Does multimarket contact affect price dispersion? Evidence from the airline industry

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Abstract

We investigate the effects of multimarket contact on price dispersion and on airlines' pricing strategies in different market types. Both carrier-specific and market-specific measures of multimarket contact are used to study the effect of rivals' contacts. We find that (i) in big markets, when the carriers meet more often, prices become more dispersed in both periods, but for different reasons. Before major mergers, carriers collude in the top portion and compete in the bottom portion of the price distribution. And they care less about the potential punishment of not colluding. After mergers, they collude in the low prices as well. (ii) In medium-size markets, the effects of multimarket contact on price dispersion are the opposite between the two periods. (iii) In small markets, our estimation results suggest that multimarket contact do not play much role in carriers' pricing strategies.

Key words: multimarket contact, price dispersion, competition, airline industry.

1 Introduction

Firms in oligopoly markets have the market power to price discriminate, yet if they face Bertrand competition at the same time, and repeatedly compete with its rivals, the firms' strategies are then more complicated. In infinitely repeated games, the

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players will cooperate if they are patient enough. To collude, the firms exercise their market power to price discriminate and price discrimination is a reason that leads to price dispersion. However, in many cases, collusion is not sustainable and firms participate in cut-throat pricing. We study how repeating their pricing games affect firms' pricing strategies, using the data of the U.S. airline industry, from January 2006 to December 2008 and January 2013 to December 2015.

The domestic airline industry in the US has gone through a dramatical changes through out the past thirty five years after deregulation. The airline carriers went through aggressive competition, collusions, bankruptcies, mergers and acquisitions, entries and exits. During different stages of their competition, they have been playing a Bertrand game repeatedly. For a carrier, it is not just one single pricing decision, it decides various prices within a market and decides in multiple markets simultaneously. Price discrimination has been a scheme for carriers to exploit their market power, and this paper aims to study how their pricing strategies vary with multimarket contact, that is to say, would carriers' pricing strategy depend on how often it competes with its opponents? Multimarket contact can be regarded as the carriers playing the Bertrand game repeatedly. In the past decade, four major mergers took place[1], which changed the airlines competition and collusion relationships.

A number of papers have investigated empirically the relationship between competition and price dispersion in the U.S. airline markets. Below we review the seminal papers of this paper. Borenstein and Rose (1994), using cross-sectional data from 1986, find a positive effect of competition on price dispersion. They explain that this is due to brand loyalty. However, Gerard and Shapiro (2009), using panel data from 1993 to 2006, reveal a negative effect of competition on price dispersion. Dai, Liu, and Serfes (2014), using data from 1993 to 2008, find that an increase in competition is associated with greater price dispersion in concentrated markets, but with less price dispersion in competitive markets. In this stream of paper, the impact of repeatedly competing on price dispersion is not considered, but firms do often compete against one another in many markets.

Since Bernheim and Whinston (1990), a stream of papers has studied mutual forbearance, claiming that firms that meet in multiple markets compete less aggressively because they recognize that a competitive attack in any one market may draw responses in a all jointly contested markets. Evans and Kessides (1994) show a positive relationship between multimarket contact measures and prices for the 1984 to 1988 period. Ciliberto and Williams (2014) demonstrate that multimarket contact facilitates tacit collusion among airlines, using a flexible model

[1] Delta Airlines merged Northwest Airlines in 2008; United Airlines merged Continental Airlines in 2010; Southwest Airlines merged AirTran Airways in 2010; American Airlines merged U.S. Airways in 2013.

of oligopolistic behavior, where conduct parameters are modelled as functions of multimarket contact. They use data from 2006 to 2008. This literature focus on studying average prices. Airlines are well known for price discriminating among different consumers, hence it would be not surprising to observe price dispersion. It could be the case that airlines collude in high prices and compete in low prices, rather than collude in all price levels. There are other papers on multimarket contact that studies the impact of multimarket contact on nonprice forms of competition. Prince and Simon (2009) investigates the relationship between multimarket contact and service quality. They find that multimarket contact increases delays and that this effect is greater for contact on more concentrated routes.

This paper contributes to the literature by addressing how a pricing repeated game effect carriers' pricing strategies and how carriers exercise market power and participate in Bertrand competition simultaneously. We study the effect of multimarket contact on price dispersion, before and after major mergers and acquisitions in three types of markets: high demand markets (routes between big cities), medium-size markets (routes between big and small cities) and low demand markets (routes between small cities). We find that the role of mulitmarket contact is different across these market types. Moreover, we find that carrier-specific or market-specific measures of multimarket contact may have different effects on price dispersion. There are more rivals in high demand markets, which make this type of markets highly competitive comparing to the other two types. Ciliberto and Williams (2014) show that multimarket contact faciliates mutual forbearance in this type markets (their top 1000 markets). However, we find that airlines care more about the direct relationships with their rivals, and compete in the bottom portion of the ticket fare distribution. In medium-size markets, airlines refrain themselves from cut-throat pricing and there indeed exist mutual forbearance as the average number of contacts in the market increases. We show that multimarket contact does not effect airlines pricing strategies in small markets, as these markets are usually in remote areas and are monopolistic markets. Mostly major airlines operate in these markets. They barely meet with others and if they do it's another major airline so the average number of multimarket contact is relatively higher. However how they compete or cooperate in high demand markets should not affect a carrier's pricing strategy in low demand markets.

2 Data

We use data from three sources. Data from the Airline Origin and Destination Survey (DB1B) database maintained by the Bureau of Transportation Statistics, a 10% random sample of all U.S. domestic itineraries from reporting carriers in each quarter, provides information on the fare paid, connections made en route to the passenger's final destination, and information on the ticketing and operating carriers. We use data from January 2006 to December 2008 (Period 1) and January 2013 to December 2015 (Period 2).

To define markets, we use the ranking of airports by enplanements in year 2014 from the Passenger Boarding(Enplanement) and All-Cargo Data for U.S. Airports maintained by the Federal Aviation Administration (FAA) and the Metropolitan Statistical Area (MSA) data for the populations of origins and destinations maintained by the Bureau of Economic Analysis.

Markets definition. We define markets as an unidirectional trip between two cities in a particular quarter regardless of the number of connections a passenger made in route to his or her final destination. Unlike Evans and Kessides (1994), Ciliberto and Williams (2014) and many other studies which define a route based on the two end-point airports, we define markets based on the two end-point cities. A few paper (see Morrison (2001); Berry and Jia (2010); Dai, Liu, and Serfes (2014)) discuss possible competition between adjacent airports. For example, both O'Hare and Midway are located in the Chicago metropolitan area, if consumers can easily substitute between them, carriers in Midway will directly compete against those in O'Hare. To address this concern, we combine airports of the same MSA into one city[2].

Markets are indexed by $m = 1, ..., M$. There are 6642 markets. Year-quarter combinations are denoted by $t = 1, ..., T$. There are 12 quarters in each of our periods. The subindex $j = 1, ..., J_{mt}$ denotes a product j in market m at time t. A product is defined by the carrier (e.g., United) and the type of service, either non-stop or connecting. In the first period, the total number of carriers in the data is 18 and includes American Airlines(AA), Alaska Airlines(AS), JetBlue Airways(B6), Continental Airlines(CO), Delta AirLines(DL), Frontier Airlines(F9), ATA Airlines(TZ), Allegiant Airlines(G4), Spirit Airlines(NK), Northwest Airlines(NW), Sun Country Airlines(SY), AirTran Airways(FL), USA3000 Airlines(U5), United Airlines(UA), US Airways(US), Southwest Airlines(WN), Midwest Airlines(YX), Hawaiian Airlines(HA). Due to mergers and exits that occurred between the two periods, Continental Airlines(CO), USA3000 Airlines(U5), Northwest Airlines(NW), Midwest Airlines(YX), ATA Airlines(TZ) are not included in period 2, and Virgin America Inc.(VX) is added, hence the total number

[2]We combine the following airports of the same metropolitan statistical area: Chicago [ORD(3), MDW(24)]; New York City [JFK(5), EWR(14), LGA(20), HPN(100)]; Dallas [DFW(4),DAL(41)]; Houston [IAH(11), HOU(32)]; Los Angeles [LAX(2), SNA(40), BUR(61), LGB(77)]; San Francisco [SFO(7), OAK(35)]; Miami [MIA(12), FLL(21), PBI(52)]; Washington, DC [IAD(23), DCA(28)]; Orlando [MCO(15), SFB(85)]; Riverside [ONT(59), PSP(89)]. Inside the parentheses behind airport codes are the ranking of airports by enplanements in year 2014.

of carriers in period 2 is 14. The unit of observation is then denoted by a combination, jmt, which indicates a product j (e.g., nonstop service by United), in market m (e.g., San Francisco to Austin), at time t (e.g., the third quarter of 2013). We drop observations that contains code sharing, *i.e.* the ticket carrier and the operating carrier are different (see Gerard and Shapiro (2009)). Our final sample contains 322,993 and 148,697 observations for both periods respectively at the product-market-time level.

We categorize the markets into three types: Big city pairs (Top 1000 markets), Big-small city pairs, and small city pairs. The top 1000 markets includes the top 42 ranked airports in Passenger Boarding(Enplanement) and All-Cargo Data, and by combining airports of the same MSA into one city, in total there are 1056 markets. These are the most competitive markets with in average more carriers than the other two types of market in both periods. And the fewest percentage of monopoly markets[3] (See Table 6). The routes between airports ranked 43 to 100 are considered small city pairs. After subtracting the top 33 cities and combining airports of same MSA, there are 2352 markets. The remaining markets are the routes between the big cities and small cities. The distribution of market structure is significantly different. It is interesting to study how carriers' pricing strategies differ between these three types of markets.

Fares. We calculate average fares level and fares of each percentile at the product-market-time level. Similar to Gerard and Shapiro (2009) and Gerard and Shapiro (2009), we drop exceedingly high and low fares (greater than \$1500 and less than \$20) which are likely the result of key-punch error and frequent-flyer tickets. From this sample, we construct the product-market-time specific average fare, avg_fare_{jmt}, and the fare of the xth percentile, px_{jmt}, $x = 10, 20, ..., 90$. The average fare across all markets in period 1 and period 2 are around \$230 and \$271 respectively, *i.e.*the average fare increased by \$40. The percentile prices are monotonically larger in period 2 and the difference is also largest at the 90th percentile. (See Table 5.)

Gini coefficient. Following the literature (Borenstein and Rose (1994); Gerard and Shapiro (2009); Dai, Liu, and Serfes (2014)) , we adopt the Gini coefficient as the measure of price dispersion,

$$G_{jmt} = 1 - 2 \times \sum_{i=1}^{N} \left\{ \frac{fare_i \times Pax_i}{TotalRevenue} \times \left[\frac{1}{2} \times \frac{Pax_i}{TotalPax} + \left(1 - \sum_{a=1}^{i} \frac{Pax_a}{TotalPax} \right) \right] \right\}, \quad (1)$$

[3]Following Borenstein and Rose (1994) and Dai, Liu, and Serfes (2014), a market is considered a monopoly if the share of a single carrier is greater than 90%. A market is considered a duopoly if it is not a monopoly and the sum of shares from the two leading carriers is greater than 90%. A market is considered oligopoly if it is neither monopoly nor duopoly.

where N is the total number of price levels that carrier j sets in market m at time t; Pax_i is the number of passenger charged at price level i by carrier j in market m; $TotalPax$ and $TotalRevenue$ are the total passenger served by carrier j and the total revenue of carrier j in market m respectively. We order the passengers in market m by the ticket fare they pay to find the accumulated percentage of revenue as a function of the percentage of accumulated percentage of passengers. When G_{jmt} is closer to 1, then the fares charged by carrier j in market m at time t are more price dispersed.

Multimarket contact. We use two different types of measurements for multimarket contact. One is the average of multimarket contact of all carriers serving actively in market m, which is a market-specific measurement. One can interpret the this measurement as the carrier not only cares about how often it meets its opponents, but also cares about how often its opponents compete with each other. Let mmc_{kh}^t denote the number of markets that two distinct carriers, k and h, concomitantly serve at time t. For example, in the first quarter of 2006, United and Southwest concomitantly served 1,767 markets. Table 1 shows a symmetric matrix, mmc^t, for the 18 carriers in our sample in the first quarter of 2006.

Table 1: Number of Common Markets in 2006-Q1

	AA	AS	B6	DL	F9	FL	G4	NK	SY	US	WN	HA	YX	CO	NW	TZ	U5	UA
AA	2,963																	
AS	162	302																
B6	252	73	366															
DL	2,455	264	341	4,633														
F9	782	158	125	854	987													
FL	565	33	116	905	170	972												
G4	5	0	0	1	2	0	10											
NK	93	12	32	94	27	58	0	99										
SY	38	6	6	38	28	19	0	3	38									
US	1,261	130	266	2,036	450	694	4	96	28	2,508								
WN	1,587	185	139	2,009	708	313	4	45	2	1,148	2,488							
HA	34	1	0	51	0	0	0	0	0	5	0	84						
YX	215	24	50	240	127	146	2	17	25	177	92	0	293					
CO	1,900	136	304	2,253	679	556	4	93	33	1,351	1,501	9	198	2,584				
NW	1,936	160	299	2,899	705	698	4	82	38	1,760	1,703	31	289	1,888	3,764			
TZ	135	23	40	139	63	65	0	22	4	98	47	15	30	130	125	140		
U5	29	0	6	45	0	33	0	13	0	43	34	0	6	38	44	7	45	
UA	2,256	275	332	2,998	870	651	10	85	38	1,829	1,767	65	263	1,989	2,669	137	43	3,980

For each quarter, we then use the mmc^t matrix to calculate the same market-specific average of multimarket contact as in Evans and Kessides (1994)and Ciliberto and Williams (2014),

$$avg\_contact_{mt} = \frac{1}{F_{mt}\left(F_{mt}-1\right)} \sum_{k=1}^{F} \sum_{h=1, h \neq k}^{F} 1[k \text{ and } h \text{ active}]_{mt} \cdot mmc_{kh}^t, \quad (2)$$

where $1[k \text{ and } h \text{ active}]_{mt}$ is an indicator function that is equal to 1 if both carrier k and h are active in market m at time t, F_{mt} is the total number of carriers active in market m at time t, and F is the total number of airlines.

In Table 2 and Table 3, we calculate the average of mmc^t for both periods. We observe that not only the number of active markets of a major carrier decreases, but also the number of common markets between major carriers falls after mergers. For example, American and United were in average both active in 2,239 markets in the first period, yet it significantly dropped to 1,627 in the second period, after United merged Continental in 2010. Intuitively, one would think that the meaning of competing in one extra market would be different in both periods.

Table 2: Average Number of Common Markets in Period 1(2006-Q1 to 2008-Q4)

	AA	AS	B6	DL	F9	FL	G4	NK	SY	US	WN	HA	YX	CO	NW	TZ	U5	UA
AA	2,963																	
AS	201	338																
B6	457	92	718															
DL	2,404	292	665	4,624														
F9	886	168	159	966	1,131													
FL	730	51	314	1,176	245	1,251												
G4	5	0	0	10	1	1	16											
NK	106	16	58	114	34	87	0	123										
SY	49	11	10	44	39	26	0	4	51									
US	1,697	236	620	2,699	710	979	7	118	43	3,309								
WN	1,623	204	304	2,081	807	425	1	51	9	1,585	2,583							
HA	33	14	0	42	0	0	0	0	0	31	0	84						
YX	233	35	68	249	151	179	1	27	27	217	122	0	303					
CO	1,880	154	541	2,304	735	713	3	107	42	1,749	1,609	6	222	2,659				
NW	1,851	181	526	2,647	789	832	4	94	47	2,045	1,705	22	296	1,847	3,451			
TZ	76	19	26	76	33	29	0	8	4	61	23	18	18	60	64	83		
U5	16	0	8	25	1	19	0	8	0	23	19	0	3	19	23	1	26	
UA	2,239	301	587	2,896	973	807	9	94	48	2,303	1,861	64	262	1,982	2,445	80	16	3,864

The second measurement, following Prince and Simon (2009), is a carrier-market-specific measurement,

$$PS\_MMC_{jmt} = \frac{1}{F_{mt}-1} \sum_{h=1,h\neq j}^{F_{mt}} 1[j \text{ and } h \text{ active}]_{mt} \cdot mmc^t_{jh}. \quad (3)$$

It is the average of contacts with its opponents in market m. An interpretation of this second measurement is that the carrier only cares about the number of competition between itself and its opponents only.

To check for robustness of our results, we also consider other measures of multimarket contact for both types of measurements. The impact of increasing the average number of contacts by meeting one more time is very vague when only looking at an absolute number, $avg\_contact_{mt}$. For example, the economic meaning of meeting one more time when two carriers have only met 10 times

Table 3: Average Number of Common Markets in Period 2(2013-Q1 to 2015-Q4)

	AA	AS	B6	DL	F9	FL	G4	NK	SY	VX	US	WN	HA	UA
AA	2,164													
AS	363	435												
B6	394	105	451											
DL	1,920	396	441	2,816										
F9	403	135	97	431	448									
FL	176	15	62	223	46	227								
G4	14	4	2	19	6	0	20							
NK	233	67	107	240	115	44	0	246						
SY	65	43	36	66	44	13	0	37	67					
VX	71	56	50	70	42	7	1	35	25	71				
US	1,184	268	302	1,502	295	205	9	156	47	45	1,696			
WN	1,494	241	386	1,731	353	202	12	235	59	67	1,062	1,899		
HA	34	40	1	34	1	0	3	1	1	3	27	1	47	
UA	1,627	385	405	1,839	384	179	15	224	65	71	1,228	1,385	37	2,081

weighs far more compared to if they met 100 times already. Let

$$pct\_mmc_{kh}^{t} = \frac{mmc_{kh}^{t}}{total\ route\ of\ k}.$$

Following Ciliberto and Williams (2014), we adopt three other measures for market-specific multimarket contact:

$$pct\_contact_{mt} = \frac{1}{F_{mt}\,(F_{mt}-1)} \sum_{k=1}^{F_{mt}} \sum_{h=1,h\neq k}^{F_{mt}} 1[k\ and\ h\ active]_{mt} \times pct\_mmc_{kh}^{t};$$

$$max\_pct\_contact_{mt} = \frac{1}{F_{mt}\,(F_{mt}-1)} \sum_{k=1}^{F_{mt}} \sum_{h=1,h\neq k}^{F_{mt}} 1[k\ and\ h\ active]_{mt} \cdot \max\{pct\_mmc_{kh}^{t}\};$$

$$weighted\_pct\_contact_{mt} = \frac{1}{F_{mt}\,(F_{mt}-1)} \sum_{k=1}^{F_{mt}} \sum_{h=1,h\neq k}^{F_{mt}} 1[k\ and\ h\ active]_{mt} \cdot Mktshare_{ht} \cdot pct\_mmc_{kh}^{t}.$$

For carrier-specific multimarket contact, we adopt the measure of multimarket contact from Baum and Korn (1996) and Zou, Yu, and Dresner (2012):

$$BK\_MMC_{jmt} = \frac{1}{F_{mt}-1} \sum_{h=1,h\neq j}^{F_{mt}} 1[j\ and\ h\ active]_{mt} \cdot \left(\frac{mmc_{jh}^{t}}{total\ route\ of\ j} \right);$$

$$ZYD\_MMC_{jmt} = \frac{1}{F_{mt}-1} \sum_{h=1,h\neq j}^{F_{mt}} 1[j\ and\ h\ active]_{mt} \cdot \frac{mmc_{jh}^{t}}{(sum\ of total\ routes\ of\ j\ and\ h)}.$$

Control variables. Carriers can offer both nonstop and connecting services. Thus, for each product offered by a carrier in a market, we generate a variable, $Nonstop_{jmt}$, equal to 1 if the service offered by a carrier is nonstop. Another source of differentiation among carriers is related to size of the carrier's network at an airport. We compute the percentage of all markets served out of an airport that are served by and airline in the DBIB data and call this variable $Networksize_{jlt}$, where l represents the origin city. To control for potential price differences in one-way and round-trip tickets, we construct the variable $Roundtrip_{jmt}$, which measures the fraction of round-trip tickets over the total number of tickets sole by a carrier in a market. We also calculate the market share of carrier j in market m, $Mktshare_{jmt}$. We construct an indicator, Hub_{jmt}, equal to one if one of the two end points of market m is a hub airport of carrier j. It captures potential cost advantages. As legacy carriers tend to operate with hub-spoke structure.

Some aspects of a market also affect the price setting of airlines. One very important element is the number of consumers in the market. Like Berry and Jia (2010) and Ciliberto and Williams (2014), we follow the industry standard and define the size of the market, $Mktsize_{mt}$, as the geometric mean of the population at the market end points. Another important factor is the nonstop distance between the end points, $distance_{mt}$.

Table 4: Variable Description

Variable	Source	Description
Carrier-Market-Specific Variables		
avg_fare_{jmt}	DB1B	Carrier-Market-Specific average fare
px_{jmt}	DB1B	The fare of the xth percentile, $x = 10, 20, ..., 90$
G_{jmt}	DB1B	Measurement of price dispersion, $G_{jmt} \in [0,1]$
$PS\_MMC_{jmt}/1000$	DB1B	Multi-market measure in Prince and Simon (2009)
BK_MMC_{jmt}	DB1B	Multi-market measure in Baum and Korn (1996)
ZYD_MMC_{jmt}	DB1B	Multi-market measure in Zou, Yu, and Dresner (2012)
$Nonstop_{jmt}$	DB1B	Indicator of nonstop service, =1 if nonstop; =0 otherwise
$Networksize_{jlt}$	DB1B	Percentage of all routes served by carrier j at originating city l
$Mktshare_{jmt}$	DB1B	Market-Carrier share of passengers
$Roundtrip_{jmt}$	DB1B	Proportion of Round-trip Passengers
Hub_{jmt}	DB1B	Indicator of Hub at either the origin or the destination, =1 if yes; =0 otherwise
Market-Specific Variables		
$avg\_contact_{mt}/1000$	DB1B	Multi-market measure in Evans and Kessides (1994), given by (2)
$pct\_contact_{mt}$	DB1B	Multi-market measure with shares
$max\_pct\_contact_{mt}$	DB1B	Multi-market measure with share using max
$weighted\_pct\_contact_{mt}$	DB1B	Multi-market measure with share weighted with passenger
HHI_{mt}	DB1B	Herfindahl-Hirshman Index
$Mktsize_{mt}$	BEA	Geometric mean of population at market end points

Table 5: Summary Statistics

Variable	Mean		Std. Dev.		Median	
	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2
avg_fare_{jmt}	230.168	271.222	107.796	117.838	205.969	250.704
$p10$	154.540	186.555	99.075	105.321	127.630	165.960
$p20$	169.591	203.615	97.447	104.820	145.010	182.840
$p30$	183.137	219.417	97.671	105.982	159.500	198.090
$p40$	198.230	236.954	99.874	108.996	174.495	215.500
$p50$	216.748	257.767	104.465	113.828	191.870	235.450
$p60$	238.123	281.447	115.541	123.914	211.000	257.330
$p70$	264.718	310.071	127.475	134.793	235.930	284.380
$p80$	299.928	347.954	142.528	149.915	269.900	320.500
$p90$	360.261	411.219	176.925	182.584	324.150	380.580
G_{jmt}	0.180	0.171	0.101	0.090	0.193	0.187
$avg\_contact_{mt}$	1,695.636	1,629.205	556.544	775.495	1,718.200	1,654.900
$avg\_contact_{mt}/1000$	1.696	1.629	0.557	0.775	1.718	1.655
$pct\_contact_{mt}$	0.571	0.676	0.121	0.167	0.592	0.701
$max\_pct\_contact_{mt}$	0.706	0.816	0.140	0.174	0.729	0.861
$weighted\_pct\_contact_{mt}$	0.048	0.087	0.012	0.029	0.049	0.087
PS_MMC_{jmt}	1,695.636	1,629.205	690.484	879.645	1,827.143	1,848.800
$PS\_MMC_{jmt}/1000$	1.696	1.629	0.690	0.880	1.827	1.849
ZYD_MMC_{jmt}	0.256	0.302	0.081	0.111	0.282	0.331
BK_MMC_{jmt}	0.571	0.676	0.155	0.195	0.583	0.701
$Mktshare_{jmt}$	0.232	0.259	0.298	0.307	0.085	0.118
HHI_{mt}	0.507	0.530	0.229	0.224	0.460	0.480
$Networksize_{jlt}$	0.623	0.697	0.200	0.240	0.642	0.785
Hub_{jmt}	0.008	0.015	0.090	0.121	0	0
$Nonstop_{jmt}$	0.300	0.372	0.458	0.483	0	0
$Roundtrip_{jlt}$	0.723	0.597	0.128	0.132	0.746	0.616
$nonstopmiles$	1,494	1,538	963	1,002	1,263	1,303
$ln\_distance_{mt}$	7.104	7.132	0.667	0.666	7.141	7.172
$MktSize_{mt}$	2,902,482	3,924,398	3,289,569	3,749,149	1,912,349	2,700,086

There are several interesting observations made from Table 6. Numbers of observations and observed markets dropped dramatically in period 2, indicating that many exits occurred after major mergers. Not only the distribution of market structure (*i.e.* monopoly, duopoly and oligopoly) varies between these three types of markets, but average passengers per carrier and average market share per carrier are also very different. In the top 1000 markets, the average passengers a carrier serves in a city pair is four times more than in a big-small city pair, and about 15 times more than in a small city pair. The average number of carriers drop from 7.9 and 5.9 in the top 1000 markets to only about 3.5 in small city pairs. It is intuitively to think that the firms will behave differently as the intensity of competition varies.

Table 6: Comparison of Summary Statistics Between Market Types

	Big City Pairs		Big-small City Pairs		Small City Pairs		All markets	
	period1	period2	period1	period2	period1	period2	period1	period2
observation	90,173	59,213	173,547	74,889	67,199	17,909	330,919	152,011
observed markets	1,045	1,005	3,279	1,740	2,101	540	6,425	3,285
Avg. percentage of monopoly mkt	0.082	0.233	0.257	0.301	0.426	0.350	0.284	0.288
Avg. percentage of duopoly mkt	0.335	0.296	0.282	0.275	0.212	0.258	0.268	0.279
Avg. percentage of oligopoly mkt	0.583	0.471	0.461	0.424	0.362	0.392	0.449	0.433
$avg\_contact_{mt}$	1,501	1,278	1,765	1,805	1,778	2,058	1,696	1,629
$pct\_contact_{mt}$	0.555	0.637	0.586	0.699	0.553	0.714	0.571	0.676
PS_MMC_{jmt}	1,501	1,278	1,765	1,805	1,778	2,058	1,696	1,629
BK_MMC_{jmt}	0.555	0.637	0.586	0.699	0.553	0.714	0.571	0.676
average number of carriers	7.949	5.979	5.436	4.353	3.664	3.426	5.761	4.877
$Mktshare_{jmt}$	0.139	0.204	0.226	0.278	0.372	0.361	0.232	0.259
HHI_{mt}	0.431	0.488	0.514	0.549	0.592	0.586	0.507	0.530
Avg. Passengers per Carrier	643	679	148	159	32	42	259	348
Avg. of Total Passengers	5,066	4,584	794	732	139	163	1,825	2,165
$average\_fare_{jmt}$	214.570	247.700	231.228	281.736	248.362	305.026	230.168	271.222
G_{jmt}	0.214	0.190	0.178	0.164	0.140	0.136	0.180	0.171

* The numbers represent averages, except for observation and observed markets.

3 Empirical Analysis

We exploit the panel structure of the data to control for the time-invariant route and carrier heterogeneities. We introduce carrier and route fixed effects, and year-quarter fixed effects in all of our specifications. This prevents cross-sectional variations from driving our results.

First we investigate whether the effect of multimarket contact on average fare has changed or not after major mergers:

$$\ln(avg\_fare_{jmt}) = \alpha \cdot MMC + X_{jmt}\beta + \eta_j + \lambda_m + \gamma_t + \varepsilon_{jmt}, \quad (4)$$

where j indexes products, m markets, t time, X_{jmt} are product and market specific control variables, and *mmc* is one of our multimarket contact measurement, which will be checked for robustness. The dependent variable is the natural logarithm of the average fare for product j. We estimate (4) by pooling all markets together and also for each type of markets. The main variables of interest are $avg\_contact_{mt}$ and PS_MMC_{jmt}. Recall that $avg\_contact_{mt}$ is a multimarket contact measurement that is the average of all carriers active in the current market, where PS_MMC_{jmt} has the subscript j which means that the number of contacts between rivals are not considered. Thus the coefficient (α) estimates are expected to have different signs between market types and the two periods, and within the same market type and same period, $avg\_contact_{mt}$ and PS_MMC_{jmt} may also have coefficient estimates with opposite signs. It is expected that multimarket contact should matter to carriers' pricing strategies in markets of large demand and in which the carriers have more interactions. We will discuss the robustness of the choice of measures for multimarket contact later. The estimation results of (4) are presented in Table 7.

Estimating (4) with $avg\_contact_{mt}$ as the measurement for multimarket contact, we replicate Evans and Kessides (1994) and Ciliberto and Williams (2014), who showed that there exists mutual forbearance in our first period of observation. We find that in both periods of our observations, when pooling all markets together, there exist significantly positive relationships between the natural logarithm of average fare and multimarket contact, implying that there exists mutual forbearance in both periods. However, when only the top 1000 markets are studied, the coefficient estimate of both $avg\_contact_{mt}$ and PS_MMC_{jmt} are not significant in period 1 possibly due to the existence of several rivals (in average 7.95 carriers) so that cooperation is not possible. In big-small city pairs, if carriers only consider the direct contacts between its rivals (PS_MMC_{jmt}), the carriers compete more aggressively the more often the rivals meet in period 1(the coefficient estimate of -0.0078). But in period 2, whether or not the relationship between rivals are considered, there exist mutual forbearance. What is interesting is that in small city pairs, it was positively significant in period 1 but becomes insignificant in period 2. And for the coefficient estimates of PS_MMC_{jmt} in small city pairs are not significant in both periods, implying that multimarket contact may not matter for low demand markets. A third of small city pair markets is monopoly, and mostly major airlines are operating in these markets. It is intuitive to think that they barely contact others and if they do it's another major airline so the average number of multimarket contact is relatively higher, however how they compete or cooperate in high demand markets should not affect a carrier's pricing strategy in remote and monopolistic markets.

Though from the estimation result of (4), there is evidence for mutual forbearance, it is well known that carriers take the advantage of their market power and price discriminate between passengers of different demand elasticity, such as business travelers and leisure travelers. Business travelers are less price elastic than that of leisure travelers and are willing to pay higher fares, whereas leisure travelers are the opposite and tend to look for cheaper fares. Thus it is reasonable to suspect there exists price dispersion as the carriers can distinguish these two groups of travelers through various ticket restrictions and prices. Hence we estimate:

$$G_{jmt} = \alpha \cdot mmc + X_{jmt}\beta + \eta_j + \lambda_m + \gamma_t + \varepsilon_{jmt}. \tag{5}$$

The results are presented in Table 8. When pooling all markets, the coefficients of

Table 7: The impact of multimarket contact on average fare.

$\ln(avg\_fare\_jmt)$	All Markets				Big City Pairs				Big-small City Pairs				Small City Pairs			
	period1		period2		period1		period2		period1		period2		period1		period2	
$avg\_contact\_mt/1000$	0.00913***		0.0174***		0.00412		0.0279***		0.00765*		0.00736*		0.00704*		0.00323	
	(0.00214)		(0.00232)		(0.0105)		(0.00542)		(0.00303)		(0.00337)		(0.00312)		(0.00461)	
$PS\_MMC_{jmt}/1000$		-0.000292		0.0268***		-0.00998		0.0655***		-0.00777*		0.00904*		0.00203		0.00161
		(0.00212)		(0.00267)		(0.0103)		(0.00602)		(0.00306)		(0.00388)		(0.00307)		(0.00473)
hub_{jmt}	0.0847***	0.0852***	0.118***	0.118***	0.0766***	0.0763***	0.121***	0.123***	0.168***	0.170***	0.149***	0.149***				
	(0.0129)	(0.0129)	(0.0108)	(0.0108)	(0.0129)	(0.0129)	(0.0119)	(0.0119)	(0.0382)	(0.0383)	(0.0282)	(0.0282)				
$Networksize_{jlt}$	0.0155*	0.0147*	0.0982***	0.0893***	0.0260	0.0285	0.0922***	0.0638***	0.0409***	0.0405***	0.101***	0.0982***	-0.0742***	-0.0747***	0.0603*	0.0602*
	(0.00746)	(0.00748)	(0.00865)	(0.00870)	(0.0174)	(0.0179)	(0.0149)	(0.0150)	(0.0101)	(0.0101)	(0.0117)	(0.0118)	(0.0143)	(0.0143)	(0.0243)	(0.0244)
$nonstop_{jmt}$	-0.0359***	-0.0355***	-0.0350***	-0.0354***	-0.0597***	-0.0598***	-0.0628***	-0.0635***	-0.0174***	-0.0170***	-0.0124**	-0.0125**	-0.0176***	-0.0171***	-0.0127	-0.0127
	(0.00233)	(0.00233)	(0.00298)	(0.00298)	(0.00419)	(0.00420)	(0.00496)	(0.00494)	(0.00307)	(0.00307)	(0.00389)	(0.00388)	(0.00468)	(0.00467)	(0.00690)	(0.00690)
$roundtrip_{jlt}$	-0.0512***	-0.0504***	0.0699***	0.0743***	-0.181***	-0.181***	0.0563*	0.0681**	-0.0166	-0.0162	0.0884***	0.0897***	-0.0168	-0.0164	0.00173	0.00185
	(0.0107)	(0.0107)	(0.0132)	(0.0132)	(0.0260)	(0.0260)	(0.0220)	(0.0219)	(0.0141)	(0.0140)	(0.0179)	(0.0179)	(0.0204)	(0.0204)	(0.0370)	(0.0370)
HHI_{mt}	0.0627***	0.0541***	0.0861***	0.0894***	0.0861**	0.0866**	0.116***	0.113***	0.0653***	0.0591***	0.0646***	0.0659***	0.0597***	0.0510**	0.0201	0.0186
	(0.00987)	(0.00992)	(0.00753)	(0.00755)	(0.0292)	(0.0296)	(0.0119)	(0.0119)	(0.0143)	(0.0144)	(0.0110)	(0.0111)	(0.0160)	(0.0159)	(0.0224)	(0.0224)
$marketshare_{jmt}$	0.0104*	0.00786	0.0118**	0.0145***	0.0385***	0.0385***	0.0327***	0.0384***	-0.00922	-0.0115*	-0.00244	-0.00194	0.00341	0.000477	0.00349	0.00292
	(0.00407)	(0.00407)	(0.00397)	(0.00400)	(0.00968)	(0.00967)	(0.00663)	(0.00660)	(0.00543)	(0.00543)	(0.00574)	(0.00581)	(0.00778)	(0.00778)	(0.0102)	(0.0103)
$MktSize_{mt}$	-3.01e-08	-2.91e-08	-0.000000138***	-0.000000136***	-2.83e-08	-2.78e-08	-0.000000167**	-0.000000160*	-6.98e-08	-6.75e-08	-3.73e-08	-3.73e-08	-5.40e-08	-5.47e-08	9.56e-08	9.78e-08
	(2.63e-08)	(2.63e-08)	(3.64e-08)	(3.64e-08)	(3.89e-08)	(3.90e-08)	(6.25e-08)	(6.27e-08)	(3.92e-08)	(3.93e-08)	(4.67e-08)	(4.67e-08)	(0.000000137)	(0.000000138)	(0.000000158)	(0.000000158)
$\ln distance_{mt}$	0.177	0.178	0.204	0.208	0.127	0.127	0.280	0.302	0.249	0.250	0.0393	0.0406	-0.465	-0.465	1.358*	1.359*
	(0.176)	(0.176)	(0.187)	(0.187)	(0.328)	(0.329)	(0.317)	(0.315)	(0.202)	(0.202)	(0.223)	(0.223)	(0.903)	(0.903)	(0.591)	(0.591)
N	322993	322993	148697	148697	90173	90173	59213	59213	168857	168857	73112	73112	63963	63963	16372	16372

* The dependent variable is the natural logarithm of the average fare of product j in market m at time t.
* Fixed effect estimation of (4). Standard errors in parenthesis: $* < 0.05$, $** < 0.01$, $*** < 0.001$.
* Year-quarter dummies, carrier dummies included in all regressions. Their coefficient estimates, as well as the constant estimate, are omitted.

Table 8: The impact of multimarket contact on price dispersion.

Gini	All Markets				Big City Pairs				Big-small City Pairs				Small City Pairs			
	period1		period2		period1		period2		period1		period2		period1		period2	
$avg\_contact_{mt}/1000$	-0.00192*** (0.000511)		0.00594*** (0.000619)		0.00737*** (0.00214)		0.0102*** (0.00142)		-0.00394*** (0.000762)		0.00388*** (0.000882)		0.00255*** (0.000756)		0.00141 (0.00129)	
$PS\_MMC_{jmt}/1000$		0.00122* (0.000566)		0.00774*** (0.000711)		0.0135*** (0.00288)		0.0102*** (0.00164)		-0.000482 (0.000869)		0.00902*** (0.00105)		0.00258*** (0.000779)		0.00238 (0.00136)
hub_{jmt}	-0.00732 (0.00388)	-0.00751 (0.00388)	0.00364 (0.00251)	0.00386 (0.00251)	0.00302 (0.00426)	0.00330 (0.00424)	0.00345 (0.00258)	0.00377 (0.00258)	-0.0221** (0.00821)	-0.0225** (0.00822)	-0.0217** (0.00781)	-0.0217** (0.00768)				
$Networksize_{jlt}$	0.122*** (0.00239)	0.122*** (0.00239)	0.120*** (0.00258)	0.118*** (0.00260)	0.114*** (0.00537)	0.110*** (0.00548)	0.145*** (0.00384)	0.142*** (0.00394)	0.127*** (0.00334)	0.127*** (0.00334)	0.101*** (0.00363)	0.0984*** (0.00365)	0.0926*** (0.00391)	0.0923*** (0.00391)	0.106*** (0.00764)	0.105*** (0.00765)
$nonstop_{jmt}$	0.00819*** (0.000658)	0.00805*** (0.000659)	0.0219*** (0.000739)	0.0218*** (0.000740)	0.0165*** (0.00113)	0.0167*** (0.00113)	0.0287*** (0.00114)	0.0286*** (0.00114)	0.0114*** (0.000921)	0.0113*** (0.000922)	0.0178*** (0.00105)	0.0176*** (0.00105)	0.00873*** (0.00148)	0.00874*** (0.00148)	0.00869*** (0.00198)	0.00866*** (0.00198)
$roundtrip_{jlt}$	-0.0143*** (0.00293)	-0.0144*** (0.00293)	-0.0344*** (0.00383)	-0.0331*** (0.00382)	-0.0273*** (0.00719)	-0.0258*** (0.00720)	-0.0435*** (0.00596)	-0.0416*** (0.00594)	-0.000206 (0.00386)	-0.000507 (0.00386)	-0.0247*** (0.00540)	-0.0235*** (0.00540)	-0.00648 (0.00465)	-0.00634 (0.00464)	-0.0250* (0.0103)	-0.0244* (0.0103)
HHI_{mt}	-0.0650*** (0.00218)	-0.0620*** (0.00219)	-0.0377*** (0.00219)	-0.0366*** (0.00219)	-0.0216*** (0.00540)	-0.0211*** (0.00541)	-0.0189*** (0.00336)	-0.0171*** (0.00334)	-0.0599*** (0.00303)	-0.0587*** (0.00305)	-0.0506*** (0.00318)	-0.0492*** (0.00318)	-0.105*** (0.00350)	-0.105*** (0.00348)	-0.0850*** (0.00568)	-0.0838*** (0.00566)
$marketshare_{jmt}$	0.120*** (0.00150)	0.121*** (0.00150)	0.0987*** (0.00124)	0.0993*** (0.00125)	0.0468*** (0.00310)	0.0469*** (0.00309)	0.0758*** (0.00193)	0.0760*** (0.00194)	0.122*** (0.00205)	0.123*** (0.00205)	0.106*** (0.00169)	0.107*** (0.00170)	0.164*** (0.00238)	0.164*** (0.00239)	0.127*** (0.00352)	0.128*** (0.00356)
$MktSize_{mt}$	-1.09e-08 (6.68e-09)	-1.12e-08 (6.67e-09)	-2.39e-08** (7.75e-09)	-2.38e-08** (7.75e-09)	-2.97e-08** (1.10e-08)	-2.99e-08** (1.10e-08)	4.92e-09 (1.27e-08)	3.89e-09 (1.26e-08)	-1.44e-11 (9.38e-09)	-5.58e-10 (9.38e-09)	-3.65e-08*** (1.06e-08)	-3.67e-08*** (1.07e-08)	-7.82e-10 (3.07e-08)	-3.95e-10 (3.07e-08)	2.13e-08 (4.14e-08)	2.09e-08 (4.14e-08)
$\ln distance_{mt}$	-0.0276 (0.0399)	-0.0276 (0.0399)	-0.0150 (0.0422)	-0.0140 (0.0423)	-0.165* (0.0757)	-0.165* (0.0759)	-0.0166 (0.0702)	-0.0137 (0.0702)	-0.0125 (0.0508)	-0.0127 (0.0509)	-0.0523 (0.0522)	-0.0511 (0.0524)	0.0965 (0.128)	0.0967 (0.128)	0.213 (0.169)	0.211 (0.169)
N	322993	322993	148697	148697	90173	90173	59213	59213	168857	168857	73112	73112	63963	63963	16372	16372

* The dependent variable is the Gini coefficeint of product j in market m at time t.
* Fixed effect estimation of (5). Standard errors in parenthesis: $* < 0.05$, $** < 0.01$, $*** < 0.001$.
* Year-quarter dummies, carrier dummies included in all regressions. Their coefficient estimates, as well as the constant estimate, are omitted.

$avg\_contact_{mt}$ change signs. An interpretation of this result could be that there was more competition in period 1 and the carriers are less likely to collude. One may think that when there is more competition, it less likely that collusion will sustain, and the carriers compete more aggressively and thus the prices are less disperse. However this contradicts with the results from estimating the markets by type. Still in Table 8, one can observe that in the most competitive markets (top 1000 markets) the multimarket contact coefficient estimate is significantly positive in both periods, yet changes signs in the moderate competitive markets (big-small city pairs). A positive coefficient estimate implies that as the carriers contact more often, the ticket fare distribution of product j is more disperse. From the distribution of competition levels, and the characteristics observed in Table 6, in top 1000 markets there is the lowest percentage of monopolies (8% and 23%), indicating that there should be more competition and less likely that the carriers would cooperate and price discriminate. And from Table 6, we observe two interesting phenomena: (i) the average Gini changed the most in the top 1000 markets; (ii) we expected to observe more price dispersion in the least competitive market (small city pairs), however the average Gini is the smallest among the three types of markets. All this suggest that the carriers may have different pricing strategies for high ticket fares and low ticket fares.

Hence we investigate whether multimarket contact matters for different level of prices,

$$\ln(px_{jmt}) = \alpha \cdot mmc + X_{jmt}\beta + \eta_j + \lambda_m + \gamma_t + \varepsilon_{jmt}, \quad x = 10, 20, ..., 90. \tag{6}$$

The results are presented in rows 3-9 of Table 9 and Table 10. There are three specifications in this paper, equations (4)- (6), in total of 11 estimations for each type of market (all markets pooled, top 1000, big-small city pairs, small city pairs) and two main multimarket contact measurements for both periods, which results in 11 complete tables. Therefore, we present the summarized results of these regressions in Table 9 and Table 10. We only report the coefficient estimates of multimarket contact measurements in these two tables. The coefficient estimates of other control variables are in general quite consistent, hence we omit them from the table. Below we analyze the results of $avg\_contact_{mt}$ (Table 9) first and then compare it with the results of PS_mmc_{jmt} (Table 10).

In the first two columns of Table 9, when all markets are pooled, we find that in period 1 the coefficient estimates are significantly positive and monotonically increasing from the 90th percentile to the 10th percentile of average fares, suggesting that as the carriers contact more often, high fares will increase less than low fares, which is counter intuitive. In period 2, it is the opposite. The coefficients of high prices are greater than low of prices. This provides evidence that firms cooperate in high prices and have less incentive to cooperate for low prices which matches the intuition of textbooks. The results show that indeed multimarket contact has different impact on pricing strategies in different types of markets. In period 1 of the most competitive markets (big city pairs), the coefficient estimates are greater and positively significant for the highest 30% of prices, and negatively significant for the lowest 10% of prices, implying that there exist mutual forbearance in high fare levels, but the carriers may participate in cut throat pricing in the lowest fares. Low fares often times appear when the flight date is approaching but still many seats remain unsold and the carriers want to sell as many seats as possible. This

Table 9: Prices and market level multimarket contact ($avg\_contact_{mt}/1000$)

Dependent Variables	All Markets period1	All Markets period2	Big City Pairs period1	Big City Pairs period2	Big-small City Pairs period1	Big-small City Pairs period2	Small City Pairs period1	Small City Pairs period2
$\ln(avg\_fare_{jmt})$	0.00913***	0.0174***	0.00412	0.0279***	0.00765*	0.00736*	0.00704*	0.00323
	(0.00214)	(0.00232)	(0.0105)	(0.00542)	(0.00303)	(0.00337)	(0.00312)	(0.00461)
G_{jmt}	-0.00192***	0.00594***	0.00737***	0.0102***	-0.00394***	0.00388***	0.00255***	0.00141
	(0.000511)	(0.000619)	(0.00214)	(0.00142)	(0.000762)	(0.000882)	(0.000756)	(0.00129)
$\ln p90$	0.0142***	0.0313***	0.0281*	0.0488***	0.00704*	0.0190***	0.0158***	0.0118*
	(0.00248)	(0.00268)	(0.0112)	(0.00612)	(0.00355)	(0.00376)	(0.00367)	(0.00570)
$\ln p80$	0.0141***	0.0254***	0.0219*	0.0425***	0.00801*	0.0153***	0.00796*	0.00271
	(0.00235)	(0.00252)	(0.0107)	(0.00578)	(0.00337)	(0.00357)	(0.00346)	(0.00535)
$\ln p70$	0.0149***	0.0205***	0.0122	0.0355***	0.00978**	0.0121***	0.00526	0.00137
	(0.00231)	(0.00243)	(0.0108)	(0.00566)	(0.00327)	(0.00346)	(0.00342)	(0.00511)
$\ln p60$	0.0176***	0.0178***	0.00822	0.0312***	0.0131***	0.0115***	0.00740*	0.00261
	(0.00223)	(0.00241)	(0.0105)	(0.00571)	(0.00319)	(0.00342)	(0.00328)	(0.00492)
$\ln p50$	0.0179***	0.0153***	0.00175	0.0274***	0.0149***	0.0105**	0.00796*	0.00313
	(0.00215)	(0.00234)	(0.0101)	(0.00552)	(0.00311)	(0.00334)	(0.00316)	(0.00468)
$\ln p40$	0.0205***	0.0150***	-0.00140	0.0252***	0.0191***	0.0113**	0.0106**	0.00791
	(0.00219)	(0.00239)	(0.00964)	(0.00553)	(0.00318)	(0.00344)	(0.00324)	(0.00487)
$\ln p30$	0.0238***	0.0132***	-0.00335	0.0203***	0.0231***	0.0103**	0.0146***	0.00889
	(0.00224)	(0.00247)	(0.00972)	(0.00570)	(0.00318)	(0.00364)	(0.00342)	(0.00489)
$\ln p20$	0.0242***	0.00982***	-0.00916	0.0120*	0.0257***	0.00689	0.0134***	0.00842
	(0.00235)	(0.00257)	(0.00995)	(0.00589)	(0.00337)	(0.00387)	(0.00358)	(0.00506)
$\ln p10$	0.0248***	0.00486	-0.0146	-0.00357	0.0279***	0.00103	0.0115**	0.00581
	(0.00265)	(0.00288)	(0.0106)	(0.00637)	(0.00379)	(0.00453)	(0.00413)	(0.00581)
observation	322993	148,697	90,173	59,213	168,857	73,112	63,963	16,372

* Fixed effect estimation of (4), (5) and (6). Standard errors in parenthesis: $* < 0.05 ** < 0.01$, $*** < 0.001$.
* Year-quarter dummies, carrier dummies included in all regressions. Their coefficient estimates, as well as the constant estimate, are omitted. Coefficient estimates of other control variables are consistent, hence we omit them as well.

Table 10: Prices and product specific multimarket contact (PS_MMC_{jmt})

Dependent Variables	All Markets period1	All Markets period2	Big City Pairs period1	Big City Pairs period2	Big-small City Pairs period1	Big-small City Pairs period2	Small City Pairs period1	Small City Pairs period2
$\ln(avg\_fare_{jmt})$	-0.000292	0.0268***	-0.00998	0.0655***	-0.00777*	0.00904*	0.00203	0.00161
	(0.00212)	(0.00267)	(0.0103)	(0.00602)	(0.00306)	(0.00388)	(0.00307)	(0.00473)
G_{jmt}	0.00122*	0.00774***	0.0135***	0.0102***	-0.000482	0.00902***	0.00258***	0.00238
	(0.000566)	(0.000711)	(0.00288)	(0.00164)	(0.000869)	(0.00105)	(0.000779)	(0.00136)
$\ln p90$	0.00821**	0.0441***	0.00256	0.0796***	-0.00227	0.0323***	0.0101**	0.0124*
	(0.00254)	(0.00313)	(0.0123)	(0.00705)	(0.00373)	(0.00451)	(0.00369)	(0.00595)
$\ln p80$	0.00402	0.0364***	-0.00957	0.0743***	-0.00622	0.0230***	0.00187	0.00187
	(0.00236)	(0.00290)	(0.0111)	(0.00658)	(0.00343)	(0.00414)	(0.00344)	(0.00558)
$\ln p70$	0.00323	0.0313***	-0.0178	0.0692***	-0.00698*	0.0171***	-0.000608	0.000988
	(0.00230)	(0.00281)	(0.0108)	(0.00643)	(0.00331)	(0.00401)	(0.00338)	(0.00535)
$\ln p60$	0.00547*	0.0279***	-0.0195	0.0658***	-0.00417	0.0140***	0.00165	0.00191
	(0.00222)	(0.00276)	(0.0106)	(0.00642)	(0.00324)	(0.00396)	(0.00323)	(0.00507)
$\ln p50$	0.00530*	0.0253***	-0.0233*	0.0640***	-0.00339	0.0116**	0.00248	0.00225
	(0.00215)	(0.00267)	(0.0103)	(0.00619)	(0.00316)	(0.00384)	(0.00310)	(0.00482)
$\ln p40$	0.00761***	0.0257***	-0.0264**	0.0648***	0.000474	0.0127**	0.00553	0.00595
	(0.00220)	(0.00272)	(0.00994)	(0.00613)	(0.00327)	(0.00398)	(0.00319)	(0.00500)
$\ln p30$	0.00994***	0.0240***	-0.0304**	0.0638***	0.00350	0.0103*	0.00915**	0.00602
	(0.00227)	(0.00280)	(0.00992)	(0.00632)	(0.00329)	(0.00417)	(0.00337)	(0.00502)
$\ln p20$	0.00956***	0.0204***	-0.0399***	0.0590***	0.00532	0.00454	0.00891*	0.00417
	(0.00239)	(0.00293)	(0.0104)	(0.00647)	(0.00353)	(0.00443)	(0.00354)	(0.00530)
$\ln p10$	0.00981***	0.0162***	-0.0475***	0.0487***	0.00898*	-0.00336	0.00804	0.000996
	(0.00278)	(0.00331)	(0.0115)	(0.00704)	(0.00408)	(0.00523)	(0.00417)	(0.00615)
observation	322,993	148,697	90,173	59,213	168,857	73,112	63,963	16,372

* Fixed effect estimation of (4), (5) and (6). Standard errors in parenthesis: $* < 0.05 ** < 0.01$, $*** < 0.001$.
* Year-quarter dummies, carrier dummies included in all regressions. Their coefficient estimates, as well as the constant estimate, are omitted. Coefficient estimates of other control variables are in general consistent, hence we omit them as well.

result matches theory and intuition. The results in column 4 strengthens the proof of the existence of mutual forbearance in period 2, and the carriers colludes more in high fares than in low fares. In big-small city pairs, we see the same pattern of the coefficient estimates of all markets pooled. The last column suggests that there is no evidence showing that multimarket contact matters for pricing strategies in small city pairs in period 2, but in period 1 the average number of contacts are showed to matter.

Do airlines care about how often their rivals contact? Next is to compare the results of $avg\_contact_{mt}$ and PS_mmc_{jmt}. The main difference between $avg\_contact_{mt}$ and PS_mmc_{jmt} is that $avg\_contact_{mt}$ is market specific and PS_mmc_{jmt} is carrier specific. Naturally, a firm cares about the interactions with its rivals that it has contact with, but do firms care about how often their rivals interact with each other? By just studying the impact of multimarket contact on average prices, it seems as if carriers care more about the relationship between rivals than just its direct rivals. Our results show that it does matter for carriers' pricing strategies, especially in period 1. In general, the period 2 result is consistent between the two measures of multimarket contact. The coefficient estimates are mostly significant and positive when all markets are pooled. But in big city pairs, the coefficient estimates of PS_mmc_{jmt} are negatively significant for price level below the 70th percentile in period 1. This suggest that if a carrier only consider the direct interactions with its rivals, they participate in Bertrand competition and are likely to cut prices more in lower prices the more often they have contact. For big-small city pairs, period 1 coefficient estimates show different patterns. First, the coefficient estimates of the 80th and 70th percentile of fares are negatively significant, different from period 2 and the lowest 20% fares in period 1, implying that the fares are not very dispersed. This is consistent with the result of the Gini measurement being not significant. In small city pairs, the results of $avg\_contact_{mt}$ and PS_mmc_{jmt} are quite consistent, continuing to suggest that the number of contacts between carriers does not matter for a carrier's pricing strategies in remote markets and monopoly markets.

Robustness analysis. In this section, we run 4 specifications for market-specific measures of multimarket contact and 3 specifications for carrier-specific measures of mulitmarket contact to test the robustness of the results in Table 9 and Table 10. In Table 11, we only represents the results on the main variable of interest- multimarket contact. We omit the estimation results of controls variables as the results are quite consistent. .

4 Conclusion

This paper studies the effect of multimarket contact on price dispersion. Airlines have the market power to price discriminate, yet they face Bertrand competition at the same time. Price discrimination is a reason that leads to price dispersion. In infinitely repeated games, the players will cooperate if they are patient enough. We study how repeating their pricing games affect airlines' pricing strategies before and after major mergers and acquisitions.

Table 11: Robustness Check

	$\ln(avg\_fare_{jmt})$	G_{jmt}	$\ln p90$	$\ln p80$	$\ln p70$	$\ln p60$	$\ln p50$	$\ln p40$	$\ln p30$	$\ln p20$	$\ln p10$
$avg\_contact_{mt}/1000$	0.0174***	0.00594***	0.0313***	0.0254***	0.0205***	0.0178***	0.0153***	0.0150***	0.0132***	0.00982***	0.00486*
	(9.90)	(11.59)	(14.22)	(12.63)	(10.66)	(9.59)	(8.59)	(8.15)	(6.89)	(4.88)	(2.13)
$pct\_contact_{mt}$	0.0649***	0.0390***	0.178***	0.137***	0.109***	0.0904***	0.0728***	0.0654***	0.0523***	0.0286***	-0.00215
	(10.42)	(21.54)	(22.86)	(19.23)	(15.97)	(13.78)	(11.58)	(10.08)	(7.75)	(4.03)	(-0.27)
$max\_pct\_contact_{mt}$	0.0427***	0.0391***	0.164***	0.120***	0.0935***	0.0752***	0.0581***	0.0512***	0.0381***	0.0160*	-0.0122
	(7.35)	(23.17)	(22.66)	(18.07)	(14.73)	(12.27)	(9.90)	(8.44)	(6.05)	(2.41)	(-1.62)
$weighted\_pct\_contact_{mt}$	0.446***	0.258***	1.133***	0.858***	0.682***	0.551***	0.445***	0.405***	0.314***	0.163***	-0.0355
	(10.78)	(21.43)	(21.93)	(18.18)	(15.08)	(12.63)	(10.64)	(9.40)	(7.00)	(3.44)	(-0.66)
$PS\_MMC_{jmt}/1000$	0.0268***	0.00774***	0.0441***	0.0364***	0.0313***	0.0279***	0.0253***	0.0257***	0.0240***	0.0204***	0.0162***
	(13.91)	(13.79)	(18.27)	(16.51)	(14.82)	(13.72)	(12.98)	(12.77)	(11.49)	(9.23)	(6.47)
BK_MMC_{jmt}	0.0296***	0.0341***	0.121***	0.0836***	0.0617***	0.0487***	0.0354***	0.0305***	0.0193**	-0.00384	-0.0327***
	(5.43)	(21.51)	(17.72)	(13.43)	(10.37)	(8.48)	(6.44)	(5.37)	(3.27)	(-0.62)	(-4.64)
ZYD_MMC_{jmt}	0.194***	0.0781***	0.392***	0.319***	0.266***	0.230***	0.196***	0.180***	0.152***	0.101***	0.0353*
	(16.35)	(22.65)	(26.42)	(23.57)	(20.50)	(18.37)	(16.38)	(14.57)	(11.84)	(7.47)	(2.30)

[*] Fixed effect estimation of (4). T-values in parenthesis: $* < 0.05 ** < 0.01$, $*** < 0.001$.
[*] Year-quarter dummies, carrier dummies included in all regressions. Their coefficient estimates, as well as the constant estimate, are omitted.
[*] Coefficient estimates of other control variables are consistent, hence we omit them as well.

Empirical research tend to focus on competition level of markets and price setting, and multimarket contact and collusion, making relatively less progress on collusion and competing in price may simultaneously occur in repeated games. This paper contributes to the literature by addressing how a pricing repeated game effect carriers' pricing strategies and how carriers exercise market power and participate in Bertrand competition simultaneously. We use data from January 2006 to December 2008 (period 1) and January 2013 to December 2015 (period 2).

We find that the impact of multimarket contact on price dispersion varies across market type. We categorize the markets into three types: big-city pairs, big-small-city pairs, and small-city pairs, according to the rank of passenger enplanements. We find that (i) in big-city pairs, when the carriers met more often, price became more dispersed, but for different reasons in the two periods. In period 1, despite whether or not the carriers take into consideration the number of contacts between their rivals, they collude in the top portion and compete in the bottom portion of the price distribution. But the carrier specific multimarket contact shows more evidence of this phenomena. There are more rivals in period 1, so that the carriers care more about the contacts between their direct rivals and care less about the relationship between rivals. In other words, they do not care as much about the punishment from rivals' collusion and prefer to participate in cut-throat pricing in cheaper fares. After major mergers, evidence show that the carriers collude and raise the top portion of the price distribution more than the bottom. (ii) In big-small-city pairs, the carrier specific multimarket contact seems to matter less, *i.e.* carriers take into consideration the contacts between rivals. Estimating with the measure of market specific multimarket contact, there exist mutual forbearance in both periods. But the effects of multimarket contact on price dispersion are the opposite between the two periods. In period 1, when multimarket contact increases, price becomes less dispersed. The top portion of the price distribution increases less than the bottom portion, which explains why we observe less price dispersion as carriers meet more often when we still observe mutual forbearance. In period 2, we find results similar to big-city pairs. (iii) In small-city pairs, both measures of multimarket contact suggest that multimarket contact is less important to carriers' pricing strategies. In period 1, when multimarket contact increases, prices are more dispersed. Carriers increase the high fares more than low fares. And in period 2, we barely observe significant estimation results. A third of small-city pair markets are monopoly, and mostly major airlines are operating in these markets. They barely meet with others and if they do it's another major airline so the average number of multimarket contact is relatively higher. However how they compete or cooperate in high demand markets should not affect a carrier's pricing strategy in remote and monopolistic markets.

This paper has not yet address the problem of endogeneity. In the error terms of our specifications, entries and exits of the carriers are not independent of both multimarket contacts and market shares. We will include the solution to endogeneity as we continue to finish this paper. An extension that we could do is to study the difference in difference of the carriers' pricing strategies between mergers and non-mergers.

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