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An Econometric Analysis on Pricing and Market Structure in the U.S. Airline Industry

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Advanced Econometrics

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I. Introduction

The relationship between market structure and airfares has been extensively studied since the enactment of the Airline Deregulation Act in 1978. At first, economists considered the airline industry to be a naturally contestable market, because aircrafts can be switched easily and almost costlessly among alternate routes.[1] Today, unfortunately, most scholars consent that the perfect contestability ideal does not apply to the airline industry, although some still argue that established carriers can enter and exit a particular market with relatively small sunk costs. These scholars, however, have divided opinions regarding the extent of its contestability and the underlying causes that prevent it from achieving perfect contestability. Overall, existing and potential competitors, customer loyalty (reflected by Frequent Flyer Programs), scarce physical equipment and ground facilities at local airports (such as landing slots and boarding gates), and electronic reservation systems are among the major barriers to perfect contestability of a particular market[2] in the airline industry.[3] Similarly, although it is widely acknowledged that the

[1] See Baumol, Panzer, and Willig (1982), and Evans and Kessides (1993). Contestability will be discussed in more details in the next section.
[2] Most scholars agree to use "city pairs" as the definition of "market" in the airline industry. Some studies, however, distinguish among airports in the same metropolitan city and used "airport pair" instead. Under such definition, the route between Kennedy Airport to Detroit and that between La Guardia to Detroit are considered to be two different "markets". I will follow the conventional definition of market as city pairs in my own analysis.
[3] Hurdle et al. (1989), and Borenstein (1989).

market structure influences airfares to some extent, it lacks consensus among economists and policy makers how much, or even to which direction, does the structure affects ticket prices.

The controversy regarding the airline market concentration and airport dominance has become more notable as it approaches the twenty-first century. The reason for it drawing more attention from the government and the general public almost two decades after its deregulation is essentially multifold. First, small airlines have either gone bankrupt or have been annexed by well-established major airlines. In other words, small firms find it increasingly difficult to compete with traditional legacy carriers and survive in the industry today. Eventually, they are often faced with only two options: declare bankruptcy and seek government protection, or become subsidiary companies of more powerful carriers. Secondly, even the majors have undergone bankruptcy and mergers in the last decade. Some of these mergers turned out to be quite successful, as the new airlines were able to claim profits after mergers. Yet, this series of mergers has altered the market composition and raised public concerns about trust and monopoly. The merger wave since the turn of the century has also caused fierce debate among economists. While some scholars claim that large carriers are able to achieve economies of scale and scope[4], and that they attain more efficient cost structures due to strategic mergers; others contend that these benefits are at the stake of sacrificing healthy market structure and balanced market power. In short, this latter group believes that mergers create market distortion and disproportionate dominant powers, which will eventually harm consumers.[5] Thirdly, some scholars have

[4] See, for instance, Hurdle et al. (1989).
[5] The major legacy airlines, after bankruptcy reorganization (the bankruptcy of American Airlines in 2011 is not included), make up 47.3% of the U.S. domestic airline market (Delta 16.4%, American 13.3%, United 9.7%, US Airways 7.9%). Perhaps even more importantly, these airlines are affiliated to global airline alliances that together make up 77.1% of the global market. Specifically, Star Alliance, which includes Continental, United and US Airways, has 27 members in the world and makes up 29.3%. Skyteam has Delta and 14 other members globally and

insightfully pointed out that the emergence and rapid expansion of low cost carriers (LCCs) can be an effective way to withhold the distorted market power of major legacy carriers. In fact, low cost carriers such as Southwest Airlines do turn out to be a significant threat to legacy airlines as it took almost 15% of domestic market share from the major airlines in 2011. Finally, the market structure has changed significantly, from a primarily linear, point-to-point structure to an almost exclusively hub-and-spoke network since deregulation. This change has also been a debatable one,[6] because it consolidates market power and airport dominance on the one hand, while economizing operation and maintenance cost structures on the other.[7] In addition, supporters of hub-and-spoke system argue that it makes more flexible travel plans possible that, in the end, shortens connecting time in general. The time factor, however, will not be discussed in this paper because it involves consumer utility, which cannot be quantitatively gauged by airfares.

In this paper, I would like to analyze the quantitative effects of airport dominance on ticket prices by routes. This article will be organized into six sections. In the next section, I will summarize the findings of existing empirical studies. My conceptual model and estimation procedure are presented in section III, and the data is described in section IV. Section V presents the results of my estimation, along with their economic interpretations. Conclusions and discussions for future research are offered in section VI.

II. Literature Review

owns 24.6% of the market. Oneworld has American and 11 other members and makes up 23.2%. All calculations are based on Revenue Passenger Miles August 2010 - July 2011, from Bureau of Transportation Statistics (BTS).

[6] See Bowen (2002).

[7] Borenstein talked about the ambivalent consequences of the hub-and-spoke system in his 1989 study.

"Airline regulation and deregulation, taken together, provide a uniquely interesting laboratory for testing basic concepts of political economy."[8] Indeed, the history of U.S. airline industry has offered some of the most insightful devices for the study of monopoly power, market structure and contestability theory.[9] To begin with, I will discuss market contestability theory and its implication on the airline industry in a bit more detail.

At first, economists thought that the airline industry is an ideal place to prove contestability theory, first proposed by Baumol, Panzer, and Willig in 1982, because the airline industry seemed to fulfill the so-called "frictionless free entry" condition, which is required for a perfectly contestable market to be established, where "legal restrictions on market entry or exit … and special costs that must be borne by an entrant that do not fall on incumbents"[10] must not exist. That is, any entry or exit barriers that may bar potential competitors from entering are not allowed in a perfectly contestable market. As a result, "a contestable market need not be populated by a great many firms; indeed, contestable markets may contain only a single monopoly enterprise or they may be comprised of duopolistic or oligopolistic firms."[11] Since aircrafts owned by potential entrants are used to serve the same market demands by using the same productive techniques as those owned by incumbent airlines, the airline industry seems to be qualify for a perfectly contestable market. Unfortunately, these studies failed to realize that one of the critical conditions for perfect contestability, namely, costless reversibility, is in fact not fulfilled in the airline industry.[12] Starting in the mid-80s, economists began to understand the

[8] Vietor, 61.
[9] For a comprehensive summary of the history of early U.S. airline industry, see Vietor (1990).
[10] Baumol, et al, foreword xx.
[11] Ibid.
[12] Bailey and Panzar (1981), also Baumol, Panzar, and Willig (1982).

deficiencies that lurked in their previous ideal of perfect contestability.[13] Consequently, these later scholars contend that the airline industry poses unique barriers that are barely observed in other markets. The primary reason that prevents the airline industry from achieving perfect contestability, according to these studies, is the need to sink huge amounts of irrevocable costs, including, but not limited to, prepaid advertisements at airports, investments in electronic reservation systems, and above all, the astronomical access fee for using scarce physical equipment and facilities at the airport such as boarding gates and landing slots.

Hurdle, Johnson, Joskow, Werden, and Williams (1989), for example, tested the alleged perfect contestability in the aviation industry by taking into account not only the number of incumbent airlines, but also the number of potential entrants. They examined the relationship between fares and market structure on 867 significant nonstop city pairs in 1985, using nonparametric regression trees, and concluded that the airline markets were only imperfectly contestable at best. They argued that the threat of entry was a necessary, albeit not sufficient, condition to make the market at least reasonably competitive, despite the existing high concentration of incumbent carriers. In conclusion, they admitted that while they successfully rejected the perfect contestability theory and concluded that structure matters, they were unable to distinguish among three alternative hypotheses between structure and performance from their regression trees results.

Next, I would like to spend some time to talk about market structure, or I should say rather the change in market structure, in the aviation industry. One of the most notable changes

[13] Graham, Kaplan, and Sibley (1983), Bailey, Graham, and Kaplan (1985), Call and Keeler (1985), Morrison and Winston(1987), Hurdle, Johnson, Joskow, Wedrem, and Williams, (1989), Vietor (1990), and Evans and Kessides (1993).

in this industry since deregulation is the so-called "hubbing,"[14] which refers to the practice of concentrating connecting flights at a particular airport. Although the tendency of airport hubbing is not new at all, it became the public cynosure as it coupled with the establishment of airline alliances and the development of code-sharing. I will not go into details about the effects of airline alliances, because it influences the global market more than the domestic ones. This inclination, however, also inexorably contributes to a shift in market structure from a point-to-point system to a hub-and-spoke system.

As I have discussed earlier, some scholars caution the potential barriers created by the wide adoption of hub-and-spoke system. Their concerns are not ungrounded, because a new entrant, if try to enter new markets under a hub-and-spoke system, has to first establish itself at one of the hub airports, which requires a great deal of fixed, usually sunk, costs to access the limited number of gates and slots. Consequently, broaching a new market can be next to impossible in some cases, especially at major hub airports where the market shares of long-established airlines have been well-defined.[15]

Numerous studies, on the other hand, have demonstrated the merits of the transformation from a point-to-point system to a hub-and-spoke one. First, the tendency of hubbing enables carriers to enjoy a more economic, more efficient, and more extensive network, which encompasses routes that were previously inaccessible under the point-to-point structure. Studies have also shown that the adoption of hub-and-spoke system has benefitted carriers in improving cost structures by realizing scale advantages in labor and capital resources. Banker and Johnson

[14] Vietor, 85-86.
[15] Bowen (2002), on the other hand, contended that the potential danger of centrality posed by the adoption of hub-and-spoke systems should not be a key concern, because hub-and-spoke system tends to even out patters of accessibility across a country. See Bowen, 431.

(1993), for example, provided some insights into the cost saving aspect of hub concentration. They in particular focused on the variable cost component (primarily jet fuels, oils, and labor costs), since the pricing strategy was believed to be closely related to variable cost structure. Using OLS on a panel of quarterly data from 1981 to 1985 for 28 carriers of various scales of operation, they concluded, after adjusting for serial correlation, contemporaneous correlation and heteroskedasticity, that dominant carriers at concentrated hub airports achieve relatively greater economies than carriers at competitive hubs.

The improved efficiency in cost structure, unfortunately, can also be used by major carriers as a weapon in price wars. Predatory pricing, as pointed by Edlin (2002), enables a dominant company to weed out more efficient rivals without necessarily pricing below average variable costs. Therefore, it is critical to distinguish aggressive pricing conduct from normal profit maximizing conduct. According to the study by Dixit, Gundlach, Malhotra, and Allvine(2006), for example, repeated entry attempts by new or expanding carriers have provoked fierce price wars following deregulation. As a result, almost all discount airlines that started after deregulation have gone bankruptcy due to entry barriers that were created partly by the aggressive pricing responses of established incumbent airlines. Estimating a simultaneous equation model that associated pricing conduct with market power, they analyzed a stratified random sample of 10% of air passengers on all domestic flights on a quarterly basis during 1991-1999. In conclusion, they found it extremely important to consider the domain of market power when judging whether a response of an incumbent airline to the entry of new competitors is reasonably profit maximizing.

A number of studies have proved that average airfare levels increase as the markets become more concentrated.[16] In order to reveal the market power that a carrier obtains relative to companies with which it competes, Borenstein (1989) estimated a pricing equation as a function of costs, market structure (indicated by, for example, the Herfindahl Index), service quality (average connecting time and average delay time), and other factors that are hypothesized to influence a carrier's market power.[17] Using data from nine largest domestic airlines in the third quarter of 1987 for service on 5428 routes, he concluded that an airline's share of passengers on a route was positively associated with its ability to charge prices above costs. It should be noted, however, that while Borenstein was able to identify the potential hazards caused by endogeneity of his explanatory variables, he could only partially correct this problem by carrying out the standard econometric procedure (instrument variables) on some of the problematic variables, which is, as himself had admitted, not likely to be complete or perfect. Acknowledging the limitation of his data, he nonetheless contended that the bias of his estimates, if any, should not cloud the general association between market dominance and higher fares. On an overall level, however, Borenstein qualified his statement by pointing out that there exists a potential increase in total surplus, possibly in the form of profits, despite the loss that consumers had to undertake due to higher fares.

It is important to note that Borenstein distinguished an individual airline's market share at an airport from the aggregate concentration among all major airlines at that airport. In other words, he refuted the naive simplification that more concentrated markets (indicated by HHI) are invariably faced with higher fares. Instead, he argued that the (singular) dominant airline tends to

[16] See Borenstein (1992), Morrison & Winston (1990), Kim & Signal (1993).
[17] Borenstein, 344-365.

charge higher prices than other major airlines with smaller operations at these airports. In short, he concluded that "the market power of a dominant airline does not spill over substantially to other airlines serving the same airport or routes."[18] This idea is enlightening, because the conventional procedure of using the aggregate market share of top firms might not, according to Borenstein, reveal the true relationship between airfares and market power, since non-dominant airlines may not be able to enjoy the price markups that are exclusive to the dominant firm. In this paper, I followed Borenstein's procedure by including the market share of the single largest carrier, instead of using market concentration index such as HHI, CR4, or CR8.

In contrast to the findings by Borenstein, Evans and Kessides (1993) questioned the alleged association between market dominance and pricing power at the route level by examining a fixed effects model in reduce form.[19] In fact, they find that the coefficient of the route share variable has a statistically significant (albeit quantitatively unimportant) negative value by examining 10% random sample of all domestic tickets in the fourth quarter of 1988. At the airport level, however, they confirm the relationship between airport dominance and higher fares, which they suspect is due to the scarce airport facilities, irrevocable advertising and promotional expenditures, and airline's ownership of computer reservation systems. Overall, this study provides original insight that airport dominance and route dominance may not always be consistent when it comes to the influence of market share on airfares.

[18] Ibid.
[19] They acknowledged two limitations of using fixed effects specification. First, market share is potentially correlated with the random error. This problem was corrected by using intra-route rank as the instrument for market share. The second problem lies in their inability to detect the variation within route. They estimated a random effects model to correct the second deficiency. As their data set contained unbalanced panels, they followed a procedure suggested in Greene (1990, 501).

Stavins (2000) yet examined the effect of market concentration from a different perspective: price discrimination. It is theoretically hypothesized that price discrimination increases with competition in the airline industry.[20] She concluded that price discrimination strategies employed by airlines such as Saturday stay-over and advanced-purchase discounts were associated with lower fares, albeit smaller on routes with higher market concentration, by estimating a cross section data of 5804 tickets offered for flights on 12 routes. Using a reduced form regression, Stavins showed that adding a Saturday stay-over requirement reduced the average fare by $211.17, while increasing the advance-purchase requirement by a day resulted in another $6.04 drop in the ticket price.

Overall, economists' attitude toward the relationship between market dominance and pricing power can be summarized as ambivalent. One the one hand, economists and policy makers are wary of the potential danger of collusion and trust in highly concentrated markets,[21] which may be used immorally, if not unjustly, to create entry barriers or conduct predatory pricing. In particular, economists are concerned that the potential hazards maybe amplified by other structural and managerial strategies such as mergers, hubbing, and code-sharing. On the other hand, researchers are not unaware of the benefits of market concentration in the airline industry, which is primarily reflected by cost saving and more efficient operations. Hubbing, for example, enables the mapping of more extensive and more sophisticated networks that were previously unavailable. It also economizes the fixed (physical equipment and corresponding

[20] Borenstein (1985), Holmes (1989), and Gale (1993).
[21] Markets can be defined as routes or markets, depending on the specific article. I will nonetheless treat "market" as city pairs, or routes, throughout my own analysis in this paper. It should be noted, however, that results may vary depending on whether to interpret "market dominance" as airport dominance or route dominance, as suggested by Evans and Kessides.

facilities) and variable (fuel, supplies, and labor)[22] costs for carriers at their hub airports. Although the cost benefits may not necessarily spillover to customers, economists concede that total surplus may still increase in the form of profits as a result of higher market concentration.

III. Conceptual Model and Estimation Procedure

For my analysis, I use two econometric techniques to deal with my panel data. The first one is a Hausman-Taylor method; while the second one is a random effects method. As shown in the Estimation Results section, the coefficients and corresponding significance levels are quite consistent throughout these two methods. However, Hausman-Taylor is theoretically and empirically superior to the plain random effects model. First proposed by Hausman and Taylor in 1981, Hausman-Taylor method marks a major improvement in estimating panel data because it captures the "unobservable individual effects" by distinguishing time varying and time invariant variables, as well as exogenous and endogenous variables.

My conceptual equation can be written as

$$\begin{aligned} AvgFare = {} & \alpha_1 Time + \alpha_2 FuelCost + \beta_1 Passengers + \beta_2 MktShrLgestCar \\ & + \beta_3 MktShrLowCar + \beta_4 PDLowCar + \beta_5 PDLgestCar + \gamma_1 Distance \\ & + \gamma_2 Hub + \delta_1 GatesRatio + \delta_2 LongHaul + \delta_3 LCC \end{aligned}$$

i. Dependent Variable

In my hypothetical model, the dependent variable is the overall average fare in each market. Here, markets are defined narrowly as city pairs, with each endpoint airport represented

[22] Labor includes flying operations labor, passenger service labor, aircraft traffic and servicing labor, promotions and sales labor, and maintenance labor. See Banker and Johnson (1993), 578.

by a unique ten-digit city code.[23] Note that each market in this paper is aggregated of all airlines that serve that route. In other words, for the same routes which might be served by multiple airlines, I do not distinguish among airlines. However, airline specific characteristics may still be reflected by including price difference between overall fare and that charged by the largest (dominant) carrier and that charged by low fare carrier on each route, as explained in more details later. While some studies used natural logs to measure ticket prices (Lichtenberg and Kim, 1989, Kim and Singal, 1993, Singal 1996, Morrison, 2000), I decide to use untransformed prices, because otherwise I will have to face a dilemma where I take natural log of overall fare but not of price differences, as price differences can be positive or negative.

ii. Time Varying Exogenous Variables

Time varying exogenous variables include time (from 1 to 14) and fuel cost in my specifications. That is, while these variables may vary spontaneously as time changes, they are unlikely to be affected by perturbations in airfares.

Fuel cost and labor cost, as the major constituents of variable cost in the aviation industry, are theoretically hypothesized to be closely associated with ticket prices. Furthermore, understanding variable cost is crucial in determining the nature of the pricing strategies, because under profit maximizing conditions, airlines should charge a price that is at least as high as their average variable cost.

Unfortunately, my data for cost variables are far from ideal. In fact, I only have quarterly industry level data, which aggregate over all airlines that operate during that time period. Therefore, my data for fuel and labor cost are essentially nominal variables with fourteen levels,

[23] For example, Chicago O'Hare to Detroit Wayne County is denoted as 30977-31295.

one for each quarter, that would eventually perform like the time variable. In the end, I decide not to include labor cost because it causes severe multicollinearity problem. While I do not exclude fuel cost altogether, the coefficient of its estimate should be treated with great caution. Having said that, I expect fuel cost to have a positive sign, due to the remarkable inflation in fuel price over the past several years. I should also note that although fuel consumption exhibits a cyclical pattern, which usually peaks in summer seasons, the general trend is that it has increased considerably over the last few years.[24] This, combined with sharp rise in average oil price, contributes to an industry wide rising devotion to fuel spending for all airlines.

iii. Time Varying Endogenous Variables

Time varying endogenous variables include the number of passengers, the largest carrier's market share on that route (*MktShrLgestCar*), the price difference between overall market fare and that charged by the largest carrier (*PDLgestCar*), the low fare carrier's market share (*MktShrLowCar*), and the price difference between market fare and that charged by the low fare carrier (*PDLowCar*). These variables and the overall market fare level can influence each other reciprocally as time varies.

Passengers can theoretically have a positive or negative coefficient. The ambivalence in its sign derives from the twofold effect it poses on airfares. On the one hand, more passengers tend to drive up airfares because the demand is higher. On the other hand, however, more passengers make economies of scales possible (Winston 1998), which tend to lower the fares. Therefore, the direction of *Passenger* variable cannot be determined unequivocally *a priori*. In my model, I simply used the aggregate number of passengers on a particular route. However,

[24] The fuel cost was $1.74 per gallon in the first quarter of 2009. Now, it is around $3 per gallon. That is, it has inflated 72.4% over the time span of fourteen quarters.

according to some empirical literature (Butler and Huston, 1989, Brueckner, Dyer, and Spiller, 1992, Morrison, 2000, Meyer and Menzies, 2000), airlines use ticket restrictions to differentiate business travelers from pleasure travelers in order to price discriminate business travelers by charging them higher fares.

The market share of the largest carrier (*MktShrLgestCar*) is an important indicator of market dominance, according to Borenstein's analyses. It is expected that higher market dominance, as reflected by the market share of the largest carrier on that route, leads to higher average fares. However, as Evans and Kessides have shown, it is also possible, at least empirically, to have a negative coefficient for market share.

A parallel to the market share of the largest carrier is that of a low fare carrier. As indicated by numerous studies, the participation of low fare carriers in a market can significantly instigate the level of competition, and thus influence the market overall price level. However, as low fare carrier becomes increasingly dominant in a market, it has the opportunity to exercise its market power and thus behave more like a normal dominant firm. Therefore, its expected sign can be ambiguous prior to the estimate.

The price differences between overall average fare and that charged by the largest carrier (*PDLgestCar*) and low fare carrier (*PDLowCar*) on each route may also provide critical insights regarding the changes in airfares. I use price differences to avoid potential multicollinearity problems with overall fares. It is expected that the price difference between overall fare and low fare to be positive; while that between overall fare and largest carrier fare to be either positive (if the market is dominated by low cost carriers) or negative (if dominated by major airlines).

iv. Time Invariant Exogenous Variables

Time invariant exogenous variables refer to those that are exogenous to the airfares and will not change as time goes on. In my conceptual model, *Distance* and *Hub* (dummy) are the two major time invariant exogenous variables.

Distance is defined as the nonstop mileage from the origin airport to the destination airport. It is expected that *Distance* will have a positive effect on price. However, the elasticity should be less than one, since the airline's cost of transporting a passenger increase less than linearly with distance of the trip.[25] It should be noted that the great influence, or predictability, of distance on price makes it a "banal" variable, according to Cattan (1995), because it somehow clouds the impact of more interesting factors.

I also include a hub dummy variable (*Hub*) that is based on the market share of the largest carrier. This hub dummy is defined as follow: if the market share of the largest carrier on a route exceeds 50%, then at least one of the endpoints can be viewed as a hub airport for that carrier. The rationale behind such definition is that an airline can hardly take the majority (50%) of the market share unless it has hub at one or both endpoints. This dummy variable might shed some light on the effects of hubbing.

v. Time Invariant Endogenous Variables

Lastly, time invariant endogenous variables include *GatesRatio*, *LCC*, and *LongHaul*. While these variables are not likely to change over time, they are considered endogenous because they are theoretically hypothesized to interact with overall market fares.

[25] Borenstein, 349.

GatesRatio indicates the percentage of the boarding gates owned by the singular dominant airline at the endpoint airport. It is a direct proxy of market concentration that causes imperfect contestability by imposing entry barrier at an endpoint airport, as indicated by Baumol, et al. in their market contestability theory. Moreover, measuring only the ratio of boarding gates owned by the top firm is meaningful, because, according to Borenstein, the market power that the dominant airline enjoys is hardly shared by other non-dominant major carriers operating at the same airports. Notwithstanding the ability to exploit pricing power, higher gates ratio may also indicate more efficient operation because it economizes equipment usage and flight connections. Consequently, the sign of this coefficient cannot be predicted with certainty in advance.

In addition, I included a dummy variable called *LongHaul*, which equals 1 when distance is above 500 miles and 0 otherwise. According to Signal (1996), long trips that exceed 500 miles exhibit qualitatively different cost and profit structures from short trips. In addition, trips that are over 500 miles become less substitutable for other modes of transportation. Therefore, *LongHaul* has an expected positive sign primarily due to its decreased substitutability.

I also use a *LCC* dummy to indicate whether a market is dominated by low cost carrier.[26] It equals 1 when the majority of the market share is occupied by a low cost carrier and 0 otherwise. *LCC*, as suggested by its name, is expected to be negative, because heavy participation of low cost carrier should drive down the overall market price. However, when the market becomes overly-concentrated, low cost carrier may behave like a normal carrier that would exploit its market power to charge mark-up prices whenever possible.

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[26] A list of low cost carriers includes AirTran, Allegiant, Frontier, JetBlue, Southwest, Spirit, Sun County, Virgin American, and Vision.

IV. Data

I was able to collect quarterly data for airfares, passengers, distances, and market dominance variables from 1st Quarter, 2005 to 2nd Quarter 2012, from *Domestic Airline Consumer Airfare Report* on the Department of Transportation (DOT) website. Based on the original dataset, I calculated the difference between overall market price level and that charged by the dominant firm and low fare carrier to get price difference variables. Dummy variables such as *Hub*, *LCC*, and *LongHaul* were obtained using procedures described in the previous section. I was able to get the number of gates owned by each airline at the airport level from Research and Innovative Technology Administration: Bureau of Transportation Statistics (RITA: BTS) website. I then divide the number of gates owned by the dominant carrier at each airport by the total number of boarding gates to obtain *GatesRatio* (percentage) data.

As I have discussed in the previous section, my data are far from perfect measurements. For example, it is hard to imagine that airport dominance and market concentration can be fully captured by market shares of carriers and the ratio of boarding gates owned by the dominant airline alone. Furthermore, economists have disputes regarding optimal measurements of these above mentioned variables. While some studies used CR4 or the Herfindahl–Hirschman Index to measure market concentration (HHI, $\sum_{i=1}^{N} s_i^2$), I instead use the market share of the top carrier in that market, following the non-spill-over theory suggested by Borenstein.

In addition, my measurement of *FuelCost* is in particular unsatisfactory. My data for fuel cost is essentially a nominal variable, aggregated over all airlines, with multiple levels, which does not reflect fluctuations in oil prices of any individual carrier in a given season. While the estimate of *FuelCost* may bear economic significance, the result should be interpreted with caution. It would be ideal, I think, to have fuel cost and labor cost of each airline for any particular route.

V. Estimate Results

The results from Hausman-Taylor method and random effects are summarized in Table 1 and Table 2 respectively.

Table 1. Hausman-Taylor results

AvgFare	Coefficient	Standard Error	z	P>|z|
TV exogenous				
Time	2.955271 ***	.0872071	33.89	0.000
FuelCost	.0011313 ***	.0001346	8.40	0.000
TV endogenous				
Passengers	-.0090032 ***	.0007929	-11.35	0.000
MktShrLgestCar	.0972915 ***	.0270071	3.60	0.000
MktShrLowCar	.0275621 ***	.0080134	3.44	0.001
PDLgestCar	-.1348637 ***	.0111536	-12.09	0.000
PDLowCar	.2524802 ***	.0090991	27.75	0.000
TI exogenous				
Distance	.0378142 ***	.0057204	6.61	0.000
Hub	-1.964001 ***	.5841256	-3.36	0.001
TI endogenous				

GatesRatio	-.9889892	.7874602	-1.26	0.209
LongHaul	32.20562 **	13.35171	2.41	0.016
LCC	-9.878329	.7335317	1.35	0.178
Constant	102.28202 ***	8.683186	11.20	0.000
N	14003			
Wald Chi^2	9441.55			
Prob > Chi^2	0.000			
Note: TV refers to time varying; TI refers to time invariant.				
* Significant at 10% level				
** Significant at 5% level				
*** Significant at 1% level				

Table 2. Random effects results

AvgFare	Coefficient	Standard Error	z	P>lzl
Time	2.837197 ***	.1005402	28.22	0.000
FuelCost	.0014283 ***	.0001517	9.41	0.000
Passengers	-.0055426 ***	.0004793	-11.56	0.000
MktShrLgestCar	.0535986 **	.0252529	2.12	0.034
MktShrLowCar	-.0019682	.008976	-0.22	0.826
PDLgestCar	-.1274802 ***	.0122401	-10.41	0.000
PDLowCar	.3092236 ***	.0100489	30.77	0.000
Distance	.0459135 ***	.0010838	42.36	0.000

Hub	-.6480759	.6505689	-1.00	0.319
GatesRatio	-.4519486	.9051566	-0.50	0.618
LongHaul	6.290918 **	1.688702	3.73	0.016
LCC	-10.53044 ***	.705899	-14.92	0.000
Constant	105.571 ***	2.391795	44.14	0.000
N	14003			
Wald Chi^2	12197.24			
Prob > Chi^2	0.000			
R^2 Within	0.3876			
Between	0.6066			
Overall	0.5926			
* Significant at 10% level				
** Significant at 5% level				
*** Significant at 1% level				

If we juxtapose the results from these two methods, it is clear that the coefficients across two models are quite similar, and they are both consistent with the theory. Only one variable (*MktShrLowCar*) switches sign, and the magnitude of most variables across these two models are fairly close. In addition, both models seem reasonable fit overall, because the Wald Chi^2 values are high. While it may be difficult to distinguish between these two alternative models, Hausman-Taylor is theoretically sounder than random effects model, because Hausman-Taylor captures unobservable endogeneity among explanatory variables. In addition, coefficients from Hausman-Taylor model obtain higher z scores and thus lower probability values. Therefore, it also seems that Hausman-Taylor method is statistically more reliable than plain random effects model.

Time has significant positive coefficients throughout two models. Unsurprisingly, due to overall inflation in ticket price over the past several years, time should have a positive impact on overall airfare level. Note however that *Time* should not be interpreted as a continuous variable because it is constituted of fourteen levels and thus has gaps.

FuelCost similarly has significant positive coefficients due to the remarkable increase in oil price in recent years. The coefficients, as discussed in the earlier section, should not be interpreted in the way that we may wish to, because it is, similar to the *Time* variable, a multiple-level variable that has gaps. Thus, we may not conclude that an additional one million dollar devotion to fuel cost would necessarily engender an increase of 0.0014 dollars in average market fare level. However, the overall positive correlation between fuel costs and airfares seems plausible and intuitive.

Passengers obtain negative and statistically significant coefficients in both models. I also calculated the elasticity of *Passengers*. It equals -.0359 under Hausma-Taylor or -.0221 under random effects. That is, a one percent increase in the number of passengers leads to a 3.59% (Hausman-Taylor, or 2.21% for random effects) decrease in overall airfare. The negative sign may suggest that scales exist on the supply side. That is, as more passengers fly on a particular route, carriers may achieve economies of scale, possibly through more efficient aircraft arrangements, and thus reduce overall market airfares. While it is hypothesized that an increase in the number of passengers may lead to market power and ultimately higher fares, the results here suggest that such mark-up prices are offset by more efficient operations.

Market shares of both the dominant carrier and the low fare carrier have positive and statistically significant coefficients, except in the case of *MktShrLowCar* under random effects model, where it is negative (albeit quantitatively close to zero) and statistically insignificant. Overall, it is safe to conclude, I think, that higher market concentration of a carrier will lead to higher fare levels, regardless that being a traditional legacy carrier or a low fare carrier. Specifically, a one percent increase in the market share of the largest carrier leads to a 9.73% increase in market fare; while a one percent increase in the market share of low fare carrier leads to a much lower 2.76% increase (based on Hausman-Taylor estimate; the results from random effects are quite similar). The justification is that when an airline achieves high market dominance power, it will seek to exploit its market power to serve its own interest, even when that carrier is a low cost one. However, as the relative magnitude of the coefficient suggests, low fare carriers will exploit their market power to a less extent.

The coefficients of price difference variables are also consistent with my expectations. As we can see from the table, the price difference between average market fare and that charged by the largest carrier has a negative coefficient; while the price difference between average price and that charged by the low fare carrier has an expected positive coefficient.

Distance has an expected positive sign. The elasticity of *Distance* is either 2.09% (Hausman-Taylor) or 2.54% (random effects), which means a one percent increase in distance leads to an approximately 2% increase in market airfare. This result is not surprising, because longer trips tend to be more expensive, due to the increased fuel cost. In addition, the substitutability of flying decreases as the distance between endpoints increase, which may also drive up the price level. Unsurprisingly, the dummy variable *LongHaul* is also significantly positive, because carriers can exert price discrimination when a trip becomes so long that other means of transportation become uneconomic, inconvenient, or even unavailable at all.

The *Hub* dummy has a negative coefficient in both models, although not statistically significant in the random effects case. This negative coefficient is illuminating, as it suggests that hubbing may actually benefit consumers by decreasing the market-wide fare level. As I have discussed in the literature section, the effect of hubbing remains debatable among economists. Some say that hubbing leads to distorted market power and thus tends to drive up price level; while others contend that hubbing enables carriers to achieve economies of scale and scope, and thus it helps reducing average fare level. My postulation is that both phenomena exist at the same time; however, the operation efficiency effect more than makes up for the pricing power effect. Consequently, the overall price level decrease as a result of hubbing. In other words, travelers may enjoy relatively lower airfares at hub airports than at competitive airports where connections are more inconvenient or even inaccessible.

Similarly, *GatesRatio* also has a negative, albeit non-significant in both models, coefficient, because the proportion of boarding gates owned by an airline also reflects market power on the one hand and operation efficiency on the other. In this case, *GatesRatio* shows that the decrease in airfare caused by the efficiency effect overshadows the increase in average price level due to potential distortion of pricing power. In short, as the dominant airline owns more boarding gates at the endpoint airport, its operation becomes so efficient that it more than compensates its ability to charge mark-up prices. As a result, a one percent increase in the gates ratio owned by the largest carrier reduces airfare by 2.86% (Hausman-Taylor) or 1.31% (random effects).

Lastly, the dummy variable *LCC* also has a negative value. The interpretation of this variable is relatively straightforward: if a market involves heavy participation of a low cost carrier, then the market average price is decreased by about 10 dollars. This result is consistent with theory that low cost carrier instigates the competition on a route level and significantly affects the pricing behavior in a market by lowering the average market price.

In sum, the result from Hausman-Taylor method and that from random effects method are fairly close, and both are theoretically sensible. However, since Hausman-Taylor captures the potential unobservable individual effects, it is a superior estimate to random effects. Having said that, the residual plots of both methods seem slightly problematic due to the potential danger of heteroskedasticity. However, as I do not have a theoretically sound correction method to adjust for the potential problem, I decide to leave the residuals as they were. In addition, the heteroskedasticity, while existent, does not seem, I think, to cause any significant biases or errors in my estimates. The residual plots of Hausman-Taylor estimate and random effects estimate are shown below.

Figure 1. Residual plot (Hausman-Taylor)

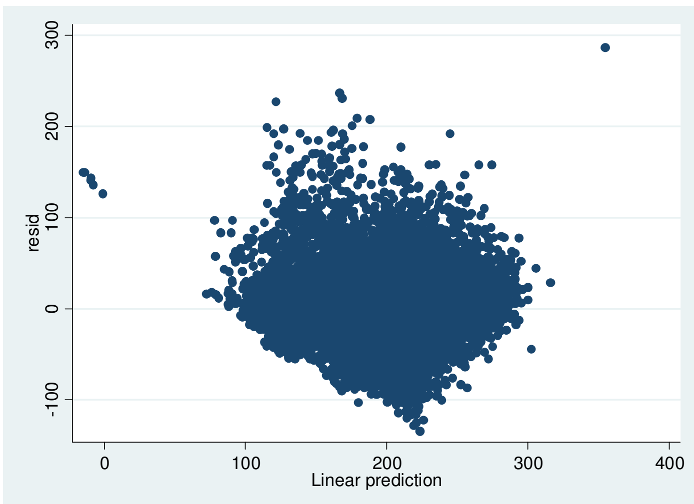
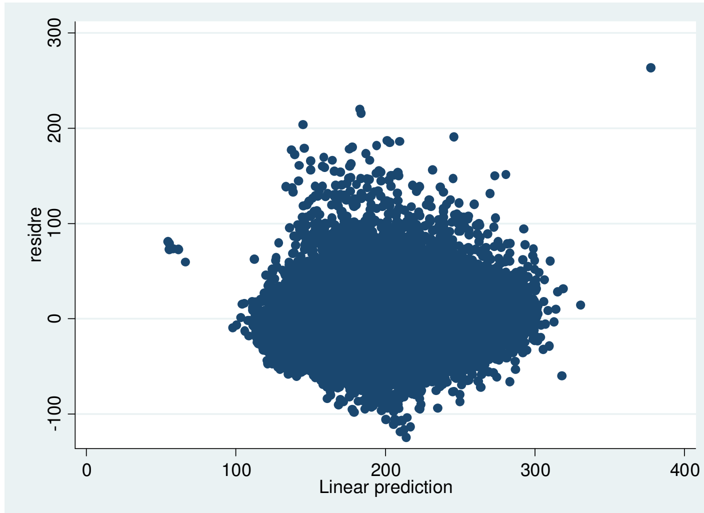


Figure 2. Residual plot (Random effects)



VI. Conclusion

In this paper, I analyzed the relationship between market structure and airfares in the aviation industry. I performed Hausman-Taylor and random effects estimation techniques on quarterly data of the top one thousand most heavily traveled city pairs from 2009 to 2012. In general, the estimate results from both methods are quite close and theoretically plausible, although Hausman-Taylor method produces more coefficients that are statistically significant. Notwithstanding these coefficients, the residual plots of both methods suffer from moderate heteroskedasticity problem. Due to a lack of proper remedies and little concern for biases caused by this potential problem, I did not perform corrections in the end.

In the final analysis, the effects of market concentration in the airline industry cannot be concluded with certainty. On the one hand, I find that higher market concentration, reflected by market share of the dominant carrier, is often associated with increases in average market fare level. On the other hand, however, higher concentration at an airport may also lead to more efficient operation and thus reduce fare level. Although there is no way to separate these two closely connected effects, one plausible explanation may be that while higher concentration at a route level increases ticket prices, it nonetheless reduces average airfare at the airport level. In any case, it is shown that higher market concentration has at least some merits to the consumers, most likely caused by the cost saving due to economic use of airport facilities and efficient operations at hub airports.

For future research, it would be ideal to use more accurate and complete data. For example, collecting fuel and labor cost data for each carrier would be helpful. Also, the study may benefit from including supply and demand characteristics. While *Passengers* may arguably capture some supply and demand characteristics in the airline industry, it is not likely to be an ideal measurement. Finally, future research may incorporate consumer utility indicators such as connecting time, delay time, and service quality. It is postulated that these qualitative factors may also contribute to market airfare levels.

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