The Impact of Cartel Dissolution on Prices: Evidence from the Air Cargo Cartel

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Abstract

I analyze pricing behavior before and after the detection of an air cargo cartel using a novel, hand-collected dataset. I find that prices did not decline after the cartel's detection. Additionally, pricing patterns are consistent with post-cartel tacit collusion. My findings suggest that airlines' cartel activity (specifically, the development of a methodology for determining the collusive price) laid a foundation for future tacit collusion. As a result, airlines profited from cartel activity, and shippers paid elevated prices, long after the cartel's dissolution.

Keywords: Antitrust, Cartels, Collusion

JEL Codes: L4, K2, C7

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1 Introduction

In the early morning of February 14th, 2006, the US Department of Justice and the European Commission[1] raided the offices of major air cargo airlines around the world, uncovering evidence of a global price-fixing conspiracy.[2] Subsequent investigations revealed that, from at least December of 1999 to February of 2006, cargo airlines illegally colluded to implement and adjust the level of fuel surcharges (a per-kilo or per-pound flat charge imposed on cargo shipments). Cartel members eventually paid billions of dollars in civil penalties and private sanctions while several executives served prison sentences. The purpose of this study is to explore the impact of the cartel's detection on prices using a novel, hand-collected dataset of fuel surcharges (FSCs) in the cartel and post-cartel periods.

I find that FSCs in the post-cartel period exceeded FSCs in the cartel period, even after accounting for changes in jet fuel costs. During the cartel's operation, cargo airlines developed a specific pricing formula, based on the price of jet fuel, for calculating a common (and collusive) FSC to be applied throughout the industry. I find that post-cartel FSCs closely resemble the FSC implied by the cartel's pricing formula. This suggests airlines continued to follow the cartel's pricing methodology after the cartel's dissolution. Thus, cartel detection caused a switch from explicit to tacit collusion, but not a reduction in prices. Airlines' cartel activity (specifically, the development of a methodology for calculating a collusive price) may have laid a foundation for future tacit collusion.[3]

My findings highlight two potential weaknesses in modern cartel enforcement. First, a fine based only on activity during the cartel period may be an inadequate punishment. If cartel activity enables firms to tacitly collude after detection, then price-fixers anticipate two distinct benefits from collusion: elevated profits in the cartel period and continued profits after cartel detection. Thus, fines based only on revenue or profit during the cartel period, as in the air cargo cartel, do not take into account the latter benefit and may be insufficient to deter future collusion.

Second, private damages based only on activity during the cartel period likely underestimate the cartel's harm. If high prices from explicit collusion persist after cartel detection, then purchasers suffer additional injury in the post-cartel period. However, private damage claimants are rarely awarded damages for post-cartel activity. Private damages may also underestimate the cartel's harm to consumers for another reason. If expert witnesses use post-cartel prices as a benchmark or reference period, as did expert witnesses in

[1] The raids also involved South Korea's competition authority, the Korea Fair Trade Commission (see https://www.law360.com/articles/5739).

[2] The investigation was prompted by a leniency application from one of the cartel's largest members-Lufthansa. See Bergman and Sokol (2015) for a discussion of Lufthansa's leniency application.

[3] My findings are consistent with the predictions of Appel (2008) who first argued that investigations and prosecutions had little impact on FSCs as airlines simply switched from explicit to tacit collusion after cartel detection. Prior literature related to the air cargo cartel is reviewed in Subsection 2.5.

damage litigation related to the air cargo cartel in the United States,[4] and firms continue to collude after the cartel's detection, then damages are underestimated (Harrington, 2004*b*).

From a policy perspective, I argue that a behavioral remedy[5] which required airlines to no longer impose fuel surcharges or, at a minimum, no longer reference a fuel surcharge index when announcing price changes, may have reduced post-cartel prices and disrupted post-cartel tacit collusion. Competition authorities have often avoided behavioral remedies (Maier-Rigaud and Loertscher, 2020), but my findings suggest they may be beneficial when cartel activity results in a clearly defined pricing policy/method that enables post-cartel tacit collusion. A targeted behavioral remedy which prevents the use of such a method could disrupt post-cartel price coordination and ensure prices decline toward competitive levels.

The air cargo cartel is a useful setting for studying cartel pricing behavior for four reasons. First, airlines colluded on a single, clearly defined element of price (surcharges) and did not engage in side payments, market sharing, bid rigging or any other practices which would complicate the analysis. Second, the dawn raids of February 14th, 2006 provide a clear boundary between cartel and post-cartel periods. Third, airlines developed a specific methodology for determining the collusive price during the cartel. Thus, it is possible to compare post-cartel prices to the collusive prices designed by the cartel. Lastly, the air cargo cartel was, at the time, the largest international cartel ever[6] and so is of interest in its own right.

Prior studies examining the effect of antitrust investigations on prices have found mixed results. For example, Erutku and Hildebrand (2010) and Clark and Houde (2014) found that prices declined after an antitrust investigation into a retail gasoline cartel. Contrarily, Sproul (1993) analyzed 25 cartels and found that prices typically rose in the 4 years following an indictment for price fixing. Prior literature analyzing the impact of antitrust intervention on prices is reviewed in Subsection 2.5.

Section 2 provides background information on the cartel, reviews prior literature, and introduces the data. Section 3 analyzes the impact of the cartel's dissolution on FSCs. In Section 4, I present evidence that suggests post-cartel tacit collusion is the most likely explanation for elevated post-cartel prices. I discuss implications and policy recommendations in Section 5. Section 6 concludes.

[4]See In re Air Cargo Shipping Services Antitrust Litig, 06-MD-1775 (E.D.N.Y. Nov. 24, 2010) (hereafter: US Case).

[5]Behavioral remedies are interventions that require or prohibit certain conduct.

[6]The air cargo cartel was, at the time, the largest international cartel ever in terms of fine amounts (Bergman and Sokol, 2015; Connor, 2020).

2 Cartel Background and Data

2.1 Industry Background

Air cargo constitutes 35% of global trade by value.[7] High-value, perishable or time-sensitive goods (e.g., vaccines, flowers, race horses, and emergency medical devices) are likely to be transported by air. Globally, the air cargo transportation industry consists of many firms with modest market shares. In 1996 (just prior to the cartel's formation), the largest cargo airline (Lufthansa) had a global market share of 7.3%. The largest 25 carriers performed 75% of international cargo traffic in 1996.[8] However, individual shipping routes (e.g., Atlanta to London) can be highly concentrated. Air cargo transportation is also a highly homogenous product. Transportation on one airline's flight is virtually indistinguishable from transportation on a rival's flight. In many markets, demand for air cargo transportation is highly inelastic because alternative shipping methods (e.g., ground or ocean shipping) are significantly slower than air transportation and unsuitable for high-value or time-sensitive goods. Prior to deregulation,[9] airlines cooperatively set rates on many routes and, as a result, executives were accustomed to discussing rates with competitors. Jet fuel costs are the largest source of variation in cargo airlines' prices and profits. Cargo airlines use a specialized kerosene-type jet fuel known as "Jet-A."

Typically, customers purchase air cargo transportation through a freight forwarder.[10] Freight forwarders act as middle-men between cargo airlines and customers. Forwarders purchase space on airlines' flights and re-sell this space to their customers–individuals or companies in need of cargo transportation. Freight forwarders also provide a range of necessary logistical services.

During the period examined in this study (2002-2013), air cargo prices had two primary components: a base rate and a fuel surcharge.[11] Base rates are the result of negotiations between freight forwarders and local cargo airline offices. Base rates typically depend on the route, volume, weight of shipment and type of good. Fuel surcharges are a per-kilogram or per-pound charge which is common to all shipments, regardless of route.[12] Fuel surcharges were set by high level executives (Chen, 2023). Immediately prior to the cartel's

[7] See https://www.iata.org/contentassets/4d3961c878894c8a8725278607d8ad52/air-cargo-brochure.pdf.

[8] Regulatory Reform in International Air Cargo Transportation. OECD Report DSTI/DOT(99)1. Dist. 07-Apr-1999 (hereafter: OECD Report 1999).

[9] Deregulation of air cargo transportation was not completed in the European Union until the "Third Package" of reforms instituted on January 1st 1993 (OECD Report 1999). Deregulation of air cargo transportation in the United States occurred much earlier with the Air Cargo Act of 1977 and the Air Deregulation Act of 1978.

[10] Some firms (e.g., FedEx, UPS and DHL), known as integrators, provide both cargo transportation and freight forwarding logistics services.

[11] Some airlines' cargo rates also implemented a "security surcharge" or a "war risk surcharge" after September 11th, 2001, purportedly due to elevated security costs. These surcharges were relatively small (5, 10 or 15 cents per kilogram) and were rarely adjusted throughout the cartel period.

[12] Fuel surcharges are not applied in some jurisdictions when prohibited by local governments. Some carriers charged different fuel surcharges in different markets (e.g., short haul vs. long haul markets). However, this practice was not widespread during the cartel or the years immediately after its detection. "Each decision to increase applied globally, except in those countries where regulatory approval was required, such as Thailand, Hong Kong and Japan, where the increases were subject to the

formation, air cargo rates did not include a fuel surcharge. Cartel members organized the imposition and adjustment of fuel surcharges throughout the industry.

2.2 Cartel Background

In the face of rising fuel costs in the late 1990s, airlines agreed to a resolution (Resolution 116ss) to impose surcharges at an IATA (the International Air Transport Association) meeting in January 1997.[13] The resolution presented a methodology for calculating the fuel surcharge on the basis of a FSC index. The FSC index was tied to jet fuel spot prices.[14] In January of 2000, IATA submitted Resolution 116ss to the US Department of Transportation (DOT) in order to secure antitrust immunity and begin implementing the resolution.[15] The DOT rejected the resolution on antitrust grounds in March of 2000.[16] As a result, IATA removed the index from its website and urged carriers to avoid using the index to calculate prices, because implementing surcharges according to the resolution could be considered illegal price-fixing.

However, airlines did not abandon the prospect of imposing industry-wide fuel surcharges through a FSC index. Instead, airlines began communicating privately in order to coordinate the imposition of FSCs industry-wide. Pursuant to these discussions, many airlines developed their own surcharge indexes and methodologies which closely resembled the methodology within Resolution 116ss. Often, airlines posted these indexes publicly on their websites and referenced their indexes in fuel surcharge announcements. Carriers that did not develop or publicly follow an index often simply referenced increasing (or decreasing) fuel costs when announcing fuel surcharge changes to their customers. Others directly referenced Lufthansa's index.[17]

Carriers engaged in extensive and regular communication, by phone, email and in-person, throughout the cartel's existence. One unnamed executive "had approximately 40 telephone calls with each of BA [British Airways], AF [Air France], KL [KLM Royal Dutch Airlines] and CV [Cargolux Airlines] in the time period between the beginning of 2003 and the end of 2005" (EU Case, ¶113). This communication served to ensure all carriers imposed the FSC and adjusted it in a near parallel fashion. Airlines often communicated when the index was approaching or exceeded a trigger point (the particular index values which indicated the FSC should be changed) in order to confirm that rivals intended to adjust their surcharges accordingly. Additionally, when jet fuel prices rose past the highest trigger points in the methodology, airlines

approval of the regulators" DHL's Opposition To United's Motion For Summary Judgement. DPWN Holdings (USA), Inc. vs. United Airlines Inc. 1:11-cv-00564-BMC, 08/31/18 (hereafter: DHL Case).

[13] IATA is an airline trade association.

[14] I discuss the fuel surcharge index and methodology in detail in the next section.

[15] IATA did not submit the resolution for approval until early 2000 because jet fuel prices had not increased enough to trigger the implementation of the FSC until that point.

[16] The DOT stated "The uniform, industry-wide index mechanism proposed here appears fundamentally flawed and unfair to shippers and other users of cargo air transportation." See Case COMP/39258 - Airfreight, 9/11/2010, Commission Decision. (hereafter: EU Case) and DPWN Holdings (USA), Inc. vs. United Airlines Inc. 2nd Cir. No. 12-4867-cv, 03/27/2014.

[17] "Many airlines openly admit that they calculate their surcharges based on the fuel price index published on the Lufthansa Cargo website since 2000" (Knibb and Conway, April 1st 2006). Also, see Appel (2008).

communicated in order to develop new trigger points. Communication also determined which airline would increase their fuel surcharge first (i.e., the price leader). As fuel costs continued to rise after 2000, the fuel surcharge became crucial to airlines' profitability (US Case, pg. 5).

In late 2005, Lufthansa secretly filed leniency applications in all major jurisdictions.[18] On February 14th, 2006, the US Department of Justice (DOJ) and European Commission (EC) conducted dawn raids at the offices of major cargo airlines and uncovered hard evidence of the conspiracy. Lufthansa publicly announced its leniency application and cooperation with the investigations in September of 2006 (Bergman and Sokol, 2015).

Following the cartel's discovery in 2006, the DOJ charged 22 airlines with price-fixing violations and the EC fined 11 airlines for collusion. Additionally, cargo airlines have faced price fixing charges in Canada, Australia, South Korea, South Africa and other jurisdictions (Ghosal and Sokol, 2013; Taylor et al., 2016). Both direct (freight forwarders) and indirect (shippers) consumers filed private class action lawsuits in both the US and Canada. In total, carriers have paid billions in government fines and antitrust damages since the cartel's discovery. Lufthansa (and its subsidiary Swiss Air) avoided government fines in major jurisdictions due to its leniency applications. However, Lufthansa paid over $100 million to settle private class action damages in the US (both from direct and indirect purchasers) and Canada. The air cargo cartel is one of the largest international cartels ever in terms of fines (Bergman and Sokol, 2015). Twenty-one executives were charged with price-fixing in the US and eight were sentenced to prison time.[19]

After the cartel's breakdown, Lufthansa[20] removed its FSC index from its website. However, other airlines (e.g., American Airlines) continued to set fuel surcharges in reference to their own indexes which remained publicly displayed on their websites. When jet fuel prices surged in late 2008, airlines added new trigger points to their respective indexes.

The exact set of firms involved in the cartel is unknown. While many large carriers pled guilty and paid large fines, some carriers did not face prosecution in certain jurisdictions despite suspicions of involvement, private class actions settlements or prosecution in other countries. For example, Alitalia did not pay a fine in Europe but was sentenced in Brazil.[21] United Airlines paid no government fines for their involvement, but faced a private suit nearly a decade later alleging new evidence proved they were involved.[22] Additionally, some airlines may have evaded prosecution due to limited involvement, a lack of evidence or relatively weak

[18] Lufthansa's leniency application to the European Commission was received on December 7th, 2005 (EU Case, ¶73).

[19] See https://www.justice.gov/opa/pr/extradited-former-air-cargo-executive-pleads-guilty-participating-worldwide-price-fixing.

[20] Virgin Atlantic and Qantas also removed their indexes from their respective websites (Appel, 2008).

[21] See EU Case and https://www.sandiegouniontribune.com/en-espanol/sdhoy-brazil-fines-4-airlines-for-price-fixing-2013aug29-story.html.

[22] DHL's Opposition To United's Motion For Summary Judgement. DPWN Holdings (USA), Inc. vs. United Airlines Inc. 1:11-cv-00564-BMC, 08/31/18.

Table 1: Lufthansa's Fuel Surcharge Methodology

Increases		Decreases	
Trigger Point	Fuel Surcharge Level	Trigger Point	Fuel Surcharge Level
115	0.05	100	0
135	0.1	120	0.05
165	0.15	145	0.1
190	0.2	170	0.15
215	0.25	195	0.2
240	0.3	220	0.25
265	0.35	245	0.3
290	0.4	270	0.35
315	0.45	295	0.4

Notes: Lufthansa's fuel surcharge methodology as of March 24, 2006. Source: Archived Versions of Lufthansa's Website. FSCs are in EUR or USD per kilogram.

antitrust enforcement in certain jurisdictions.[23]

2.3 Fuel Surcharge Methodology

Resolution 116ss defined an index (hereafter, the FSC index), calculated on the basis of jet fuel spot prices. The index was the average of kerosene-type jet fuel spot prices in five major markets (New York Harbor, U.S. Gulf Coast, Los Angeles, Rotterdam and Singapore), normalized such that an index value of 100 corresponded to an average jet fuel price of $0.535 per gallon (the average fuel price in June of 1996). When the index exceeded a pre-defined trigger point for at least two weeks, the fuel surcharge was raised (typically in increments of 5 cents). When the index fell below another pre-defined trigger point for at least two consecutive weeks, the fuel surcharge was reduced (again, typically in increments of 5 cents). If the index dropped below the lowest trigger point, the fuel surcharge would be withdrawn entirely. Throughout the cartel, airlines refined and expanded the index and fuel surcharge methodology. Table 1 presents a portion of Lufthansa's index methodology at the time of the dawn raids.[24] To illustrate the how the FSC methodology worked, suppose the current FSC is .05. Additionally, suppose the FSC index two weeks ago was 140 and the FSC index was 150 last week. As the FSC index exceeded the trigger point of 135 for both of the previous

[23]These considerations render a difference-in-difference approach, where non-penalized airlines are treated as a control group and penalized airlines are treated as a treatment group, infeasible.

[24]Other airlines' indexes were very similar. For comparison, American Airlines' index is available in the online appendix.

two weeks, the FSC would be increased to .10. A similar procedure governed FSC decreases.

Airlines did not always price exactly in accordance with the index, sometimes delaying fuel surcharge adjustments or not changing the FSC when it crossed a trigger point.[25] Additionally, fuel surcharge changes were not implemented instantaneously. Once the index exceeded (or fell below) a specific trigger point for two consecutive weeks, airlines would typically announce a change to the FSC, but this change would not become effective until a later date (often about two weeks after the announcement). Fuel surcharges were not adjusted for exchange rate fluctuations. Also, carriers often imposed the same surcharge on European customers (in Euros) as they imposed on American customers (in Dollars). For example, American Airlines increased the fuel surcharge to .45 USD or .45 EUR if the index exceeded a level of 170 for 2 consecutive weeks. When FSCs were set in pounds or another currency, they were typically adjusted, in some way, for currency differences.

The fuel surcharge methodology was, at most, weakly connected to an airline's actual jet fuel costs for at least three reasons (Appel, 2008).[26] First, longer routes require larger amounts of fuel than shorter routes, yet the same FSC was applied, in most cases, to all of an airline's routes regardless of flight distance.[27] Second, airlines often purchase fuel through long term contracts and, as a result, an airline's jet fuel cost was not directly determined by the spot price.[28] Third, as illustrated in Table 1, the fuel surcharge methodology involved different trigger points for increases and decreases. This meant that a particular FSC increase could potentially remain in effect even after jet fuel prices declined below the point that triggered the increase. For example, suppose the current FSC is .05 and the jet fuel index was 137 for the two prior weeks. As Table 1 illustrates, the Lufthansa methodology would require the FSC to be increased from .05 to .10, because 137 exceeds the trigger point of 135. If the fuel index declined back to 130 after this increase, then the fuel surcharge would remain at .10 because the index had not reached the applicable trigger point for an FSC reduction (i.e., 120).

2.4 Surcharge Collusion

The air cargo cartel employed a unusual form of price-fixing. Airlines colluded on fuel surcharges, a portion of the final price, and did not collude on base rates, the remainder of the final price. Colluding on surcharges,

[25] For example, "The LH [Lufthansa] fuel price indicated that an announcement to increase the FSC was due on the 10th of October, 2005. However LH decided to postpone the increase as AF/KL [Air France/KLM] would not give a commitment to follow an LH increase" (EU Case, ¶511)

[26] As Marc Rosman, a former assistant chief in the antitrust division of the DOJ, states, "if you actually peel the onion on either a fuel surcharge or a security surcharge and look behind it, I think you would find that there are not dollar-for-dollar cost recovery mechanisms, and in fact, there's probably a very loose correlation between the actual costs that are associated with the fuel and security and the actual surcharge" (see https://aircargoworld.com/news/surcharges-fair-or-foul/).

[27] Additionally, different aircrafts have different fuel efficiencies, but the fuel surcharge did not depend on the aircraft type.

[28] For example, Qantas had fuel hedging arrangements (see ¶44 of Australian Competition and Consumer Commission v Qantas Airways Limited [2008] FCA 1976).

rather than base rates, may have been preferable to airlines for a number of reasons. First, as fuel surcharges are announced publicly and are common to all routes, they are easy to monitor. Base rates are the result of negotiations between cargo airlines and forwarders and, as a result, are not easily observed by rival airlines. Second, base rates are complex and depend on a variety of factors (e.g., volume, route, type of good and negotiating skill). Determining a collusive base rate on each route and for each type of good would be exceedingly complicated. Third, fuel surcharge collusion may be less likely to raise suspicion among buyers or antitrust authorities because firms can attribute price increases to rising costs. Additionally, collusion on base rates would require the involvement of many local managers that determine base rates. As fuel surcharges are set by a small number of high level executives, surcharge collusion requires the involvement of fewer individuals which may reduce the probability of detection (Chen, 2023).

Collusion based on only a portion of the final price (e.g., the surcharge), at first glance, seemingly suffers from an important flaw. As firms do not collude on the remainder of price (i.e., the base rate), airlines could potentially match rivals' fuel surcharges, to give the appearance of complying with the collusive agreement, while simultaneously cheating on the agreement by offering customers reduced base rates. In this sense, airlines' announcements of surcharge changes could be cheap talk which does not ultimately impact the final price.[29]

However, recent theoretical research suggests that colluding on a portion of the final price can be highly effective (Harrington and Ye, 2019; Harrington, 2022; Chen, 2023). Crucially, theoretical studies suggest that firms are not required to set the remainder of the price (e.g., the base rate) collusively, nor are they required to monitor the entirety of the final price. In Harrington and Ye (2019), collusion is effective because increased fuel surcharges induce buyers to negotiate less aggressively when determining base rates and, as a result, pay higher final prices. In Chen (2023), owners determine the surcharge and delegate the setting of base rates to a manager. As managers are compensated on the basis of profits generated by the base rate, they do not wish to fully reduce base rates in order to offset surcharge increases. Chen (2023) demonstrates that surcharge collusion is as profitable as collusion on the entire final price. In Harrington (2022), collusion on surcharges (which act as a signal of the firm's cost to lower-level employees) induces lower-level managers to price "as if" the firm's cost is higher than it actually is, which results in higher final prices and effective collusion. Put differently, collusion on surcharges (among higher-level executives) raises the perceived cost of lower-level executives setting final prices. See Garrod (2006), Boshoff and Paha (2021) and Ross and

[29]There are other (alleged) instances of collusion on a portion of the final price (Harrington and Ye, 2019; Harrington, 2022; Chen, 2023). For example, six battery manufacturers in Belgium colluded to impose a surcharge on lead (see Belgian Competition Authority, Press Release, N◦ 4/2016, 23, February, 2016). Railroads were accused of fixing surcharges from 2003 to 2007 (see In re Rail Freight Surcharge Antitrust Litig., 587 F.Supp.2d 27, (2008), United States District Court, District of Columbia. November 7, 2008). Also, see European Commission Decision 98/247/ECSC (Alloy Surcharge), 1998 O.J. (L 100) 55, and European Commission Decision 97/84/EC (Ferry Operators-Currency Surcharges), 1996 O.J. (L 026) 23.

Shadarevian (2021) for other explanations and discussion of this type of collusion.

In addition to the arguments of prior theoretical literature, there are at least three reasons to believe surcharge collusion was effective in the air cargo cartel. First, airlines' continued use of fuel surcharges throughout the cartel suggests this type of collusion benefited carriers. Second, the cartel appears to have been highly stable. Antitrust cases do not indicate any instances of persistent cheating or price wars. Lastly, to my knowledge, airlines never attempted to monitor or even discuss fixing base rates during the cartel period.

2.5 Literature Review

Prior studies analyzing the impact of antitrust investigations on prices have found mixed results. Erutku and Hildebrand (2010) and Clark and Houde (2014) found that prices fell following the announcement of an investigation into a retail gasoline cartel in Canada. González and Moral (2019) study a cartel involving Spain's largest oil operators. They find that prices increased after the announcement of antitrust fines. Sproul (1993) analyzed 25 cartels and found that prices typically rose in the 4 years following an indictment for price fixing.[30] Asker (2010), in his analysis of an international maritime chemical shipping cartel, also finds evidence that cartel distortions persist in the post-cartel period. Elevated cartel prices persisted beyond the formal cartel end date in the European sodium chlorate cartel (Boswijk, Bun and Schinkel, 2019). Starc and Wollmann (2022) also find evidence of post-cartel tacit collusion after the recent discovery of a generic drug cartel.

In their study of a road surfacing cartel in Switzerland, Hüschelrath, Leheyda and Beschorner (2010) find that prices declined after the cartel's detection, but began to rise again after a few years. In some cases, for example, the German cement cartel (Hüschelrath, Müller and Veith, 2013; Frank and Schliffke, 2013), price wars (intended to punish a defecting firm) can lead to post-cartel prices which are below competitive levels. Khumalo, Mashiane and Roberts (2014) find that prices did not immediately fall in some provinces after the end of a cartel involving pre-cast concrete products in South Africa (i.e., there was a transition period between collusion and more competitive pricing). After the detection of the vitamins cartel, the prices of some products did not decline after the cartels detection (and seemed to continue as if the conspiracy never ended) while the prices of other products returned to pre-conspiracy levels (Kovacic et al., 2007).

Prior literature studying the air cargo cartel has suggested the possibility of post-cartel tacit collusion. Appel (2008) first argued that criminal investigations into collusion did not disrupt concerted FSC increases among cargo airlines, although he did not present an empirical analysis.[31] Additionally, Appel (2008)

[30] Sproul (1993) suggests this could be due to antitrust intervention disrupting efficient, cost-reducing cartels. Post-cartel tacit collusion is an alternative explanation for this result.

[31] In Table 1, Appel (2008) presents a small sample of fuel surcharges as of November/December of 2007 which illustrates

argued the cartel's specialized methodology (the FSC index) eliminated the need for explicit communications between airlines. Using the air cargo industry as a motivating example, he contends that courts should adopt a stricter approach towards tacit collusion in order to provide adequate restitution to consumers. Generally, my findings provide strong empirical support for the arguments and predictions of Appel (2008). Jacobs (2008), Atkinson and Monteiro (2010) and LeClair (2012) also provide reviews and discussion of the air cargo cartel. Jacobs (2008) discusses antitrust lessons from the air cargo cartel, particularly for merger law. Atkinson and Monteiro (2010) review the air cargo industry, the competitive landscape in the industry, and antitrust investigations into the cartel. LeClair (2012) discusses the novel method of collusion (i.e., the fixing of surcharges) employed by the cartel and the risk of financial exigency prior to cartel formation. However, these studies do not present a direct empirical analysis of firm-level pricing behavior. In this study, I analyze a novel, hand-collected dataset of fuel surcharges unavailable to prior research.

2.6 Data

Data consists of an unbalanced panel of fuel surcharges by airline from 2002-2013.[32] Data is available from 41 cargo airlines and was collected from a variety of sources including the Official Airlines Guide in-forwarding service,[33] various industry news reports,[34] archives of airline's websites, reports in prior literature (Appel, 2008), and antitrust cases against the cartel.[35] Additional information regarding the collection and cleaning of data is presented in the online appendix. I also use data on the daily US Gulf Coast Kerosene-Type Jet Fuel Spot Price, in dollars per gallon, provided by the US Energy Information Administration.[36] Unless otherwise stated, I convert fuel surcharges and jet fuel prices into real values, using January 1st, 2000 as a base date. I also convert all FSCs to US dollars for comparison purposes, using the exchange rate that prevailed at the time each surcharge was in place.[37] The final sample size is 81,493 observations where each observation corresponds to a particular airline-day combination.

I also compute the FSC index in each week. As described in Subsection 2.3, airlines typically used the average of the jet fuel spot price across five markets (US Gulf Coast, New York Harbor, Los Angeles, Rotterdam and Singapore) when computing the FSC index. Unfortunately, historic data is no longer available

that the cartel's detection does not appear to have resulted in reduced FSCs.

[32]Data is unavailable before 2002. Fuel surcharges were often not charged prior to 2002 because jet fuel prices were too low to trigger the imposition of FSCs.

[33]OAG In-forwarding (http://inforwarding.oagcargo.com) provides operational announcements for the air cargo industry. The service was discontinued in April/May of 2022.

[34]News sources include freightwaves.com, insidelogistics.ca, aviationweek.com, canadianshipper.com and aircargonews.net.

[35]Specifically, data was obtained from the Australian case against Qantas Airlines (Australian Competition and Consumer Commission v Qantas Airways Ltd - [2008] FCA 1976), the European Commission case (Case COMP/39258 - Airfreight (Sep 11, 2010)) and the DHL Case.

[36]See https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EER_EPJK_PF4_RGC_DPG&f=D. Data is unavailable for Saturdays and Sundays. For these days, I use the jet fuel price on the previous Friday.

[37]Exchange rate data is from FRED (https://fred.stlouisfed.org/series/GDPDEF).

from jet fuel spot price markets other than the US Gulf Coast.[38] Thus, I use a FSC index based only on the US Gulf Coast jet fuel price as a proxy for the true index. In the online appendix, I show that my proxy closely matches partial records of Lufthansa's true index (based on spot prices from all five markets), which suggests the proxy is likely to be reasonably accurate. Using the FSC index, I compute the FSC level implied by Lufthansa's methodology (hereafter, the index-based FSC).[39] I also compute the index-based FSC implied by American Airlines' surcharge methodology for comparison purposes (the two indexes closely mirror each other). When computing the index-based FSC, I account for the delay between an airline announcing a FSC change and the FSC increase or decrease actually being implemented. FSC announcements indicate that this lag was, on average, two weeks. As a result, the actual index-based FSC used in the analysis is the FSC implied by the index two weeks prior. For example, if the FSC index exceeds the trigger point for two consecutive weeks, the index-based FSC is increased two weeks later. Additional details are provided in the online appendix.

I do not analyze security surcharges or war risk surcharges imposed after September 11th, 2001 for two reasons. First, data on security surcharges or war risk surcharges are unavailable. Second, security surcharges were rarely adjusted throughout the cartel or post-cartel period.[40]

I use February 14th, 2006 (the date of the dawn raids) as the date of cartel detection/dissolution. Zhou (2016) also uses the date of the competition authority's raid to analyze the impact of antitrust investigation.[41] Antitrust authorities considered collusion to have ended in February of 2006.[42]

In the main analysis, I do not differentiate between airlines that paid penalties (either government fines or private damages) and airlines that did not. As discussed in Subsection 2.1, the exact set of colluding firms is unknown and it is possible that some firms participated in the cartel without ever facing antitrust penalization. Results are robust to restricting the sample to firms that paid government fines for cartel activity (see Table 4).

Figure 1 plots the average fuel surcharge (averaging across firms) over time. The vertical dotted line denotes the date of cartel dissolution (February 14th, 2006). Figure 1 also plots the daily U.S. Gulf Coast

[38] Jet fuel spot prices in other markets were previously published under a licensing agreement between the US Energy Information Administration and a private data supplier. This agreement has since expired.

[39] The online appendix includes a full description of the Lufthansa's fuel surcharge methodology, a portion of which is depicted in Table 1. Lufthansa's fuel surcharge methodology was removed from their website shortly after the dawn raids. However, the surcharge methodology was recovered through internet archives.

[40] For example, Lufthansa's security surcharge remained in place until 2015 (see https://www.freightwaves.com/news/swiss-lufthansa-update-cargo-pricing-structure).

[41] An alternative "end date" for the cartel is the date that Lufthansa's leniency application became public (September 12th, 2006). I show results are robust to this alternative end date in Section 3. Additionally, I explore changes in fuel surcharges after the publication of government fines (both in the EU and US) in the online appendix.

[42] The Department of Justice used February as an end date when setting cartel fines (see https://www.justice.gov/archive/atr/public/press_releases/2007/224928.htm). The Australian Competition and Consumer Commission's case against Qantas Airways states "The conduct ceased in February 2006, when allegations concerning the Fuel Surcharge Understanding were publicized following "raids" undertaken by regulatory bodies in the United States and Europe" (Australian Competition and Consumer Commission v Qantas Airways Ltd - [2008] FCA 1976).

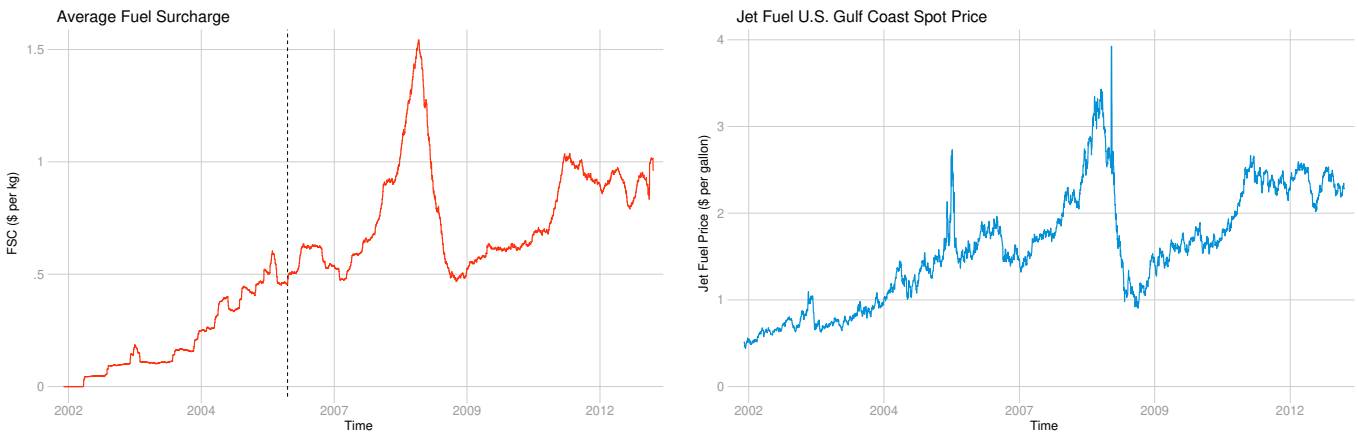

Figure 1: Average Fuel Surcharge and Jet Fuel Prices

Kerosene-Type Jet Fuel Spot Price, in dollars per gallon, over the same period. Fuel surcharges closely track jet fuel prices both in the cartel and post-cartel period.

3 Impact of Cartel Dissolution

In this section, I test for differences in fuel surcharges between the cartel and post-cartel periods. Figure 1 illustrates that fuel surcharges were, on average, larger in the post-cartel period. However, jet fuel prices (i.e., airline costs) increased substantially in the post-cartel period (especially in early 2008). I test if FSCs declined after the cartel's detection while accounting for fuel costs.

As an initial exploration of how FSCs changed relative to jet fuel prices after the cartel's detection, I normalize the average FSC (across firms) and jet fuel price such that both series equal 1 on the date of cartel detection.[43] These series represent the fuel price or FSC relative to the date of cartel dissolution. For example, if the normalized average fuel surcharge is 2, this implies that fuel surcharges are twice their level on February 14th, 2006. Figure 2 presents the normalized average fuel surcharge and jet fuel price. Figure 2 shows that FSCs increased, relative to fuel prices, in the post-cartel period (i.e., the red line is above the blue line). This result persists throughout the post-cartel period.

To test this observation more formally, I estimate the following fixed effect specification:

$$FSC_{it} = \beta_0 + \beta_{post} post_t + \beta_1 fuel_t + \beta_2 fuel_t^2 + \alpha_i + \epsilon_{it} \tag{1}$$

where FSC_{it} denotes airline i's fuel surcharge on day t (in Dollars). α_i denotes a firm-level fixed effect

[43] Graphic scheme source for figures: Bischof (2017).

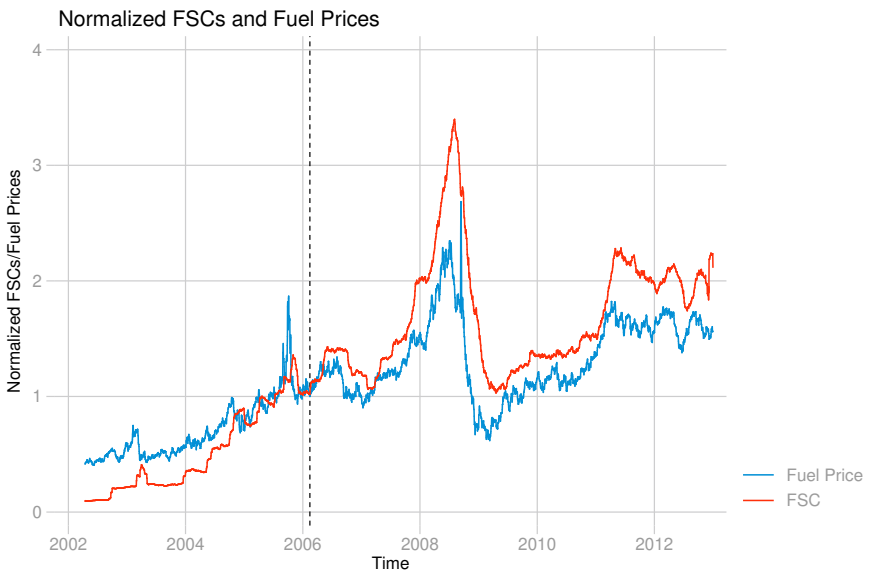

Figure 2: Normalized FSCs and Fuel Prices

and ϵ_{it} is an error term. α_i captures firm-specific pricing differences over the entire sample period. $fuel_t$ denotes the US Gulf Coast spot fuel price in dollars per gallon (as depicted in Figure 1). I include the square of $fuel_t$ to account for the possibility of airline jet fuel costs impacting FSCs non-linearly.[44] Results are robust to dropping this term and instead accounting for jet fuel prices linearly (see Table 2). Results are also robust to the inclusion of a cubic term (see Table 3). β_{post} is the coefficient of interest. If $\hat{\beta}_{post} < 0$ (resp. $\hat{\beta}_{post} > 0$), then airlines reduced (resp. increased) their FSCs after the cartel's detection, controlling for jet fuel prices and airline fixed effects. Note that no data on fuel surcharges are available prior to the cartel. Thus, post-cartel changes in FSC are relative to levels during the cartel period.

Table 2 presents results. Column (4) corresponds to the main specification. I find that FSCs increased by 17.8 cents after the cartel's dissolution after accounting for changes in fuel prices and airline fixed effects. Moreover, the increase is statistically significant at the .01 level. I discuss potential causes of this result in the following section. As expected, FSCs are increasing in jet fuel prices. The quadratic relationship between jet fuel prices and FSCs is also statistically significant. The R-squared value in the main specification is .866 which indicates the model explains a large proportion of the total variation in FSCs.

Next, I examine the evolution of FSCs in the post-cartel period by year. Specifically, I estimate a specification including interactions between the $post_t$ variable and indicator variables for each year in the post-cartel period (i.e., 2006-2012). This specification decomposes post-cartel FSC levels by year. Column

[44] Expert witnesses in US private damage litigation also included a quadratic cost term when estimating damages (US Case, pg. 21).

(5) presents results. I find that FSCs in every post-cartel year exceeded FSCs during the cartel. With the exception of 2008 (which was affected by the 2008 oil price shock and the Great Recession), FSCs gradually increase after the dawn raids.[45] These results suggest that elevated FSCs were not transitory or present only in the years immediately after the dawn raids, but persisted many years afterwords.

Table 3 presents various robustness checks. The second column (titled "Baseline") reproduces the baseline specification for comparison. The third column (titled "Alt. Detection Date") uses an alternative definition of the post-cartel period. Specifically, I use the date that Lufthansa's leniency application became public (September 12th, 2006) as the date of cartel breakdown. The dawn raids on February 14th, 2006 and their intent (to investigate price fixing in the air cargo industry) were widely publicized. As a result, all firms were likely fully aware of antitrust investigations into price-fixing. However, airlines may not have believed the investigations were likely to be successful (perhaps due to the lack of a cooperating witness/firm) until Lufthansa's role as a leniency applicant was made public in September. Thus, the date that Lufthansa's leniency application became public may represent a more accurate date of cartel dissolution. When using September 12th, 2006 as a cartel end date, I find that FSCs increased by 16.6 cents after Lufthansa's leniency application became public, after accounting for jet fuel price changes and airline fixed effects.

The fourth column presents estimates when the cube of jet fuel prices (i.e., $fuel_t^3$) is included. Results are unchanged. The fifth column (titled "Firm Specific Fuel Eff.") includes interactions between carrier fixed effects and the fuel variables ($fuel_t$ and $fuel_t^2$) to allow for differences in fuel efficiency between airlines. For example, the prices of airlines operating newer, and more fuel efficient, aircraft may be less responsive to jet fuel costs. As in the baseline setting, I find that FSCs in the post-cartel period exceeded FSCs in the cartel period. When setting FSCs, airlines often announced upcoming FSC changes approximately 2 weeks prior to implementation. Thus, the FSC imposed on cargo shipments on any particular date may be determined by the price of jet fuel two weeks before the change is implemented. To account for this possibility, I re-estimate the specification in Equation (1) using $fuel_{t-14}$ and $fuel_{t-14}^2$ (i.e., the 14 day lag of the jet fuel price and its square) in place of $fuel_t$ and $fuel_t^2$. I find that FSCs increased by 16.4 cents after the cartel's detection. In the online appendix, I show that all regression results from the main text are robust to the use of lagged fuel prices in place of the $fuel_t$ and $fuel_t^2$ variables.

Next, I analyze the robustness of my results to alternative subsamples. Table 4 presents results. First, I show that results are not driven by anomalous pricing during the great recession (December 1st, 2007 to June 30th, 2009). The third column (titled "No recession") presents results excluding any data from the Great Recession. The fourth column (titled "Before Recession") includes only data from before the Great Recession.

[45] In Section 4, I argue that post-cartel pricing behavior is consistent with tacit collusion. Thus, this result may reflect airlines learning to collude more effectively over time or steadily becoming more confident that collusion would persist in the post-cartel period.

Table 2: Impact of Cartel Dissolution

	(1)	(2)	(3)	(4)	(5)
Post	0.475***	0.157***	0.172***	0.178***	
	(0.00149)	(0.00140)	(0.00144)	(0.00143)	
Fuel Price		0.398***	0.281***	0.265***	0.489***
		(0.00149)	(0.00506)	(0.00503)	(0.00375)
Fuel Price Sq.			0.0310***	0.0349***	-0.0499***
			(0.00148)	(0.00143)	(0.00117)
Post 2006					0.110***
					(0.00117)
Post 2007					0.131***
					(0.00126)
Post 2008					0.452***
					(0.00257)
Post 2009					0.201***
					(0.00151)
Post 2010					0.160***
					(0.00125)
Post 2011					0.262***
					(0.00225)
Post 2012					0.255***
					(0.00225)
Firm FE	NO	NO	NO	YES	YES
N	81,493	81,493	81,493	81,493	81,493
R sq.	0.499	0.823	0.825	0.866	.911

*This table presents estimates of the impact of cartel dissolution. Standard errors are heteroskedasticity robust. *** p<.01, ** p<.05, *p<.1. The dependent variable in all regressions is an airline's FSC in US dollars.*

Table 3: Impact of Cartel Dissolution: Robustness

	Baseline	Alt. Detection Date	Cubed Fuel Prices	Firm Specific Fuel Eff.	Lagged Fuel Prices
Post	0.178***		0.178***	0.175***	0.164***
	(0.00143)		(0.00141)	(0.00143)	(0.00134)
Post Len.		0.166***			
		(0.00120)			
Fuel Price	0.265***	0.363***	0.319***		
	(0.00503)	(0.00418)	(0.0195)		
Fuel Price Sq.	0.0349***	0.0105***	0.00361		
	(0.00143)	(0.00125)	(0.0124)		
Fuel Price Cub.			0.00554**		
			(0.00238)		
Lag. Fuel Price					0.272***
					(0.00524)
Lag. Fuel Price Sq.					0.0383***
					(0.00151)
Firm FE	YES	YES	YES	YES	YES
N	81,493	81,493	81,493	81,493	81,493
R sq.	0.866	0.870	0.866	0.888	0.894

*Notes: This table presents robustness checks for Table 2. Standard errors are heteroskedasticity robust. *** p<.01, ** p<.05, *p<.1. The dependent variable in all regressions is an airline's FSC in US dollars.*

Table 4: Impact of Cartel Dissolution: Subsample Robustness

	Baseline	No Recession	Before Recession	Appear Before and After Detection	Penalized Firms Only
Post	0.178***	0.119***	0.103***	0.174***	0.153***
	(0.00143)	(0.00125)	(0.000830)	(0.00148)	(0.00186)
Fuel Price	0.265***	0.439***	0.794***	0.249***	0.291***
	(0.00503)	(0.00346)	(0.00491)	(0.00515)	(0.00614)
Fuel Price Sq.	0.0349***	-0.0133***	-0.159***	0.0420***	0.0346***
	(0.00143)	(0.00116)	(0.00192)	(0.00147)	(0.00183)
Firm FE	YES	YES	YES	YES	YES
N	81,493	69,192	46,686	75,908	47,253
R sq.	0.866	0.908	0.917	0.871	0.887

*Notes: This table presents subsample robustness checks for Table 2. Standard errors are heteroskedasticity robust. *** p<.01, ** p<.05, *p<.1. The dependent variable in all regressions is an airline's FSC in US dollars.*

Some carriers appear in the dataset only in the cartel or post-cartel period. If carriers that reduced their FSC after the cartel's detection are more likely to be missing from the dataset in the post-cartel period (i.e., the occurrence of missing data in the post-cartel period is negatively correlated with FSCs), then the estimated increase in FSCs could be driven by the absence of these carriers. To examine this possibility, I re-estimate the baseline specification using only carriers with some data availability before and after the cartel's breakdown. The fifth column titled ("Appear Before and After Detection") presents results. The last column (titled "Penalized Firms Only") estimates the main specification including only firms which paid government fines, in at least one jurisdiction, for cartel activity.[46] For all subsamples, the main result holds– FSCs increased significantly after the cartel's dissolution after accounting for jet fuel costs and carrier fixed effects.

Next, I analyze the impact of cartel dissolution on FSCs at the firm level. Specifically, I estimate the

[46]See the appendix for a summary of government fines. Data on government fines are from government plea agreements and the Connor's Cartel Database (Connor, 2020). Note that Lufthansa (and its subsidiary Swiss Air) avoided a fine for cartel activity in many jurisdictions due to its leniency applications. However, Lufthansa is included as a penalized firm in this regression as it was involved in the cartel. In the online appendix, I estimate the main specification for two additional subsamples: one involving only firms which paid government fines in the EU and one involving only firms that paid fines in the US. Results are qualitatively unchanged.

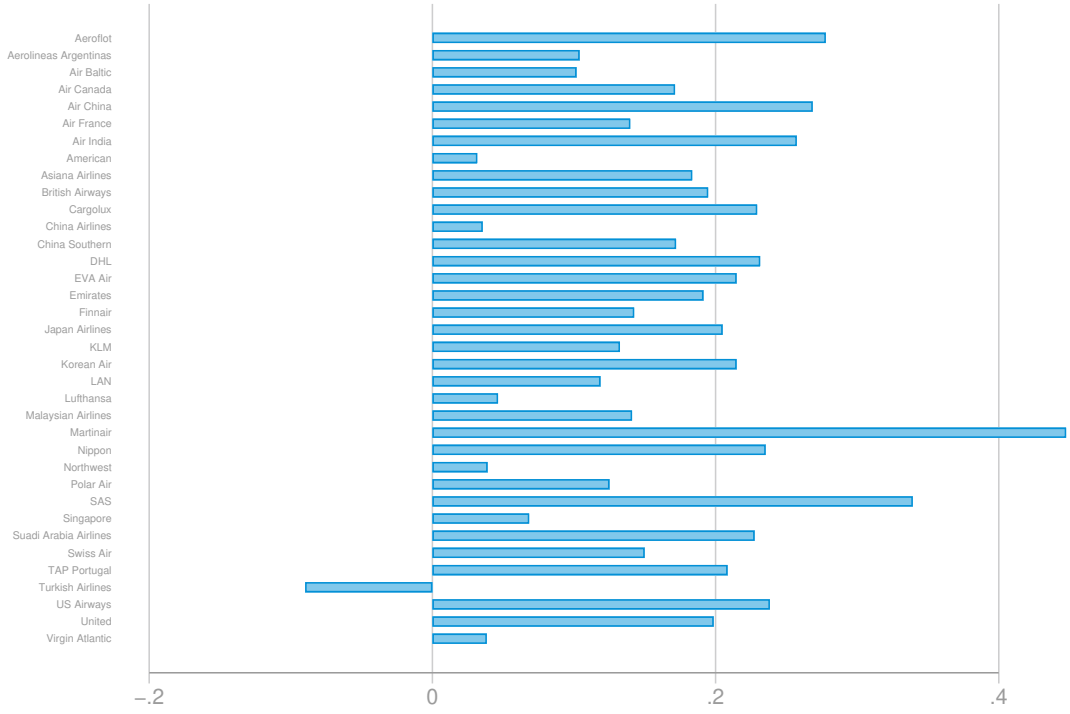

Figure 3: Change in FSC by Firm ($\hat{\beta}_{i,post}$)

following specification:

$$FSC_{it} = \beta_0 + \sum_i \beta_{i,post} post_{it} + \beta_1 fuel_t + \beta_2 fuel_t^2 + \alpha_i + \epsilon_{it}$$

where $\beta_{i,post}$ represents the change in airline i's FSC, after accounting for fuel prices and airline fixed effects. $post_{it} = 1$ for airline i in the post-cartel period. Figure 3 presents $\hat{\beta}_{i,post}$ by airline. The post-cartel price increase is homogenous throughout the industry. All airlines in the dataset except for Turkish Airlines increased their FSCs in the post-cartel period.[47]

4 Post-Cartel Tacit Collusion

Regression results from Section 3 suggest that FSCs did not decline after the cartel's dissolution, even after controlling for changes in jet fuel prices. However, these estimates do not speak to the cause of this result. FSCs may have increased due to unobservable changes in demand, cost, or market exit. Alternatively, elevated post-cartel prices could be the result of post-cartel tacit collusion (Appel, 2008). In this section, I

[47]Turkish Airlines consistently set the lowest FSCs in the post-cartel period. Additionally, Turkish Airlines regularly announced that it would not increase its FSC when other airlines were announcing increases.

present evidence suggesting that post-cartel tacit collusion is the most likely explanation of observed pricing behavior. Specifically, I will show that airline pricing closely matched the FSC implied by the FSC index (hereafter, the index-based FSC) after the cartel's dissolution. This suggests that airlines continued to set fuel surcharges, at least approximately, according to the collusive FSC methodology developed during the cartel. Additionally, I show that pricing behavior did not change abruptly after the dawn raids which is consistent with continued collusion and inconsistent with a switch to competitive pricing.

Figure 4 plots the average raw FSC (i.e., the FSC before adjusting for inflation or exchange rate fluctuations) and the index-based FSC (based on Lufthansa's Index) across time. I compare the raw FSC and the index-based FSC because the FSC methodology determined the raw FSC that airlines would charge. The FSC methodology did not adjust for inflation or exchange rates.[48] The dashed vertical black line in Figure 4 denotes the date of cartel dissolution.

The two series are highly correlated. After the cartel's detection, FSCs continued to closely track the index-based FSC. This suggests that airlines may have continued to set prices using the FSC index after the cartel's dissolution. Indeed, many airlines (e.g., American Airlines) continued to publicly display their FSC indexes on the websites and continued to directly reference the FSC methodology when announcing FSC changes. By the time of the cartel's detection, the FSC index and methodology was well understood from years of setting FSCs using the methodology during the cartel's operation. Thus, explicit communication may have no longer been necessary to ensure airlines complied with the FSC methodology (Appel, 2008).

To examine how the relationship between the FSC and index-based FSC changed after the cartel's dissolution, I estimate the following fixed effect specification:

$$\frac{|FSC_{it} - indexFSC_t|}{FSC_{it}} = \beta_0 + \beta_{post} post_t + \beta_1 fuel_t + \beta_2 fuel_t^2 + \alpha_i + \epsilon_{it}. \quad (2)$$

$indexFSC_t$ denotes the index-based FSC at time t (from either American Airlines or Lufthansa). The dependent variable is airline i's percentage absolute deviation from the index-based FSC at time t.[49] β_{post} represents the change in the percentage absolute deviation from the index-based FSC after the cartel's dissolution. If β_{post} is positive, then FSCs deviated from the index to a greater extent in the post-cartel period. If β_{post} is negative, airlines followed the index-based FSC more closely in the post-cartel period.

Table 5 presents results. I estimate the regression specification in Equation (2) using an index-based FSC calculated from Lufthansa's index and an index-based FSC calculated from American Airlines' index. The second column (titled "Baseline LH") presents results with Lufthansa's index-based FSC. I find that

[48] Additionally, I exclude any airlines for which data is only available in British pounds (i.e., data from China Airlines, KLM, Finnair and LAN Cargo) because the FSC methodology (from Lufthansa's website) is unavailable in pounds.

[49] Andreoli-Versbach and Franck (2015) employ a similar response variable when testing for price leadership in the Italian petrol market.

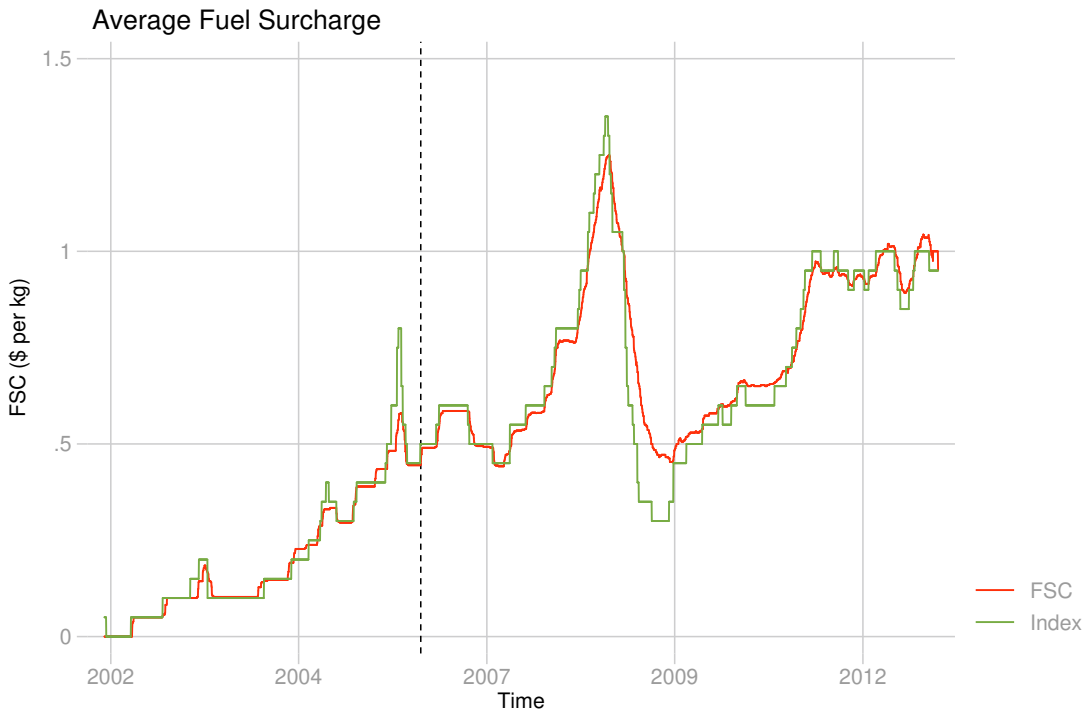

Figure 4: Average FSC versus Lufthansa's Fuel Surcharge Index

the percentage absolute deviation between the FSC and the index-based FSC increased after the cartel's dissolution by a modest 3%. However, this result is entirely driven by unprecedented fuel price volatility during the Great Recession (see Figure 2). When jet fuel prices are more volatile, the FSC index rapidly crosses trigger points in the FSC methodology and, as a result, airlines must quickly adjust their FSC to remain consistent with the index. However, as airlines typically do not implement a FSC change until two weeks after the FSC index has reached a trigger point, this creates a discrepancy between an airline's FSC and the index-based FSC. This discrepancy is largest when jet fuel prices are highly volatile and many trigger points are reached in rapid succession, because new trigger points are reached before an airline has finished adjusting its FSC in response to a prior trigger point being reached. When I exclude data from the Great Recession from the regression in Equation (2) (see the third column of Table 5), the previous result (in the second column) reverses and airlines' FSCs more closely match the index-based FSC in the post-cartel period (although this difference is small). I find similar results using American Airlines' FSC index (see the fourth and fifth columns of Table 5). As a whole, results suggest the relationship between FSCs and the index-based FSC did not significantly change after cartel detection (excluding a period of increased jet fuel price volatility during the Great Recession). These results support the conclusion that airlines continued to set FSCs using the FSC index methodology in the post-cartel period.

Table 5: Impact of Cartel Dissolution on Price Deviation

		No		No
	Baseline	Recession	Baseline	Recession
Index Airline	LH	LH	AA	AA
Post	0.0318***	-0.0461***	0.0430***	-0.00781***
	(0.00164)	(0.00130)	(0.000947)	(0.000596)
Fuel Price	-0.134***	-0.0103	-0.0583***	0.0377***
	(0.00508)	(0.00632)	(0.00238)	(0.00202)
Fuel Price Sq.	0.0270***	0.00974***	0.0145***	-0.00144**
	(0.00122)	(0.00146)	(0.000571)	(0.000597)
Firm FE	YES	YES	YES	YES
N	75,864	64,576	75,864	64,576
R sq.	0.191	0.143	0.238	0.309

*Notes: This table presents estimates of the impact of cartel dissolution on the price deviation. Standard errors are heteroskedasticity robust. *** p<.01, ** p<.05, *p<.1. The dependent variable in Columns (2) and (3) is the percentage absolute deviation from LH's index-based FSC. The dependent variable in Columns (4) and (5) is the percentage absolute deviation from AA's index-based FSC.*

To further investigate the impact of cartel detection on FSCs, I next analyze airline pricing behavior in the months immediately after the dawn raids. Airline pricing behavior around the raids shows little evidence of a breakdown in collusion. In fact, the majority of airlines successfully increased FSCs two days after the dawn raids[50] and again in mid-May, as dictated by the FSC methodology. Table 6 presents a summary of airline pricing behavior in the 100 days following the dawn raids (for airlines with available data during this period). Table 6 also reports any changes in the index-based FSC in the months following the dawn raids. FSCs continued to closely track the index-based FSC. The close connection between the index-based FSC and the FSC in the post-cartel period suggests airlines continued to set collusive prices in the post-cartel period. If airlines stopped setting prices using the FSC methodology after the dawn raids, we would expect FSCs to no longer closely match the index-based FSC (and likely decrease). To the contrary, airlines continued their lockstep pattern of parallel price changes after the dawn raids.[51] On the basis of regression results in Table 5 and airline pricing behavior immediately after the raids (Table 6), I conclude that post-cartel tacit collusion is a plausible explanation of observed post-cartel behavior.

The close connection between FSCs and the index-based FSC suggests that post-cartel tacit collusion occurred because airlines continued to follow the FSC methodology after the cartel's detection. The econometric methods used to compute private class action damages may have contributed to airlines' incentives to continue colluding (by following the FSC methodology) after the dawn raids (Harrington, 2004*b*). Cartel damages are typically estimated by comparing the cartel price with a counterfactual but-for price. The but-for price represents the price that would have been charged in the absence of a collusive agreement. Often, the but-for price is computed by analyzing prices in the post-cartel period (where collusion is presumed to have ended). Indeed, direct purchaser claims in the US used the post-cartel period to estimate but-for prices for the air cargo cartel (US Case, pg. 11).[52] If airlines anticipate future damage claims, and the possibility of the post-cartel period being used to determine a but-for price, then airlines have an incentive to increase prices in the post-cartel period in order to increase the estimated but-for price and, thus, reduce expected damages.[53]

The empirical estimates in Section 3 imply that FSCs not only did not fall after cartel detection, but actually increased. There are at least four potential explanations for this result which are consistent with post-cartel tacit collusion. First, firms engaging in illegal collusion have an incentive to reduce cartel prices

[50] Note that, as airlines typically pre-announced FSC changes approximately two weeks prior to a change, many airlines had already announced this FSC change when the dawn raids occurred. However, these FSC announcements are not binding.

[51] A similar pattern is observed after Lufthansa's leniency application was made public in September of 2006.

[52] Note that direct purchaser suits in the US sought damages for price fixing activity from January 1st 2000 to September 30, 2006 (US Case, pg. 3).

[53] Unfortunately, this hypothesis cannot be properly tested in the present setting. Ideally, an empirical test of this hypothesis would involve comparing post-cartel prices before and after antitrust litigation is settled or concluded. However, cartel damage claims continued for many years after the cartel's detection (US Case; DHL Case) and, as a result, post-litigation prices are not available. Erutku (2012) provides an empirical test of Harrington (2004*b*) and finds support for the hypothesis.

below the joint profit maximizing level in order to avoid creating suspicions of collusion (Harrington, 2004*a*, 2005) among buyers or other industry observers, which may lead to investigation and penalization. After the cartel's detection, airlines were no longer subject to antitrust penalization as their collusion was tacit and, therefore, no longer had an incentive to reduce cartel prices. Second, the threat of private damages, based on cartel prices, can create an incentive to reduce prices during the cartel (Katsoulacos, Motchenkova and Ulph, 2020). After detection and a switch to tacit collusion, no such incentive remains. Third, collusive prices may have been relatively low during the cartel period because airlines were still learning to implement and follow the FSC methodology. Consistent with this explanation, Figure 2 shows that FSCs were relatively low in comparison to jet fuel prices in the first few years of collusion. By the time the cartel was detected, FSCs were much higher relative to jet fuel prices. This suggests that by the time of cartel detection, airlines had learned to effectively collude and could set higher prices (tacitly or explicitly).

Fourth, airlines may have been hesitant to reduce prices in the post-cartel period when jet fuel prices declined. Figure 4 shows that when jet fuel prices declined in 2008, airlines were relatively slow in implementing the corresponding FSC reductions. Airlines may have been concerned that a rapid FSC decrease would be misinterpreted as deviation from the collusive agreement, which could cause retaliation or an industry-wide price war. During the cartel period, airlines constantly communicated about FSCs to verify all firms were following the agreement and correct any pricing differences. Thus, price changes were less likely to be misinterpreted as defection. However, if airlines colluded tacitly in the post-cartel period, these communications did not occur.

Table 6: Airline Pricing Behavior around the Raid Date

Firm	First Change		Second Change		Third Change		Currency
	Change	Date	Change	Date	Change	Date	
Index	.5	29 Jan 2006	.55	16 Apr 2006	.6	30 Apr 2006	
Aeroflot	.5	15 Feb 2006	.55	8 May 2006	.6	1 Jun 2006	EUR
Aerolineas Argentinas	.5	22 Feb 2006	.55	8 May 2006	.6	16 May 2006	EUR
Air Baltic	.5	20 Feb 2006	.55	8 May 2006	.6	16 May 2006	EUR
Air Canada	.5	20 Feb 2006	.55	16 May 2006	.6	25 May 2006	EUR
Air France			.55	3 May 2006	.6	17 May 2006	EUR
American	.5	17 Feb 2006	.55	10 May 2006	.6	24 May 2006	USD
Asiana Airlines	.5	16 Feb 2006	.55	6 May 2006	.6	18 May 2006	EUR
British Airways	.5	16 Feb 2006	.55	11 May 2006	.6	18 May 2006	EUR
Cargolux	.5	17 Feb 2006	.55	5 May 2006	.6	18 May 2006	EUR
China Southern	.5	16 Feb 2006	.55	5 May 2006	.6	21 May 2006	EUR
DHL	.5	16 Feb 2006	.55	8 May 2006	.6	19 May 2006	EUR
EVA Air	.5	15 Feb 2006	.55	5 May 2006	.6	19 May 2006	EUR
Emirates	.5	16 Feb 2006	.55	8 May 2006	.6	15 May 2006	EUR
Finnair	.34	23 Feb 2006	.38	9 May 2006	.4	29 May 2006	GBP
Japan Airlines	.5	14 Feb 2006	.55	3 May 2006	.6	15 May 2006	EUR
KLM			.55	3 May 2006	.6	17 May 2006	EUR
Korean Air	.5	15 Feb 2006	.55	4 May 2006	.6	18 May 2006	EUR
Malaysian Airlines	.5	20 Feb 2006	.55	8 May 2006	.6	1 Jun 2006	EUR
Northwest	.5	16 Feb 2006	.6	8 May 2006			USD
Polar Air	.5	15 Feb 2006	.55	5 May 2006	.6	12 May 2006	EUR
Saudi Arabia Airlines	.5	16 Feb 2006	.55	8 May 2006	.6	15 May 2006	EUR
Swiss Air	.5	20 Feb 2006	.55	8 May 2006	.6	15 May 2006	EUR
TAP Portugal	.5	20 Feb 2006	.55	1 May 2006	.6	1 Jun 2006	EUR
United	.5	20 Feb 2006	.55	11 May 2006	.6	18 May 2006	EUR

Notes: Air France/KLM's surcharge had already been increased at the time of the dawn raids. Northwest increased two levels to .60 on May 8th, 2006.

5 Discussion

In this section, I discuss the implications of my findings for antitrust policy. Additionally, I argue that a behavioral remedy may have prevented relatively high post-cartel prices. For the discussion in this section, I presume, as empirical evidence in Section 4 suggests, that elevated post-cartel prices are the result of post-cartel tacit collusion.[54]

5.1 Insufficient Fines and Damage Awards

The results of Section 3 and 4 indicate two possible weaknesses in modern antitrust enforcement. First, fines based on activity in the cartel period were likely a weak punishment for cartel behavior (i.e., insufficient to deter cartel activity). By developing a specific methodology for determining the collusive FSC, cartel members developed a publicly visible and collusive pricing policy which could be followed after the cessation of explicit communication. This suggests that collusion not only generated immediate profits for cartel members but also constituted an investment that would yield additional profits after detection. Thus, a fine based only on revenue during the cartel's existence does not fully account for all the potential gains from cartel activity. If cartel members anticipate additional profits after detection, antitrust fines may be insufficient to deter price-fixing.

Second, damages from private litigation may have underestimated consumer harm from cartel activity. This is the case for two reasons. First, the majority of private damage suits pursued damages only for the cartel period (as is the norm). Thus, consumers were not compensated for elevated post-cartel prices which were likely directly caused by cartel activity. While the award of damages for activity after the cartel period is uncommon, the German Federal Court of Justice recently took "lingering effects" of a cartel into account when computing damages.[55] Encouraging the pursuit of damages for harm incurred during the post-cartel period may help deter the formation of cartels and provide adequate restitution to damaged parties.

Private damages were also likely underestimated for another reason. Private damage calculations typically compute the cartel overcharge, and therefore damages, by comparing prices during the cartel period to prices during a benchmark period. The benchmark period is intended to represent competitive pricing.[56] The overcharge is the difference between prices in the collusive and benchmark periods, after controlling for other relevant factors. In the case of the air cargo cartel, prices were high in the post-cartel period due to continued

[54]The possibility of explicit (and illegal) communication between firms after cartel detection cannot be ruled out. However, considering the high level of scrutiny and antitrust authority involvement after the cartel's detection, explicit collusion seems unlikely.

[55]See German Federal Court of Justice, June 28, 2011, ORWI, recital 84 and also Hüschelrath, Müller and Veith (2013) and Boswijk, Bun and Schinkel (2019).

[56]See Van Dijk and Verboven (2008) for a review of damage estimation methods.

(tacit) collusion.[57] Thus, the benchmark period likely did not represent competitive pricing. This results in the underestimation of the overcharge and, thus, damages.[58]

5.2 Behavioral Remedies

While antitrust authorities have recently imposed record fines on price-fixers, agencies have often avoided imposing strong behavioral remedies upon cartel members. Behavioral remedies are interventions that require or prohibit certain conduct (Maier-Rigaud and Loertscher, 2020). Antitrust authorities often refrain from applying behavioral remedies because they require the authority to monitor firms' behavior to ensure compliance with the behavioral requirements.[59] Additionally, some scholars[60] have argued that behavioral remedies, like any other regulatory intervention, could disrupt or distort the free market process.[61]

However, behavioral remedies have been applied in a number of previous price-fixing cases. For example, Brazilian antitrust authorities replaced the managers of a firm involved in a gasoline cartel with a government appointee in order to ensure collusive conduct ended.[62] Duarte and Chaves (2021) find that prices did not decline after the detection of the cartel but did decline after the government appointee was put in charge of the largest firm. Miller (2010) analyzes the impact of a consent degree which prohibited passenger airlines from communicating through a shared fare database and finds that the case had only a temporary downward effect on prices.

Three potential behavioral remedies may have hampered or prevented post-cartel tacit collusion in the air cargo industry. First, if antitrust authorities had forbidden airlines from publicly referencing the FSC index when announcing changes, airlines may have been unable to coordinate FSCs after the cartel's dissolution. By publicly referencing the index when announcing price changes, airlines signaled their intent to continue using the methodology after the cartel's breakdown. Second, antitrust authorities could have forbidden airlines from publicly displaying their FSC indexes on their websites. In late 2007 and early 2008 (see Figure 1), jet fuel prices soared to a level that exceeded the maximum jet fuel price observed during the cartel. As a result, airlines' surcharge indexes/methodologies did not include trigger points that were applicable to such

[57] As discussed in Section 4, elevated post-cartel prices may have been caused, at least partially, by airlines' incentives to reduce estimated damages (Harrington, 2004*b*).

[58] Daubert motions from the US antitrust case show that some models did not show an overcharge at all (US Case, pg. 13) which may reflect the underestimation of overcharges due to post-cartel tacit collusion.

[59] In the context of mergers, the 2004 DOJ policy guide to merger remedies (Department of Justice, Antitrust Division Policy Guide to Merger Remedies (Oct. 2004), available at http://www.justice.gov/atr/public/guidelines/205108.pdf) states that a behavioral remedy "typically is more difficult to craft, more cumbersome and costly to administer, and easier than a structural remedy to circumvent."

[60] For example, Kwoka and Moss (2012) argue that difficulties related to behavioral remedies "are in some ways analogous to those associated with economic regulation, which seeks to constrain firm incentives and behavior."

[61] Harrington (2023) proposes an alternative remedy wherein each former cartel member is obligated to distribute competitor coupons, coupons to purchase from a firm's competitors, to past customers. Harrington (2023) demonstrates that competitor coupons can disrupt post-cartel tacit collusion.

[62] See Duarte and Chaves (2021) for details.

a high jet fuel price. In response, airlines updated their fuel surcharge indexes to include new trigger points enabling them to increase the fuel surcharge. If airlines had been prevented from updating and publicly releasing their FSC indexes/methodologies, fuel price spikes in late 2007 and early 2008 may have caused a breakdown in post-cartel tacit collusion because the formula developed during the cartel, to calculate the collusive FSC, would no longer be applicable or relevant.

A more severe behavior remedy would involve forbidding the use of fuel surcharges altogether. The prevalence of cartels colluding on surcharges (see footnote 29 for examples) suggests that surcharges themselves may be conducive to collusive behavior (Harrington and Ye, 2019; Harrington, 2022; Chen, 2023). Airlines did not utilize fuel surcharges prior to the cartel's formation which implies that splitting the cargo rate into a base rate and a fuel surcharge is not fundamentally necessary. Subsuming fuel surcharges into the base cargo rate could inhibit tacit monitoring of a collusive agreement because base rates are private and negotiated between freight forwarders and cargo airlines. As a result, colluding firms may have been unable to monitor prices and detect deviations from the tacitly collusive agreement.

6 Conclusion

This study has compared pricing behavior before and after the detection of an air cargo cartel using a novel dataset of fuel surcharges. I find that prices did not decline after the cartel's detection, even after accounting for changes in jet fuel prices. During the cartel period, colluding firms developed a specific methodology for calculating a surcharge, to be applied industry-wide, based on jet fuel prices. I find that fuel surcharges in the post-cartel period closely mirror the surcharge implied by the cartel's pricing methodology. Additionally, price changes immediately after the cartel's detection do not indicate a switch from collusive to competitive pricing. This suggests airlines tacitly colluded after the cartel's detection by continuing to set fuel surcharges using the methodology developed during the cartel.

The results of this study, in conjunction with studies of other cartels which also find evidence of post-cartel tacit collusion (e.g., Starc and Wollmann, 2022), suggest fines and damages based on activity prior to the cartel's detection may be insufficient to deter cartels. If collusive activity continues (tacitly) after a cartel's detection, cartel members' profit and consumer harm from price fixing activity extend beyond the cartel period. Fines based only on activity during the cartel period may not provide strong enough punishments for colluding firms to deter cartel activity. Additionally, damages based only on harm incurred during the cartel period may not provide adequate restitution for harmed customers. Private suits pursuing damages for harm incurred after the cartel period would help compensate customers for post-cartel harm and, potentially, deter cartel activity.

I argue that the imposition of a behavioral remedy upon cartel detection or prosecution may have prevented or inhibited post-cartel collusion. Specifically, a behavioral remedy which prevented airlines from using the fuel surcharge methodology to set prices may have prevented tacit coordination in the post-cartel period.

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