) implies that if consumer expectations adapt more slowly, which could result from higher search costs, then prices will also decrease more slowly. An additional implication of Yang and Ye (2008) is that if the proportion of "shoppers" decreases, prices will adjust downward more slowly in response to a negative cost shock, but rise at the same rate following a cost increase.

Assumptions (i) and (ii) in conjunction with the results from search-based asymmetric pricing theory imply the following testable hypothesis:

Hypothesis (III): Firms will decrease first-class airfare more slowly than economy-class airfare when fuel cost decreases and there is no difference between changes in first-class and economy-class airfares in response to fuel cost increases.

3 | METHODOLOGY AND DATA DESCRIPTION

3.1 | Methodology

To test for the presence of asymmetric pricing of airline tickets responding to changes of jet fuel cost, we rely upon the econometric model derived in Borenstein, Cameron and Gilbert (1997), which is further modified in Bachmeier and Griffin (2003) and tested in Remer (2015). The model has become standard in the literature. It is an extension of the error correction model derived in Engle and Granger (1987). The model is specified as follows:

$$\begin{aligned}(P_{ir,t} - P_{ir,t-1}) &= \beta_0 + \beta^+(C_{i,t} - C_{i,t-1})^+ + \beta^-(C_{i,t} - C_{i,t-1})^- + \beta_1 \mathit{Change\ in\ Seats}_t \\ &+\gamma^+(P_{i,t-1} - P_{i,t-2})^+ + \gamma^-(P_{ir,t-1} - P_{ir,t-2})^- + \theta^+(P_{i,t-1} - \varphi_1 C_{i,t-2} - \varphi_0)^+ + \theta^-(P_{i,t-1} - \varphi_1 C_{i,t-2} - \varphi_0) + \varepsilon_{i,t.}\end{aligned} \tag{1}$$

where $P_{ir,t}$ is the average airline ticket price per mile flown in year quarter t for a given carrier i operating in market r, and market is origin–destination airport pair regardless of direction; $C_{i,t}$ is the total jet fuel cost normalized by revenue

[6] Hwang and Lyu (2018), Moniter (2011) and Mouawad (2011) show that first-class passengers are wealthy and less price sensitive.

passenger-miles for carrier i during period ending at year quarter t. $(C_{i,t} - C_{i,t-1})^{+}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^{-}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. We also included *Change in Seats*, measured by the quarterly change in the number of available seats in a given market in year quarter t to control for change in capacity. Following Azar, Schmalz & Tecu (2018a, 2018b, 2018c), we also add the logarithm of population and the logarithm of income per capita as additional control variables. *Aircraft Load*, defined as revenue passenger-miles scaled by available passenger-miles, is also included as a control variable. Lagged ticket price changes and the error correction term are analogously defined. Thus Equation (1) allows for positive and negative cost changes to have a unique effect on current prices.

The model also implicitly assumes a long-run linear relationship between price and cost:

$$P_{it,t} = \varphi_0 + \varphi_1 C_{i,t} + \varepsilon_{i,t,} \tag{2}$$

Thereby $(P_{i,t-1} - \varphi_1 C_{i,t-2} - \varphi_0)$ in Equation (1) captures the extent to which prices and costs are out of their long-run equilibrium. Consequently, Equation (1) separately identifies the effect on prices of short-run changes in cost and own prices from the pressure for prices to return to their long-run relationship with cost. Equation (2) is first estimated using OLS and the resulting parameter values are substituted into Equation (1). Equation (1) is then estimated with operating carrier–market fixed effects as well as year quarter fixed effects. In general, if $\beta^{+} > \beta^{-}$ then price asymmetry exists.

3.2 | Data

3.2.1 | Oil and jet fuel price data

Prices of three types of oil (Brent, West Texas Intermediate (WTI), and Dubai) serve as benchmarks for other types of crude oil and are obtained from US Energy Information Administration of the Department of Energy. It covers daily, monthly, quarterly, and annual crude oil prices between 2001Q1 and 2016Q4. The prices of all three types of oil are over 99% correlated with each other. WTI's market is primarily in the United States, and we use WTI price as the primary benchmark of crude oil prices. Jet fuel prices are also retrieved from US Energy Information Administration.

3.2.2 | Airline transportation data

TranStats Database of the Bureau of Transportation Statistics (BTS) collects airline statistics, including fuel cost, revenue passenger-miles, available passenger-miles and financial information at both the industry and firm level.

3.2.3 | DB1B air ticket data

The primary source of airline ticket data is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by BTS. The DB1B is a quarterly, 10% random sample of domestic airline tickets. There are three different subcomponents to the DB1B database, market data, coupon data, and ticket data, and we combine variables from all three sources. Information in the DB1B includes itinerary fares, miles flown, endpoint airports, passenger quantities, number of plane changes, fare class, number of seats available, and the identity of the ticketing and operating carrier. We focus our empirical analysis on the time period between 2001Q1 and 2016Q4.

Following the standard in the literature on airline ticket pricing (Borenstein (1989), Berry (1990), Borenstein and Rose (1994), Borenstein and Rose (1995), and Dennis, Gerardi and Schenone (2021)), we apply the DB1B filters to

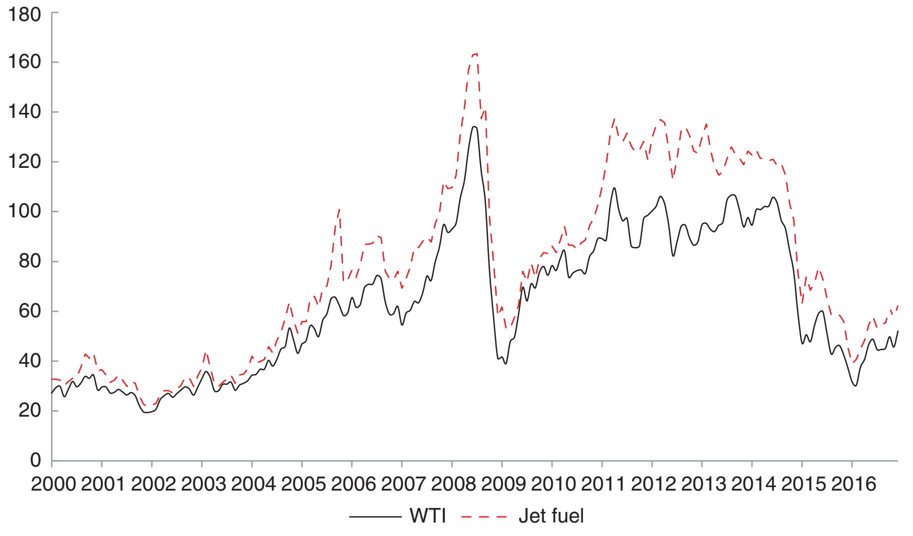

FIGURE 1 The relationship between crude oil prices (WTI) and jet fuel prices. This figure plots monthly jet fuel prices per barrel versus WTI prices per barrel from January 2000 to December 2016 in current dollars. Price information is obtained from the US Energy Information Administration of the Department of Energy

our sample as summarized below. For DB1B coupon data, we eliminate tickets with more than two coupons;[7] we then eliminate one-way tickets with two coupons, thus retaining only nonstop flights. We also eliminate tickets for which the ticketing or operating carrier is missing in one or more coupons or tickets with multiple ticketing/operating carriers. Tickets where the operating and ticketing carrier differ in one or more coupons are removed. We also eliminate tickets that include a surface segment.[8] Tickets with non-reporting carriers or foreign carriers or involving coupons outside the lower 48 contiguous US States are removed. Charter and non-US airlines are excluded from our sample. For DB1B ticket and market data, we eliminate tickets flagged as "not credible" or with fare values less than $20.[9]

3.2.4 | Common ownership data

The data for institutional holdings comes from the Thomson-Reuters 13f institutional holdings dataset.

3.3 | The relationship between crude oil prices and jet fuel prices

We start by exploring the relationship between WTI prices and jet fuel prices. Jet fuels are primarily derived from crude oil; 1 gallon of crude makes about 0.1 gallons of jet fuel, 0.4–0.5 gallons of gasoline, and 0.3 gallons of diesel and other products.

Figure 1 plots monthly jet fuel prices per barrel versus WTI prices per barrel from January 2000 to December 2016 in current dollars. Jet fuel is approximately 20% more expensive than WTI and they are highly correlated (the

[7] A coupon is a piece of paper indicating the itinerary of a passenger.

[8] A surface segment is a part of the itinerary to which the plane does not travel.

[9] Fare deemed "not credible" by the BTS means a questionable fare value based on credible limits. Fare values less than $20 are eliminated from our sample as they are presumably key punch errors, or reporting of frequent flyer bonus trips, which is not done in any consistent way.

TABLE 1 Summary statistics

Variables	N	Mean	Std. Dev	Median
$P_{ir,t}$ –$P_{ir,t-1}$	187,399	0.0010	0.0679	0.0007
$(C_{i,t} - C_{i,t-1})$	187,399	0.0002	0.0047	0.0007
HHI	187,399	0.8115	0.2314	0.9795
$(C_{i,t} - C_{i,t-1})^+$	187,399	0.0020	0.0025	0.0007
$(C_{i,t} - C_{i,t-1})^-$	187,399	–0.0016	0.0031	0
Common institutional holdings	148,783	0.4178	0.2336	0.4552

This table reports summary statistics of key variables. $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter *t* for a given carrier *i* operating in market *r*, market is origin–destination airport pair regardless of direction. $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier *i* during period ending at time *t*. $(C_{i,t} - C_{i,t-1})^+$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^-$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. We calculate Herfindahl-Hirschman index (HHI) as the sum of squared market share at each year quarter. Market share is the percentage of sales over total market sales, where market is origin–destination airport pair regardless of direction. *Common institutional holdings* is the number of institutional investors reporting holdings in an airline company as well as on any of the "same-market" peers in the year, divided by the number of institutional investors holding the airline company's stock. The data are from Thomson-Reuters institutional holdings (i.e., 13F). Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost and revenue passenger-miles are collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001 Q1 and 2016 Q4. To mitigate the influence of observations with extreme values, we have winsorized the variables at the 1% and 99% percentile level.

correlation coefficient is 98.4%).[10] The prices of jet fuel and WTI have shown substantial fluctuations over our sample period.

3.4 | Summary statistics

Table 1 reports summary statistics of key variables. $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter *t* . for a given carrier *i* operating in market *r*, and market is origin–destination airport pair regardless of direction; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier *i*n year quarter *t*. The industry standard measure for air transportation sales volume, revenue passenger-miles, measures the distance a revenue-generating passenger travels aboard an aircraft. Revenue passenger-miles is calculated as the product of the number of passengers and the distance flown in thousands. We normalize fuel cost by revenue passenger-miles (Cannon, 2014). $(C_{i,t} - C_{i,t-1})^+$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^-$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. We calculate the Herfindahl-Hirschman Index (HHI) as the sum of squared market share at each year quarter. Market share is the percentage of sales over total market sales, where market is origin–destination airport pair regardless of direction. *Common institutional holdings* is the number of institutional investors reporting holdings in an airline company as well as on any of the "same-market" peers in the year, divided by the number of institutional investors holding the airline company's stock.

[10] Fuel hedging is a contractual tool airlines use to reduce their exposure to volatile fuel costs. Many carriers are citing fuel hedges for the lag in lowering airfares. We test the correlation between US airline fuel cost and contemporary and lagged WTI prices. In untabulated results we find that airline fuel cost is mostly correlated with one month lagged WTI price, the correlation coefficient is 97%. However, no significant differences are detected when we compare oil price increasing versus oil price decreasing sub periods.

TABLE 2 Asymmetric response of airline ticket prices to fuel cost changes

Variables	(1) $P_{ir,t} - P_{ir,t-1}$
$(C_{i,t} - C_{i,t-1})^{+}$	0.421***
	(3.73)
$(C_{i,t} - C_{i,t-1})^{-}$	−0.025
	(−0.30)
Change in Seats$_t$	−0.000***
	(−2.85)
Population	0.012
	(0.59)
Income	0.015*
	(1.70)
Aircraft Load	0.022**
	(2.33)
Observations	116,517
Adjusted R^2	0.274
Market-carrier FE	Yes
Year quarter FE	Yes

This table presents regressions of the average ticket price changes on fuel cost changes, as well as various controls and fixed effects. $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter **t** for a given carrier *i* operating in market *r*; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier ***i*** in year quarter *t*. $(C_{i,t} - C_{i,t-1})^{+}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^{-}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats*$_t$ is defined as the quarterly change in the number of available seats in a given market in year quarter *t*. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands. *Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Available passenger-miles is calculated as the product of the number of seats available and the distance flown in thousands. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

4 | EMPIRICAL RESULTS

4.1 | Asymmetric response of airline ticket price to fuel cost change

We establish the presence of asymmetric pricing in airline ticket prices in Table 2. In Column (1), we estimate Equation (1) and find that when fuel cost increases, the coefficient of fuel cost change is 0.421 and significant at 1% level, which implies that fuel cost increase has a significantly positive effect on price adjustment. However, when fuel cost decreases, the coefficient of fuel cost change is −0.025 and statistically insignificant, which indicates that a decrease in fuel cost does not have a significant impact on price adjustment. Economically, for every one dollar increase in fuel cost per mile, airfare per mile increases by 0.421, but remains essentially unchanged following a negative shock.[11]

Collectively, our baseline results show that when fuel cost increases, airfares adjust upwards correspondingly; however, airfares do not reflect the decreases in fuel cost accordingly. Other coefficients are economically plausible. The coefficients for being above or below the long-run equilibrium ticket price are both negative. This implies that when ticket prices are above (below) their long-run equilibrium value, there exists downward (upward) pressure guiding ticket prices towards their long-run equilibrium.

4.2 | Tacit collusion and asymmetric pricing

In this section, we test if focal price tacit collusion can explain price asymmetry in the airline ticket prices.

4.2.1 | Common ownership

Common ownership and price asymmetry

The ability to maintain tacit collusion increases in common ownership.[12] We delve deeper by examining common overlapping sets of investors in airline firms and their peers in the same market. We use *common institutional holdings* to measure common ownership. Following Cohen and Frazzini (2008) and Jiang, Qian, and Yao (2016), *common institutional holdings* is defined as the number of institutional investors reporting holdings in an airline company as well as in any of the "same-market" peers in the year, divided by the number of institutional investors holding the airline company's stock. *Common institutional holdings* thus measures the fraction of all institutions owning the airline company that also own its same-market peer companies. The idea behind this measure is that competing firms with common institutional owners are more likely to take coordinated actions (i.e., tacitly collude) if their institutional investors hold both an airline and its peers in their portfolios as opposed to holding only one firm.[13] Data on institutional ownership are obtained from Thomson-Reuters institutional holdings (i.e., 13F).

If investors holding financial stakes in multiple airlines have less incentive to foster competition among those airlines, we would expect the price asymmetry to increase with common ownerships in the airline industry (Hypothesis (II)). To test this hypothesis, we interact common institutional holdings with fuel cost increase and fuel cost decrease, respectively. The results are reported in Table 3.[14] In Column (1), when common ownership is measured with common institutional holdings, the coefficient of the interaction term between common institutional holdings and fuel cost increase is 2.027, which is significant at 1% level. This implies that the in firms with a higher degree of common institutional holdings, average airfares increase more in response to rising fuel cost than in firms with a lower degree of overlapping institutional holdings. On the other hand, the coefficient of the interaction

[11] We can further gauge the economic significance. According to Table 1, the mean value for cost increase is \$0.2 per thousand passenger miles. We then use mean-centered transformations of the control variables to update Table 2. Based on the unreported results, the average price increase is \$0.092 (= \$0.2 × 0.459) in response to an average cost increase. Therefore, the net loss is \$0.108 (= \$0.2 – \$0.092) per thousand passenger miles when cost increases. Conversely, when cost decreases, the coefficient of $(C_{i,t} - C_{i,t-1})^{-}$ is not statistically significant. It implies that prices do not change significantly when fuel cost goes down. Thus, the gain due to fuel cost saving is \$0.0016 per passenger mile, or \$1.6 gain per thousand passenger miles. During our sample period of 2001Q1 to 2016Q4, fuel cost is increasing in 56% and decreasing in 44% of the periods. As a net effect, firms have gained about \$0.644 (= 1.6×0.44 – 0.108×0.56) per thousand passenger miles on average.

[12] Collusion under common ownership is studied, for example, by Alley (1997), Azar (2012), and de Haas and Paha (2016). These authors show that common ownership can make sustained collusion easier depending on the mode of competition and various other assumptions.

[13] We acknowledge that our measure is one out of a rich set of common ownership measures used in the literature. Alternative measures can be found in, but are not limited to, O'Brien and Salop (2000), Azar, Schmalz and Tecu (2018a, 2018b, 2018c) and Dennis, Gerardi and Schenone (2021).

[14] Given that some of our variables have high correlations, we also test for multi-collinearity. According to collinearity diagnostics associated with our main tests in Table 3, all variables show a variance inflation factor (VIF) of less than ten and a tolerance greater than 0.1, which pass the multi-collinearity test. The general rule of thumb is a VIF less than ten or a tolerance greater than 0.1 (Allison, 2012).

TABLE 3 Common ownership and asymmetric pricing

Variables	(1) $P_{ir,t} - P_{ir,t-1}$
Common Institutional Holdings $\times (C_{i,t} - C_{i,t-1})^+$	2.027***
	(3.04)
Common Institional Holdings $\times (C_{i,t} - C_{i,t-1})^-$	0.116
	(0.18)
Common Institional Holdings	0.012***
	(3.20)
$(C_{i,t} - C_{i,t-1})^+$	−0.311
	(−1.22)
$(C_{i,t} - C_{i,t-1})^-$	0.206
	(0.67)
Change in Seats$_t$	−0.000
	(−1.40)
Population	−0.052***
	(−2.86)
Income	0.005
	(0.66)
Aircraft Load	0.034***
	(3.33)
Observations	63,560
Adjusted R^2	0.212
Market-carrier FE	Yes
Year quarter FE	Yes

This table presents regressions of the average ticket price changes on the interaction of common institutional holdings and fuel cost changes, as well as various controls and fixed effects. *Common institutional holdings* is the number of institutional investors reporting holdings in an airline company as well as on any of the "same-market" peers in the year, divided by the number of institutional investors with holdings in the airline company. The data are from Thomson-Reuters institutional holdings (i.e., 13F). $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter t for a given carrier i operating in market r; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier i during period ending at time t. $(C_{i,t} - C_{i,t-1})^+$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^-$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats*$_t$ is defined as the quarterly change in the number of available seats in a given market in year quarter t. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands.*Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database. Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

term between common institutional holdings and fuel cost decrease is 0.116 (statistically insignificant), which implies that the average airfares do not move significantly in response to a decrease in fuel cost in firms with more overlapping institutional holdings.[15]

These results indicate the price asymmetry is more pronounced in firms with more overlapping investors, which is consistent with investors' common ownership lacking the incentive to temper collusive selling price behavior. In sum, our results support Hypothesis (I), suggesting common institutional ownership may be conducive to collusive managerial behavior.

Endogeneity concerns in common ownership

The main methodological concern of the above results is the potential endogeneity issue of ownership structure. A potential endogeneity concern can arise because institutional investors may choose to invest in certain airlines whose managers are more likely to collude if given the opportunity, which results in reserve causality (or simultaneity). Another concern is that omitted variables, such as unobservable firm characteristics (e.g., firm culture, management styles, etc.), correlated with both a firm's cross-holding status and asymmetric pricing could make our ordinary least squares (OLS) results spurious. To address these endogeneity concerns, we follow He and Huang (2017) by examining the financial institutions merger as an exogenous shock to the cross-ownership of airlines to investigate whether the price asymmetry effect persists.

As suggested by He and Huang (2017), financial institutions typically merge for reasons unrelated to the performance and characteristics of individual firms in their portfolios. When there is a merger between two financial institutions, each of which owns a block in one of two same-industry rivals, a new common ownership linkage forms between the two competitors post-merger. Hence, these mergers between financial institutional investors provide an arguably exogenous increase to the common ownership of the merging institutions' portfolios, and thus provide a suitable quasi-experimental setting for analyzing the causal effect of common ownership on price asymmetry in the airline industry. Along this line, we extend the He and Huang (2017) framework to examine financial institution mergers and their impact on price asymmetry.

We follow the procedure in He and Huang (2017) to construct our financial institution merger sample using Securities Data Company (SDC) Mergers and Acquisitions database. We identify treatment firms as those that are likely to experience an increase in common ownership with rival firms in the airline industry due to institution mergers. Specifically, we require that (1) the firm be held by one of the merging institutions before the merger announcement date, and (2) the other merging institution does not have holdings in the firm but has holdings in at least one of the airline's competitors before the merger. Firms satisfying these two conditions are classified as treatment firms because they are likely to experience an increase in common ownership after a merger. The control sample, on the other hand, consists of other firms in the same institution's portfolios that are unlikely to experience such changes. *Treat* is an indicator variable that equals one for treatment firms and zero for control firms. *Post* is an indicator variable that equals one for the post-merger period and zero for the pre-merger period. In the regressions, we also include the interaction of *Treat* and *Post*, and the interaction of *Treat* × *Post* with fuel cost increase and fuel cost decrease measures. We expect that a larger increase in common ownership induced by the merger will be associated with a greater price asymmetry effect in the airline industry.

Table 4 reports these results. In Column (1), the estimated coefficient before *Treat* × *Post* is significantly positive, suggesting that a greater increase in common ownership induced by the merger leads to a significantly positive effect on price adjustment. The coefficient of the interaction term between *Treat* × *Post* and fuel cost increase is 0.346, which

[15] We can also gauge the economic significance. We use mean-centered transformations of the control variables to update Table 3. Based on the unreported results, the average price increase is \$0.2030 (= \$0.2 × 0.4178 × 2.429) in response to an average cost increase. Therefore, the net gain is \$0.0030 (= 0.2030–0.2) per thousand passenger miles when cost increases. On the other hand, when cost decreases, neither the coefficient of *Common Institutional Holdings* × $(C_{i,t} - C_{i,t-1})^{-}$ nor the coefficient of fuel cost decrease is statistically significant. It implies that prices do not change significantly when fuel cost goes down. Thus, the gain due to fuel cost saving is \$0.0016 per passenger mile, or \$1.6 gain per thousand passenger miles. As discussed earlier, fuel cost is increasing in 56% and decreasing in 44% of the sample periods. As a net effect, firms have gained about \$0.706 (= 1.6×0.44 + 0.0030 × 0.56) per thousand passenger miles on average.

TABLE 4 Address endogeneity concerns in common ownership

Variables	(1) $P_{ir,t} - P_{ir,t-1}$
$Treat \times Post \times (C_{i,t} - C_{i,t-1})^{+}$	0.346*
	(1.68)
$Treat \times Post \times (C_{i,t} - C_{i,t-1})^{-}$	0.066
	(0.14)
$Treat \times Post$	0.001**
	(2.17)
Treat	0.001
	(0.77)
Post	0.000
	(0.31)
$(C_{i,t} - C_{i,t-1})^{+}$	0.195
	(0.80)
$(C_{i,t} - C_{i,t-1})^{-}$	0.188
	(1.07)
$Change\ in\ Seats_t$	−0.000***
	(−2.85)
Population	−0.096***
	(−2.98)
Income	0.023**
	(2.03)
Aircraft Load	0.000***
	(3.82)
$Treat \times (C_{i,t} - C_{i,t-1})^{+}$	0.256**
	(2.07)
$Treat \times (C_{i,t} - C_{i,t-1})^{-}$	−0.160
	(−1.00)
$Post \times (C_{i,t} - C_{i,t-1})^{+}$	0.271***
	(3.65)
$Post \times (C_{i,t} - C_{i,t-1})^{-}$	−0.108
	(−1.03)
Adjusted R^2	0.361
Market-carrier FE	Yes
Year quarter FE	Yes

(Continues)

TABLE 4 (Continued)

This table addresses the endogeneity issue of the results presented in Table 3. We follow the procedure in He and Huang (2017) to construct our financial institution merger sample using SDC's Mergers and Acquisitions database. We identify treatment firms as those that are likely to experience an increase in common ownership with rival firms in the airline industry due to the institution mergers; the control sample, consists of other firms in the same institution's portfolio that are unlikely to experience such changes. *Treat* is an indicator variable that equals one for treatment firms and zero for control firms. *Post* is an indicator variable that equals one for the post-merger period and zero for the pre-merger period. $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter t for a given carrier i operating in market r; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier i during period ending at time t. $(C_{i,t} - C_{i,t-1})^+$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^-$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats*$_t$ is defined as the quarterly change in the number of available seats in a given market in year quarter t. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands. *Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Available passenger-miles is calculated as the product of the number of seats available and the distance flown in thousands. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

is significant at 10% level. This implies that average airfares increase more in response to fuel cost increase for the treatment group relative to the controls in the post-merger period. Conversely, the coefficient of the interaction term between *Treat* × *Post* and fuel cost decrease is 0.066 (statistically insignificant), which implies that average airfares do not change significantly in response to fuel cost decrease for the treatment group relative to the controls in the post-merger period. These results suggest that the price asymmetry effect is more pronounced in firms with more overlapping institutional investors due to the merger, especially for the post-merger period.

4.2.2 | Market concentration

The ability to maintain tacit collusion also increases with market concentration. We use the Herfindahl-Hirschman Index (HHI) to measure market concentration. HHI is calculated as the sum of squared market share at each year-quarter. Market share is the percentage of sales over total market sales, where the market is the origin–destination airport pair regardless of direction. Compared to low concentration markets, high HHI market players usually have more power in price determination. We expect pricing asymmetry to be more noticeable for high HHI markets than for low HHI markets (Hypothesis (II)). To test this hypothesis, we interact HHI with fuel cost increase and fuel cost decrease, respectively. The results are reported in Column (1) of Table 5. The coefficient of the interaction term between HHI and fuel cost increase is 0.493, which is significant at 5% level. This implies the average airfares increase more in response to fuel cost increase in high concentration markets than in low concentration markets. On the other hand, the coefficient of the interaction term between HHI and fuel cost decrease is 0.148 (statistically insignificant), which implies that the average airfares do not change significantly in response to fuel cost decreases in high concentration markets. Thus, the pricing asymmetry is more pronounced for high concentration markets than for low concentration markets. Overall, the results here show that price asymmetry is more severe when market concentration is high and confirm Hypothesis (II).

TABLE 5 Market concentration and asymmetric pricing

Variables	(1) $P_{ir,t} - P_{ir,t-1}$
$HHI \times (C_{i,t} - C_{i,t-1})^{+}$	0.493**
	(1.99)
$HHI \times (C_{i,t} - C_{i,t-1})^{-}$	0.148
	(0.70)
HHI	0.018***
	(10.59)
$(C_{i,t} - C_{i,t-1})^{+}$	0.077
	(0.39)
$(C_{i,t} - C_{i,t-1})^{-}$	0.063*
	(0.39)
Change in Seats$_t$	−0.000*
	(−1.70)
Population	0.014
	(1.52)
Income	−0.002
	(−1.57)
Aircraft Load	0.004
	(0.58)
Observations	116,517
Adjusted R^2	0.212
Market-carrier FE	Yes
Year quarter FE	Yes

This table presents regressions of the average ticket price changes on the interaction of the Herfindahl-Hirschman index (HHI) and fuel cost changes, as well as various controls and fixed effects. We calculate HHI as the sum of squared market share at each year-quarter, $HHI = \sum_{i=1}^{N} (Market\ Share_i)^2$, where $Market\ Share_i$ is the market share of firm i in the market, and N is the number of firms in the market. Market share is the percentage of sales over total market sales, $Market\ share_i = \frac{Sale_i}{\sum_{i=1}^{N} Sale_i}$, where $Sale_i$ is sales of firm i. Market is origin–destination airport pair regardless of direction. $P_{ir,t}$ is the average economy-class airline ticket price per mile flown in year quarter *t* for a given carrier *i* operating in market *r*; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier *i* year quarter *t*. $(C_{i,t} - C_{i,t-1})^{+}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^{-}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats*$_t$ is defined as the quarterly change in the number of available seats in a given market in year quarter *t*. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands. *Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Available passenger-miles is calculated as the product of the number of seats available and the distance flown in thousands. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

4.2.3 | Excluding major airlines bankruptcies

For a robustness check, we aim to remove the impact of bankruptcies on our estimates. In Table A1, we exclude the sample quarters in which one of the major airlines was in bankruptcy, leaving us with the periods 2001Q1–2002Q2, 2007Q2–2011Q3, and 2014Q1–2014Q4.[16] Following Azar, Schmalz & Tecu (2018a, 2018b, 2018c), we classify as major bankruptcy events the bankruptcies of United Airlines, Delta, American Airlines, US Airways, Northwest, and Mesa Airlines. We rerun the tests in Tables 2, 3, and 5 using the non-bankruptcy sample quarters and the results are presented in Table A1. The estimates are similar to those in the Tables 2, 3, and 5.[17] Thus, we conclude that the asymmetric pricing results are not driven by bankruptcies.

4.3 | Consumer search and asymmetric pricing

To empirically examine if asymmetric pricing is the consequence of consumer search, we rely upon the differences in consumers who purchase first-class versus those who purchase economy-class airline tickets. Consumers that purchase first-class tickets generally earn higher incomes, are less price sensitive, and are possibly less informed than consumers of economy-class. They therefore can be described as having a higher cost of price search than consumers of economy-class airline tickets.

The results of estimating the Equation (1) using the average airfare markup of the first-class over the economy-class airline tickets are reported in Table 6 Column (1). The most striking aspect is the distinct negative response to a negative cost shock. The coefficient is −4.334 and significant at 1% level. This suggests that the gap between first-class and economy-class airfare increases when fuel cost decreases; thereby, first-class prices fall more slowly than economy-class prices following a decrease in fuel cost. To further investigate this issue, we focus on first-class airfares and re-estimate Equation (1) considering only the first-class airfares. The results are reported in Table 7 Column (1). We find that first-class airfares actually increase substantially during periods when fuel cost decreases (the coefficient of fuel cost decrease is −4.105 and is significant at 1%). Combined with what we find in Table 2––that economy-class airfares do not respond to fuel cost decreases—the gap between first-class and economy-class airfares widens in periods when fuel cost decreases as reported in Table 6.

By contrast, the response of the markup to a positive fuel cost change is not significantly different from zero. A markup unaffected by positive cost changes implies that first-class and economy-class airfares increase at the same rate. In sum, these estimates confirm Hypothesis (III) and support consumer search as the mechanism driving asymmetric pricing.

Particularly noteworthy about our analysis is that a significant number of potentially omitted variables are differenced out via market-carrier and year quarter fixed effects. Nevertheless, other factors that are potentially correlated with price adjustment remain, for example, shifts in demand. We examine how shifts in demand affect price adjustment when fuel cost decreases versus increases. When fuel cost decreases, a potential increase in discretionary income might result in an increase in consumer demand, which could make consumers more willing to pay higher air ticket prices. Consequently, airlines have little incentive to decrease price in this scenario. However, on the other hand, when fuel cost goes up, a potential decrease in discretionary income would cut back consumer's demand, which will cause them to be less willing to pay higher air ticket prices. Airlines that keep this in mind should be very reluctant to raise their prices for fear of losing their customers. Thus, while the effects of fuel cost changes on consumer demand through discretionary income might reduce the magnitude of price change responses to fuel cost fluctuations, they would not

[16] Table A1 is included in the online appendix which is available in the supporting materials section online.

[17] In Panel A of Table A1, the coefficient of *Population* is positive and significant at 5% level, indicating *Population* is positively associated with airline ticket price changes in the subsample excluding major bankruptcies. The coefficient of *Income* is negative and insignificant, indicating that *Income* is not significantly associated with airline ticket price changes in the subsample excluding major bankruptcies.

TABLE 6 Consumer search costs and asymmetric pricing

Variables	(1) $M_{ir,t} - M_{ir,t-1}$
$(C_{i,t} - C_{i,t-1})^{+}$	1.881
	(1.52)
$(C_{i,t} - C_{i,t-1})^{-}$	– 4.334***
	(–6.74)
Change in Seats$_t$	0.000**
	(2.44)
Population	–0.011***
	(–4.16)
Income	0.005***
	(4.25)
Aircraft Load	0.944***
	(3.73)
Observations	35,419
Adjusted R^2	0.274
Market-carrier FE	Yes
Year quarter FE	Yes

This table presents regressions of the average airfare markup of the first-class over economy-class changes on fuel cost changes, as well as various controls and fixed effects. $M_{ir,t}$ is the average airfare markup per mile flown of the first-class over the economy-class in year quarter t for a given carrier i operating in market r; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier i in year quarter t. $(C_{i,t} - C_{i,t-1})^{+}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^{-}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats$_t$* is defined as the quarterly change in the number of available seats in a given market in year quarter t. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands. *Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Available passenger-miles is calculated as the product of the number of seats available and the distance flown in thousands. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses. .

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

be expected to reduce asymmetry between price increases and decreases. Furthermore, when fuel cost decreases, an increase in discretionary income will give rise to a greater proportion of non-searchers relative to searchers, which will result in slower downward price adjustment (Yang & Ye, 2008). Therefore, shifts in discretionary income imply an indirect mechanism through which consumer search drives asymmetric pricing.

5 | CONCLUSIONS AND DISCUSSIONS

We establish the presence of asymmetric airline ticket price adjustments to fuel cost changes in the US airline industry using a comprehensive sample of all US airlines between 2001Q1 and 2016Q4. We find evidence that the average

TABLE 7 Asymmetric pricing in first-class airline tickets

Variables	(1) $F_{ir,t} - F_{ir,t-1}$
$(C_{i,t} - C_{i,t-1})^{+}$	2.307***
	(3.12)
$(C_{i,t} - C_{i,t-1})^{-}$	−4.105***
	(−6.44)
Change in Seats$_t$	0.000
	(1.23)
Population	−0.011***
	(−3.45)
Income	0.013***
	(4.21)
Aircraft Load	0.851***
	(3.96)
Observations	35,914
Adjusted R^2	0.278
Market-carrier FE	Yes
Year quarter FE	Yes

This table presents regressions of the average first-class airfare changes on fuel cost changes, as well as various controls and fixed effects. $F_{ir,t}$ is the average first-class airfare per mile flown in year quarter t for a given carrier i operating in market r; $C_{i,t}$ is the total jet fuel cost normalized by revenue passenger-miles for carrier i during period ending at time t. $(C_{i,t} - C_{i,t-1})^{+}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is positive, and zero otherwise; $(C_{i,t} - C_{i,t-1})^{-}$ takes the value of $(C_{i,t} - C_{i,t-1})$ if it is negative, and zero otherwise. *Change in Seats*$_t$ is defined as the quarterly change in the number of available seats in a given market in year quarter t. *Population* is the logarithm of the geometric mean of endpoint populations in millions. *Income* is the logarithm of the geometric mean of endpoint incomes per capita in thousands. *Aircraft Load* is defined as revenue passenger-miles scaled by available passenger-miles. Available passenger-miles is calculated as the product of the number of seats available and the distance flown in thousands. Lagged ticket price changes and the error correction term are analogously defined and the coefficients are suppressed for brevity. Average airfare data source is the Department of Transportation's Airline Origin and Destination Survey (DB1B) database, which is constructed by the Bureau of Transportation Statistics (BTS). Quarterly fuel cost is collected from TranStats Database of the Bureau of Transportation Statistics (BTS) between 2001Q1 and 2016Q4. The specification includes market-carrier and year quarter fixed effects. Standard errors are clustered at market-carrier levels. T-stats are provided in parentheses. .

*** $p < 0.01$,

** $p < 0.05$.

* $p < 0.10$.

airfares increase in response to rising fuel costs but do not decrease in response to falling fuel costs. Focal price tacit collusion as a common explanation for asymmetric pricing predicts that airlines in highly concentrated markets will exhibit more price asymmetries than those in low concentration markets. Our evidence supports this hypothesis. The likelihood of collusion also increases in common ownership and we find that a greater degree of overlapping institutional investors is associated with a greater price asymmetry effect in the airline industry. To further address the endogeneity concern, we perform a difference-in-differences test based on the quasi-natural experiment of financial institution mergers to establish the causal effect of common ownership on price asymmetry. Further testing shows that first-class airfares fall more slowly than economy-class airfares to fuel cost decreases, which supports consumer search as an explanation for asymmetric pricing.

Potentially fruitful areas for future research include the implications of price asymmetry for different aspects of corporate performance and decisions. For instance, when exploring firms' operating performance and corporate decisions associated with asymmetric pricing, we find that firms that raise prices when fuel cost increases exhibit better operating performance and financial status due to significant increases in revenue. The results also show when fuel cost increases, firms that raise their prices do not make significantly different investment or dividend payment decisions. However, when the cost of fuel decreases, firms that decrease their prices accordingly spend more in long-term investment and pay more dividends.[18] We leave analyses of these related questions to future research.

ACKNOWLEDGEMENTS

We thank Michael Goldstein (the editor), Richard Warr, two anonymous referees, Matthew T. Billett, Yingying Dong, Erik Lie, David C. Mauer and seminar participants at University of Alabama in Huntsville for helpful comments. Tingting Que acknowledges research funding support from College of Business, University of Alabama in Huntsville.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Abdoh, H., & Liu, Y. (2021). Executive risk incentives, product market competition, and R&D. *Financial Review*, *56*, 133–156.

Allison, P. (2012). When can you safely ignore multicollinearity. Available at: http://www.statisticalhorizons.com/multicollinearity,

Azar, J., Raina, S., & Schmalz, M. C. (2019). Ultimate ownership and bank competition." SSRN working paper.

Azar, J., Schmalz, M. C., & Tecu, I. (2018a). Anticompetitive effects of common ownership. *Journal of Finance*, *73*, 1513–1565.

Azar, J., Schmalz, M. C., & Tecu, I. (2018b). Reply to: "Common ownership does not have anti-competitive effects in the airline industry", working paper.

Azar, J., Schmalz, M. C., & Tecu, I. (2018c). The competitive effects of common ownership: economic foundations and empirical evidence: reply." working paper.

Bachmeier, L. J., & Griffin, J. M. (2003). New evidence on asymmetric gasoline price responses. *Review of Economics and Statistics*, *85*, 772–776.

Berry, S. T. (1990). Airport presence as product differentiation. *American Economic Review*, *80*, 394–399.

Borenstein, S. (1989). Hubs and high fares: Dominance and market power in the us airline industry. *RAND Journal of Economics*, *20*(3), 344–365.

Borenstein, S. (2011). Why can't us airlines make money? *American Economic Review*, *101*, 233–237.

Borenstein, S., Cameron, A. C., & Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *Quarterly Journal of Economics*, *112*, 305–339.

Borenstein, S., & Rose, N. L. (1994). Competition and price dispersion in the us airline industry. *Journal of Political Economy*, *102*, 653–683.

Borenstein, S., & Rose, N. L. (1995). Bankruptcy and pricing behavior in us airline markets. *American Economic Review*, *85*, 397–402.

Cannon, J. N. (2014). Determinants of "sticky costs": An analysis of cost behavior using united states air transportation industry data. *Accounting Review*, *89*, 1645–1672.

Cohen, L., & Frazzini, A. (2008). Economic links and predictable returns. *Journal of Finance*, *63*, 1977–2011.

Dennis, P. J., Gerardi, K., & Schenone, C. (2021). Common ownership does not have anti-competitive effects in the airline industry. *Journal of Finance*, Forthcoming.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*(2), 251–276.

Gilje, E. P., Gormley, T. A., & Levit, D. (2020). Who's paying attention? Measuring common ownership and its impact on managerial incentives. *Journal of Financial Economics*, *137*, 152–178.

Green, E. J., & Porter, R. H. (1984). Noncooperative collusion under imperfect price information. *Econometrica*, *52*(1), 87–100.

[18] The untabulated results are available from the authors upon request.

Green, R. C., Li, D., & Schürhoff, N. (2010). Price discovery in illiquid markets: Do financial asset prices rise faster than they fall? *Journal of Finance*, *65*, 1669–1702.

Harwell, D., Halsey, A. III, & Moore, T. (2015). Justice dept. investigating potential airline price collusion. *The Washington Post*, *9*. https://www.washingtonpost.com/business/economy/doj-investigating-potential-airline-collusion/2015/07/01/42d99102-201c-11e5-aeb9-a411a84c9d55_story.html

Hastings, J. S., & Shapiro, J. M. (2013). Fungibility and consumer choice: Evidence from commodity price shocks. *Quarterly Journal of Economics*, *128*, 1449–1498.

He, J. J., & Huang, J. (2017). Product market competition in a world of cross-ownership: Evidence from institutional blockholdings. *Review of Financial Studies*, *30*, 2674–2718.

Hwang, J., & Lyu, S. O. (2018). Understanding first-class passengers' luxury value perceptions in the US airline industry. *Tourism Management Perspectives*, *28*, 29–40.

Jackson, W. E. (1997). Market structure and the speed of price adjustments: Evidence of non-monotonicity. *Review of Industrial organization*, *12*, 37–57.

Jiang, G., & Yuksel, H. Z. (2019). Sentimental mutual fund flows. *Financial Review*, 54, 709–738.

Jiang, J., Shrider, D. G., Ting, H., & Wu, Y. (2021). Are mutual fund investors loss adverse? Evidence from China. *Financial Review*, 56, 231–250.

Jiang, Y., Qian, Y., & Tong, Y. (2016). R&D spillover and predictable returns. *Review of Finance*, *20*, 1769–1797.

Karrenbrock, J. D. (1991). The behavior of retail gasoline prices: Symmetric or not? *Federal Reserve Bank of St. Louis Review*, *73*, 19–29.

Kim, E. H., & Singal, V. (1993). Mergers and market power: Evidence from the airline industry. *American Economic Review*, *83*(3), 549–569.

Koch, A., Panayides, M., & Thomas, S. (2021). Common ownership and competition in product markets. *Journal of Financial Economics*, *139*, 109–137.

Koopmans, C., & Lieshout, R. (2016). Airline cost changes: To what extent are they passed through to the passenger? *Journal of Air Transport Management*, *53*, 1–11.

Levenstein, M. C., & Suslow, V. Y. (2006). What determines cartel success? *Journal of Economic Literature*, *44*, 43–95.

Lewellen, K., & Lowry, M. (2021). Does common ownership really increase firm coordination? *Journal of Financial Economics*, *141*(1), 322–344.

Lewis, M. S. (2011). Asymmetric price adjustment and consumer search: An examination of the retail gasoline market. *Journal of Economics and Management Strategy*, *20*, 409–449.

López, Á. L., & Vives, X. (2019). Overlapping ownership, r&d spillovers, and antitrust policy. *Journal of Political Economy*, *127*, 2394–2437.

Moniter, C. S. (2011). Airline travel: Life in first class is getting cushier. Retrieved from: http://www.csmonitor.com/USA/2011/1119/Airline-travel-life-in-first-class-is-getting-cushier-but-not-backin-steerage

Mouavwad, J. (2011). Taking first-class coddling above and beyond, *New York Times*, Retrieved from: http://www.nytimes.com/2011/11/21/business/taking-first-class-coddling-above-and-beyond.html

Neumark, D., & Sharpe, S. A. (1992). 'Market structure and the nature of price rigidity: Evidence from the market for consumer deposits. *Quarterly Journal of Economics*, *107*, 657–680.

O'Brien, D. P., & Salop, S. C. (2000). Competitive effects of partial ownership: Financial interest and corporate control. *Antitrust Law Journal*, *67*, 559–614.

Pawliczek, A., Skinner, A. N., & Zechman, S. L. (2019). Facilitating tacit collusion: A new perspective on common ownership and voluntary disclosure. SSRN working paper. Available at SSRN: https://ssrn.com/abstract=3382324 or https://doi.org/10.2139/ssrn.3382324

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy*, *108*, 466–502.

Remer, M. (2015). An empirical investigation of the determinants of asymmetric pricing. *International Journal of Industrial Organization*, *42*, 46–56.

Riley, T. B. (2021). Portfolios of actively managed mutual funds. *Financial Review*, *56*, 205–230.

Stigler, G. J. (1964). A theory of oligopoly. *Journal of Political Economy*, *72*, 44–61.

Sun, L., Phan, H. V., & Simpson, T. (2021). Blockholder exit threats and corporate cash holdings. *Financial Review*, 56, 821–843.

Tappata, M. (2009). Rockets and feathers: Understanding asymmetric pricing. *RAND Journal of Economics*, *40*, 673–687.

Tosun, O. K. (2019). Why do large shareholders adopt a short-term versus long-term investment horizon in different firms? *Financial Review*, 54, 763–800.

Verlinda, J. (2008). Faster rockets and slower feathers with local market power. *Journal of Industrial Economics*, *57*, 581–612.

Yang, H., & Ye, L. (2008). Search with learning: Understanding asymmetric price adjustments. *RAND Journal of Economics*, *39*, S547–564.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Jiang, Y., Que, T., & Yu, M. (2022). Price asymmetries in the US airline industry. *Financial Review*, *57*, 793–814. https://doi.org/10.1111/fire.12293