Cash, Financial Flexibility, and Product Prices:

Evidence from a Natural Experiment in the Airline Industry*

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Abstract

Corporate cash holdings and rivalry networks jointly impact firms' product pricing strategies. Exploiting the Aviation Investment and Reform Act of the 21st Century as a quasi-natural experiment to identify exogenous shocks to competition in the airline industry, I find that firms with more cash than their rivals respond to intensified competition by pricing more aggressively, primarily when there is less concern of rival retaliation. Financially flexible firms based on alternative measures respond similarly. Moreover, cash-rich firms that face less market overlap with rivals experience greater market share gains and long-term profitability growth. The results highlight the importance of strategic interdependencies across firms in the effective use of flexibility provided by cash.

JEL Classification: G30, G32, G35, L10

Keywords: Cash, Cash Holdings, Financial Flexibility, Pricing, Product Market, Competition, Multimarket Contact

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1 Introduction

At the end of 2015, U.S. non-financial companies held some $2 trillion in cash, nearly twice the amount half a decade ago, heightening interest among finance academics and policy makers alike.[1] In light of the era of large corporate cash holdings, recent studies have argued that cash can be a valuable source of financial flexibility for firms (see Gamba and Triantis (2008), Denis and Sibilkov (2010), Denis and McKeon (2012)). An important avenue through which this flexibility can prove valuable is product market dynamics. A number of papers have recently shown, for example, that cash holdings have a large positive impact on market share outcomes (see Fresard (2010)), or that product market threats significantly influence cash retention decisions (see Hoberg, Phillips, and Prabhala (2014)). Yet, while the flexibility from cash is viewed as a source of competitive ammunition consistent with 'Long purse' arguments (see Telser (1966), Bolton and Scharfstein (1990)), little is understood how rivalry dynamics may affect the utilization of such financial war chests. In a novel empirical investigation of the airline industry incorporating the interdependence of competition strategies across firms, this paper shows that cash provides financial flexibility which enables firms to undercut their competitors, predominantly when they face less potential retaliation from rivals.

To capture potential rival retaliation, I draw from the industrial organization literature the idea of multimarket contact and mutual forbearance. Firms very often serve several markets, for example by having multiple product lines or operating across geographical segments. In such a multimarket setting, altering strategy in one market can affect the actions of rival firms in other markets due to rivalry networks and the resulting interconnection of competition strategies across markets (see Bulow, Geanakoplos, and Klemperer (1985)). Bernheim and Whinston (1990) expand on this idea and argue that competitors who en-

[1] J.P. Morgan Chase & Co. reported that non-financial companies in the S&P 500 had nearly $2.1 trillion in cash at the end of October, 2015. At the end of 2014, Standard & Poor's Ratings Services had reported that around 2,000 rated U.S. non-financial companies held $1.82 trillion in cash, and Moody's had reported a similar amount of $1.73 trillion.

counter more frequently due to broader market overlap (i.e. higher multimarket contact) recognize the interdependence of their strategies, and are more likely to collude in equilibrium (i.e. engage in mutual forbearance) for fear of what rival firms might do in other jointly contested markets. Evans and Kessides (1994) show that airlines indeed live by the 'golden rule' where they refrain from initiating aggressive pricing actions when multimarket contact is high. Hence, I take the multimarket contact measure motivated by IO theory to capture potential rival retaliation concerns, and form the hypothesis that higher multimarket contact should dampen the strategic benefit of cash predicted by financial economic theory. In this paper, I empirically investigate whether cash-rich firms price more aggressively and whether multimarket contact weakens this competitive role of cash.

There are two main challenges to this analysis. First is that there need be a setting where rivalry and markets are cleanly defined, and second is that both cash and market overlap are likely to be endogenously linked to firm pricing behavior, making it difficult to make causal inferences. I overcome both of these issues by focusing on the airline industry. Taking directional air routes as markets, defining rivalry is a simple and clean task in this industry since route services are comparable across airline companies, and rich data on ticket prices serve as a readily available source of market pricing information.[2] The airline industry is also an appropriate place to study the impact of cash holdings in the sense that it is an industry with relatively high financial constraints where financial distress and bankruptcies associated with borrowing constraints have frequented headlines throughout recent decades.[3] Figure 1 charts the average KZ index (following Kaplan and Zingales (1997), Lamont, Polk, and Saá-Requejo (2001)), WW index (following Whited and Wu (2006)), and SA index (following Hadlock and Pierce (2010)) of firms in the airline industry in comparison with Fama

[2]This has led a number of recent studies in finance to rely on the airline industry. For example, Azar, Schmalz, and Tecu (2016) focus on the airline industry to study the effects of common ownership on competition, while Parise (2017) uses the industry to demonstrate that potential changes in competition dynamics can influence the debt structure decisions of firms ex-ante.

[3]See Weiss and Wruck (1998) for a detailed study of the famed bankruptcy case of Eastern Airlines.

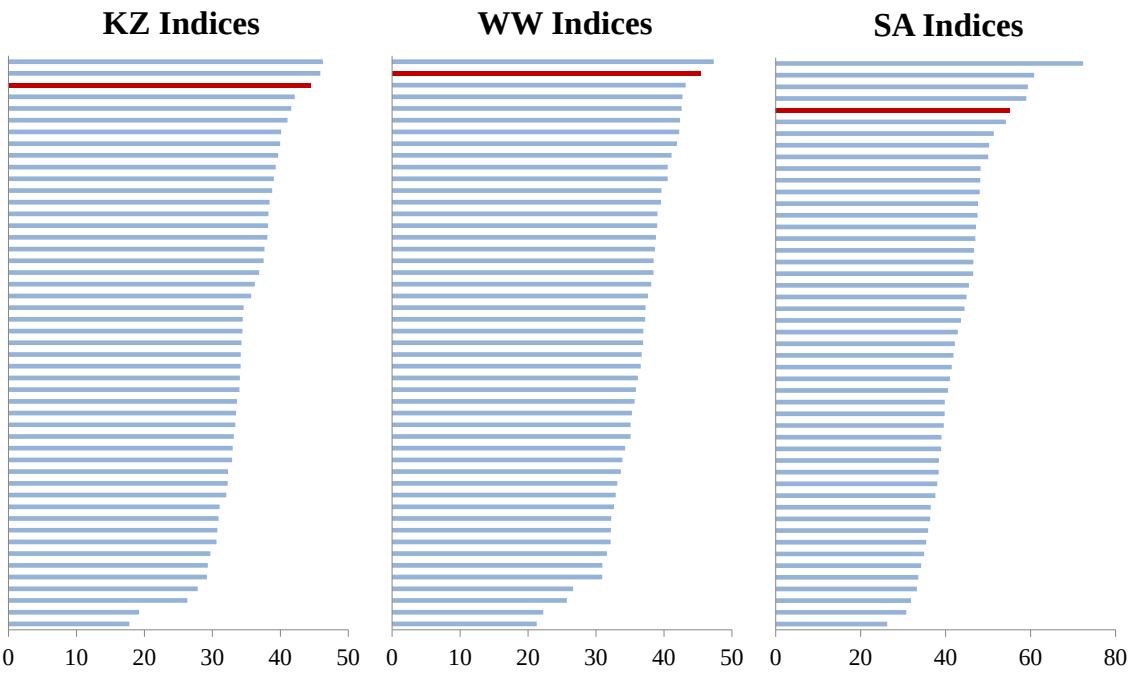


Figure 1. Industry Financial Constraints

This figure compares the average KZ index (following Kaplan and Zingales (1997), Lamont, Polk, and Saá-Requejo (2001)), WW index (following Whited and Wu (2006)), and SA index (following Hadlock and Pierce (2010)) of firms in the airline industry (SIC code 4512) with firms in Fama and French (1997) 48 industries. Using the Compustat universe of firms, the KZ index is computed for each firm as -1.002×Cash flow+0.283×Tobin's Q+3.139×Debt−39.368×Dividends−1.315×Cash, where cash flow is $oibdp/at$, Tobin's Q is market value of assets $(at + csho \times prcc\_f - ceq - txdb)$ divided by 0.9×book value of assets (at)+0.1×market value of assets, debt is $(dlc + dltt)/at$, dividends are $(dvc + dvp)/at$, and cash is che/at. The WW index is computed for each firm as -0.091×Cash flow−0.062×DIVPOS+0.021×Long-term debt−0.044×Log assets+0.102×Industry sales growth−0.035×Sales growth, where DIVPOS is an indicator variable for whether the firm pays dividends and long-term debt is $dltt/at$. The SA index is computed for each firm as -0.737×Size+0.043×Size^2−0.040×Age, where size is the log of Min(at, \$4.5 billion) and age is Min(Firm age, 37 years). Each year, firms are ranked into 1/100th percentiles based on their KZ, WW, and SA indices. Then, the KZ, WW, and SA ranks are averaged across firms in the same industry. Finally, the time-series averages of the industry KZ, WW, and SA ranks are presented on a scale of 1 to 100.

and French (1997) 48 industries. The indices show that airline companies on average are more constrained than firms in many other industries, indicating that cash holdings should play a role in their corporate decisions.[4] The relevance of corporate cash holdings for pricing competition in the airline industry is very real. At the end of 2015, American Airlines stated

[4]In a frictionless Modigliani and Miller (1958) world where firms can freely borrow from the external capital market, cash holdings should have no bearing on the firm's policies.

its intent to engage in a price war with low cost carrier rivals such as Spirit Airlines, which coincided with its CFO's announcement that the company had "more cash than we need at this time" and was widely purported to be due to ample financial slack in times of low fuel prices.

The empirical design of this study allows me to effectively sidestep the endogeneity problem. Cash is measured for each firm in comparison with its rivals' in each market, such that the amount of relative-to-rival cash is not self-selected solely by the firm but determined in conjunction with the choice of its competitors, as is multimarket contact by construction. On top of that, I exploit an industry wide regulation, the Aviation Investment and Reform Act for the 21st Century (AIR-21), as a quasi-natural experiment to identify plausibly exogenous shocks to market-level competition and infer how ex-ante relative-to-rival cash holdings and multimarket contact prior to such shocks affect ex-post pricing. Under AIR-21, airports of certain size whose two largest airlines board more than 50% of the airport's total passengers are required to submit competition enhancement plans to the Federal Aviation Administration (FAA) and implement them under periodic FAA monitoring (detailed in the following section). Therefore, AIR-21 serves as a competition shock to a market with a covered airport at either endpoint (e.g. the origin). The design of this regulation ensures exogeneity of these shocks in two ways. First, assessment of the treatment effect can be made just around the 50% top-two airline concentration ratio threshold, facilitating a regression discontinuity (RD) approach which circumvents concerns regarding large unobservable differences between treated and non-treated markets. Second, AIR-21 coverage for a given year is determined by passenger enplanement of the two most dominant airlines relative to airport totals based on data from two years prior. It is thus unlikely that an airline would be able to manipulate boardings in a way that purposefully affects AIR-21 coverage of an airport.

With this setting, I implement a triple difference framework with a flavor of regression discontinuity (RD) design on firm-market and quarter panel data. Specifically, I run regres-

sions of changes in pricing strategy on ex-ante relative-to-rival cash, ex-ante multimarket contact, and AIR-21 treatment, including a host of firm and market-level control variables as well as firm, market, and time fixed effects. Notably, I explicitly control for relative-to-rival debt and its interactions with AIR-21 and multimarket contact to tease out the impact of cash distinct from the effect of leverage well known in the literature. To apply a quasi-RD framework, I run regressions on progressively narrower windows around the 50% treatment cutoff of endpoint airports and show that results are robust, if not stronger, in closer regions surrounding the threshold.

The main results confirm that firms with larger cash holdings relative to their rivals respond to market-level competition shocks by pricing more aggressively, but only when multimarket contact is sufficiently low (i.e. when there is less concern of retaliation from rivals). In economic magnitudes, a one standard deviation or approximately 9 percentage point increase in relative-to-rival cash as a fraction of assets one year prior to an AIR-21 competition shock in a market leads to roughly 15 percentage points lower price growth over the next 36 months compared to the previous 36 months (i.e. half standard deviation lower price growth differential). Multimarket contact has a sizable impact on this strategic effect of cash: a 5% increase would almost overturn the cash effect.

Figure 2 provides a snapshot of the main results, where pricing to cash holding sensitivities are charted across multimarket contact terciles, based on a sample close to the AIR-21 treatment threshold. The sensitivities are obtained from coefficients of the interaction terms in difference-in-differences regressions of changes in pricing strategy on AIR-21 treatment and relative-to-rival cash. It can be seen that the competitive effect of cash, namely that greater cash reserves enable firms to price aggressively, is pronounced when there is less concern of rival retaliation and is attenuated, even reversed, as multimarket contact increases.

In addition, I exploit heterogeneity in fare levels and market shares across firms to show that the effects of AIR-21 on different firms are consistent with what would be expected

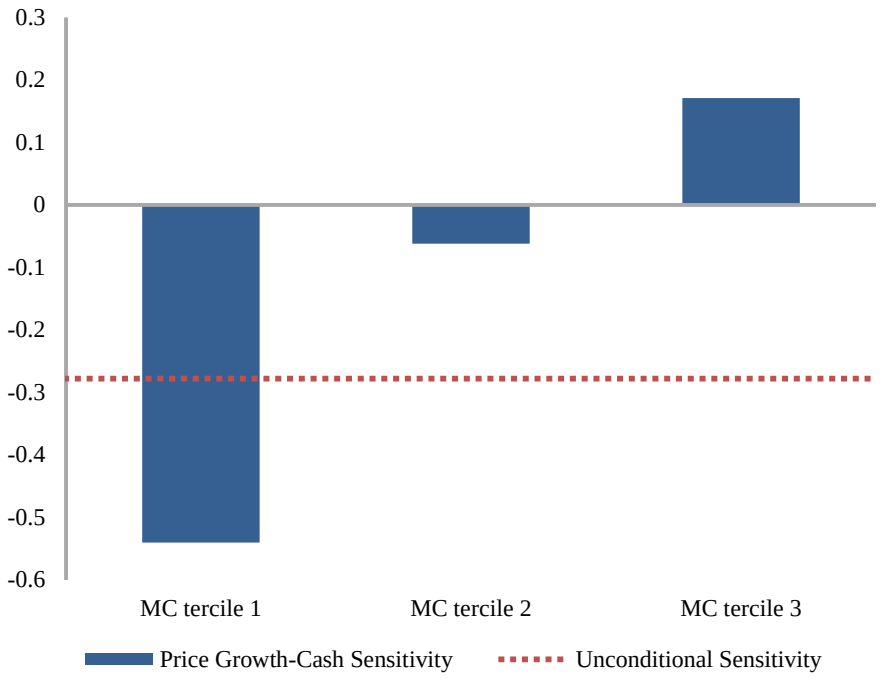


Figure 2. The Impact of Cash on Pricing across Multimarket Contact Terciles

This figure illustrates the main results of the paper. Price growth differential to cash holding sensitivities are charted across multimarket contact terciles. Each period, firm-market observations are sorted into terciles based on multimarket contact. Within each multimarket contact (MC) tercile group, price growth differential to cash holding sensitivity is obtained as the coefficient on the interaction term between AIR-21 treatment and relative-to-rival cash holding in a difference-in-differences regression of change in pricing strategy (price growth over the next 36 months compared to the previous 36 months) on AIR-21 treatment and relative-to-rival cash to assets ratio. The unconditional sensitivity across all multimarket contact (MC) terciles is shown as the dotted line. Results are based on a restricted sample where 2-year prior top-two airline concentration ratios at market origin airports are 10% above and below the 50% AIR-21 treatment cutoff. Variable constructions are detailed later in Section 3.

given the nature of the regulation. Arguably, AIR-21 treatment should have differential effects across firms in the same market since the aim of its legislation is to lower prices and distribute passenger boardings more evenly across airlines. For instance, Snider and Williams (2015) show that AIR-21 led to lower airline fares mainly through gate reallocations toward entrant low cost carriers (LCCs). Consistent with these implications, I find that LCCs respond to AIR-21 competition shocks by pricing aggressively irrespective of their cash holdings, while legacy airlines respond aggressively conditional on holding more cash.

In both cases, their responses are dampened by higher multimarket contact. Also, the main results hold only for firms that had high ex-ante market share (i.e. firms for which AIR-21 indeed serves as a competition shock), but are non-existent for firms that had low market share to begin with (i.e. firms for which AIR-21 rather serves as an accommodative event).

I further provide evidence from a number of robustness checks. To alleviate concerns that firms might predict AIR-21 coverage and build-up cash reserves in advance, I use relative-to-rival cash measured 3 and 4 years prior to treatment (one year prior in baseline specifications) and show that results are robust. Placebo tests using alternative threshold levels of top-two airline passenger shares as AIR-21 treatment cutoffs, 40% and 60% instead of the baseline 50%, confirm that the main results are unlikely due to other confounding effects that happen to coincide with competition shocks induced by AIR-21.

To cement the argument that the effect of cash holdings on price growth differentials is that of financial flexibility, I show that high net cash or high payout firms compete aggressively in response to AIR-21 as do cash-rich firms, in contrast to the opposite accommodating behavior of supposedly constrained firms that had cut dividends in the previous year. I also demonstrate that the market performance outcomes of holding more cash than rivals, i.e. market share gains and long-term profitability growth, are consistent with cash being a valuable source of financial flexibility. Finally, I show suggestive evidence that AIR-21 competition shocks lead to increased corporate cash holdings, which is consistent with firms rationally responding to intensified competition by building up financial war chests to use for aggressive pricing.

This paper contributes to the growing literature studying the interaction of financial flexibility and product market competition. The predominant approach to understanding the relationship between financial strength and competition is based on 'long purse' or 'deep pocket' arguments (see Telser (1966), Bolton and Scharfstein (1990)). Under this approach, a weak balance sheet (e.g. little cash, high leverage) takes away the 'long purse' from firms,

rendering them unable to price aggressively and prone to forgo future market shares for profits today. This line of argument has gained empirical support by papers relating financing decisions to competition, notably by Chevalier (1995a, 1995b) in the context of leveraged buyouts in the supermarket industry, and Campello (2003) who provides more general evidence that levered firms raise prices during recessions to maximize short-term profits when rivals are also levered, consistent with markup counter-cyclicality theories à la Chevalier and Scharfstein (1996). In a similar spirit but focusing on capacity investments in the casino industry rather than pricing, Cookson (2017) also shows that high leverage prevents firms from responding to competition threats. Parise (2017) conversely shows that firms in the airline industry increase their debt maturities in the face of entry threats to lower roll-over risk. Only more recently has this 'deep pocket' story been tied to the precautionary motive for cash. Haushalter, Klasa, and Maxwell (2007) find that the extent to which firms have interdependent growth prospects with rivals (i.e. face higher predation risk) is positively associated with cash holdings and the use of hedging derivatives. Fresard (2010) uses shifts in import tariffs as exogenous competition shocks and shows that firms with large cash reserves beforehand gain larger market shares ex-post. This paper adds more color to recent developments in the literature by documenting how cash affects firm pricing strategies, thereby shedding light on the mechanism through which cash impacts product market outcomes.

At its roots, this paper is part of a vast literature on corporate cash policy. The precautionary saving motive for cash argued by Keynes (1936) has been studied by numerous papers. Fazzari and Petersen (1993) find that firms use working capital (e.g. cash) to smooth fixed investments. Opler, Pinkowitz, Stulz, and Williamson (1999) and Bates, Kahle, and Stulz (2009) suggest cash flow volatility to be a key determinant of corporate cash holdings. Consistent with the insight of Modigliani and Miller (1958) that financial slack should matter only when there are financing frictions, Almeida, Campello, and Weisbach (2004) show that only financially constrained firms accumulate cash out of their cash flows. Faulkender and

Wang (2006) also show that the marginal value of cash is greater when firms are financially constrained. Acharya, Almeida, and Campello (2007) point out the hedging role of cash when cash flows are low and investment opportunities are high. In the recent 2007-2008 financial crisis, Duchin, Ozbas, and Sensoy (2010) show that cash serves as a buffer to supply shocks to external financing. How these cash reserves are used in firms' day-to-day operations are of ever growing interest inside and outside of academia, and this paper furthers our understanding of such matters.

The remainder of the paper is organized as follows. In Section 2, I discuss the identification strategy in greater detail. Data, variables, and the empirical specification are described in Section 3. The main results of the paper and robustness tests are presented in Section 4. Finally, I conclude in Section 5.

2 Identification Strategy

2.1 The Endogeneity Problem

In this section, I elaborate on the background of my research design and identification strategy. The ideal method to study the effect of cash holdings on firm pricing strategy would be to take a firm-market observation, duplicate it, treat only one of them with a shock to cash, and then examine how each of their pricing policies subsequently evolve. To test the role of multimarket contact in weakening or strengthening the strategic effect of cash, one would extend the duplication and treatment exercise this time with a shock to multimarket contact.

There are obvious challenges to this ideal approach. Not only am I incapable of observing exact counterfactuals for treated observations, but I am also unable to change firm-market characteristics at random. This means that my explanatory variables, cash holdings and multimarket contact, would likely be endogenously linked to the outcome variable of in-

terest, firm pricing strategy, via some unobserved factor that is also correlated with the explanatory variables, causality flowing in the other direction, or other selection biases at play. Establishing causality from cash and multimarket contact to pricing is therefore a critical challenge of this study.

The framework of my analysis minimizes this issue in a number of ways. To start with, the relevant amount of cash in this study is what the firm has in excess of what its rivals have. This variable, which I refer to as relative-to-rival cash, is determined not by the firm alone but jointly by the firm *and* its rivals. It therefore varies across markets for a given firm, and suffers less from self-selection than would firm-level cash holdings. In a similar vein, multimarket contact is also a jointly determined variable over which the firm does not have complete control. That said, this does not ensure that relative-to-rival cash and multimarket contact are exogenously given. Another device is needed to fully address endogeneity.

2.2 Aviation Investment and Reform Act for the 21st Century

This endogeneity problem is circumvented by exploiting exogenous changes in the competitive environment of markets, and studying the firm's ex-post pricing policy responses with respect to ex-ante variations in relative-to-rival cash and multimarket contact. These exogenous changes are identified by use of an industry-wide regulation that was legislated at the end of 2000, and went into effect at the beginning of 2001. The Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21) called into question anti-competitive practices at airports, and required those above a certain concentration level to undergo concrete procedures to make sure entrant airlines could access airport facilities.[5]

[5]A Federal Aviation Administration (FAA)/Optimal Solutions & Technologies (OST) task force study "Airport business practices and their impact on airline competition" conducted in 1999 states that access at many of the nation's most heavily used airports are limited due to business practices that prevent entry by new airlines or hinder competition among incumbent airlines, such as long-term exclusive-use gate lease agreements. The study's recommendation of a competition enhancing policy was directly linked to the inclusion of competition plan requirement provisions in AIR-21.

Each year, large commercial airports (i.e. those that enplane more than 0.25% of total U.S. passengers) are subject to coverage by AIR-21 if the two most dominant airlines control more than 50% of those airports' passenger boardings, based on boarding data from two years prior. Covered airports are required to file detailed competition enhancement plans with the Federal Aviation Administration (FAA) and the Department of Transportation (DOT), and are otherwise not approved of their Passenger Facility Charges (PFC) and Airport Improvement Program (AIP) grants, which have been shown to comprise the bulk of airport capital funding.[6] Airports are subsequently required to submit two status updates at 18 month intervals after initial coverage that show significant progress in implementing their competition plans, giving them a total of 36 months until they are potentially re-treated as a covered airport.[7] Taking advantage of this regulation, markets that originate from airports treated by AIR-21 are then identified as those experiencing shocks to competition.

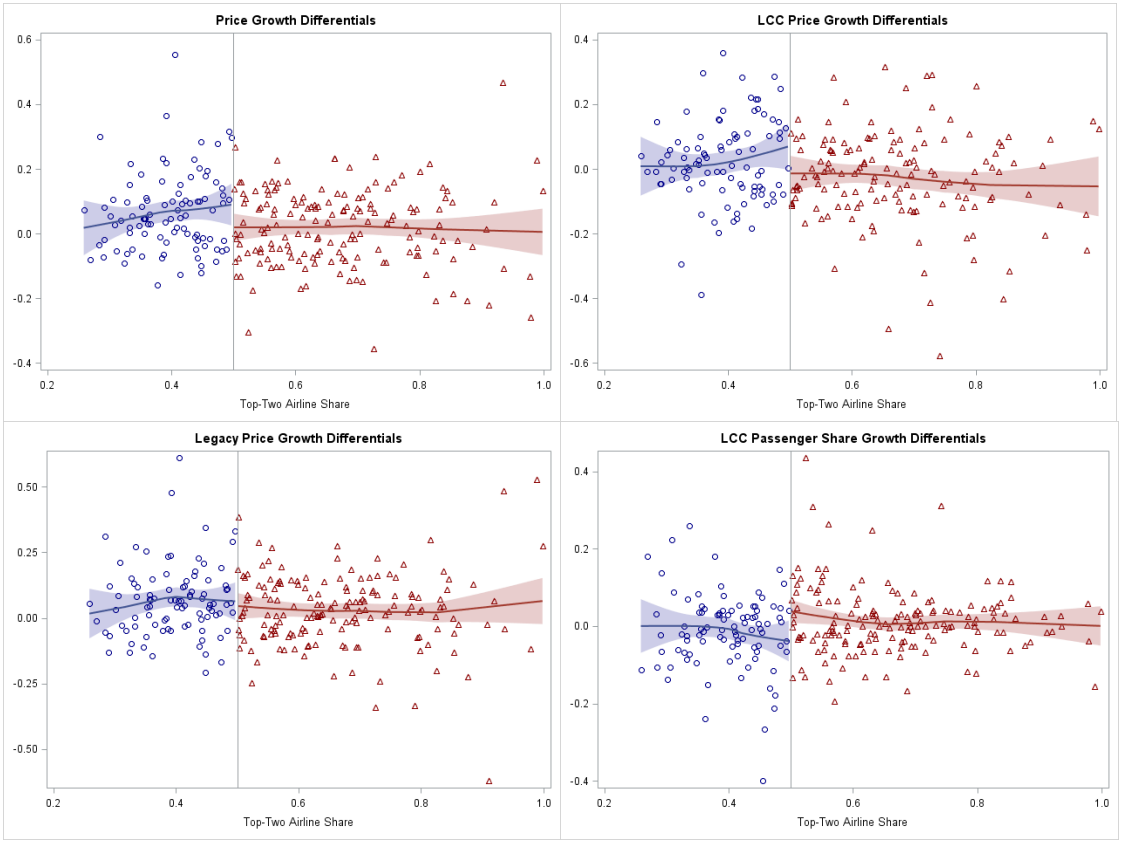
Using AIR-21 to identify shocks to market-level competition addresses the endogeneity issue in two ways. To begin with, because AIR-21 coverage of an airport in a given year is determined by the passenger boarding *share* of the two largest airlines based on data from two years prior, it is unlikely that airlines could manipulate boardings relative to their rivals' such that they purposefully influence AIR-21 treatment to an airport two years down the road. More importantly, the regulation allows a regression discontinuity (RD) approach in which the local treatment effect of competition shocks can be measured just around the 50% top-two airline concentration ratio cutoff. This mitigates concerns about large unobservable differences between treated and non-treated firm-markets, so long as there is an apparent discontinuity in market-level competition around the threshold which arguably has little to

[6] A 2009 study "Airport capital development costs" conducted by Airports Council International North America (ACI-NA) finds that PFCs (21.7%), PFC backed bonds (30%), and AIP grants (22.2%) comprise the bulk of airport capital funding for committed projects.

[7] In a program guidance letter sent by the FAA to commercial airports, the following, among other details, are required to be addressed by filed competition plans: availability of gates and related facilities, leasing and subleasing arrangements, gate assignment policy, and gate use requirements. This indicates that gate reallocations are among the primary tools at the disposal of airports to enhance competition.

do with conditions other than the AIR-21 treatment rule itself.

Figure 3 demonstrates the impact of AIR-21 on competition, specifically the discontinuities in various measures of changes in competition around the 50% treatment threshold at market origin airports. In scatter plots of airport-quarter observations, I map average price growth differentials (top left), average low cost carrier (LCC) price growth differentials (top right), average legacy airline price growth differentials (bottom left), and LCC passenger share growth differentials (bottom right) with respect to the AIR-21 treatment forcing variable, the total passenger share of the top-two airlines at each airport. To take into account the accumulative 36 month period covered airports are given to foster competition, growth differentials are computed as the difference of growth rates in the next 36 months and the past 36 months. The fitted lines and confidence bands are from local linear regressions with triangle kernels on each side of the 50% forcing variable cutoff. The top left plot reveals a clear downward discontinuity in average price growth differentials, confirming that AIR-21 has an impact on price competition. This reduction in price growth is evident for LCCs (top right) but not for legacy airlines (bottom left) and coincides with a discrete increase in LCC passenger share growth (bottom right), consistent with Snider and Williams (2015) where they find AIR-21 to have impacted competition mainly through gate reallocations toward entrant LCCs. The accompanying table shows the discontinuities more formally with results from non-parametric RD estimations via local linear regressions with triangle kernels and Imbens and Kalyanaraman (2012) optimal bandwidths. The local treatment effect of AIR-21 around the 50% threshold manifests in 7.3% lower average price growth, 6.4% lower LCC price growth, and 5.9% higher LCC passenger share growth. To show that these discontinuities are not simply the product of statistical coincidence due to confounding effects that happen to occur around the threshold, placebo results are shown for alternative cutoffs. At arbitrary threshold top-two airline concentration levels of 40% and 60%, there are no such discontinuities, strengthening the interpretation that the estimated local treatment effects



	All Fares	LCC Fares	Legacy Fares	LCC Share
50% Cutoff Threshold	-0.073**	-0.064**	-0.048	0.059**
	(0.031)	(0.030)	(0.033)	(0.027)
Alternative Thresholds				
40% Threshold	-0.009	0.004	-0.024	-0.030
	(0.039)	(0.043)	(0.043)	(0.025)
60% Threshold	-0.022	-0.021	-0.034	-0.009
	(0.025)	(0.030)	(0.029)	(0.021)
Observations	259	238	258	259

Figure 3. Discontinuity around the AIR-21 Treatment Threshold

These figures plot airport-quarter level observations of differences in average price growth between the next and previous 12 quarters for all airlines; low cost carriers (LCCs) only; legacy airlines only, and changes in LCC passenger share growth, with respect to the AIR-21 forcing variable, i.e. total passenger share of the top-2 airlines at each airport. Average prices and passenger shares are based on markets originating from each airport. The fitted lines and confidence bands are from local linear regressions with triangle kernels on each side of the 50% forcing variable treatment cutoff. The accompanied table shows results from non-parametric RD estimations via local linear regressions with triangle kernels and Imbens and Kalyanaraman (2012) optimal bandwidths. Placebo results are shown for alternative cutoffs (40% and 60%). Standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

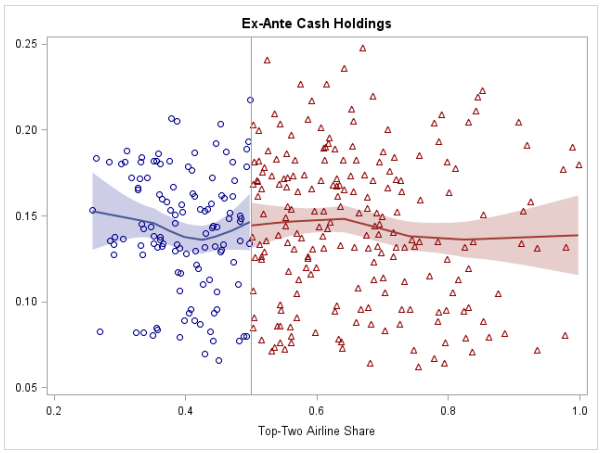


Figure 4. No Anticipatory Adjustment of Cash Holdings

This figure plots airport-quarter level observations of ex-ante (lagged by 1 year) airport-level average airline cash holdings (scaled by total assets) with respect to the total passenger share of the top-2 airlines at each airport. All variables are based on markets originating from each airport. The fitted lines and confidence bands are from local linear regressions with triangle kernels on each side of the 50% forcing variable treatment cutoff.

are due to AIR-21 rather than omitted factors that arise arbitrarily at different regions of the forcing variable.

A remaining concern is that firms may be able to predict AIR-21 treatment to markets and adjust their cash holdings in anticipation of such shocks, rendering cash holdings endogenous. This is unlikely to be a concern. First of all, it is highly implausible that firms could adjust their relative-to-rival cash holdings in each and every market they serve (i.e. at the firm-market level), especially given that the average firm operates in roughly 750 markets. Their cash holdings are determined primarily at the firm level, while AIR-21 shocks occur at the market level. Moreover, there is no evidence that firms adjust firm-level cash holdings prior to AIR-21 treatment to markets. Figure 4 plots the ex-ante average cash holdings of airlines at each airport measured one year earlier, against the top-two airline passenger share: the AIR-21 forcing variable. Clearly, there is no discontinuity or bunching around the 50% threshold, indicating that changes in the forcing variable do not lead firms to preemptively

reconfigure their cash holdings in the region near the cutoff. Although values of the forcing variable that are far away from the 50% cutoff, for example 30% or 70%, might have firms believe with little doubt that the likelihood of AIR-21 treatment is low or high, Figure 4 largely suggests that the treatment outcome is much less predictable *just around* the 50% threshold.

Figure 5 further solidifies the exogeneity of AIR-21 competition shocks by demonstrating that there are no ex-ante observable differences between treated and non-treated airports, especially around the 50% treatment threshold. Each subfigure plots various ex-ante airport-level control variables measured one year prior such as the total number of passenger boardings, average route distance, total number of originating routes, average market prices, average LCC prices, and average legacy airline prices against the top-two airline concentration ratio (i.e. the AIR-21 forcing variable). In contrast to ex-post changes in competition, there are no visible discontinuities in these variables around the 50% cutoff.

In short, AIR-21 provides a clean exogenous shock to competition in markets that originate from treated airports.[8] Next, I describe the data, variables, and the triple difference empirical specification.

3 Data and Empirical Specification

3.1 Data Sources and Screening

The data used in this study can be found at the Bureau of Transportation Statistics (BTS) and is comprised of three parts. The first part is firm-market pricing data, which is taken from the Airline Origin and Destination Survey (DB1B) database. The DB1B database is a quarterly 10% random sample of all passenger-level itinerary purchases, domestic and directional. Each itinerary purchase observation has information on the airline's identity

[8] In untabulated analysis, I find similar results for destination airport-level plots and RD estimations.

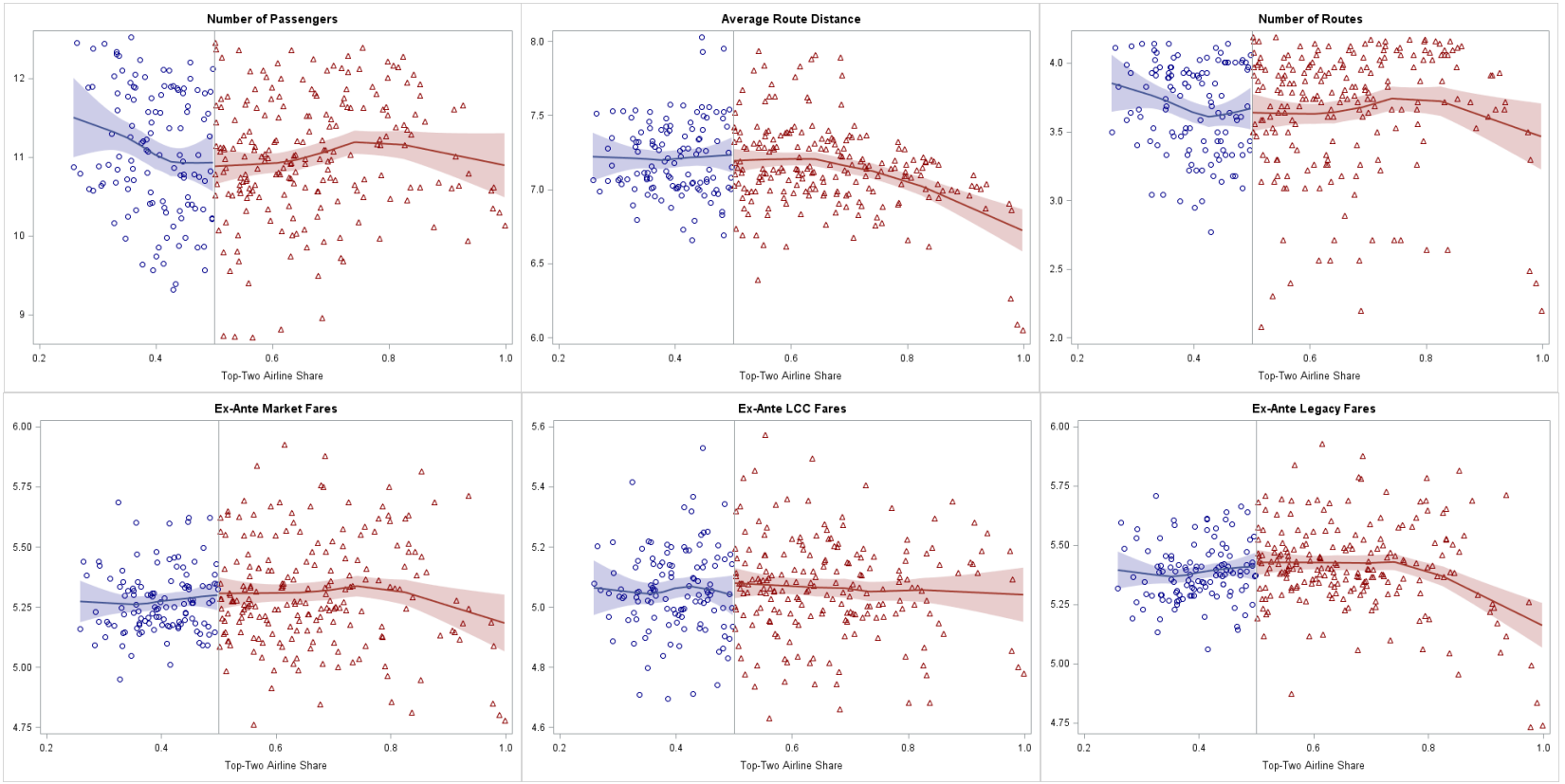


Figure 5. No Discontinuity in Airport-Level Control Variables

These figures plot airport-quarter level observations of ex-ante (lagged by 1 year) airport-level total number of passengers, average route distance, total number of routes, average market prices, average low cost carrier prices, and average legacy airline prices, with respect to the total passenger share of the top-2 airlines at each airport. All variables are based on markets originating from each airport. The fitted lines and confidence bands are from local linear regressions with triangle kernels on each side of the 50% forcing variable treatment cutoff.

(firm), origin and destination of the itinerary (market), per-passenger fare paid, number of passengers, any connections made, flight distance, whether it is part of a round-trip purchase, and whether it is an interline or online ticket. Markets are pre-defined in the DB1B database by the BTS as directional routes without 'trip breaks', which are points in an itinerary where the passenger is assumed to have stopped for reasons other than changing flights. For example, an itinerary BOS-LAS-BOS would have two markets BOS-LAS and LAS-BOS, with a trip break occurring at LAS. Firm-market level prices are computed by taking the quarterly passenger weighted-average of itinerary-level prices. These quarterly average prices are calculated separately for indirect and direct flights, where round-trips are considered to be two equally priced one-way trips.

The second part is passenger boarding data used for identifying airport AIR-21 coverage, gathered from the T-100 Segment database. Unlike the DB1B database, the T-100 Segment database represents the full sample of all flights with at least one endpoint including a U.S. airport. It contains monthly data on airline identity, origin and destination of flight, and number of passengers. Because T-100 Segment data does not include information on on-demand and in-transit passengers, which are used by the FAA to determine AIR-21 coverage, I supplement this with annual airport-level all-enplanement data provided by the FAA.[9]

Finally, firm financial data are obtained from Schedule B-1 of Form 41 Financial Data. Balance sheet information is available at quarterly frequency for large airlines with annual operating revenues exceeding $20 million, and at semi-annual frequency for smaller airlines. Virtually all airlines in the final sample report quarterly financial data. Cash holdings and control debt variables are computed as a fraction of assets. The sample period is from 2001Q1 to 2014Q4.

Several standard screening procedures are implemented on the data. To remove effects

[9]Though on-demand flights (e.g. charter flights) and in-transit passengers (e.g. passengers remaining on planes stopping to refuel) comprise but a small number, they are important for facilitating a regression discontinuity analysis.

of abnormally low or high prices due to ticket punching errors or mileage redemptions, I follow Snider and Williams (2015) and drop itineraries with prices lower than $25 or higher than $2,500 in 2008 dollars. I also drop itineraries with more than 4 connections for round-trips, and those with more than 2 connections for one-way trips. Itineraries associated with interline tickets or open-jaw travel are removed as well.[10] To determine whether an airline serves a particular market, I follow previous papers (see Berry (1992), Ciliberto and Tamer (2009)) and require that at least 90 passengers appear in the DB1B 10% random sample each quarter for a given firm-market. Also, routes are required to have at least 180 passengers in the DB1B sample each quarter to satisfy as a market. I focus the analysis on markets where both endpoints are airports with passenger boardings above 0.25% of the U.S. total, which is the requirement for an airport to be considered for potential coverage by AIR-21. Financial variables are winsorized at the bottom and top 1% to handle outliers.

To account for the fact that covered airports have two 18-month periods after which their AIR-21 coverage is re-determined, the dependent variable is constructed such that the effect of treatment is evaluated over the next accumulative 36-month period. Due to this feature, a number of further adjustments are made to the sample. First, to avoid over-counting treatment, I track each airport starting with their initial AIR-21 coverage after the legislation, and remove observations within 36 months of each subsequent coverage.[11] Conversely, I check backwards to remove periods when an airport appears as non-treated according to boarding data where it subsequently becomes treated within the next 36 months.[12] Finally, I track non-treated observations and remove non-treated periods that occur within 36 months of a previous non-treated period.

[10] Interline tickets refer to itineraries where different segments or legs of the travel are served by different airlines. Open-jaw travels are round-trips where the destination and/or origin are not the same in both directions.

[11] An airport treated as of 2002Q1 should not be considered "re-treated" or "un-treated" in, say, 2002Q2 or 2003Q1 even though the top-two airline concentration ratio might suggest so.

[12] An airport treated in 2003Q1 should not be considered non-treated in, say, 2002Q1 even though the top-two airline concentration ratio might suggest so.

Table 1 provides some descriptive statistics of firms and markets in the data. The final sample includes 26 unique airline firms, all at the consolidated parent company level, and 2,786 markets. Time-series averages of the quarterly cross-sectional mean, median, and standard deviation for a variety of airline and market characteristics are shown for 7 sub-periods as well as averaged over the full sample period. It is first worth emphasizing that the large number of markets in the sample allows precise estimation and statistically powerful inference of the effect of relative-to-rival cash and multimarket contact on pricing at the firm-market level, despite the somewhat small number of firms. It is also interesting to note that after the legislation of AIR-21, I observe a sharp increase in cash holdings accompanied by higher leverage as seen in Panel A. For instance, mean cash reserves increase from 9% of assets in the 2001-2002 period to 15% in the 2005-2006 period, while the average long-term debt to asset ratio increases from 22% to 35% over the same period. Moreover, Panel B of Table 1 reveals a decrease in prices following the enactment of AIR-21, coinciding with an increase in passenger boarding shares by low cost carriers (LLCs) but not accompanied by a sustained reduction in the number of passengers. Average fares fall from $269.07 in 2001-2002 to $227.6 in 2005-2006 and low cost carrier (LCC) passenger shares rise from 20% to 26%, whereas the average number of passengers remains flat around 31 thousand.

These patterns imply intensified competition in the industry which does not appear to be driven by supposed demand shocks around the 9/11 terrorist attacks, and is associated with the accumulation of corporate cash holdings. I provide more evidence on the latter in Section 4, which is consistent with the notion that firms would rationally build up their cash holdings in response to increased competition if indeed financial war chests come in handy under such competitive circumstances. Next, I describe how the main variables in the analysis are constructed based on the dataset.

Table 1. Airline and Market Summary Statistics

This table summarizes airline and market characteristics, which are computed for 7 sub-periods as well as for the entire sample period. Panel A documents airline statistics. The first row shows time-series averages of the number of firms in each period. The remainder of the panel presents time-series averages of cross-sectional means, medians, and standard deviations of firm financial positions (cash, short-term debt, and long-term debt, all scaled by total assets) and firm size measured by total assets (in $ billions). Panel B documents market statistics. Time-series averages of the number of routes (markets) and cross-sectional means, medians, and standard deviations of quarterly average market prices charged by all airlines; by low cost carriers (LCCs); by legacy airlines, market-level number of passengers (in thousands), market-level LCC passenger shares, and market size in terms of total dollar revenues (in $ millions) are reported.

	N	2001-02'	2003-04'	2005-06'	2007-08'	2009-10'	2011-12'	2013-14'	Average
Panel A. Airline Statistics									
Firm N	26	21	18	18	19	17	15	14	17
Cash	Mean	0.09	0.13	0.15	0.18	0.16	0.19	0.17	0.15
	Median	0.08	0.10	0.13	0.17	0.15	0.21	0.17	0.14
	Std. Dev	(0.05)	(0.07)	(0.08)	(0.07)	(0.05)	(0.06)	(0.07)	(0.06)
Short-Term Debt		0.03	0.04	0.04	0.04	0.03	0.05	0.04	0.04
		0.02	0.03	0.03	0.04	0.03	0.04	0.04	0.03
		(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Long-Term Debt		0.22	0.32	0.35	0.30	0.28	0.30	0.24	0.29
		0.24	0.34	0.39	0.34	0.29	0.30	0.23	0.30
		(0.11)	(0.10)	(0.12)	(0.14)	(0.10)	(0.08)	(0.08)	(0.10)
Size ($ billion)		12.76	15.22	14.51	14.61	15.85	17.09	22.45	16.07
		10.38	10.38	10.92	13.84	15.36	14.61	18.08	13.37
		(8.30)	(9.76)	(8.94)	(8.55)	(8.78)	(11.80)	(14.80)	(10.13)
Panel B. Market Statistics									
Route N	2786	1925	1831	1791	1739	1623	1670	1735	1759
Fares	Mean	269.07	231.60	227.60	226.64	230.61	221.77	245.54	236.12
	Median	255.45	218.14	221.13	222.67	224.93	217.11	241.01	228.63
	Std. Dev	(88.94)	(68.91)	(59.94)	(59.03)	(58.80)	(56.95)	(60.36)	(64.70)
LCC Fares		197.09	184.10	181.81	179.42	187.39	183.34	201.24	187.77
		196.88	184.18	183.36	178.92	185.58	183.64	202.08	187.81
		(57.22)	(49.76)	(41.84)	(41.58)	(44.51)	(41.99)	(50.10)	(46.71)
Legacy Fares		266.86	225.99	221.75	216.73	223.90	218.61	244.91	231.25
		252.16	211.85	213.67	210.28	214.42	213.09	239.32	222.11
		(100.63)	(75.02)	(66.53)	(61.61)	(63.56)	(61.47)	(67.71)	(70.93)
Passengers		30.80	26.83	30.80	33.85	32.76	31.75	32.19	31.28
(thousands)		20.23	19.74	21.09	24.32	24.07	22.81	21.76	22.00
		(28.46)	(22.32)	(27.58)	(29.83)	(29.21)	(30.34)	(31.92)	(28.52)
LCC Share		0.20	0.23	0.26	0.31	0.37	0.41	0.40	0.31
		0.09	0.13	0.15	0.25	0.34	0.39	0.38	0.25
		(0.26)	(0.27)	(0.28)	(0.30)	(0.30)	(0.32)	(0.31)	(0.29)
Market Size		7.39	5.57	6.08	6.55	6.58	6.21	6.96	6.48
($ million)		5.08	4.08	4.58	4.81	4.89	4.40	4.86	4.67
		(7.32)	(4.76)	(5.30)	(5.95)	(6.15)	(6.36)	(7.45)	(6.18)

3.2 Variables

The outcome variable of interest in this study is the change in firm pricing policy, which is the difference between firm-market level price growth over the next 36 months and the previous 36 months, skipping the previous and next year. It is computed as the second difference of log prices, denoted by $\Delta\Delta_{36}$Log(Market Fares).[13] Key among the explanatory variables, AIR-21 treatment is assigned as follows. Each year, I begin by computing airport-level concentration ratios as the passenger boarding shares of the top-two airlines at each airport. Then I assign a treatment indicator variable for each market, denoted by AIR21, that equals 1 if the concentration ratio at the origin airport two years prior to the beginning of the present year (i.e. the forcing variable) exceeds 50% and equals 0 otherwise.[14]

Table 2 lists airlines and airports in the sample, and provides airport-level statistics related to AIR-21 treatment. For each airport, the time-series average, minimum, and maximum share of passengers boarded by the top-two airlines, as well as the airport's average share of total U.S. enplanement are shown in Panel B. Airport lists are shown separately for those covered by AIR-21 at some point, in which case the initial year of coverage is shown, and those never covered. An interesting takeaway is that there is not only substantial cross-sectional variation in top-two airline concentration across airports, but also sizable time-series variation within airports. For example, the average top-two airline passenger shares for ORD (Chicago) and LAX (Los Angeles) are widely apart at 63.34% and 31.27% respectively, but the track record for ORD itself also ranges from as low as 49.72% to as high as 75.45%. This indicates considerable within and cross-variation in AIR-21 treatment

[13] Snider and Williams (2015) also use price growth differentials to show the impact of AIR-21. In untabulated analysis, I confirm that results are qualitatively similar using price growth over the next 36 months skipping the first year, Δ_{36}Log(Market Fares), as an alternative dependent variable.

[14] It is plausible that AIR-21 treatment at the destination airport equally serves as a source of intensified competition in a market through shifts in access to gates. Snider and Williams (2015) implement a simple two-dimensional regression discontinuity design and show that this is the case. In untabulated analysis, I assign AIR-21 treatment based on the top-two airline concentration ratio at the destination airport instead of the origin, and find similar results.

Table 2. Airlines and Airports

This table presents lists of legacy airlines and low cost carriers (Panel A), as well as a list and summary statistics of origin airports included in our sample (Panel B). For each airport, the time-series average, minimum, and maximum share of passengers boarded by the top-2 airlines, as well as the airports average share of total U.S. enplanement are shown. Airport lists and statistics are presented separately for airports that are covered by AIR-21 at some point within the sample period, in which case the initial year of coverage is shown, and those that are never covered.

Panel A. List of Airlines

Legacy Airlines: AA, AQ, AS, CO, DL, HA, HP, JI, NW, TW, UA, US, YV, YX
Low Cost Carriers: B6, F9, FL, G4, N7, NJ, NK, SY, TZ, U5, VX, WN

Panel B. Airport Statistics

	Concentration (Top 2, %)			Relative to	AIR21		Concentration (Top 2, %)			Relative to	AIR21
Airports	Average	Min	Max	US (%)	Year	Airports	Average	Min	Max	US (%)	Year
					B-1. Covered Airports						
ABQ	67.24	63.60	71.34	0.46	2001	MIA	63.03	53.95	70.02	2.25	2001
ANC	59.67	51.57	71.03	0.34	2001	MKE	48.39	37.97	57.02	0.50	2001
ATL	78.66	73.41	82.30	5.76	2001	MSP	71.72	58.56	79.77	2.28	2001
AUS	59.34	39.83	61.94	0.56	2002	MSY	47.57	40.55	53.14	0.63	2001
BHM	73.13	73.13	73.13	0.26	2003	OAK	74.73	67.46	82.42	0.84	2001
BNA	65.10	62.42	69.89	0.68	2001	OGG	60.46	48.76	69.33	0.39	2001
BUR	77.05	70.72	84.12	0.35	2001	OKC	49.52	43.36	55.68	0.26	2011
BWI	64.43	55.50	72.29	1.45	2001	ONT	61.03	55.63	63.95	0.42	2001
CLE	56.27	49.03	61.68	0.74	2001	ORD	63.34	49.72	75.45	4.70	2001
CLT	76.24	69.27	87.04	2.06	2001	PBI	47.69	38.49	58.75	0.43	2001
CVG	75.18	51.87	93.70	1.12	2001	PHL	58.29	50.59	67.51	1.95	2001
DAL	97.94	94.77	99.84	0.53	2001	PHX	69.22	57.35	72.92	2.74	2001
DCA	41.03	33.16	51.68	1.12	2002	PIT	52.49	31.53	80.76	0.88	2001
DEN	60.21	45.90	72.58	3.02	2001	PVD	59.88	54.42	66.74	0.35	2001
DFW	81.00	73.14	85.33	3.82	2001	RNO	62.57	56.04	67.63	0.34	2001
DTW	71.06	61.02	77.84	2.30	2001	SAN	48.29	45.36	52.38	1.16	2012
ELP	77.28	74.08	80.56	0.26	2001	SAT	55.28	53.66	57.49	0.53	2001
EWR	63.59	58.95	69.91	2.30	2001	SDF	47.67	41.31	54.44	0.26	2001
HNL	49.27	43.90	60.56	1.35	2011	SFO	50.04	41.32	57.18	2.47	2001
HOU	91.26	88.51	93.54	0.66	2001	SJC	60.05	53.51	66.30	0.72	2001
IAD	50.77	45.62	57.51	1.45	2001	SJU	58.61	44.33	68.58	0.66	2001
IAH	82.42	77.85	86.11	2.53	2001	SLC	72.81	66.77	82.63	1.36	2001
JAX	46.99	41.10	54.89	0.38	2003	SMF	61.97	58.07	68.31	0.64	2001
LAS	50.63	47.67	54.13	2.71	2003	SNA	41.74	33.63	53.14	0.60	2014
MCI	49.83	44.19	55.14	0.80	2005	STL	68.49	54.81	86.33	1.31	2001
MDW	84.30	73.29	92.57	1.22	2001	TPA	43.82	39.80	51.14	1.17	2012
MEM	69.17	55.87	76.89	0.72	2001	TUL	52.76	51.59	53.93	0.25	2001
MHT	57.53	55.43	61.10	0.27	2004	TUS	48.52	42.93	53.83	0.26	2007
					B-2. Non-Covered Airports						
BDL	43.60	39.27	49.25	0.44		LGA	38.70	30.76	44.50	1.67	
BOS	33.50	27.23	39.15	1.80		MCO	35.89	32.49	42.17	2.19	
BUF	39.11	30.73	46.70	0.33		OMA	41.09	37.62	45.05	0.28	
CMH	34.35	28.49	40.27	0.46		ORF	38.97	34.43	41.28	0.26	
FLL	34.21	27.51	40.75	1.36		PDX	37.78	35.50	39.53	0.93	
IND	31.27	26.93	35.19	0.54		RDU	35.32	30.13	40.52	0.64	
JFK	41.35	32.42	45.80	2.75		RSW	35.49	22.82	45.16	0.46	
LAX	31.27	26.41	36.03	4.16		SEA	46.83	42.46	49.98	2.05	

even though most covered airports appear to have become initially covered as soon as the legislation went into effect.

The ex-ante variables to explain the changes in pricing strategies after AIR-21 competition shocks are relative-to-rival cash holdings and multimarket contact. For both of these variables, the first step is to identify rivalry. Competitors of firm i in market r are firms j (where $j \neq i$) also operating in that market. Relative-to-rival financial variables, cash and various control measures of debt, are then defined as the excess financial positions of a firm relative to the average of all rival firms. They are computed each quarter as follows,

$$RelFin_{ir} = Fin_i - \frac{1}{n_r - 1} \sum_{j=1}^{n_r} Fin_j$$

where $j \neq i$, n_r denoting the number of firms in market r, and Fin_j denoting financial variables scaled by total assets. To construct multimarket contact, I follow Evans and Kessides (1994) and begin by counting the number of markets in which firm i encounters rival company j, which can be written as

$$a_{ij} = \sum_{r=1}^{n} D_{ir} D_{jr}$$

where n is the number of markets and D_{ir} is a dummy variable equal to one if firm i operates in market r and 0 otherwise. Then each quarter, firm i's average multimarket contact with rivals in market r is

$$MC_{ir} = \frac{1}{n_r - 1} \sum_{j=1}^{n_r} a_{ij}$$

MC_{ir} essentially captures the average number of markets jointly contested by firm i and its rivals, and is logarithmized in the triple difference regressions. $RelFin_{ir}$ and MC_{ir} are both winsorized at the bottom and top 1% to lessen the impact of outliers, and are measured one

year prior to AIR-21 treatment.[15]

Table 3 describes the quantities of the outcome variable (i.e. changes in firm pricing policy) and the ex-ante explanatory variables explained above (i.e. relative-to-rival finances and multimarket contact). In Panel A, time-series averages of the cross-sectional mean, standard deviation, minimum, median, and maximum are shown for each variable. The mean difference between price growth over the next and previous 36 months is 4.28% with a standard deviation of 33.72%. There is substantial cross-sectional variation in both relative-to-rival cash holdings and multimarket contact, mitigating concerns that there is unlikely much action on these dimensions. Relative-to-rival cash to asset ratios range from -28.37% to 29.44% with an average standard deviation of 8.89%. The average multimarket contact is 193.18 routes, ranging from 10.7 to as large as 422, with a standard deviation of 103.47.[16] Panel B presents Pearson correlations between relative-to-rival finances and multimarket contact. None of the financial variables are highly correlated with multimarket contact. The correlation between relative-to-rival cash and multimarket contact is -0.09, leaving little room to suspect that one strongly influences the other.

3.3 Empirical Specification

To explore how cash holdings affect firm pricing behavior, and whether multimarket contact strengthens or weakens this effect, I employ a triple difference framework on firm-market

[15]A concern here is that not all rivals may be equally important. For example, in the first quarter of 2014, Virgin America had a 23.4% passenger share in the BOS (Boston)-SFO (San Francisco) market. Between its rival firms American Airlines and United Airlines, each of which had 2.4% and 41.7% passenger shares respectively, United Airlines would have been a more formidable and important competitor for Virgin America in the BOS-SFO market. In light of such situations, equally weighting all rival firms in the same market may incorrectly assign a firm with more or less multimarket contact or relative-to-rival cash than is actually relevant. To take this into account, I reconstruct these variables weighting rival firms in each market by their passenger boardings. Doing so essentially leaves the results of this paper unchanged. These alternative results are reported in the Appendix (Table A.1).

[16]To facilitate the interpretation of economic magnitudes of the regression results presented in Section 4, I also report the key variable statistics for a number of select subsamples (the results for which economic magnitudes are discussed in the paper) in the Appendix (Table A.2).

Table 3. Key Variable Statistics

This table presents summary statistics of airline price growth differentials, relative-to-rival finances, and multimarket contact over the sample period 2001Q1 to 2014Q4. Price growth differential is defined as the difference between the next 36-month's and previous 36-month's price growth, skipping the previous year and next year, and is computed by taking the second difference of log prices ($\Delta\Delta_{36}$Log(Market Fares)). Rivals are identified as firms operating in market r. Relative-to-rival finances and multimarket contact are computed following equations (1) and (2) as detailed in Section 3.

(1) $RelFin_{ir} = Fin_i - \frac{1}{n_r - 1}\sum_{j=1}^{n_r} Fin_j \quad \text{where} \quad j \neq i$

(2) $MC_{ir} = \frac{1}{n_r - 1}\sum_{j=1}^{n_r} a_{ij} \quad \text{where} \quad a_{ij} = \sum_{r=1}^{n} D_{ir}D_{jr} \quad \text{and} \quad j \neq i$

Price growth differentials are computed each quarter for each firm-market separately for nonstop and connecting flights. Relative-to-rival finances and multimarket contact variables are computed each quarter for each firm-market. Then, time-series averages of the cross-sectional mean, standard deviation, minimum, median, and maximum for each of these variables are presented in Panel A. Price growth differentials are presented as percentage growth rates, financial variables as percentages of total assets, and multimarket contact as average number of routes. The number of firms and markets are shown as well. Panel B presents Pearson correlations between the relative-to-rival finance and multimarket contact variables.

Panel A. Average Cross-Sectional Statistics

	Mean	Std. Dev	Min	Median	Max
Price Growth Differential	4.28	33.72	-350.95	3.91	350.66
Relative-to-Rival Finance					
Cash	-0.03	8.89	-28.37	-0.42	29.44
Short-Term Debt	-0.20	3.53	-13.76	-0.35	13.92
Long-Term Debt	-0.64	13.53	-41.89	-0.04	41.07
Total Debt	-0.85	15.09	-48.51	-0.33	47.92
Multimarket Contact	193.18	103.47	10.70	191.28	422.00
No. of Firms	26				
No. of Markets	2786				

Panel B. Pearson Correlations

	Relative-to-Rival Finance				Multimarket
	Cash	ST Debt	LT Debt	T Debt	Contact
Relative-to-Rival Finance					
Cash	1	0.08	-0.05	-0.02	-0.09
Short-Term Debt	0.08	1	0.24	0.48	-0.05
Long-Term Debt	-0.05	0.24	1	0.96	-0.04
Total Debt	-0.02	0.48	0.96	1	-0.05
Multimarket Contact	-0.09	-0.05	-0.04	-0.05	1

and quarter panel data where I regress price growth differentials on relative-to-rival cash, multimarket contact, and an AIR-21 treatment indicator, as well as a host of control variables and fixed effects. To capture a plausibly exogenous local treatment effect, this regression is run on progressively narrower windows surrounding the 50% top-two airline passenger share threshold for AIR-21 treatment in market origin airports. The baseline model is specified as follows.

$$\begin{aligned}\Delta\Delta_{36} log\left(P_{irt}\right) = \beta_0 &+ \beta_1 \cdot MC_{irt-1} + \beta_2 \cdot RelCash_{irt-1} + \beta_3 \cdot AIR21_{rt} \\ &+ \beta_4 \cdot (MC_{irt-1} \times RelCash_{irt-1}) \\ &+ \beta_5 \cdot (AIR21_{rt} \times MC_{irt-1}) \\ &+ \beta_6 \cdot (AIR21_{rt} \times RelCash_{irt-1}) \\ &+ \beta_7 \cdot (AIR21_{rt} \times MC_{irt-1} \times RelCash_{irt-1}) \\ &+ \gamma' \cdot \mathbf{X}_{irt-1} + a_i + b_r + c_t + \epsilon_{irt}\end{aligned}$$

In the baseline specification as well as in additional tests, I control for relative-to-rival short-term debt, long-term debt, and their cross interactions with multimarket contact and AIR-21 treatment to tease out the impact of cash holdings distinct from well-established leverage effects.[17] I further include as control variables an indicator for whether the service is a direct flight, firm's passenger share in the market, one year lagged firm size measured by log assets, number of rivals in the market, passenger share of low cost carriers (LCCs) in the market, and market size in terms of log dollar revenues. Firm, market, and time fixed effects are also included in all specifications.[18]

[17] In their concluding remark, Opler, Pinkowitz, Stulz, and Williamson (1999) emphasize the fact that determinants of cash holdings and debt are closely related. In an examination of this point, Acharya, Almeida, and Campello (2007) show that there are instances where cash is not necessarily negative debt, indicating that cash should have implications that are distinct from those of debt. Fresard (2010) shows this in the context of product market outcomes.

[18] To address concerns of multicollinearity between variables included in the regressions, I report a correlation table (Figure A.1) in the Appendix. While there is some correlation among certain variables, they are moderate in magnitude and intuitive to understand. For example, the highest correlation is 0.59 between

To understand the meaning of the coefficients, recall that there are two hypotheses being tested. First, I examine the implications of 'deep pocket' theories about the mechanism through which cash may affect product market outcomes, namely that cash holdings provide the financial flexibility that enables firms to price aggressively (see Bolton and Scharfstein (1990)). To do this, I test whether firms with large ex-ante relative-to-rival cash reserves reduce prices more aggressively after AIR-21 competition shocks. This test is captured by β_6, the coefficient on the interaction term of AIR21 and $RelCash$, for which the hypothesized prior is a negative value. Second, incorporating insights from the industrial organization literature on multimarket contact and collusive behavior (see Bernheim and Whinston (1990)), I test whether high multimarket contact attenuates the competitive effect of cash. The attenuation effect of multimarket contact is captured by β_7, which is expected to take the opposite sign of β_6 and therefore have a positive value.

In the following section, I present results from baseline regressions, a number of subsample analyses, and additional robustness tests to cement the argument of the paper.

4 Results

4.1 Main Results

Table 4 presents results from the baseline firm-market-quarter level triple difference regressions of price growth differentials on AIR-21 treatment, relative-to-rival cash holdings, multimarket contact, and their cross interactions. Cash and multimarket contact are both measured one year prior to AIR-21 treatment. Firm, market, and time fixed effects are controlled for, and standard errors adjusted for clustering at the firm and market levels are

firm size and multimarket contact (MC), which is not surprising since larger firms will tend to operate in a greater number of major routes where they will make contact with a broader set of rivals.

reported in parentheses.[19] The five columns show the main results, where triple difference regressions are run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff.

Moving away from the full sample, results imply a strong causal impact of cash on changes in firm pricing policy which is attenuated by higher levels of multimarket contact. In the sample of observations where the value of the forcing variable, the ex-ante top-two airline concentration ratio at the origin airport of the market, ranges from 35% to 65% (i.e. 15% above and below the 50% cutoff), a one standard deviation (i.e. 8.55 percentage point) increase in ex-ante relative-to-rival cash holdings as a fraction of assets leads to 15.22 percentage points lower price growth over the next 36 months compared to the previous 36 months (i.e. 0.47 standard deviations lower price growth differential). This competitive effect of cash in which cash-rich firms respond to competition shocks by pricing more aggressively, captured by the coefficient on the interaction term of AIR-21 treatment and relative-to-rival cash, is rapidly eroded by increases in multimarket contact: a 5.3% increase completely cancels out the effect. This is consistent with the hypothesis that firms facing higher chances of retaliation from rivals are less likely to make use of their financial war chests. These effects are not only robust, but even stronger as I move to narrower samples where the regressions are focused on observations with top-two airline concentration ratios 10%, 5%, and 2.5% above and below the 50% threshold. For example, in the second-narrowest sample 5% above and below the cutoff, a one standard deviation (i.e. 8.93 percentage point) increase in the relative-to-rival cash to asset ratio results in a reduction of price growth by 26.52 percentage points (i.e.

[19] A stricter test is to zero in on the change in pricing behavior of the same firm in the same market after being treated by AIR-21, which can be implemented by controlling for firm-by-market fixed effects instead of firm and market fixed effects separately. Results from this alternative specification, which are robust if not stronger, are reported in Panel A of Table A.3 in the Appendix. It is also important to verify the robustness of the results to adjusting for alternative forms of error clustering. For example, a hypothetical measurement error in a firm-level financial variable in a particular time period will likely cause errors to correlate across all market observations for the same firm at that time. Panel B of Table A.3 shows robust results after adjusting standard errors for such a case of firm-time level clustering, as well as a number of other error clustering schemes.

Table 4. Cash, Competition, and Multimarket Contact

This table presents results from firm-market-quarter level triple-difference regressions of 12-quarter price growth differentials on an AIR-21 coverage indicator (AIR21), ex-ante relative-to-rival cash holdings (Cash), ex-ante multimarket contact (MC), and their interactions. Specifically, the dependent variable ($\Delta\Delta_{36}$Log(Market Fares)) is defined as the difference between the next 36-month's and previous 36-month's price growth, skipping the previous year and next year, and is computed by taking the second difference of log prices. The AIR-21 dummy variable equals to 1 if the top-2 airlines' passenger boardings exceed 50% of the origin airport total during the calendar year 2 years prior to the current quarter, and equal to 0 otherwise (In untabulated analysis, I find similar results using an AIR-21 treatment indicator for the destination airport). Relative-to-rival cash and multimarket contact are constructed as described in Section 3, and are measured as of the previous year. Other control variables include relative-to-rival short-term debt, long-term debt, their interactions with multimarket contact and the AIR-21 indicator, a nonstop service indicator, firm's passenger share in the market, firm size measured by the logarithm of total assets, number of rivals in the market, total passenger share of low cost carriers (LCCs) in the market, and market size measured as the logarithm of market-level aggregate dollar revenues. The five columns show results from triple difference regressions using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Firm, market, and time fixed effects are included in all specifications. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)				
	Full Sample	15%	10%	5%	2.50%
AIR21 × *Cash*	-0.518	-1.776***	-1.942***	-2.967***	-3.628**
	(0.543)	(0.488)	(0.665)	(0.770)	(1.706)
AIR21 × *MC* × *Cash*	0.092	0.333***	0.348**	0.590***	0.713*
	(0.110)	(0.103)	(0.132)	(0.159)	(0.382)
MC	-0.038***	-0.033**	-0.027	-0.023	-0.007
	(0.012)	(0.013)	(0.020)	(0.030)	(0.034)
Cash	1.193***	1.619***	1.306**	2.109***	2.672**
	(0.395)	(0.465)	(0.493)	(0.670)	(1.216)
MC × *Cash*	-0.272***	-0.360***	-0.321***	-0.485***	-0.610*
	(0.082)	(0.096)	(0.102)	(0.138)	(0.299)
AIR21	0.043	0.082	0.112	-0.245*	-0.326**
	(0.070)	(0.089)	(0.103)	(0.124)	(0.151)
AIR21 × *MC*	-0.018	-0.026	-0.030	0.040	0.040
	(0.013)	(0.017)	(0.020)	(0.025)	(0.033)
Observations	15,958	9,097	6,047	2,828	1,701
Firms	19	19	19	19	18
Markets	1,941	1,404	1,036	561	394
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
R-squared	0.226	0.271	0.301	0.349	0.401

0.87 standard deviations lower price growth differential), which is wiped out by 5% higher multimarket contact.[20] This is not surprising since I am more likely to capture the action of interest with a sample closer to the treatment threshold, where observations are more likely to be similar across controlled or unobserved dimensions, if the treatment is truly discontinuous at that point. Similarly, it is also natural that the results are less significant with the full sample as it includes observations at the far ends of the forcing variable's domain that are more likely to be heterogeneous across unobservable dimensions. For example, observations where the top-two airline concentration ratio exceeds 70% exhibit substantially higher price growth differentials and lower low cost carrier passenger shares compared to observations below the 50% cutoff, indicating that differences in market dynamics may be large enough to dominate the impact of AIR-21.[21]

It is worth noting that the coefficients on relative-to-rival cash and its interaction with multimarket contact imply that firms with more cash price aggressively even absent AIR-21 shocks. For example, the average log multimarket contact in the 15% window sample is 5.3,

[20] As an observational example to help understand the results, consider American Airlines and two of its markets, San Diego (SAN) to New York (JFK) and San Diego (SAN) to Chicago (ORD). At the end of 2010, American held 22% of its assets in cash. At the end of 2009, the two largest airlines in terms of passenger boardings, United and Southwest, boarded 49% of all passengers at SAN. At the end of 2010, the two largest airlines, Delta and Southwest, crossed the 50% AIR-21 threshold at SAN by boarding 50.3% of the airport's passengers. As a result, SAN was covered by AIR-21 in 2012. American subsequently reduced its price growth by 8.2 percentage points for its service from SAN to JFK, where its rival, jetBlue, held 15% of its assets in cash as of 2010 year-end, considerably less than American. On the other hand, American raised its price growth rate by 12.4 percentage points on its route SAN to ORD, where its rival, United, held 24% of its assets in cash, even more than the amount American held. American also happened to overlap with United across a larger number of routes.

[21] In the Appendix (Table A.4), I report the means of numerous observable variables for AIR-21 control (AIR21=0) and treatment (AIR21=1) observation groups, as well as p-values from t-tests of their differences. Comparison of the means of firm-level and airport-level variables suggest that airline companies and market origin airports are similar across control and treatment groups, although airport characteristics are marginally different as the sample is broadened away from the tighter window around the 50% top-two airline passenger share threshold. At market and firm-market levels, there are more statistically significant differences across a number of variables, but those differences are small in magnitude in the full sample and further diminish as the sample window is narrowed to 15% above and below the 50% cutoff. Beyond explicitly controlling for a large number of these variables to the extent that multicollinearity issues do not arise, I also include firm, market, and time fixed effects, and adjust standard errors for clustering at firm and market levels to address such differences.

at which the coefficient for relative-to-rival cash when AIR21=0 is $1.619 + (-0.360) \times 5.3 = -0.289$. In a simple OLS regression of price growth differentials on relative-to-rival cash and control variables, the coefficient on relative-to-rival cash is -0.252 with an adjusted standard error of 0.101.

Interestingly, I do not find significant coefficients on the interaction terms from difference-in-differences analyses where I regress changes in firm pricing policy on AIR-21 treatment and each of relative-to-rival cash or multimarket contact. I interpret this as an indication that cash reserves or multimarket contact alone do not suffice to influence firm pricing policy to a great extent, but rather it is the interplay of financial and strategic rivalry considerations that is of critical importance. In addition, using 18 month horizons instead of 36 months to measure changes in firm pricing policy yields no results in my analysis, which is consistent with the idea that airports are likely to fully utilize the two 18 month periods given to them before their AIR-21 coverage is re-determined to address the problems raised by the FAA. Their tendency to postpone the remedy until the last minute may arise from a variety of reasons, such as relationships with incumbent airlines, physical capacity constraints, or distracted management.

It is important to realize that the main results imply a cash impact on firm competition strategy that is markedly different from previously documented effects of debt. Busse (2002) finds that airline companies with greater leverage are more likely to start price wars, consistent with the notion that risk-shifting by highly indebted firms leads them to 'gamble harder' by lowering prices (see Brander and Lewis (1986), Maksimovic (1988)). Thus if cash were simply the flip side of debt, one would expect airlines with smaller cash holdings to price more aggressively following a competition shock, which is the opposite from what I find. While it should be kept in mind that the relationship between capital structure and product market competition is likely to vary across industry structures (see Phillips (1995)), the airline industry in particular highlights the distinct effects of cash and debt since larger

cash holdings and higher leverage both appear to result in more aggressive pricing behavior, contradicting the notion that cash is merely negative debt.

In the following subsections, I supplement the main results with a variety of alternative tests to cement the story that cash provides financial flexibility which enables firms to compete aggressively, and that potential rival retaliation attenuates the competitive benefit of this flexibility.

4.2 Subsample Analyses

While the baseline results imply a competitive benefit of cash that varies with multimarket contact *on average*, an important aspect of the AIR-21 regulation is that it likely affects heterogeneous firms in the same market differentially. The reason is that AIR-21 pushes covered airports to redirect gate allocations toward new entrant airlines, mostly low cost carriers (LCCs), and incumbent airlines with small market shares, as documented by Snider and Williams (2015). It is therefore important to verify these heterogeneous effects in subsample analyses to clarify the source of the main results.

Table 5 shows triple difference regression results from splitting the sample of firms into LCCs and legacy airlines. A natural way to think about how LCCs and legacy airlines would respond to AIR-21 treatment is to view them as serving loosely substitutable, but distinct, clienteles. Because AIR-21 tends to open up airports to new entrant LCCs, incumbent LCCs serving the same clientele are likely to respond aggressively across the board, whereas legacy airlines will tend to respond less unanimously given their services are to some extent differentiated from LCCs' although still quite substitutable. Consistent with this hypothesis, I find that LCCs respond to AIR-21 shocks by pricing more aggressively irrespective of their cash holdings, while legacy airlines do so conditional on holding large cash reserves. Both of their responses, however, are dampened by higher multimarket contact. While performing each of the subsample analyses on increasingly closer windows around the 50% treatment threshold

Table 5. Low Cost Carriers vs. Legacy Airlines

This table presents subsample results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante relative-to-rival cash holdings (Cash), ex-ante multimarket contact (MC), and their interactions. Two sets of regressions are run for subsamples restricted to include only (1) low cost carriers and (2) legacy airlines. In each subsample analysis, the results are shown in five columns where the triple difference regression is run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)									
	Low Cost Carriers					Legacy Airlines				
	Full Sample	15%	10%	5%	2.50%	Full Sample	15%	10%	5%	2.50%
AIR21 × *Cash*	-0.033	-1.133	-0.057	-0.401	5.279***	-0.858	-2.389***	-2.437***	-4.371***	-7.341***
	(0.609)	(0.638)	(0.759)	(0.982)	(1.018)	(0.695)	(0.512)	(0.779)	(0.857)	(2.110)
AIR21 × *MC* × *Cash*	-0.015	0.162	-0.113	-0.037	-1.156***	0.128	0.424***	0.411**	0.892***	1.499***
	(0.115)	(0.120)	(0.155)	(0.217)	(0.258)	(0.146)	(0.123)	(0.147)	(0.168)	(0.470)
MC	-0.070**	-0.098***	-0.120***	-0.142**	-0.398**	-0.040**	-0.045*	-0.021	0.010	0.022
	(0.023)	(0.019)	(0.021)	(0.035)	(0.152)	(0.015)	(0.023)	(0.028)	(0.034)	(0.050)
Cash	0.402	0.936	0.319	-0.072	-4.581***	1.809***	2.188***	1.702*	2.967**	3.984
	(0.798)	(0.810)	(0.995)	(1.297)	(0.962)	(0.366)	(0.570)	(0.819)	(1.029)	(2.531)
MC × *Cash*	-0.079	-0.151	-0.016	0.119	0.871**	-0.352***	-0.437***	-0.403**	-0.722***	-0.953
	(0.147)	(0.136)	(0.210)	(0.304)	(0.247)	(0.090)	(0.118)	(0.158)	(0.204)	(0.561)
AIR21	-0.226**	-0.334***	-0.456***	-0.321	-2.313**	0.054	0.058	0.104	-0.266	-0.218
	(0.090)	(0.073)	(0.094)	(0.207)	(0.591)	(0.095)	(0.124)	(0.140)	(0.164)	(0.233)
AIR21 × *MC*	0.029	0.058***	0.091***	0.053	0.494**	-0.021	-0.023	-0.030	0.041	0.003
	(0.016)	(0.012)	(0.019)	(0.037)	(0.147)	(0.018)	(0.024)	(0.028)	(0.032)	(0.050)
Observations	4,623	2,655	1,773	893	566	11,086	6,219	4,075	1,845	1,061
Firms	7	7	7	6	6	12	12	12	12	11
Markets	961	675	470	256	194	1,625	1,140	818	443	294
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.300	0.373	0.411	0.459	0.573	0.245	0.293	0.327	0.378	0.432

presents possible small-sample issues (e.g. the number of firm-market-quarter observations drop below 1,000 for the LCC subsample when the forcing variable range is within 5% above and below the 50% cutoff), the results are strikingly robust and consistent for legacy airlines as I close in from the full sample. In response to AIR-21 competition shocks, legacy airlines with one standard deviation (i.e. 8.42 percentage points) greater cash holdings as a fraction of assets relative to rivals exhibit as much as 61.8 percentage points lower price growth over the next 36 months compared to the previous 36 months (i.e. 1.71 standard deviations lower price growth differential), and a mere 4.9% increase in multimarket contact cancels out this effect. The legacy airline subsample results have important ramifications. Not only are legacy airlines such as Delta, American, and United representative firms of the airline industry, but the manner in which they respond to AIR-21 competition shocks is also representative of how most firms in other industries with differentiated products and incompletely substitutable clienteles are likely to behave.

In Table 6, I present results from subsample analyses for firms that are clear market dominators ex-ante (i.e. firms with passenger shares above 45% one year prior to treatment) and those that are not (i.e. firms with passenger shares below 45% one year prior to treatment). Given that the aim and result of AIR-21 are to reallocate gates toward new entrants and dominated incumbents at covered airports, one would expect to see the effect of AIR-21 as a competition shock for firms that have high market shares to begin with, but not for ex-ante market laggards for whom treatment would rather come as a blessing. This prediction is confirmed in the results. I do not find that firms with low ex-ante market shares respond to competition shocks in terms of their pricing strategies, irrespective of their cash holdings or multimarket contact. On the other hand, firms that dominate the market prior to AIR-21 treatment respond by pricing more aggressively with their cash holdings (e.g. in the window sample 15% above and below the 50% cutoff, a one standard deviation, or 8.49 percentage point, increase in relative-to-rival cash to asset ratio corresponds to 22.41 percentage points

Table 6. Ex-Ante Market Dominators vs. Laggards

This table presents subsample results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante relative-to-rival cash holdings (Cash), ex-ante multimarket contact (MC), and their interactions. Two sets of regressions are run for subsamples restricted to include only (1) ex-ante market dominators and (2) ex-ante market laggards. Ex-ante market dominators (laggards) are defined as firms with ex-ante, i.e. measured 1 year prior to a given point of time, passenger shares equal to or larger than (less than) 45% in a given market and quarter. In each subsample analysis, the results are shown in five columns where the triple difference regression is run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)									
	Dominators (Market Share ≥ 45%)					Laggards (Market Share < 45%)				
	Full Sample	15%	10%	5%	2.50%	Full Sample	15%	10%	5%	2.50%
AIR21 × Cash	-1.320	-2.643**	-3.062**	-5.437**	-11.549	0.737	-0.467	0.163	-1.060	-1.541
	(0.866)	(0.939)	(1.164)	(1.979)	(8.397)	(0.894)	(1.259)	(1.389)	(1.614)	(2.696)
AIR21 × MC × Cash	0.280	0.477**	0.515**	1.091**	2.247	-0.188	0.083	-0.079	0.186	0.255
	(0.165)	(0.197)	(0.233)	(0.414)	(1.791)	(0.194)	(0.259)	(0.281)	(0.311)	(0.531)
MC	-0.050**	-0.040	-0.023	-0.028	0.130	-0.051***	-0.070***	-0.076**	-0.002	-0.013
	(0.023)	(0.026)	(0.035)	(0.064)	(0.113)	(0.013)	(0.019)	(0.027)	(0.050)	(0.070)
Cash	2.653***	2.362***	1.599	2.349	7.341	-0.698	0.051	-1.064	0.415	-0.740
	(0.627)	(0.651)	(0.966)	(1.338)	(7.024)	(0.772)	(0.994)	(1.048)	(1.061)	(1.964)
MC × Cash	-0.563***	-0.464***	-0.344*	-0.537*	-1.584	0.078	-0.107	0.117	-0.173	0.039
	(0.098)	(0.122)	(0.189)	(0.283)	(1.544)	(0.166)	(0.201)	(0.215)	(0.219)	(0.402)
AIR21	0.009	0.076	0.036	-0.072	0.845	0.002	-0.061	-0.067	-0.264	-0.378
	(0.130)	(0.174)	(0.183)	(0.184)	(0.550)	(0.117)	(0.148)	(0.208)	(0.191)	(0.244)
AIR21 × MC	-0.012	-0.032	-0.027	-0.001	-0.226*	-0.007	0.008	0.012	0.044	0.087
	(0.023)	(0.032)	(0.032)	(0.036)	(0.113)	(0.022)	(0.029)	(0.042)	(0.035)	(0.057)
Observations	7,940	4,407	2,887	1,331	759	7,615	4,318	2,858	1,325	827
Firms	18	17	16	14	14	18	18	18	18	16
Markets	1,696	1,128	795	427	277	1,270	866	603	311	221
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.301	0.349	0.383	0.423	0.469	0.290	0.340	0.357	0.413	0.466

lower price growth, or 0.76 standard deviations lower price growth differential), and greater ex-ante multimarket contact erodes this effect (e.g. the reduction in price growth associated with larger cash reserves is wiped out by 5.5% higher multimarket contact).

From the subsample analyses above, I conclude that the average effects shown in the main results are driven by legacy airlines and ex-ante market dominators, which are the representative firms for which AIR-21 serves as a valid competition shock.

4.3 Do Firms Hold Cash Anticipating AIR-21 Coverage?

To further cement the main results of this paper, I conduct a number of robustness checks to address some remaining concerns. One concern is that firm cash holdings may still be endogenously linked to ex-post changes in pricing policy since firms may be able to *predict* AIR-21 coverage and accumulate cash reserves in advance. If this is the case, the causal interpretation of cash on pricing fails because firms that are intent on pricing aggressively turn out to be the ones that hoard cash.

In Table 7, I address this particular issue by using relative-to-rival cash holdings measured 3 or 4 years prior to AIR-21 treatment instead of one year in the triple difference regressions. This alleviates the remaining endogeneity concern since firms are unlikely to be able to predict AIR-21 coverage of an originating airport in a market so far in advance. To do so, they would have to be able to foresee airport total passenger boardings as well as boardings by the two largest airlines 1 or 2 years in advance, which is implausible. Panel A and Panel B report coefficients on the AIR21×Cash and AIR21×MC×Cash interaction terms from the triple difference regressions each using 3-year and 4-year lagged relative-to-rival cash as the Cash variable. My results are strongly robust to these alternative specifications across all forcing variable windows, even in the full sample when I use 4-year lagged cash. Focusing on a narrower sample where the forcing variable ranges from 45% to 55% (i.e. 5% above and below the treatment threshold), a one standard deviation (i.e. 7.62 percentage

Table 7. Cash 3 to 4 Years Prior, Competition, and Multimarket Contact

This table presents results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante multimarket contact (MC, measured as of the previous year), ex-ante relative-to-rival cash holdings (Cash 3Y, measured 3 years prior, or Cash 4Y, measured 4 years prior), and their interactions. The results are shown in five columns where the triple difference regression is run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Panel A reports results from using relative-to-rival cash measured 3 years prior, and Panel B reports results from using relative-to-rival cash measured 4 years prior. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)				
	Panel A. Relative-to-Rival Cash Lagged by 3 Years				
	Full Sample	15%	10%	5%	2.50%
AIR21 × Cash 3Y	-0.370	-1.303**	-2.194**	-3.208**	-3.244**
	(0.448)	(0.602)	(0.818)	(1.381)	(1.146)
AIR21 × MC × Cash 3Y	0.092	0.244*	0.444**	0.643**	0.591**
	(0.100)	(0.125)	(0.172)	(0.272)	(0.235)
Observations	10,528	5,904	3,829	2,058	1,275
R-squared	0.284	0.321	0.346	0.352	0.434
	Panel B. Relative-to-Rival Cash Lagged by 4 Years				
	Full Sample	15%	10%	5%	2.50%
AIR21 × Cash 4Y	-1.160**	-2.293***	-3.240***	-5.138***	-5.101**
	(0.476)	(0.476)	(0.946)	(1.207)	(2.199)
AIR21 × MC × Cash 4Y	0.236**	0.430***	0.629***	0.988***	0.961**
	(0.101)	(0.098)	(0.201)	(0.252)	(0.432)
Observations	9,861	5,413	3,448	1,782	1,049
R-squared	0.282	0.328	0.349	0.367	0.464
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

point) increase in relative-to-rival cash holdings measured 4 years prior to treatment leads to 39.17 percentage points less price growth in the next 36 months compared to the previous 36 months (i.e. 1.29 standard deviations lower price growth differential). The competitive effect of cash is cancelled out by a 5.2% increase in multimarket contact. Even still, one might

argue that if boardings are persistent, firms would still be able to predict AIR-21 coverage. While this may be true for regions in the sample where the forcing variable takes values far away from the 50% treatment threshold, the quasi-RD approach of my analysis sidesteps this problem as firms would not be able to predict whether the top-two airline concentration ratio of an airport will fall slightly above or below the 50% cutoff.

4.4 Is the AIR-21 Discontinuity Spurious?

Another concern is that the triple difference regression results may not be confined to the case where the treatment cutoff of the forcing variable is 50%. Suppose that there is some other force at play apart from AIR-21 competition shocks that influences firm pricing strategies, and that this force is present not only when the forcing variable equals 50% but in other regions of the sample as well. Then, it might be the case that the AIR-21 indicator in the regressions captures an effect that is not due to AIR-21, purely by chance. To tackle this problem, I run placebo tests using alternative and arbitrary values as the treatment cutoff.

Table 8 shows results from these placebo tests. I run the same triple difference regressions, but with a fake AIR-21 indicator variable that equals one if the top-two airline concentration ratio of the originating airport of the market is greater than an arbitrary threshold, and 0 otherwise. These placebo regressions are run on progressively narrower windows surrounding the arbitrary threshold. Using two alternative cutoffs of the forcing variable, 40% and 60%, I find no similar results as in the previous analyses, indicating that it is unlikely that my main results are driven by unknown effects that just happen to be present at the AIR-21 treatment threshold.

This is consistent with results from the non-parametric RD estimations in Figure 3, where it is shown that there are no statistically significant discontinuities in price growth differentials at arbitrary thresholds. Together, these examinations bolster confidence on the validity of the effects of AIR-21 around the 50% cutoff.

Table 8. Placebo Tests with Alternative Treatment Thresholds

This table presents placebo test results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante relative-to-rival cash holdings (Cash), ex-ante multimarket contact (MC), and their interactions. Two sets of placebo regressions are run using alternative top-2 airline passenger share thresholds, 40% and 60%. In each placebo analysis, the results are shown in five columns where the triple difference regression is run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)									
	Cutoff: Top-2 Airline Passenger Share = 40%					Cutoff: Top-2 Airline Passenger Share = 60%				
	Full Sample	15%	10%	5%	2.50%	Full Sample	15%	10%	5%	2.50%
AIR21 × *Cash*	0.444	0.520	0.843	-0.211	1.780	0.568	0.591	1.271	0.851	-2.408
	(0.504)	(0.494)	(0.530)	(0.767)	(2.744)	(0.599)	(0.593)	(0.908)	(1.425)	(3.480)
AIR21 × *MC* × *Cash*	-0.093	-0.100	-0.161	0.038	-0.390	-0.096	-0.068	-0.185	-0.049	0.655
	(0.105)	(0.100)	(0.111)	(0.160)	(0.555)	(0.119)	(0.120)	(0.191)	(0.282)	(0.719)
MC	-0.037***	-0.037**	-0.046**	-0.031	-0.057	-0.047***	-0.059**	-0.068**	-0.073**	-0.113*
	(0.011)	(0.013)	(0.017)	(0.024)	(0.051)	(0.012)	(0.023)	(0.025)	(0.028)	(0.059)
Cash	0.567	0.540	1.031*	1.855*	1.556	0.675	-0.033	-0.547	-0.180	2.210
	(0.466)	(0.484)	(0.546)	(0.958)	(1.381)	(0.425)	(0.559)	(0.756)	(1.109)	(1.739)
MC × *Cash*	-0.150	-0.147	-0.234**	-0.417**	-0.268	-0.184**	-0.066	0.014	-0.069	-0.513
	(0.097)	(0.097)	(0.106)	(0.194)	(0.308)	(0.085)	(0.110)	(0.149)	(0.212)	(0.368)
AIR21	0.108*	-0.015	-0.005	0.077	-0.108	0.031	-0.061	-0.104	-0.181	-0.397
	(0.060)	(0.078)	(0.089)	(0.109)	(0.241)	(0.062)	(0.117)	(0.103)	(0.166)	(0.337)
AIR21 × *MC*	-0.016	0.008	0.006	-0.011	0.020	-0.004	0.014	0.027	0.034	0.064
	(0.013)	(0.015)	(0.017)	(0.021)	(0.050)	(0.011)	(0.021)	(0.019)	(0.030)	(0.065)
Observations	15,958	7,942	5,658	3,266	1,408	15,958	8,559	6,096	2,886	1,469
Firms	19	19	18	17	16	19	19	19	16	14
Markets	1,941	1,034	784	599	340	1,941	1286	1021	557	314
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.226	0.261	0.265	0.315	0.386	0.226	0.261	0.281	0.327	0.371

4.5 Are Cash Rich Firms Constrained?

An important argument that has been made in the finance literature is that firms value and accumulate cash when they are financially constrained and lack access to external capital (see Almeida, Campello, and Weisbach (2004), Faulkender and Wang (2006)). A potential issue for this paper, then, is that firms with more cash are actually those that are constrained, and therefore the reported effects of cash are capturing not the impact of financial flexibility but rather the lack of it. While the methodology of this paper attempts to circumvent the endogenous selection problem of firms' cash holdings, it is nonetheless helpful to examine the effects of financial flexibility implied by other measures to confirm that the cash effect is consistent with a flexibility story.

To address this issue, I show that firms that are less likely to be financially constrained compared to their rivals based on alternative measures behave in the same way as cash-rich firms do, whereas those more likely to be constrained do the opposite. Specifically, I first use 'net cash' as a more general measure of financial flexibility. Since net cash is the amount of cash a firm has in excess of its debt obligations, firms with larger net cash balances should be less constrained. Next, I take cues from the financial constraints literature and assume that high payout firms are likely to be unconstrained (see Fazzari, Hubbard, and Petersen (1988, 2000), Almeida, Campello, and Weisbach (2004) among others). Conversely, I take a reduction of dividend payments in the previous year as a sign that a firm must have been constrained, given that cutting dividends is an expensive action that firms would avoid absent dire financial straits (see DeAngelo and DeAngelo (1990), DeAngelo, DeAngelo, and Skinner (1992)).[22]

[22] Another source of flexibility for firms are lines of credit. Based on data from Capital IQ, however, I find little evidence that the use of credit lines by airline companies are commensurate with their cash holdings in magnitude or importance. Airlines on average hold roughly 15% of their assets in cash during my sample period, whereas their lines of credit amount to approximately 1% of assets with very little left undrawn. In untabulated analysis, I find that lines of credit have no impact on pricing and do not weaken the effects of cash when controlled for.

In Table 9, I report results from triple difference regressions where cash is replaced by the firm's net cash position (i.e. cash minus total debt, scaled by total assets), payout ratio (i.e. dividends and repurchases scaled by total capital), and a dividend cut dummy (i.e. indicator for whether the firm had cut dividends in the previous year). While Form 41 Financial Data, the primary source of firm-level financial data used in this paper, covers all airline companies that report to the Department of Transportation regardless of whether they are publicly listed or privately held, dividend payments or stock repurchases are not part of the reported items. For this reason, I use Compustat data to compute Payout and Dividend Cut which excludes privately held firms from the sample, dropping 6 out of 26 firms and truncating the sample period for a number of remaining firms. Net Cash, Payout, and Dividend Cut are transformed into relative-to-rival values as described for Cash in previous sections.

Panel A demonstrates that relative-to-rival net cash, payout, and cash (computed from either Form 41 or Compustat) are all negatively correlated with the company's status as a dividend cutter in comparison to its rivals. The correlation between cash and payout is negative, consistent with previous papers in the literature, but modest. Cash and net cash are positively correlated since net cash is a linear combination of cash and debt. Assuring that using Form 41 or Compustat data does not make a notable difference, cash computed from Form 41 and Compustat are very highly correlated, and the correlations between cash and the alternative measures are similar regardless of which data is used to measure cash.

Panel B reports the regression coefficients. The triple difference regressions are run on the sample window where top-two airline passenger shares range from 45% to 55% (i.e. 5% above and below the 50% AIR-21 treatment threshold). The result from using net cash instead of cash is shown in the first column. Because leverage is already incorporated in computing net cash, I drop leverage and its interactions with AIR-21 and multimarket contact from the set of control variables in the first regression. The regression shows that financially flexible firms with high net cash respond to AIR-21 by pricing more aggressively. A Firm

Table 9. Financial Flexibility vs. Constraints

This table presents results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 indicator (AIR21), a set of alternative ex-ante relative-to-rival financial flexibility measures (Flexibility), ex-ante multimarket contact (MC), and their interactions. Financial flexibility measures include Net Cash ((cash - total debt) / total assets), Payout (from Compustat as (dividends ($dvc + dvp$)+ repurchases ($prstkc$))/at), Dividend Cut (an indicator variable equal to 1 if a firm had cut dividends in the previous year and 0 otherwise), and $\text{Cash}_{Compustat}$ (from Compustat as che/at). Relative-to-rival flexibility and multimarket contact are constructed as described in Section 3, and are measured as of the previous year. Correlations between the flexibility measures are shown in Panel A. The regressions are run using the sample window 5% above and below the 50% AIR-21 cutoff. Results are reported in Panel B. Firm, market, and time fixed effects as well as control variables are included as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Panel A. Correlations

	Net Cash	Payout	Dividend Cut	$\text{Cash}_{Compustat}$
Net Cash	1			
Payout	0.25	1		
Dividend Cut	-0.01	-0.11	1	
$\text{Cash}_{Compustat}$	0.48	-0.07	-0.18	1
Cash_{Form41}	0.51	-0.03	-0.19	0.85

Panel B. Regressions with Alternative Measures

	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)			
		Compustat Sample		
Flexibility (Constraint) Variables	Net Cash	Payout	Dividend Cut	$\text{Cash}_{Compustat}$
AIR21 × Flexibility	-1.272***	-9.163**	0.407**	-2.630***
	(0.382)	(3.385)	(0.173)	(0.713)
AIR21 × MC × Flexibility	0.237***	1.650**	-0.081**	0.528***
	(0.074)	(0.730)	(0.034)	(0.172)
MC	-0.036	-0.012	-0.030	-0.023
	(0.029)	(0.033)	(0.032)	(0.036)
Flexibility	0.773***	6.858***	-0.352***	1.833**
	(0.228)	(1.747)	(0.062)	(0.611)
MC × Flexibility	-0.136**	-1.358***	0.061***	-0.353**
	(0.047)	(0.433)	(0.013)	(0.118)
AIR21	-0.274**	-0.267*	-0.310**	-0.278**
	(0.129)	(0.130)	(0.123)	(0.128)
AIR21 × MC	0.046*	0.042	0.051**	0.045*
	(0.026)	(0.024)	(0.024)	(0.025)
Observations	2,828	2,458	2,458	2,458
Firms	19	14	14	14
Markets	561	508	508	508
Firm / Market / Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.343	0.355	0.357	0.356

with one standard deviation (i.e. 18.67 percentage point) greater ex-ante relative-to-rival net cash reduces its price growth rate over the next 36 months by 23.75 percentage points more from the last 36 months (i.e. 0.78 standard deviations lower price growth differential). The second and third columns present results from replacing cash with payout and the dividend cut indicator. Consistent with the story that financial flexibility strengthens firms' war chests, high payout firms respond to competition shocks by pricing more aggressively while firms that had cut dividends compete in a more accommodating manner. Firms with one standard deviation (i.e. 1.35 percentage points) greater payout as a fraction of total capital relative to rivals exhibit 12.37 percentage points (i.e. 0.42 standard deviations) lower price growth differentials. In sharp contrast, a firm that had (not) cut dividends in the previous year while none (all) of its rivals had would raise (reduce) the rate of its price growth in the next 36 months by 40.7 percentage points more from the previous 36 months compared to a firm whose dividend cut status is the same as its rivals. The last column shows that using Compustat cash delivers similar results to the main analysis using cash from Form 41 Financial Data, despite the changes in firms and time periods composing the sample. A one standard deviation (i.e. 9.16 percentage point) increase in ex-ante relative-to-rival cash holdings as a fraction of assets leads to 24.09 percentage points lower price growth over the next 36 months compared to the previous 36 months (i.e. 0.81 standard deviations lower price growth differential). The effects of net cash, payout, dividend cut, and cash are canceled out by an increase in multimarket contact of 5.37%, 5.55%, 5.02%, and 4.98% respectively.

The evidence that supposedly constrained firms raise their price growth rates while financially flexible companies reduce them supports the notion that cash-rich firms are able to price aggressively due to the financial flexibility provided by cash. Another way to establish the flexibility story of cash is to demonstrate that it creates value. I do this next.

4.6 Cash and Market Performance Outcomes

To what extent is financial flexibility from cash valuable? Does the aggressive use of competitive firepower lead to economic benefit? A testable implication of the theory in this regard is that firms with financial resources at their disposal can afford to invest in longer term market shares at the expense of profits today (see Telser (1966), Bolton and Scharfstein (1990)). I explore this by examining how ex-ante relative-to-rival cash positions and multimarket contact affect two metrics of market performance outcomes: market share gains and profitability growth.

To do this, I run the triple difference regressions using market share and profitability gains as alternative dependent variables. Market share gains are 36-month growth rates of firms' market shares measured in terms of number of passengers and dollar revenues (i.e. average fare price $\times$ number of passengers). Profitability gains are 18-month (short-term) and subsequent 18-month (long-term) changes in firms' profitability (i.e. return on assets (ROA)) attributable to each market. Firm-level profitability is attributed to each market by first obtaining market level operating profits as market revenue multiplied by the firms overall operating profit margin (i.e. operating profits/loss over operating revenues), and then dividing market level operating profits/losses by the firm's total assets. The regressions are then run on the sample window where top-two airline passenger shares range from 45% to 55% (i.e. 5% above and below the 50% AIR-21 treatment cutoff).

The results shown in Table 10 suggest that firms with more cash than their peers, which previous sections have shown to compete more aggressively, gain market shares by more (or lose them by less) over the course of 36 months. The coefficients on the interaction term between AIR21 and Cash imply that a one standard deviation (i.e. 8.93 percentage point) increase in relative-to-rival cash leads to 19.56% and 17.24% greater market share growth based on number of passengers and dollar revenues, respectively. Moreover, while these firms appear to suffer mildly in terms of profitability in the shorter term (1-18 months),

Table 10. Cash and Market Performance Outcomes

This table presents results from triple-difference regressions of market performance outcomes (i.e. market share gains and profitability gains) on an AIR-21 coverage indicator (AIR21), ex-ante relative-to-rival cash holdings (Cash), ex-ante multimarket contact (MC), and their interactions. Market share gains are 12-quarter growth rates of the firm's market shares measured in terms of number of passengers and dollar revenues (i.e. average fare price × number of passengers). Profitability gains are changes in the firm's profitability (ROA) per market over the first 6-quarters and next 6-quarters. Profitability per market is computed by first obtaining market level operating profits as market revenue multiplied by the firm's overall operating profit margin (i.e. operating profits/loss over operating revenues), and then dividing market level operating profits/losses by the firm's total assets. The triple difference regressions are run using the sample window 5% above and below the 50% AIR-21 treatment cutoff. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

	Dependent Variables			
	Market Share Gain (12Q)		Profitability (ROA) Gain	
	Passengers	Revenue	First 6Q	Next 6Q
AIR21 × *Cash*	2.190*	1.931*	-0.255	0.537***
	(1.153)	(1.031)	(0.261)	(0.159)
AIR21 × *MC* × *Cash*	-0.408*	-0.390*	0.042	-0.102***
	(0.224)	(0.202)	(0.044)	(0.030)
MC	-0.010	-0.018	-0.004	0.001
	(0.065)	(0.070)	(0.007)	(0.003)
Cash	0.274	0.729	0.369	-0.335**
	(1.135)	(1.165)	(0.269)	(0.131)
MC × *Cash*	-0.096	-0.189	-0.063	0.071**
	(0.208)	(0.214)	(0.045)	(0.027)
AIR21	-0.466	-0.473	0.010	-0.021
	(0.370)	(0.383)	(0.025)	(0.023)
AIR21 × *MC*	0.077	0.081	-0.002	0.004
	(0.061)	(0.062)	(0.005)	(0.004)
Observations	2,828	2,828	2,781	2,781
Firms	19	19	19	19
Markets	561	561	553	553
Firm / Market / Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R-squared	0.354	0.364	0.524	0.646

their profitability improves significantly by the time they gain market shares due to the strategic advantages of cash (18-36 months). Coefficients imply that in the nearer term after AIR-21 treatment, profitability drops by 2.28 basis points with a one standard deviation increase in relative-to-rival cash (though not statistically significant), but increases substantially and significantly by 4.8 basis points in the longer term, indicating that cash rich firms gain value in the long haul. Note that the magnitude of the profitability gain per market is non-trivial given that firms on average serve around 750 markets. This provides further support for interpreting the cash effect on pricing as a financial flexibility effect, and therefore complements the findings of Fresard (2010) who, while inconclusive about the underlying mechanism, also documents that cash rich firms gain more market shares after competition shocks.

Overall, the findings thus far are consistent with the hypothesis that financially flexible firms are better equipped to engage in aggressive pricing strategies, and that the possibility of rival retaliation deters the competitive use of such flexibility. One question remains: If cash benefits firms under increased competition, do firms accumulate cash when competition unexpectedly intensifies?

4.7 The Effects of Competition on Corporate Cash Holdings

While the main focus of this paper is to establish a causal link from cash holdings to firm product pricing behavior, it is a more challenging task under my setting to claim causality from competition to cash holdings. The reason is that competition shocks arrive at the market level while cash positions are a decision variable only at the firm level. There are 2,786 markets and 26 firms, so the market level is granular whereas the firm level is much less so. Furthermore, while it is plausible that firms may alter their pricing strategies depending on how much more financial slack they happen to have than their rivals, it is harder to argue that they would dynamically adjust their cash positions relative to their competitors in each

market they serve. Therefore, it is not statistically feasible to test the impact of market level AIR-21 shocks on firm level cash holdings, and even meaningless to test the effects of market level competition shocks on firm-market level relative-to-rival cash holdings. Notwithstanding these challenges, a suggestive answer is given in Table 1 of Section 3 where cash holdings are shown to increase following the legislation of AIR-21. A better visualization of the effect of market-level competition shocks imposed by AIR-21 on corporate cash holdings is provided by Figure 6.

Here, I set the first date at which the origin airport of a market is covered by AIR-21 as Quarter 0, and compute the passenger-weighted average cash-to-asset ratio of companies operating in each market for 12 quarters before and after the initial coverage date. Then, the cross-market passenger-weighted average of these within-market average cash holdings is plotted separately for the full sample, a restricted sample where the top-two airline passenger share determining coverage at Quarter 0 lies within 15% of the 50% AIR-21 treatment cutoff (i.e. 35% to 65%), and a restricted sample where the top-two airline passenger share lies within 10% of the cutoff (i.e. 40% to 60%). Because markets will have varying initial coverage dates, this approach alleviates the concern that shifts in cash holdings are simply due to some unobserved time effect. The plots from narrow window samples also strengthen the argument that the depicted changes in cash holdings are due to AIR-21 shocks.

In Figure 6, I observe a sharp increase in passenger-weighted average cash holdings after initial AIR-21 coverage, consistent with the idea that firms rationally respond to competition shocks by accumulating their financial war chests, which in turn enable them to price aggressively in the face of such shocks in the future.[23] While the jump in cash holdings is substantial (i.e. nearly a 50% increase from 10% to 15% of total assets within a year) and therefore strongly supportive of the impact of AIR-21 competition shocks, it should be

[23]Note that although firm cash holdings increase on average, there can be heterogeneity in the degree of such responses depending on the potential likelihood of rival retaliation faced by each firm (captured by the level of multimarket contact).

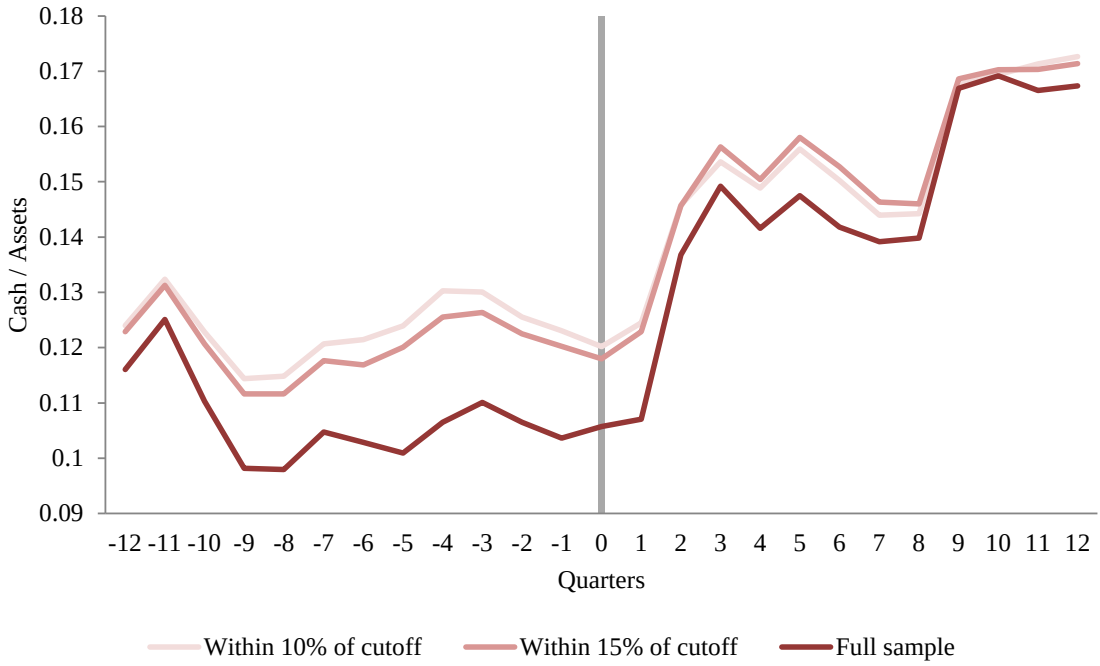


Figure 6. Cash Holdings Before and After AIR-21 Coverage

This figure illustrates the impact of market-level AIR-21 competition shocks on airline company cash holdings. For each market, I set the first date at which the origin airport of the market is covered by AIR-21 as Quarter 0. I then compute the passenger-weighted average cash holdings (as a fraction of assets) of companies operating in each market for 12 quarters before and after the initial coverage date (from Quarter -12 to 12). I then plot the passenger-weighted average of these within-market average cash holdings across all markets for each relative quarter. Plots are shown separately for the full sample, a restricted sample where the top-two airline passenger share determining coverage at Quarter 0 lies within 15% of the 50% AIR-21 treatment cutoff (35% to 65%), and a restricted sample where the top-two airline passenger share determining coverage at Quarter 0 lies within 10% of the cutoff (40% to 60%).

cautioned that this is by no means proof of a causal impact since there is no counterfactual trend of cash holdings that the plotted trend can be compared against. The set of firms operating in markets never covered by AIR-21 are in fact almost identical to the set of firms operating in markets covered by AIR-21 at some point. Nonetheless, Figure 6 suggests that competition dynamics maybe a potential determinant of corporate cash holdings.[24]

[24]There is a very large literature on the determinants of corporate cash holdings. Among several papers, Opler, Pinkowitz, Stulz, and Williamson (1999) and Bates, Kahle, and Stulz (2009) suggest cash flow volatility to be a key determinant of corporate cash holdings. Haushalter, Klasa, and Maxwell (2007) come closer to the spirit of my argument that competition dynamics are also a likely determinant of cash holdings. They

In the last section, I make some concluding remarks.

5 Conclusion

Can cash be a source of financial flexibility that enables firms to compete aggressively in product markets? Yes, especially when there is less concern of retaliation from rivals (i.e. when there is little multimarket contact). In this paper, I investigate one mechanism through which corporate cash holdings affect product market outcomes: firm pricing strategy. I test whether firms with larger cash reserves relative to their rivals price more aggressively as 'deep pocket' theories predict (see Telser (1966), Bolton and Scharfstein (1990)), and whether greater concern of potential rival retaliation (i.e. higher multimarket contact) attenuates this competitive effect of cash as implied by theories from industrial organization (see Bernheim and Whinston (1990), Evans and Kessides (1994)).

I turn to the airline industry where markets and rivalry are cleanly defined. To circumvent concerns that cash and multimarket contact are endogenously linked to firm pricing strategy, I exploit an industry-wide regulation, the Aviation Investment and Reform Act for the 21st Century (AIR-21), to identify exogenous market-level competition shocks and test the effects of ex-ante relative-to-rival cash holdings and multimarket contact on ex-post changes in firm pricing policy. Under AIR-21, large commercial airports whose two largest airlines enplane more than 50% of the airport's total passengers are required to submit and implement competition enhancement plans under the supervision of the Federal Aviation Administration (FAA). The features of this regulation facilitate a regression discontinuity (RD) design that mitigates endogeneity concerns and ensure that firms are not able to predict or self-select into AIR-21 treatment.

find that the extent to which firms have interdependent growth prospects with rivals (i.e. face higher predation risk) is positively associated with cash holdings and the use of hedging derivatives. Hoberg, Phillips, and Prabhala (2014) also show that product market threats significantly influence cash retention decisions.

In triple difference regressions on progressively narrower windows surrounding the 50% treatment threshold, I find that firms with greater cash holdings relative to rivals respond to market-level competition shocks by pricing more aggressively, particularly when multimarket contact is sufficiently low (i.e. when there is less concern of retaliation from rivals). A one standard deviation, or 8.55 percentage point, increase in relative-to-rival cash as a fraction of assets one year prior to an AIR-21 competition shock in a market leads to 15.22 percentage points lower price growth over the next 36 months compared to the previous 36 months (i.e. 0.47 standard deviations lower price growth differential). Multimarket contact has a sizable impact on this strategic effect of cash: a 5.3% increase would completely overturn the cash effect. Consistent with the competitive impact of AIR-21 mainly being driven by airport gate reallocations toward low-cost carriers (LCCs), I find that LCCs respond to AIR-21 competition shocks by pricing aggressively irrespective of their cash holdings, while legacy airlines respond aggressively conditional on holding more cash. In both cases, the responses are dampened by higher multimarket contact. Also, the main results hold only for firms that had high ex-ante market share (i.e. firms for which AIR-21 indeed serves as a competition shock), but are non-existent for firms that had low market share to begin with (i.e. firms for which AIR-21 rather serves as an accommodative event).

To alleviate concerns that firms might predict AIR-21 coverage in a given market and build-up cash reserves relative to rivals in that market in advance, I use relative-to-rival cash measured 3 and 4 years prior to treatment (one year prior in baseline specifications) and show that results are robust. Placebo tests using alternative threshold levels of top-two airline passenger shares as AIR-21 treatment cutoffs confirm that the main results are unlikely due to other confounding effects that happen to coincide with competition shocks induced by AIR-21. I further cement the role of cash as a source of financial flexibility by showing that firms with high net cash or high payout ratios compete aggressively in response to AIR-21 as do cash-rich firms, and that supposedly constrained firms that had cut dividends in the

previous year behave in an opposite accommodating manner. I also demonstrate that such flexibility is valuable by showing that firms holding more cash than rivals gain more market shares and experience long-term profitability growth.

How corporate cash holdings are used in the firm's day-to-day operations are of central interest both in the academic literature and among policy makers. This paper contributes to the growing body of research exploring the interplay between financial flexibility and product market competition by documenting how cash affects firm pricing strategies, thereby highlighting the mechanism through which cash impacts product market outcomes. This study also opens the door to further exploration of how competition dynamics shape corporate cash decisions. I look forward to future research broadening our understanding in this dimension.

Appendix

This section is apportioned to the presentation of additional figures and tables that serve as addenda to the main analysis of the paper. They mostly pertain to side discussions (e.g. footnotes) within the text.

	Cash	ST Debt	LT Debt	MC	AIR21	Nonstop	LCC Passenger Share	Firm Passenger Share	Number of Rivals	Market Size	Firm Size
Cash	1.00	0.08	-0.05	-0.09	-0.02	0.02	0.02	-0.05	0.00	-0.02	-0.45
ST Debt	0.08	1.00	0.24	-0.05	0.00	0.00	-0.04	-0.09	-0.01	0.02	-0.15
LT Debt	-0.05	0.24	1.00	-0.05	0.00	-0.02	-0.09	-0.10	0.02	0.06	0.01
MC	-0.09	-0.05	-0.05	1.00	0.06	-0.10	-0.02	0.02	-0.07	-0.19	0.59
AIR21	-0.02	0.00	0.00	0.06	1.00	0.04	-0.05	0.11	-0.20	-0.04	0.02
Nonstop	0.02	0.00	-0.02	-0.10	0.04	1.00	0.00	0.12	-0.07	0.09	-0.07
LCC Passenger Share	0.02	-0.04	-0.09	-0.02	-0.05	0.00	1.00	0.04	-0.05	-0.09	-0.11
Firm Passenger Share	-0.05	-0.09	-0.10	0.02	0.11	0.12	0.04	1.00	-0.44	-0.22	0.11
Number of Rivals	0.00	-0.01	0.02	-0.07	-0.20	-0.07	-0.05	-0.44	1.00	0.45	-0.08
Market Size	-0.02	0.02	0.06	-0.19	-0.04	0.09	-0.09	-0.22	0.45	1.00	-0.12
Firm Size	-0.45	-0.15	0.01	0.59	0.02	-0.07	-0.11	0.11	-0.08	-0.12	1.00

Figure A.1. Correlations Between Explanatory and Control Variables

This figure tabulates the correlations between various explanatory and control variables that are included in the triple-difference regressions. Cash, ST Debt, and LT Debt are excess financial positions (scaled by total assets) of a firm relative to the average of all rival firms in the market as described in Section 3, MC is multimarket contact which captures the average number of markets jointly contested by the firm and its rivals in the market as described in Section 3, AIR21 equals 1 if the top-two airline passenger share at the origin airport of the market 2 years prior to the beginning of the present year exceeds 50% and equals 0 otherwise, Nonstop is an indicator for whether the service provided by the firm is a direct flight, LCC Passenger Share is the passenger share of low cost carriers (LCCs) in the market, Firm Passenger Share is the firm's passenger share in the market, Number of Rivals is the number of rival firms excluding the firm itself in the market, Market Size is the log of total dollar revenues generated by all firms in the market, and Firm Size is the log of the firm's total assets. Except for AIR21, all variables are lagged by 1 year.

Table A.1. Passenger-Weighted Relative-to-Rival Cash and Multimarket Contact

This table presents results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante passenger-weighted relative-to-rival cash holdings (Cash), ex-ante passenger-weighted multimarket contact (MC), and their interactions. Relative-to-rival cash and multimarket contact are constructed as described in Section 3, except that rivals are weighted by their passenger boardings in the market. The results are shown in five columns where the triple difference regression is run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. In the next four columns, two sets of subsample analysis are conducted on a sample window 10% above and below the 50% AIR-21 treatment cutoff: (1) low cost carriers (LCCs) vs. legacy airlines and (2) ex-ante market winners vs. laggards. Firm, market, and time fixed effects as well as control variables are included in all specifications as in previous analysis. Standard errors adjusted for clustering at firm and market levels are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Variables	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)								
						Type (10%)		Market Share (10%)	
	Full Sample	15%	10%	5%	2.50%	LCC	Legacy	Winners	Laggards
AIR21 × *Cash*	-0.547	-1.494***	-1.708**	-2.719***	-3.996**	0.050	-2.012**	-2.683**	-0.608
	(0.530)	(0.514)	(0.660)	(0.753)	(1.676)	(0.720)	(0.759)	(1.134)	(1.187)
AIR21 × *MC* × *Cash*	0.105	0.285**	0.309**	0.550***	0.802*	-0.141	0.344**	0.454*	0.078
	(0.109)	(0.109)	(0.133)	(0.163)	(0.389)	(0.125)	(0.144)	(0.226)	(0.235)
MC	-0.043***	-0.042***	-0.042**	-0.047	-0.040	-0.122**	-0.042	-0.036	-0.080***
	(0.012)	(0.014)	(0.018)	(0.030)	(0.032)	(0.041)	(0.025)	(0.039)	(0.026)
Cash	1.220***	1.377***	1.250**	2.029***	3.089**	0.843	1.348*	1.533*	-0.092
	(0.321)	(0.363)	(0.456)	(0.681)	(1.249)	(0.724)	(0.722)	(0.792)	(0.750)
MC × *Cash*	-0.273***	-0.313***	-0.302***	-0.463***	-0.695**	-0.109	-0.330**	-0.330**	-0.043
	(0.067)	(0.078)	(0.089)	(0.143)	(0.312)	(0.177)	(0.129)	(0.149)	(0.153)
AIR21	0.031	0.065	0.126	-0.268*	-0.344*	-0.394**	0.096	0.117	0.021
	(0.074)	(0.091)	(0.106)	(0.138)	(0.169)	(0.122)	(0.139)	(0.217)	(0.191)
AIR21 × *MC*	-0.016	-0.023	-0.031	0.046	0.044	0.080**	-0.026	-0.041	-0.003
	(0.014)	(0.016)	(0.020)	(0.028)	(0.036)	(0.025)	(0.028)	(0.038)	(0.039)
Observations	15,958	9,097	6,047	2,828	1,701	1,773	4,075	2,887	2,858
Firms	19	19	19	19	18	7	12	16	18
Markets	1,941	1,404	1,036	561	394	470	818	795	603
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.227	0.272	0.303	0.351	0.401	0.412	0.329	0.382	0.356

Table A.2. Key Variable Statistics for Select Subsamples

This table presents summary statistics of airline price growth differentials, relative-to-rival cash, and multimarket contact over the sample period 2001Q1 to 2014Q4 for a number of select subsamples. Variables are computed as detailed in Section 3. Statistics for each of these variables are shown across four subsamples: (1) sample window 15% above and below the 50% AIR-21 treatment cutoff, (2) sample window 5% above and below the 50% AIR-21 treatment cutoff (for which I report separately for default 1-year lagged, 3-year lagged, and 4-year lagged relative-to-rival cash), (3) legacy airlines in the sample window 2.5% above and below the 50% AIR-21 treatment cutoff, (4) and ex-ante market dominators (with ex-ante market share equal to or larger than 45%) in the sample window 15% above and below the 50% AIR-21 treatment cutoff.

Panel A. Price Growth Differentials

Subsample	Mean	Std. Dev	Min	Med	Max
15% above and below treatment cutoff	4.82	32.26	-197.99	4.47	184.24
5% above and below treatment cutoff	4.93	30.48	-133.37	3.26	154.45
Legacy & 2.5% above and below treatment cutoff	7.10	36.17	-120.39	5.03	145.47
Dominator & 15% above and below treatment cutoff	6.42	29.55	-107.74	5.37	177.52

Panel B. Relative-to-Rival Cash

Subsample	Mean	Std. Dev	Min	Med	Max
15% above and below treatment cutoff	0.30	8.55	-24.83	0.18	27.03
5% above and below treatment cutoff (1-year Lagged)	0.26	8.93	-24.74	-0.08	27.38
5% above and below treatment cutoff (3-year Lagged)	0.09	7.69	-21.04	0.17	21.97
5% above and below treatment cutoff (4-year Lagged)	-0.42	7.62	-21.11	-0.58	21.31
Legacy & 2.5% above and below treatment cutoff	-1.35	8.42	-21.44	-1.12	19.10
Dominator & 15% above and below treatment cutoff	0.23	8.49	-24.25	0.26	20.56

Panel C. Multimarket Contact

Subsample	Mean	Std. Dev	Min	Med	Max
15% above and below treatment cutoff	200.65	101.89	11.88	202.68	414.43
5% above and below treatment cutoff	199.16	99.99	12.10	204.00	422.69
Legacy & 2.5% above and below treatment cutoff	199.50	95.31	24.95	199.99	422.69
Dominator & 15% above and below treatment cutoff	210.38	108.81	12.88	219.45	411.04

Table A.3. Alternative Fixed Effects and Standard Error Clustering

This table presents results from triple-difference regressions of 12-quarter price growth differentials ($\Delta\Delta_{36}$Log(Market Fares)) on an AIR-21 coverage indicator (AIR21), ex-ante multimarket contact (MC), ex-ante relative-to-rival cash holdings (Cash), and their interactions. Panel A reports results controlling for firm-by-market fixed effects with standard errors adjusted for clustering at firm and market levels. Panel B reports results controlling for firm and market fixed effects separately, with standard errors adjusted for a variety of clustering schemes: (1) Firm and market (baseline), (2) firm-by-time and market, (3) firm-by-time, (4) firm and time, (5) market and time levels. Control variables are included as in previous analysis. Results are shown in five columns where triple difference regressions are run using progressively narrower sample windows surrounding the 50% AIR-21 treatment cutoff: (1) full sample, (2) 15% above and below the 50% cutoff, (3) 10% above and below the 50% cutoff, (4) 5% above and below the 50% cutoff, and (5) 2.5% above and below the 50% cutoff. Standard errors are reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

	Dependent Variable: $\Delta\Delta_{36}$Log(Market Fares)				
Panel A. Within Firm-Market Effects					
	Full Sample	15%	10%	5%	2.50%
AIR21 × Cash	-0.717	-2.429***	-2.288**	-3.692***	-4.014
	(0.701)	(0.570)	(0.843)	(0.855)	(4.014)
AIR21 × MC × Cash	0.116	0.424***	0.357**	0.743***	0.814
	(0.132)	(0.107)	(0.164)	(0.191)	(0.850)
Observations	15,018	8,323	5,412	2,492	1,435
Firm-by-Market / Time FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.306	0.362	0.379	0.419	0.487
Panel B. Alternative Clustering Schemes					
	Full Sample	15%	10%	5%	2.50%
AIR21 × Cash	-0.518	-1.776	-1.942	-2.967	-3.628
Firm and Market (Baseline)	(0.543)	(0.488)***	(0.665)***	(0.770)***	(1.706)**
Firm-by-Time and Market	(0.528)	(0.650)***	(0.790)**	(0.891)***	(1.647)**
Firm-by-Time	(0.510)	(0.608)***	(0.760)**	(0.813)***	(1.541)**
Firm and Time	(0.612)	(0.690)**	(0.711)**	(0.844)***	(1.353)**
Market and Time	(0.605)	(0.829)*	(0.849)**	(0.932)***	(1.172)**
AIR21 × MC × Cash	0.092	0.333	0.348	0.590	0.713
Firm and Market (Baseline)	(0.110)	(0.103)***	(0.132)**	(0.159)***	(0.382)*
Firm-by-Time and Market	(0.111)	(0.138)**	(0.166)**	(0.185)***	(0.364)*
Firm-by-Time	(0.109)	(0.132)**	(0.162)**	(0.171)***	(0.347)**
Firm and Time	(0.131)	(0.148)**	(0.146)**	(0.172)***	(0.314)**
Market and Time	(0.131)	(0.172)*	(0.176)*	(0.189)**	(0.264)**
Observations	15,958	9,097	6,047	2,828	1,701
Firm / Market / Time FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.226	0.271	0.301	0.349	0.401

Table A.4. Difference of Means: Control vs. Treated Groups

This table reports variable means of control (AIR21=0) and treatment (AIR21=1) observations, as well as p-values from t-tests of whether their means are equal (*** p<0.01, ** p<0.05, * p<0.1). This is done for the full sample as well as for a subsample where the top-two airline passenger share is within 15% of the 50% AIR-21 treatment cutoff (35% to 65%). Firm level variables include Cash, Short-Term Debt, Long-Term Debt, Total Debt, all scaled by total assets, and firm Size (log $ millions). Airport level variables include Market Size (log of $ revenues earned by all airlines serving markets originating from airport), average Distance of routes originating from airport (log miles), average Price Level of markets originating from airport (log $), Price Level charged by LCCs (log $), Price Level charged by Legacy airlines (log $), LCC Passenger Share, number of Passengers (log), and Number of Routes (log). Market level variables include Market Size, Distance, Price Level, Price Level LCC, Price Level Legacy, LCC Passenger Share, and number of Passengers, all measured analogously to airport level variables but at the market level. Firm-market level variables include Relative-to-Rival Cash/Assets, Short-Term Debt/Assets, Long-Term Debt/Assets, Multimarket Contact (log), all constructed as described in Section 3, Price Level charged by airline (log $), Price Growth during the previous 12 and 6 quarters (%), number of Passengers boarded by airline (log), airline's Passenger Share in market, and Number of Rivals. All variables are lagged by 1 year.

	Full				15%			
Variable	Control	Treated	p-val		Control	Treated	p-val	
Firm Level								
Cash / Asset	0.18	0.17	(0.44)		0.18	0.17	(0.39)	
ST Debt / Asset	0.04	0.04	(0.52)		0.04	0.04	(0.89)	
LT Debt / Asset	0.29	0.29	(0.69)		0.30	0.29	(0.57)	
Tot Debt / Asset	0.33	0.33	(0.72)		0.34	0.33	(0.48)	
Size (log $ millions)	15.00	14.88	(0.54)		14.99	14.94	(0.81)	
Airport Level								
Market Size (log $)	16.35	16.33	(0.77)		16.28	16.20	(0.48)	
Distance (log miles)	7.21	7.15	(0.06)	*	7.21	7.21	(0.95)	
Price Level (log $)	5.27	5.31	(0.05)	*	5.28	5.30	(0.31)	
Price Level LCC (log $)	5.06	5.06	(0.61)		5.06	5.07	(0.58)	
Price Level Legacy (log $)	5.39	5.42	(0.08)	*	5.39	5.43	(0.05)	*
LCC Passenger Share	0.39	0.40	(0.80)		0.39	0.41	(0.44)	
Passengers (log)	11.08	11.01	(0.47)		11.00	10.89	(0.34)	
Num of Routes (log)	3.67	3.67	(0.93)		3.65	3.62	(0.62)	
Market Level								
Market Size (log $)	12.77	12.77	(0.79)		12.72	12.64	(0.00)	***
Distance (log miles)	7.09	6.99	(0.00)	***	7.09	7.03	(0.00)	***
Price Level (log $)	5.41	5.46	(0.00)	***	5.42	5.43	(0.33)	
Price Level LCC (log $)	5.20	5.20	(0.81)		5.21	5.22	(0.28)	
Price Level Legacy (log $)	5.38	5.42	(0.00)	***	5.39	5.40	(0.20)	
LCC Passenger Share	0.31	0.28	(0.00)	***	0.29	0.32	(0.00)	***
Passengers (log)	7.42	7.36	(0.01)	**	7.36	7.26	(0.00)	***
Firm-Market Level								
Cash / Asset (Relative-to-Rival)	0.00	0.00	(0.21)		0.00	0.00	(0.12)	
ST Debt / Asset (Relative-to-Rival)	0.00	0.00	(0.50)		0.00	0.00	(0.02)	**
LT Debt / Asset (Relative-to-Rival)	-0.01	-0.01	(0.39)		-0.01	-0.01	(0.27)	
Multimarket Contact (log)	4.98	5.05	(0.00)	***	5.00	5.12	(0.00)	***
Price Level (log $)	5.40	5.45	(0.00)	***	5.41	5.42	(0.16)	
Price Growth - Prev. 12Q (%)	1.72	-0.04	(0.00)	***	1.72	1.11	(0.15)	
Price Growth - Prev. 6Q (%)	3.46	2.25	(0.00)	***	3.25	2.41	(0.01)	**
Passengers (log)	5.18	5.20	(0.32)		5.14	5.18	(0.12)	
Passenger Share	0.36	0.41	(0.00)	***	0.36	0.40	(0.00)	***
Number of Rivals	2.62	2.05	(0.00)	***	2.52	2.14	(0.00)	***

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