

**ESSAYS ON THE RELATIONSHIP OF COMPETITION AND FIRMS'
PRICE RESPONSES**

A Dissertation

by

SUNGBOK LEE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2010

Major Subject: Economics

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Approved by:

Chair of Committee,	Qi Li
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	David A. Bessler
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ABSTRACT

Essays on the Relationship of Competition and Firms' Price Responses.

(December 2010)

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Chair of Advisory Committee: Dr. Qi Li

This dissertation investigates the relationship of competition and firms' price responses, by analyzing: i) whether new entry reduces price discrimination, ii) when incumbents reduce price discrimination preemptively in response to the threat of entry, and iii) how competition increases prices. The dissertation consists of three independent essays addressing each of the above questions. The first two essays present an empirical analysis of the airline industry and the third essay presents a theoretical analysis of the credit card industry.

In the empirical study of the relationship between competition and firms' pricing in the airline industry, I emphasize the importance of distinguishing the equilibrium behaviors with respect to different market characteristics. Major airlines can price discriminate differently in a market where they compete with low-cost carriers comparing to in another market where they don't, and also they can respond differently to the threat of entry depending on whether they are certain about the rival's future entry.

The study reveals that competition has a positive effect on price discrimination in the routes where major airlines compete against one another. In these routes, competition reduces lower-end prices to a greater extent than upper-end prices. In contrast, an entry by low-cost carriers results in a significant negative relationship

between competition and price discrimination. Thus, the opposite results in the literature are both evident in the airline industry, and it is very important to identify the different forces of competition on price discrimination.

Firms can respond to potential competition as well as actual competition. So, I extend the study to the relationship of potential competition and price discrimination, specially in cases where major airlines compete against one another while facing Southwest's threat of entry. I also attempt to suggest major airlines' motives of reducing price discrimination preemptively. The results of the study suggest that incumbents reduce price dispersion when it is possible to deter the rival's entry and that the potential rival discourages incumbents from deterring entry by announcing before its beginning service.

Finally, I examine when competition can increase prices in a market, by analyzing the issuing side of the credit card industry. This industry is characterized by a two-sided market with a platform. Under the no-surcharge rule that restricts merchants to set the same price for cash and card purchases, the equilibrium interchange fee increases with competition. This occurs because issuers can compensate losses from competing on the issuing side by collectively increasing the interchange fee. As a result, limiting competition may improve social welfare when the interchange fee is higher than the social optimal level. In contrast, in the absence of the no-surcharge rule, the analysis shows that competition always improves social welfare by lowering the price of the market.

To my parents,
my love, Sung-ok,
my pride, Chaihyun,
my happiness, Yuhyun

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Dr. Qi Li leads me to be further sophisticated in economics, like his substantial contributions to the literature of nonparametric econometrics. I am planning to extend this parametric study to a non-parametric approach that overcomes lack of knowledge of a functional relationship of competition and firms' pricing. Dr. Stephanie Houghton has given me insightful and professional guidance over the journey. I must thank her more than words. Dr. Silvana Krasteva has taught me what should be done for a theoretical study, step by step. I still have her notes and remind myself of them every time. Dr. David A. Bessler gave one of his lessons that I remind myself of: walk before run. The lesson is beyond economics to me, as he has dedicated himself to much more than economics.

I am deeply indebted to my wife Sung-ok because she gave up her career as a Chinese teacher in high schools and everything that I don't still recognize from her. It is time to dedicate my everything to her until the end of my life, as she has been sacrificing her everything.

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CHAPTER I

INTRODUCTION

How prices are formed in oligopoly markets has been a central issue in the economic discipline. In a monopoly market, a monopolist can (perfectly) price discriminate according to consumers' heterogeneous reservation prices, and so the prices will be larger than or equal to the marginal cost. In a perfectly competitive market, no firms can price discriminate and the price will be the lowest one which is equal to the marginal cost of production. However, markets mostly lie between the two extreme cases, and the relationship between competition and firms' price responses is more complicated.

This dissertation investigates the effects of competition on firms' pricing in oligopoly markets, by asking three specific questions as follow: i) does new entry reduce price discrimination? ii) when do incumbents reduce price discrimination preemptively in response to the threat of entry? and iii) how does competition increase prices? The questions seem to contradict the conventional wisdom that competition always reduces firms' market power in oligopoly markets so that prices fall, but the results of this study enhance the reasoning behind the conventional wisdom of competition.

Intuitively, as competition is intensified, it seems that the degree of price discrimination is decreasing with competition and that the (average) price is also decreasing with competition. Though, there are still debates on the relationship between competition and firm's responses in pricing. For instance, Gerardi and Shapiro (2009) contradict the results of Borenstein and Rose (1994) by showing that competition

This dissertation follows the style and format of *Journal of Political Economy*.

has a negative effect on price dispersion, in line with the textbook treatment of price discrimination.

In Chapter II, I reconcile the opposite results of the literature by recognizing different forces of competition on price dispersion and by showing that both opposite results are empirically evident, depending on the types of competitors in the market. In the airline industry, low-cost carriers has brought lower prices and higher demand over the several decades after the Airline Deregulation Act (1978). In this perspective, it is possible that major airlines price discriminate differently when they compete with low-cost carriers from when they don't. Like Gerardi and Shapiro (2009), the results obtained from pooling all routes suggest that the negative effect of competition on price discrimination exists in all routes regardless of whether major airlines don't compete with low-cost carriers. The positive relationship between competition and price dispersion in Borenstein and Rose obtained from their analysis on the 11 major airlines in 1986. So, I test whether major airlines price discriminate differently depending on whether they don't compete with low-cost carriers.

I find that competition has a positive effect on price dispersion in the routes where major airlines compete against one another, like the findings of Borenstein and Rose. In these routes, major airlines rely on consumers' cross-price elasticities or brand loyalties in their discriminatory pricing when they compete against one another so that a new entry of a major airline reduces lower-end prices much more than higher-end prices. In contrast, competition has a negative effect on price dispersion in the routes where major airlines compete with low-cost carriers, like the findings of Gerardi and Shapiro. The opposite results are evident in the airline industry, which suggests that the different forces of competition must be taken into account in analyzing the relationship of competition and price dispersion.

Firms can respond to potential competition as well as actual competition. Though

a rival has not yet entered a market, its threat of entry may induce incumbents to respond preemptively by cutting prices or increasing investments. The airline industry has been a free-entry (exit) market since the Airline Deregulation Act of 1978. Many studies have investigated whether a potential competitor servicing both endpoints of a route can induce incumbents to cut prices before actual entry. In Chapter III, I also extend the study to the relationship of potential competition and price dispersion, especially in cases where major airlines compete against one another while facing the threat of entry from Southwest airlines, a low-cost carrier.

I also attempt to uncover the reasoning behind major airlines' preemptive reducing in price dispersion. If they reduce price dispersion responding to the rival's threat of entry, what motives drive them to reduce price dispersion preemptively? Goolsbee and Syverson (2008) attempt to find the motives of preemptive responses, but their results obtained from pooling all threatened routes do not clearly identify whether incumbents are responding in order to deter or accommodate entry. If incumbents don't know about the rival's future entry, they may choose to deter or accommodate entry depending on which strategy is more profitable to incumbents. In this case, it is difficult to identify the motives of preemptive responses because the equilibrium strategic response in each route depends on the belief about the rival's future entry and because the beliefs are different across the threatened routes. Therefore, the price cuts in the threatened routes could be seen as intended for either deterring or accommodating entry.

If incumbents' price cuts are motivated by uncertainty about a rival's entry, the rival also has motives to inform its entry earlier and to discourage incumbents from entry deterrence by reducing price dispersion. Then, incumbents' preemptive responses may depend on whether they are informed about the potential rival's entry. The results suggest that incumbents reduce price dispersion in the routes which are

still threatened by Southwest. In these routes, incumbents are uncertain about the rival's entry and believe they can profitably deter that entry, so they persistently reduce price dispersion. In the routes which are once-threatened and entered by Southwest, incumbents do not significantly reduce price dispersion responding to Southwest's presence in both endpoints. These routes are regarded as pre-announced routes so that incumbents are certain about the rival's entry. The overall results suggest that Southwest discourages incumbents from pursuing a strategy of entry deterrence by reducing price dispersion.

Finally, in Chapter IV, I examine when competition can increase the interchange fee in the credit card market, focusing on the issuing side of the market. It is a well-established economic principle that higher levels of competition lead to lower prices. In the credit card industry, empirical evidence indicates that the interchange fee increases with competition. The industry is characterized by a two-sided market with a platform. So, the platform interconnects consumers and merchants by charging the customer fee and the interchange fee, respectively. Under the no-surcharge rule that restricts the merchants to set the same price for cash and card purchases, the consumers are not informed of the interchange fee even though it is partly or fully paid by the consumers. Thus, competition among issuers may not be effective in reducing the interchange fee while lowering the customer fee.

In equilibrium, under the no-surcharge rule, issuers (members of the platform) have a collective interest in setting the interchange fee such that all merchants accept the credit cards. Since the issuers' profits are increasing in the interchange fee, they will set the largest interchange fee resulting in all merchants accepting the cards. Subsequently, the paper shows that the interchange fee increases with competition since issuers can compensate losses from competing on the issuing side by collectively increasing the interchange fee.

I show that limiting competition may increase social welfare. The issuers must be a member of the association to provide its card payment services through the platform, and so the association serves a barrier for entry and exit. That is, even though the privately optimal number of issuers is less than the number of member issuers, no issuers will exit the market as long as their profit is positive. As a result, there will be too many issuers so that the customer fee is too low and the interchange fee is too high. In this case, limiting competition improves social welfare.

If the no-surcharge rule restricts issuers to compete only over the customer fee, lifting the no-surcharge rule may induce the issuers to compete over the total fee including the interchange fee. Without the no-surcharge rule, the total fee of a card payment service paid by the consumers decreases with competition among issuers. If the issuers collectively determine the interchange fee even after the no-surcharge rule is lifted, the privately optimal total fee is greater than the socially optimal level and thus the card payment services are under-provisioned. It suggests that a fee policy must be followed by abolishing the no-surcharge rule in this case.

The rest of the dissertation is organized as follows: Chapter II answers for the first question by examining whether major airlines price discriminate differently when they compete with low-cost carriers from when they don't. Chapter III investigates when firms reduce price dispersion preemptively, by disentangling the incumbents' responses on price dispersion in the routes which are serviced by Southwest later from those in the routes which are still threatened by Southwest. Chapter IV solves a model of the credit card market to investigate how the interchange fee increases with competition. Chapter V provides the conclusion of this study and discusses future works.

CHAPTER II

DOES COMPETITION ALWAYS REDUCE PRICE DISPERSION? NEW ANALYSIS ON DIFFERENT FORCES OF COMPETITION IN THE U.S. AIRLINE INDUSTRY

A. Introduction

Many economists agree that a firm in oligopoly settings can price discriminate when it directly observes consumer heterogeneity or indirectly elicits it.¹ However, they have been still not agreed on whether price discrimination is persistent over increases in competition. For instance, Borenstein and Rose (BR) (1994) and Gerardi and Shapiro (GS) (2009), the two seminal papers in the literature of price dispersion, investigate the relationship between route competition and price dispersion in the U.S. domestic airline industry, but their results are quite opposite on whether competition reduces price dispersion.²

The paper investigates the same question by analyzing different forces of competition in the U.S. domestic airline industry which is not examined in the literature. The different forces of competition are sourced from whether or not major airlines compete with low-cost carriers. The empirical results suggest that the findings of the two studies are not contradictory, but both are evident in the airline industry.

The literature has mostly agreed with BR's finding that competition has a positive effect on price dispersion. Borenstein (1985) and Holmes (1989), in each independent theoretical paper, find that "segmenting consumers on the basis of their

¹See Stole (2008) which discusses the relationship of price discrimination and competition in depth.

²Price dispersion may not imply price discrimination if the dispersion is only because of cost differentials across consumers. The literature widely uses the term of dispersion instead of discrimination.

cross-elasticity of demand among brands typically will produce greater price dispersion if the market is more competitive.”³ Intuitively, as more firms enter the market, firms compete on consumers who are relatively cross-price elastic. In a symmetric equilibrium, though firms lose market power as the market gets more competitive, it can be shown that the resulting price discrimination can increase with competition.

BR empirically test the hypothesis of a positive effect of competition on price discrimination in a more general setting of Borenstein (1985).⁴ They show that a positive effect of competition on price discrimination is significantly evident in the U.S. airline domestic ticketing market. Subsequently, many economists have tested whether a positive relationship is really evident in the airline industry or in other price-discriminating industries. Busse and Rysman (2005) investigate yellow pages advertising and Leslie (2004) did Broadway theater, and their findings are generally consistent with BR’s findings

On the other hand, Lott and Roberts (1991) argue that observed price dispersion may simply involve unrecognized cost variations, not generated from discriminatory pricing. BR partly control for cost variations by considering systematic peak-load pricing, which is not enough to control for all other cost variations from stochastic peak-load pricing. Hayes and Ross (1998) support the argument of Lott and Roberts (1991) by showing that “price dispersion in the domestic airline industry is mostly related to peak-load pricing and the fare wars.”⁵

³See Borenstein and Rose (1994): This type of discrimination is referred to “competitive-type” discrimination since firms depend on consumers’ heterogeneous cross-price elasticities or brand loyalties. If firms rely on consumers’ reservation prices, it is called as “monopoly-type” discrimination.

⁴The model considers multi-brand firms in order to fit the context of the domestic airline industry where a brand stands for a flight in a route. Thus, it allows asymmetric number of flights between firms.

⁵The fare wars were known to be related to financial difficulties of the early 1990. Their sample includes fifteen carriers on 973 routes where runs for top 100 airports.

Meanwhile, Stavins (2001) controls for cost variables by using the information of Saturday-night stay-over and advance-purchase discounts.⁶ These restrictions may have some effects on airlines' cost which may not vary with the different degree of competition. They find that "both restrictions are associated with lower fares, but the discount decreases somewhat with market concentration."

However, GS find that "competition has a negative effect on price dispersion, in line with the textbook treatment of price discrimination" and also suggest that BR's opposite finding from using cross-sectional data of 1986:Q2 could be reconciled "by showing that the cross-sectional estimator suffers from omitted variable bias." They use panel data having 55 quarters from 1993:Q1 to 2006:Q3 which make it possible to control for carrier-route-specific effects.⁷ If carrier-route-specific effects are time-invariant and correlated to route competition, omitting them could result in a (asymptotically) biased estimate from the regression. They show that plane size is a possible omitted variable which is related to one of instrumental variables, route distance, but the inclusion of plane size is not enough to correct other possible omitted variable biases.⁸ As a result, they suggest that the fixed-effects panel estimation method is appropriate to control for all other unobservable omitted variables and to analyze the relationship of competition and price dispersion.

One thing common in Hayes and Ross (1998) and GS is that they include low-cost

The list of 6 non-major carriers is as follows: Aloha Airlines, Hawaiian Airlines, Southwest Airlines, Trump Shuttle, Midwest Express, and Air Wisconsin.

⁶His sample includes 5,804 observations offered by 11 airlines on twelve routes on the same day, September 28, 1995.

⁷GS's cross-sectional estimates are generally consistent with BR's results, which suggests that the different time period does not explain the opposite results.

⁸In my replications of GS's cross-sectional estimations, 23 positive estimates are reversed into negative and mostly insignificant estimates after including plane size. 22 significant positive estimates are still positive but become insignificant after including plane size.

carriers (LCCs) in their analyses, which is different from BR. BR address that they restrict the analysis to the 11 major U.S. airlines in 1986 to enhance comparability across airlines. So, their sample would include routes where major airlines compete against one another.⁹ Also, their selection of the 11 major airlines is in line with the theoretical assumptions of Borenstein (1985) and Holmes (1989).¹⁰

On the other hand, GS intentionally include LCCs “because of the important role that they have played in the airline industry” over the period of the sample. If LCCs enter and compete with major airlines in all routes, the results obtained from pooling all routes are treated as evidence for all routes. Though the route penetration of LCCs has been increasing over time, there are still routes served by only major airlines which are similar to the routes selected by BR. Thus, it is questionable whether competition has a negative effect on price dispersion in BR’s selected routes, which is not separately investigated in GS.

It is theoretically possible that major airlines price discriminate differently when they compete with LCCs from when they don’t. In the context of Borenstein (1985) and Holmes (1989), consumers may be more likely to switch to LCCs if they are able to buy a ticket at a lower fare. That is, in a route where major airlines and LCCs take off flights together, consumers may gain greater benefits by switching from major airlines to LCCs. On the other hand, in a route where only major airlines provide services, consumers have no theoretical benefits from switching airlines. As a result, major airlines’ discriminatory pricing may be limited by entries of LCCs.

⁹They selected the 1,201 largest airport-pair routes which more than 80 percent of the passengers traveled without a change of plane in 1986:Q2. And they chose the 11 major airlines so that 521 routes remained in the sample.

¹⁰The increasing price discrimination over competition is predicted at the equilibrium under the assumption that firms are homogeneous in cost. They also assume that firms face symmetric demand functions. Stole (2008) refers these conditions to *best-response symmetry*.

Thus, the results from aggregating all types of routes and carriers in a pool would be inconsistent unless the hypothesis is rejected. GS's data can be classified into three different types of routes: major-carrier routes, mixed-carrier routes, and LCC routes. If major airlines compete against one another in a route, the route is classified into a major-carrier route which is similar to BR's selected routes. Then, it can be tested whether competition also has a negative effect on price dispersion in these major-carrier routes. Also, by comparing the results from major-carrier routes with those from mixed-carrier routes, it can be examined which type of routes major airlines produce greater price dispersion to a greater extent.

Another empirical issue arises from GS's model specification. They follow BR's specification for the cross-sectional analysis as much as possible, and they believe that the specification would not be different across route types. Of course, with the specification, they suggest that the positive omitted variable biases are evident in all routes, showing that the cross-sectional estimates on route competition may be positively biased. If major airlines in mixed-carrier routes treat LCCs as other major airlines, their responses will be consistent with those in major-carrier routes. So, the biases should be observed in both of major-carrier and mixed-carrier routes. However, it is likely that the model for mixed-carrier routes has to be more specified in controlling for asymmetric responses between majors and LCCs than in major-carrier routes. Thus, it is testable whether the omitted variable biases are large enough to reverse the cross-sectional estimate in both types of routes.

Following the previous airline studies and the definition of Department of Transportation (DOT), 8 legacy airlines are classified into major airlines (majors) and the rest of carriers into LCCs. According to carrier types, three types of routes are classified as described above. If the total quarterly market share of LCCs in a route is more than 5 percent, the route is named as a mixed-carrier route. For the panel analysis, a

route is classified into a major-carrier route if the route has never been mixed-carrier or LCC routes during the sample period. LCC routes are also classified in the same way. And all other transitional routes which have ever been changed into other types of routes are treated as mixed-carrier routes.

By introducing the market classification, competition has a positive effect on price dispersion in major-carrier routes. The results hold in other similar market classifications. Though the cross-sectional estimators suffer from omitted variable biases found by Gerardi and Shapiro, the biases are not large enough to reverse the positive relationship in the major-carrier routes. It is in the mixed-carrier routes that the omitted variable biases evidently reverse the negative estimated effect of competition on price dispersion into the positive. This suggest that GS's findings explain a part of industry, the mixed-carrier routes, and the inclusion of LCCs without the market classification may mislead to the result that the negative effect of competition on price dispersion is prevalent in all routes.

Furthermore, majors in the major-carrier routes compete on consumers with higher cross-price elasticities while LCCs compete on consumers with high reservation prices. Thus, in the mixed-carrier routes where both types of carrier compete together, competition reduces higher-end prices much greater than lower-end prices. In line with these findings, the empirical results consistently suggest that majors in the major-carrier routes are price discriminating more than in the mixed-carrier routes.

The remainder of the paper is organized as follows: Subsection B describes how the data are subsampled to reflect the different forces of competition on price dispersion according to the types of route, and discusses empirical specifications. Subsection C reports all results of estimations. Finally, in Subsection D, the primary findings are summarized and the limits of the paper are discussed.

B. Data and Market Classification

The domestic airline industry has evolved through the emergence of LCCs. Even in the second quarter of 1986, LCCs were threats to major full-service airlines. However, at that time, the effect of LCCs would not be very significant on the pricing of major full-service airlines. In the record, LCCs account for about 10 percent of passengers in 1990, but they account for 30 percent of passengers in 2009. The drastic increases in the LCCs' total market share in the domestic market must have been reflected in the pricing of majors. If LCCs are prevalent in all routes, it is not necessary to classify route types for distinguishing different forces of competition on price dispersion. However, there are still about one fifth of routes where LCCs do not provide direct flights in 2006:Q3. Thus, it is testable whether majors price discriminate differently when they compete with LCCs from when they don't.

The recent data set processed by GS is used in the analysis, which are generated from the DB1B and T-100 domestic direct segments. The DB1B data are a 10 percent random sample of all domestic tickets, and the T-100 data contain ticket information on domestic nonstop flights. GS's sample covers domestic, direct, directional, and coach-class airline tickets over the period of 1993:Q1 - 2006:Q3.¹¹ The recent data are not included to keep the consistency of the data.¹² Some variables are added for defining route types and for applying BR's sample criteria to GS's sample.¹³

¹¹GS addressed the issue of double counting since a route is defined as a directional trip and any round-trip would count twice. For instance, a round-trip fare from Phoenix to Philadelphia would appear twice as PHX-PHL and also as PHL-PHX. They decide to drop one of the directions since double counting would have no effect on the consistency of estimates but would increase the size of the standard errors. Meanwhile, I revise GS's dummy variable for dropping one direction of routes in order to correct some misclassified observations.

¹²The most recent DB1B and T-100 data are released at <http://www.transtats.bts.gov>.

¹³Thank Gerardi and Shapiro for privately providing their data-processing STATA

1. *Carrier Type*

It is well-known that there are three types of carriers in the U.S. domestic airline industry: major, low-cost, and regional airlines.¹⁴ Regional airlines are treated as LCCs and code-sharing flights of regional airlines are dropped in the sample. For analyzing the different effects of competition on price dispersion according to competitors' carrier types, full-service network airlines are classified into major airlines in that they are distinguishable from LCCs in terms of cost structure. Currently, 8 airlines are listed as full-service network airlines by the DOT: American, Continental, Delta, Northwest, United, USAir, TWA, and Alaska. These airlines are also called by legacy airlines in that they existed prior to the Airline Deregulation Act (1978) (ADA) and are burdened by 'legacy' fleets, relatively expensive labor contracts, and organizational structures.

LCCs are different from majors in that they are characterized by a single passenger class, standardized aircraft utilization, limited in-flight services, use of smaller and less expensive airports, and lower employee wages and benefits. GS list 9 majors including America West in their analysis, but I decide to exclude America West in the list of majors. It was established in 1981 after the ADA, and it has been also classified as a LCC by the DOT before merging into USAir in 2006.¹⁵ Thus, America

and Matlab codes. The variables for market classification and sampling criteria are generated by using the codes of GS.

¹⁴The term of 'major' is not adequate in the classification of carrier types since it does not explain differences across carrier types. For instance, Southwest is not only a well-known LCC but also a major airline by the DOT definition. If an airline's operating revenue is over \$1 million in a fiscal year, it is classified as a major airline by the DOT.

¹⁵Meanwhile, the DOT defined America West as a network airline in 1997 despite the fact that it has a lower operating expense per seat mile than at least 3 LCCs: Airtran Airways, Western Pacific, and Vangaurd. See Reynolds-Feighan (2001) for more details. Also, Goolsbee and Syverson (2008) don't include America West as a major airline in their analysis of 1993:Q1 - 2004:Q4.

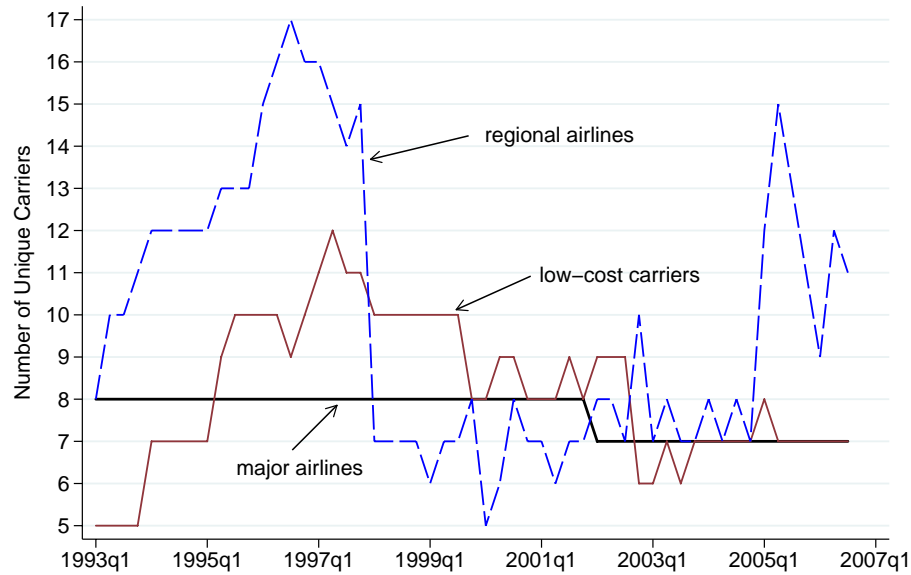


FIG. 1.— Trends of Carrier Types

West is counted as one of LCCs.¹⁶

During the period of 1993:Q1 - 2006:Q3, more than 200 carriers are uniquely observed after the DB1B data are filtered into direct flights. 8 major, 19 low-cost, and 38 regional airlines remain in the final data set that merged While the filtered DB1B data and the T-100 data. One of the reasons is because a direct flight in the DB1B data would not be recorded in the T-100 data.¹⁷ Figure 1 indicates the trends of carrier types over the period. Though 19 LCCs were recorded in the sample, at average 9 LCCs take off direct flights during the period. About 12 - 16 regional airlines operated in direct routes before 1998:Q1, and then, around 7 regional airlines had operated in direct routes until 2005:Q1. The introduction of ‘regional jet’ in 1997 contributed to reducing regional airlines’ direct flights and increasing code-sharing

¹⁶See Ito and Lee (2003) for the detailed list of LCCs.

¹⁷See Goolsbee and Syverson (2008)

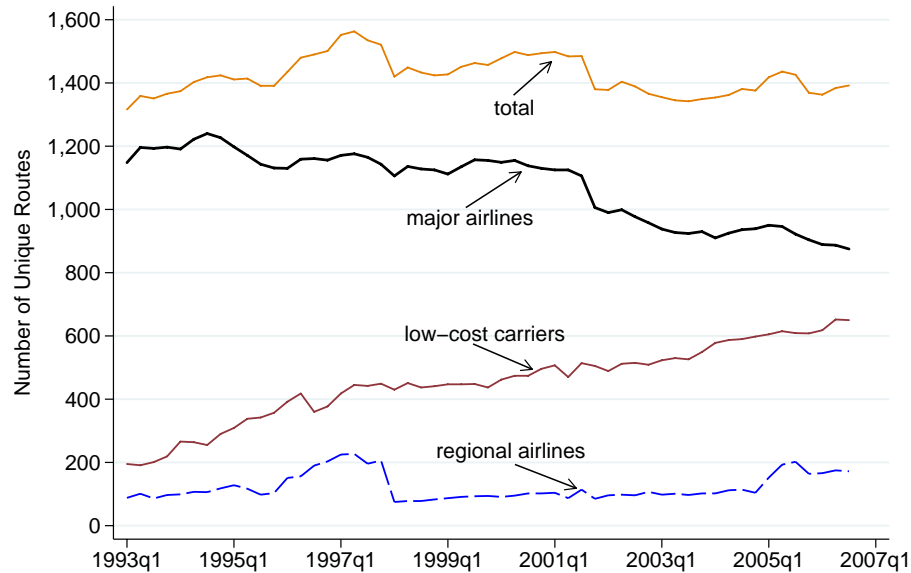


FIG. 2.— LCC's Route Penetration

flights to serve the hubs of majors. Around 11 regional airlines have provided direct services from 2005:Q1.

The number of routes serviced by LCCs has been tripled by about 455 routes over the period while the route number by majors has decreased by about 365 routes. Figure 2 indicates how many routes have been penetrated by LCCs, and that the trend of LCCs' route penetration seems to keep increasing.¹⁸

2. Route Type

According to carrier types, the types of routes are classified corresponding to possible different forces of competition on incumbents. The different forces of competition on incumbents may depend on whether carriers in a route compete with the same type of carriers or not. For the cross-sectional estimations, if the quarterly market share

¹⁸Without losing data from merging the DB1B and T-100 data, the decreasing trend of routes served by majors is more downward-sloping.

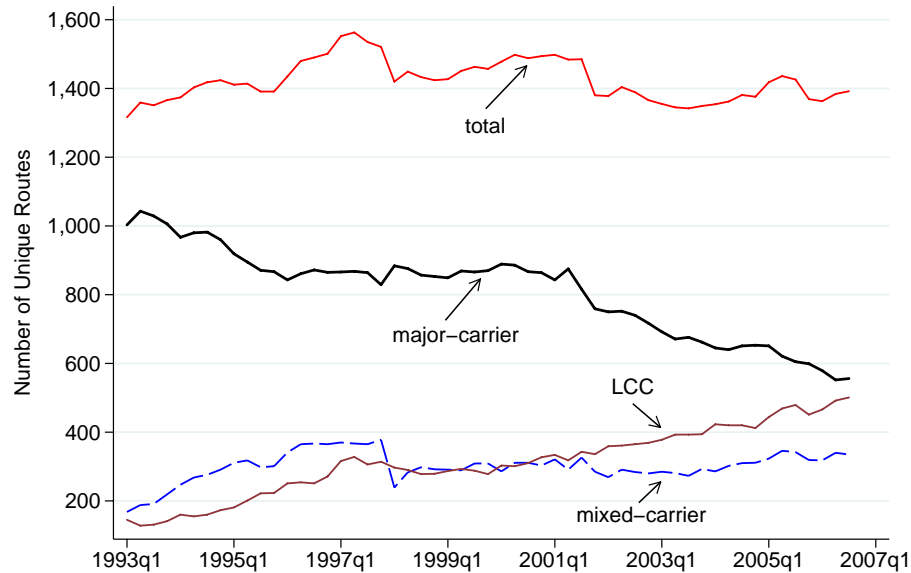


FIG. 3.— Quarterly Trends of Airport-Pair Route Types

of LCCs is less than 5 percent in a route, majors must be competing against one another. The route is classified into a major-carrier route. If the quarterly market share of majors is less than 5 percent in a route, LCCs must be competing against one another. The route is called into a low-cost-carrier (LCC) route. If a route does not meet the above two criteria, the route is classified into a mixed-carrier route.¹⁹

Figure 3 shows that the number of major-carrier routes has been decreasing from 1,029 route in 1993:Q2 to 556 routes in 2006:Q3 whereas the number of mixed-carrier routes has been increasing by 167 routes. Also, the number of LCC routes has been

¹⁹The 10 percent cutoff is examined since there is no rule of thumb for the cutoff of market share. The cutoff of the market share is consistent with the findings of the DOT (1996) in some sense. It analyzes the entry effects of LCCs on Delta's ticket prices in Salt Lake City and Atlanta routes. Delta's fares fell 33 percent where it competes with Morris Air but did not either rise or fall on routes where Morris Air did not compete in Salt Lake City routes. On the other hand, Delta's fares changed only modestly after ValueJet entries in Salt Lake City routes. The only difference is that ValueJet achieved relatively lower market share in Atlanta routes than Morris did in Salt Lake City routes.

TABLE I
QUARTERLY AND OVER-THE-PERIOD TYPES OF ROUTES
(NUMBER OF UNIQUE ROUTES)

	$0 \leftrightarrow 0$	$1 \leftrightarrow 1$	$2 \leftrightarrow 2$	$0 \leftrightarrow 1$	$0 \leftrightarrow 2$	$1 \leftrightarrow 2$	$0 \leftrightarrow 1 \leftrightarrow 2$
major-carrier (0)	498	0	0	659	69	0	362
mixed-carrier (1)	0	32	0	583	0	112	507
LCC (2)	0	0	249	0	149	134	532

increasing by 356 routes, which is more than the increase in the number of mixed-carrier routes during the same period. One of possible reasons is because majors tend to discontinue their direct flights when LCCs begin direct services.

Since the panel data is also analyzed in the paper, the three types of routes are also defined for the panel analysis. If a route has never been mixed-carrier or LCC routes, the route is named as a major-carrier route. Also, a route is named as a LCC route if the route has never been major-carrier or mixed-carrier routes. If a route does not meet both criteria, the route is classified as a mixed-carrier route.

Table I summarizes the seven transitions of rout types over the period. In the routes of $0 \leftrightarrow 2$, majors tend to discontinue direct flights when LCCs like SouthWest, JetBlue, Airtran Airways, and Frontier start to provide direct flights. In the routes of $1 \leftrightarrow 2$ as well as $0 \leftrightarrow 1 \leftrightarrow 2$, majors such as Continental, Delta, American, and Northwest have discontinued or reduced direct flights over time.

The direct-passenger ratio in a route is also considered for sampling the data. Considering that at least one-stop flights could be close substitutes to non-stop flights, the direct-passenger ratio would indirectly control for the effects of indirect flights. BR selected routes which more than 80 percent of the passengers traveled without a change of plane in the 1,201 largest airport-pair markets. The same criterion is applied in selecting routes for the cross-sectional analysis by using the DB1B data.

In the panel analysis, a route is dropped if the average ratio of direct passengers in the route is less than 75 percent over the period.

Finally, a market is defined by airport-pair endpoints to enhance comparability across studies. A market could be defined by city-pair since LCCs tend to enter into smaller airports in multi-airports areas. Then, the city-pair route could measure the degree of competition more exactly while airport-specific variables may be diluted. To consider the effect of defining a route by city-pair, the numbers of each type of firms are counted by city-pair as a way of measuring the degree of competition.²⁰ As a result, 111,098 carrier-route observations remain in the final sample. It covers 2,558 unique airport-pair routes.

C. Empirical Analysis

1. Model Specifications

1.1. Cross-Section

The model for cross-sectional estimations follows GS's cross-sectional specification. The Gini log-odds ratio given by $G^{lodd} = \ln G / (1 - G)$ is a measure for price dispersion.²¹

²⁰Interestingly, majors service multiple airports in most of the 10 Metropolitan areas, and LCCs also tend to service multiple airports in those areas if possible. The 10 metropolitan areas are used in defining city-pair routes: Chicago(MDW, ORD), Dallas(DFW, DAL), Detroit(DTW, DET), Houston(IAH, HOU), LA(LAX, ONT, BUR, LGB, SNA), Charlotte(CLT, GSP), New York(JFK, LGA, ISP, EWR, HPN), San Francisco(SFO, OAK, SJC), Miami(MIA, FLL) and Washington DC(DCA, IAD, BWI) For instance, Southwest takes off its direct flights in multiple airports of the five Metropolitan areas (Los Angeles, San Francisco, Detroit, Dallas, Houston). Thus, the estimation results may not depend on the alternative market definition.

²¹The Gini-coefficient G follows the calculation of Borenstein and Rose (1994). See Appendix A. The log-odds ratio produces an unbounded statistic whereas the Gini coefficient is bounded between zero and one.

The cross-sectional model is

$$\begin{aligned}
G_{ij}^{lodd} = & \beta_0 - \beta_1 \ln \widehat{HERF}_j + \beta_2 \ln \widehat{MKTSHARE}_{ij} + \beta_3 \ln \widehat{FLTTOT}_j \\
& + \beta_4 \ln TOURIST_j + \beta_5 HUB_{ij} + \beta_6 SMALL_j \\
& + \beta_7 \ln \widehat{ASEATCAP}_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij}
\end{aligned} \tag{2.1}$$

where where i indexes the carrier and j the route.

Like BR and GS, I treat carrier-specific effects α_j as fixed and route-specific effects γ_j as random. The degree of competition on a route is measured by the Herfindahl index, $-\ln HERF_j$. The larger value of $-\ln HERF_j$ indicates the higher competition in a given route. The market share of a given carrier in a route, $\ln MKTSHARE_{ij}$, may explain the effect of the carrier's relative market power on its price dispersion in the route. The market share is measured by the proportion of passengers, and subsequently used in measuring the Herfindahl index.

The variable $FLTTOT$ is the total number of flights on a route. It is included as a proxy for market density. An increase in market density is likely to lower the shadow value of capacity but increase the demand uncertainty for any given flight on the route, resulting in reducing price discrimination.²² $TOURIST$, the maximum of the ratio of accommodation earnings to total non-farm earnings for the origin and destination airports, is included as a proxy for consumer heterogeneity. An increase in $TOURIST$ indicates that consumers are closer to homogeneous ones so that a carrier would lose its discriminatory power. HUB is a dummy variable indicating whether the origin or the destination is a hub airport for the given carrier, which controls for a carrier's hub dominance. $SMALL$ is a dummy variable equal to one if the route

²²In a monopoly route, the predicted effect of market density could be positive on price dispersion if the increased number of flights plays a role of increasing monopoly power to price discriminate.

does not include a big city, which is a proxy of a congested route. However, it should be careful to interpret the coefficient on *SMALL* since the variable *SMALL* may not indicate that big cities are always congested.²³

Finally, as GS show that plane size is one of possible omitted variables in the cross-sectional estimations, $\ln ASEATCAP$ is explicitly included in the model since plane size is one of the determinants of price dispersion and also is related to included variables or instrumental variables. Of course, whether the inclusion of plane size has a similar effect in any type of routes will be examined as one way of looking at the omitted variable problems. $-\ln HERF$, $\ln MKTSHARE$, $\ln FLTTOT$, and $\ln ASEATCAP$ are instrumented by using the same instruments as GS; these include route distance, two versions of mean population, total enplaned passengers, and the other two variables.²⁴ The hats on these variables denote instrumented variables.

Since the three types of routes and two types of carriers are classified, there would be four single cross-sectional estimations: (1) majors in major-carrier routes, (2) majors in mixed-carrier routes, (3) LCCs in mixed-carrier routes, and (4) LCCs in LCC routes. It is usual that joint estimation is asymptotically more efficient than single estimation for each group. However, if there are misspecification problems as GS showed, the joint estimation may increase misspecification biases even in single estimations which are not actually misspecified.²⁵ Furthermore, since carrier-specific and route-specific effects are controlled in the estimations, the four single estimations may be unrelated so that single estimations can be justified.

GS performed the quarterly cross-sectional estimations which implicitly assume

²³BR use the list of 24 congested airports for the variable *SMALL* while GS select 40 big airports

²⁴See Appendix A for more details, and also see Borenstein and Rose (1994) and Gerardi and Shapiro (2009).

²⁵See Hayashi (2000).

that all coefficients are different over time, in order to compare their results to BS's. It is not clear whether the differences across the quarterly estimates come from the industry's structural changes or the differences in quarterly data. If the structural changes are not significant, the estimates would be more consistent if they are obtained from pooling all quarterly data or gradually adding quarterly data at each time. Thus, these three different approaches are examined.²⁶ When the latter two cross-sectional approaches are estimated, the time dummies are included to control for exogenous shocks over the industry.

1.2. Panel

A panel specification can be written like the cross-sectional model (2.1):

$$\begin{aligned} G_{ijt}^{lodd} = & \beta_0 - \beta_1 \ln \widehat{HERF}_{jt} + \beta_2 \ln \widehat{MKTSHARE}_{ijt} + \beta_3 \ln \widehat{FLTTOT}_{jt} \\ & + \beta_4 \ln \widehat{TOURIST}_{jt} + \beta_5 \widehat{HUB}_{ijt} + \beta_6 \widehat{SMALL}_{jt} \\ & + \beta_7 \ln \widehat{ASEATCAP}_{ijt} + \alpha_i + \gamma_j + \varepsilon_{ijt}. \end{aligned} \quad (2.2)$$

The fixed-effects panel specification is driven by within-transforming the equation (2.2). The within transformation results in dropping time-invariant variables, but rarely-changing variables remain so that they may increase the inefficiency of the fixed-effects estimates.²⁷

²⁶For brevity, the results obtained from quarterly and rolling estimations are reported in Appendix B.

²⁷For instance, in a simple univariate regression with a rarely-changing variable X_1 , the asymptotic variance of the fixed-effects estimator can be written as

$$\widehat{Avar}(\hat{\beta}_{FE}) = \sigma_\varepsilon^2 (X_1' M_D X_1)^{-1},$$

where M_D is the matrix that takes deviations from the over-time means \bar{X}_1 . If there is another variable X_2 which is varying over time, the estimate for X_2 will be less efficient than in the estimation dropping the rarely-changing variable X_1 . The within-

The variables $\ln TOURIST$, HUB and $SMALL$ are rarely-changing variables so that they are not included in the panel analysis. Also, the variable $\ln ASEATCAP$ is not included in the panel analysis since the over-time variations of carrier i 's plane size in a given route are mostly attributed to a new introduction of fleet rather than strategic responses to new entries.²⁸

GS exclude the variable $\ln MKTSHARE$ and $\ln FLTTOT$ in the panel analysis since they “do not vary much within a carrier-route observation over time or do not exhibit independent variation from the competition variables.” Simply, these two variables are dropped to keep the comparability across studies.²⁹ The panel model follows GS's specification:

$$G_{ijt}^{lodd} = \beta_0 - \beta_1 \ln \widehat{HERF}_{jt} + \beta_2 Bankrupt_{it} + \tau_t + \nu_{ij} + \varepsilon_{ijt} \quad (2.3)$$

where τ_t indicates time dummies to control for exogenous events on cost variables and cyclical demand effects, and the dummy $Bankrupt$ is to control for carrier-specific events on price dispersion. As GS pointed out, there could be other carrier's unobservable carrier-specific shocks that affect all prices over all of the routes serviced by the carrier. The standard errors are clustered by route to control for serial correlation and correlation across carriers on the same route.

To see if there are omitted variable biases which reverse the sign of the cross-

transformed variables, $M_D X_1$ and $M_D X_2$, are not highly correlated since the variations of X_1 are sourced from the over-time means across individuals while the variations of X_2 are also from the within-transformed values.

²⁸Ito and Lee (2003) found that it is not evident that incumbents are not affected in deciding plane size in a given route by a new entry or the entrant's decision of plane size.

²⁹I also examine what are the effects of dropping or including these two variables in the panel analysis. As a result, it turns out that omitting these variables only slightly affects the estimates for $-\ln \widehat{HERF}$, but increases the efficiency rather than in any combinations. The estimation results are not reported, but they may be provided by request.

sectional estimates on $-\ln HERF$ in each single estimation, four single estimations are also performed in the panel analysis. For a robustness purpose of the panel analysis, the estimates on three different measures for route competition are also compared. The three measures are the Herfindahl index, the total number of carriers, and the number of legacy airlines and LCCs. The first two measures are $-\ln HERF$ and N (total number of carriers) measured by airport-pair route while the last are N^{LEG} (number of majors) and N^{LCC} (number of LCCs) by city-pair route.³⁰

Finally, the price percentile regressions are performed by using the 10th, 20th, 80th and 90th price percentiles as independent variable instead of the log-odds ratio of Gini coefficient:

$$\ln P(k)_{ijt} = \beta_0 - \beta_1 \ln \widehat{HERF}_{jt} + \beta_2 Bankrupt_{it} + \tau_t + \nu_{ij} + \varepsilon_{ijt} \quad (2.4)$$

where $P(k)$ indicates the k th percentile of the prices. The percentile regressions provide information on the effects on the tails of the price distribution rather than on a measure for price dispersion. The Gini log-odds ratio regression does not distinguish the direction of the effects of competition on price dispersion. For instance, a positive estimate on route competition in the Gini log-odds ratio regression could explain differently about the relationship of competition and market power to price discriminate.³¹ That is, the results from the price percentile regressions can be more explaining the behaviors of discriminatory pricing in the airline industry.

³⁰In counting N^{LCC} , regional carriers are not included. Since America West as classified into one of LCCs in the analysis, the numbers of majors and LCCs are a little different from GS's.

³¹A positive estimate on competition may indicate that the higher-end prices increase with competition.

2. *Estimation Results*

The results of using the two different samples respectively chosen by BR and GS are compared to see if the fixed-effects estimates on competition are consistent between the two studies. GS aggregate all routes in a pool while BR select routes where majors would compete against one another. If the negative effect of competition on price dispersion is evident in all routes, the fixed-effects estimate from using major-carrier routes would be negative. If they are not significantly consistent in sign, pooling all types of routes may mislead into believing that the negative relationship between competition and price dispersion founded by GS are evident in all routes.

Assuming that majors are different from LCCs in terms of cost structure, majors may respond differently to competitors' types. If it is not rejected, the results of GS could be because of pooling different types of routes or pooling different types of carriers. To test whether majors price discriminate differently when they compete with LCCs from when they don't, the four single fixed-effect panel estimations are performed by using the market classification. Hausman tests are performed to see if there are significant omitted variable problems in each single regression. Finally, the results from the pooled cross-sectional estimation are provided to examine the effects of other variables on price dispersion according to the market classification.

2.1. Comparisons of the Two Studies

Table II reports the results obtained from using the three different measures of competition as dependent variable, respectively. The first three columns are obtained by using observations of all routes, whereas the last three columns by using observations of majors in major-carrier routes which are similar to the routes selected by BR.

If there are omitted variable problems in the cross-sectional estimations in all

routes and the fixed-effects approach corrects the misspecification, the results of the two different approaches must be consistent. GS show that the estimate on route competition is significantly negative in the fixed-effect panel regression for all routes. The estimates from the first three column are generally consistent with the results in GS. The differences from those of GS's original sample are because the dummy for dropping one direction of routes is updated and the routes not satisfied with the direct-ratio criterion are dropped. The estimates on $-\ln \widehat{HERF}$ and $\ln \hat{N}$ are -0.117 and -0.196 , respectively, and both are significant at 1 percent level.

Meanwhile, the estimates on the number of majors and on the number of LCCs in the third column of Table II give some messages where the negative effect of competition comes from. Indeed, GS show that the negative effect of competition on price dispersion are sourced from changes in competition by LCCs, but they do not extend these results to a possibility that there would not be a negative effect of competition on price dispersion if a route is not serviced by LCCs.³² Rather, by pooling all routes in the regressions, they suggest that the number of LCCs has a much larger negative effect on price dispersion than the number of majors.

On the other hand, the results in the last three columns of Table II indicate that the negative effect of competition on price dispersion is not evident in the major-carrier routes. The estimates for $-\ln \widehat{HERF}$ and $\ln \hat{N}$ are positive but insignificant while the estimated effect of N^{LEG} is 0.009, significant at 5 percent level. These results suggest that the effect of competition on price dispersion could be positive as BR found in their analysis. The omitted variable biases, corrected here through the use of the fixed-effects, would not be large enough to flip the relationship of

³²They also obtained an insignificant estimate on the number of majors and a significantly negative estimate on the number of LCCs in the regressions reported in their Table 2. Please see Gerardi and Shapiro (2009).

TABLE II
 GS's APPROACH VS. BR's APPROACH: FIXED-EFFECTS PANEL ESTIMATES
 (DEPENDENT VARIABLE: G_{ij}^{lodd})

	GS's Approach			BR's Approach		
	(1)	(2)	(3)	(1)	(2)	(3)
$-\ln \widehat{HERF}$	-0.117*** (0.023)			0.097 (0.062)		
$\ln \widehat{N}$		-0.196*** (0.035)			0.078 (0.086)	
N^{LEG}			0.001 (0.002)			0.009** (0.005)
N^{LCC}			-0.016*** (0.005)			-0.004 (0.015)
Observations	110,160	110,160	110,164	20,645	20,645	20,646

Notes: 1) All regressions include time dummies, quarter dummies, and a dummy variable for bankruptcy. The carrier-route-specific effects are treated as fixed. Standard errors in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

competition and price dispersion in the major-carrier routes.

GS reconcile the opposite results on route competition in the cross-sectional and fixed-effects panel estimation by showing that the cross-sectional estimates could be biased due to omitting variables. They suggest that plane size is one of possible omitted variables which is correlated with route distance, one of instruments, and that route distance is also correlated with competition. Demand for air travel increases with long distance, and the sample somewhat reveals positive correlation between the two variables, so omitting plane size results in an asymptotically and positively biased estimate for route competition.

Figure 4 displays the quarterly cross-sectional estimates on route competition obtained from using observations of all routes, comparing the estimates before and

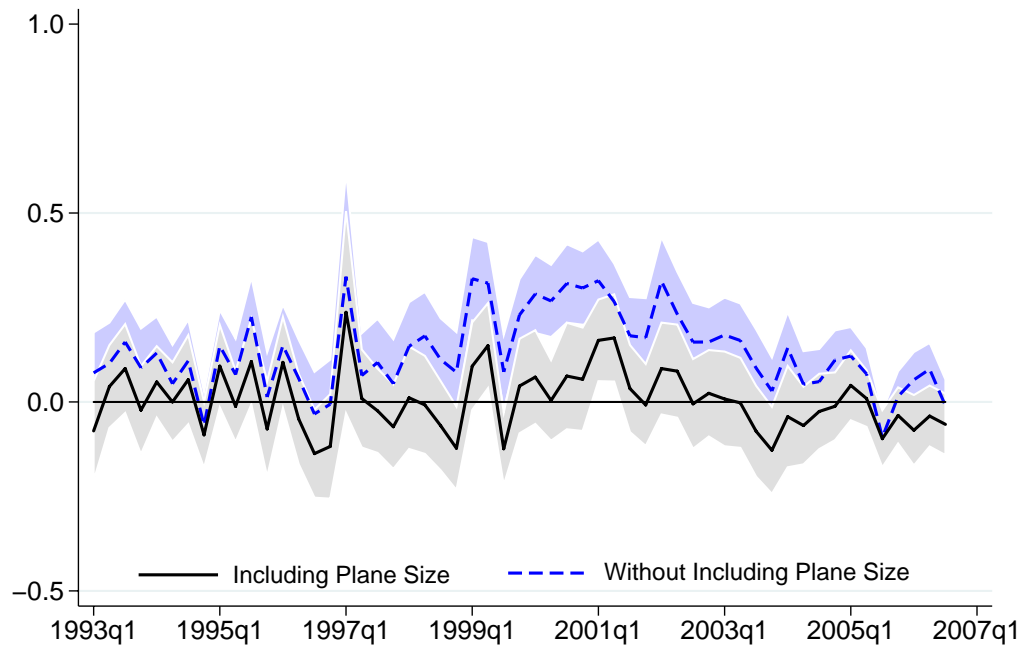


FIG. 4.— Quarterly Cross-Sectional Estimates for Competition: All Routes

after including plane size.³³ The estimates significantly fall with the inclusion of plane size, but they are mostly insignificant. The colored area indicates the confidence interval at 95 percent level. 36 positive estimates among 50 positive estimates are significant at 10 percent level or less before the inclusion of plane size whereas 41 estimates become insignificant after the inclusion of plane size.

Figure 5 indicates that the corrections by the inclusion of plane size are very slight in the regressions for the major-carrier routes. The estimates on route competition mostly remain positive and significant even after the inclusion of plane size. The sample of the major-carrier routes reveals a weaker correlation between plane size and route distance relative to the correlation between route distance and competition.

³³The differences from the original cross-sectional estimations of GS are from the altered dummy for dropping one direction of routes and the sample selection of using the ratio of direct flights.

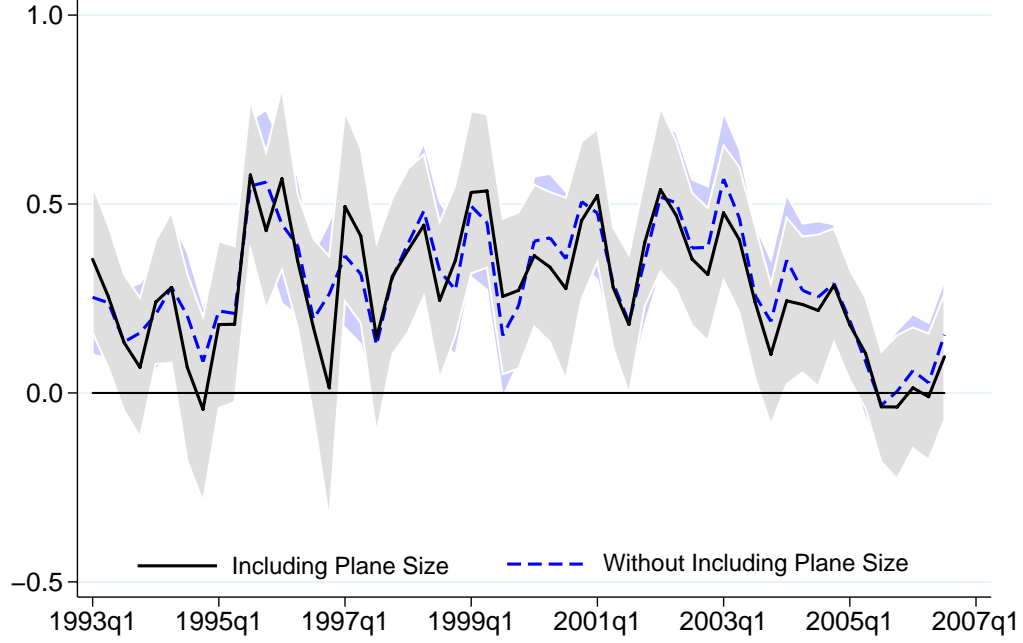


FIG. 5.— Quarterly Cross-Sectional Estimates for Competition: Major-carrier Routes

The results of Table II and Figure 5 suggest that the omitted variable biases are not large enough to change the positive sign of the estimate on route competition in the regressions for the major-carrier routes. Competition has a positive effect on price dispersion when majors compete against one another, not with LCCs.

2.2. Pooling Route or Carrier Types

Table III reports the estimation results from (1) pooling all, (2) pooling route types for major carriers, (3) pooling route types for LCCs, (4) pooling carriers for non-mixed-carrier routes, and (5) pooling carriers for mixed-carrier routes. In the second and third columns of Table III, it is assumed that different types of carriers would be different on price discrimination while the same type of carriers are homogeneous regardless of which types of carriers they compete with. On the other hand, in the

TABLE III
 POOLING ROUTES TYPES VS. POOLING CARRIER TYPES: CROSS-SECTIONAL
 ESTIMATES
 (DEPENDENT VARIABLE: G_{ij}^{lodd})

	Pooling All (1)	Pooling Route Types		Pooling Carrier Types	
		(2) majors	(3) LCCs	(4) non-mixed	(5) mixed
$-\ln \widehat{HERF}$	0.057*** (0.010)	0.072*** (0.011)	-0.063*** (0.016)	0.261*** (0.011)	-0.011 (0.020)
$\ln \widehat{MKTSHARE}$	0.025*** (0.004)	0.011*** (0.004)	0.022*** (0.009)	0.055*** (0.004)	0.064*** (0.007)
$\ln \widehat{FLTOT}$	-0.038*** (0.003)	-0.090*** (0.005)	0.024*** (0.004)	-0.063*** (0.003)	0.046*** (0.005)
$\ln \widehat{TOURIST}$	-0.098*** (0.003)	-0.157*** (0.004)	-0.017*** (0.003)	-0.090*** (0.003)	-0.024*** (0.003)
\widehat{HUB}	0.177*** (0.006)	0.203*** (0.006)	0.008 (0.016)	0.206*** (0.008)	0.149*** (0.010)
\widehat{SMALL}	-0.065*** (0.006)	-0.081*** (0.008)	-0.040*** (0.008)	-0.053*** (0.007)	-0.130*** (0.012)
$\ln \widehat{ASEATCAP}$	1.023*** (0.026)	1.009*** (0.027)	0.719*** (0.060)	1.435*** (0.032)	0.117*** (0.035)
Observations	80,013	54,093	25,920	54,629	25,384

Notes: 1) All regressions include time dummies and carrier-specific dummies. Route-specific effects are treated random. Hats over the variables indicate that the variables were instrumented. Standard errors are in parentheses.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

fourth and fifth columns of Table III, carriers are assumed to be broadly homogeneous if they compete in the same route. Here, I also assume that majors in the major-carrier routes are not different from LCCs in the LCC routes in that they are competing with the same type of carriers.

GS's results are obtained under the assumption that there are no significant differences in route and carrier types. However, as shown earlier, the results of Table II do not seem to support the negative effect of competition on price dispersion in all routes. Chow tests between (2) and (3) and between (4) and (5) are performed to test the poolability across groups. The null hypothesis of identical coefficients between

two groups was rejected in all cases.³⁴ The test results suggest that it may not be able to pool route types or carrier types.³⁵

Table IV contains the fixed-effects panel estimates obtained from single estimations corresponding to the regressions in Table III. Comparing with the results of the pooled cross-sectional estimations, the omitted variable biases seem to exist in all regressions, and the biases flipping the sign of the estimate on route competition are evident in the second columns of Table IV which aggregate observations of majors regardless of whether they compete with LCCs or not. Like the results from pooling all observations, the cross-sectional estimate on $-\ln \widehat{HERF}$ in the second column of Table III is 0.072, significant at 1 percent level, but the corresponding fixed-effects panel estimate is -0.070, significant at 1 percent level. If majors price discriminate differently when they compete against one another from when they don't, the negative estimate $-\ln \widehat{HERF}$ in the second column of Table IV would be also inconsistent.

Meanwhile, the estimates in the third and fourth columns of Table IV have the same sign in both cross-sectional and panel estimations. These results could be interpreted as follow: competition has a negative effect on LCCs' price dispersion regardless of route types; competition has a positive effect on price dispersion if carriers in a route are relatively homogeneous. I do not want to interpret these results too much, but they carry some information how the market classification is important to identify different forces of competition on price dispersion.

³⁴I tested three different null hypotheses: the first one is that the coefficient of $-\ln \widehat{HERF}$ are identical between two groups; the second one is that the coefficient of $-\ln \widehat{HERF}$, $\ln \widehat{MKTSHARE}$ and $\ln \widehat{FLTOT}$ are identical; the third one is that all coefficients are identical.

³⁵In order to perform the Chow tests, the estimates must be consistent, but at least one of the estimates are not consistent since there must be omitted variable biases. The results from the Chow tests should be limitedly interpreted.

TABLE IV
 POOLING ROUTES TYPES VS. POOLING CARRIER TYPES: FIXED-EFFECTS PANEL
 ESTIMATES
 (DEPENDENT VARIABLE: G_{ijt}^{lodd})

	Pooling All (1)	Pooling of Route Types		Pooling of Carrier Types	
		(2) major	(3) low-cost	(4) non-mixed	(5) mixed
$-\ln \widehat{HERF}$	-0.104*** (0.025)	-0.070*** (0.027)	-0.224*** (0.041)	0.135** (0.058)	-0.142*** (0.027)
Observations	87,807	60,430	27,377	27,792	60,015

Notes: 1) All regressions include time dummies, quarter dummies, and a dummy variable for bankruptcy. The carrier-route-specific effects are treated as fixed. Standard errors in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

2.3. Effects of Route Competition

Table V contains the fixed-effects panel estimates for route competition which are obtained from using observations of (1) majors of the major-carrier routes, (2) majors in the mixed-carrier routes, (3) LCCs in the mixed-carrier routes, and (4) LCCs in the LCC routes. These regressions are performed without any restriction on the coefficients across route and carrier types, and then identify the relationships of competition and price dispersion in each group.

The Hausman tests between random-effects and fixed-effects estimations are performed, which are the over-identification test on the validity of instrumental variables. The null hypothesis of zero correlation between carrier-route-specific effects and instrument variables were all rejected. Thus, even in the major-carrier routes, there are omitted variables which are biasing the estimates for route competition. But, as shown earlier and in Table V, the estimated effect of competition on price dispersion is positive but insignificant in the major-carrier routes.³⁶ It suggests that the omitted

³⁶The insignificance of the estimate could be due to using the log-odds ratio of the

TABLE V
FIXED-EFFECTS PANEL ESTIMATES FOR COMPETITION FROM THE GINI COEFFICIENT
REGRESSIONS
(DEPENDENT VARIABLE: G_{ijt}^{lodd})

	Majors		LCCs	
	(1) major routes	(2) mixed routes	(3) mixed routes	(4) LCC routes
$-\ln \widehat{HERF}$	0.097 (0.062)	-0.107*** (0.030)	-0.223*** (0.042)	-0.102 (0.149)
Observations	20,645	39,590	20,425	6,931

Notes: 1) All regressions include time dummies, quarter dummies, and a dummy variable for bankruptcy. The carrier-route-specific effects are treated as fixed. Standard errors in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

variable biases in the major-carrier routes are not large enough to reverse the positive cross-sectional estimate on competition.

On the other hand, in the mixed-carrier routes, the estimated effects of competition on price dispersion are significantly negative at 5 percent level or less for both majors and LCCs. The magnitude for majors is -0.107 , less than that for LCCs, -0.223 . Comparing the estimate in the second column of Table IV with the estimates in the first and second columns of Table V, the pooling of route types for majors results in a negative estimate on route competition whereas the separating of route types for majors reveals that majors price discriminate differently when they compete with LCCs from when they don't.

The results from the price percentile regressions in Table VI show how majors price discriminate differently when they compete with LCCs and how LCCs price discriminate differently from majors. The results in the first row of Table VI indicate that majors seem to perform competitive-type discrimination when they compete

Gini coefficient weighting more on the middle part of the price distribution.

TABLE VI
FIXED-EFFECTS PANEL ESTIMATES FOR COMPETITION FROM THE PRICE PERCENTILE
REGRESSIONS
(DEPENDENT VARIABLE: $\ln P(k)_{ijt}$)

	$\ln P(10)$	$\ln P(20)$	$\ln P(80)$	$\ln P(90)$
<i>(1) majors in major-carrier routes</i>				
$-\ln \widehat{HERF}$	-0.122*** (0.042)	-0.117*** (0.042)	-0.042 (0.066)	-0.018 (0.064)
<i>(2) majors in mixed-carrier routes</i>				
$-\ln \widehat{HERF}$	-0.238*** (0.020)	-0.266*** (0.022)	-0.388*** (0.030)	-0.397*** (0.032)
<i>(3) LCCs in mixed-carrier routes</i>				
$-\ln \widehat{HERF}$	-0.078*** (0.022)	-0.132*** (0.020)	-0.299*** (0.028)	-0.293*** (0.026)
<i>(4) LCCs in LCC routes</i>				
$-\ln \widehat{HERF}$	-0.058 (0.099)	-0.134 (0.091)	-0.256*** (0.083)	-0.237*** (0.070)

Notes: 1) All regressions include time dummies, quarter dummies, and a dummy variable for bankruptcy. The carrier-route-specific effects are treated as fixed. Standard errors in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

with one another. The estimated effects of competition on the 10th and 20th price percentiles is -0.122 and -0.117, respectively, and both are significant at 1 percent level. The negative effect on the 10th price percentile is much larger than that on the 20th percentile. Meanwhile, the estimates on the 80th and 90th price percentiles are much less than on the 10th and 20th price percentiles and they are both insignificant. These results are exactly identical to the equilibrium prediction by Borenstein (1985) and Holmes (1989). Since majors rely on consumers' cross-price elasticities or brand loyalties in discriminatory pricing when they compete against one another, competition reduces the lower portion of the prices much more than the upper portion.

Meanwhile, LCCs seem to price discriminate based on consumers' different reser-

vation prices. Thus, competition tends to reduce higher-end prices much more than lower-end prices since higher-end prices are more profitable. The estimates on $-\ln \widehat{HERF}$ for the 80th and 90th price percentiles in the fourth row of Table VI are -0.256 and -0.237, respectively, and both are significant at 1 percent level while the estimates for the 10th and 20th percentiles are less than for the 80th and 90th price percentiles and both are insignificant.

The results from the first and fourth rows of Table VI suggest that majors compete on more cross-price elastic consumers but LCCs compete on more profitable consumers. Thus, when the two different types of carriers compete in a route, the different forces of competition on price dispersion could be both evident. It seems that the effect of LCCs would be much larger than that of majors. I do not report the results from the price percentile regressions of using the number of majors and LCCs for brevity. It turns out that the effects of the number of majors are all insignificant on the price percentiles whereas those of the number of LCCs are negative and significant. The results suggest that the negative effect of competition on price dispersion in the mixed-carrier routes are mostly from entries by LCCs. As a result, the overall effect of competition on price dispersion is much larger on the upper portion of the price distribution than on the lower portion in the mixed-carrier routes.

The results in (2) and (3) of Table VI show that competition in the mixed-carrier routes has a much larger effect on the upper portion of the price distribution than on the lower portion. The estimates on $-\ln \widehat{HERF}$ from the 80th and 90th price percentile regressions are -0.388 and -0.397 for majors, respectively, significant at 1 percent level, which are much larger in absolute value than the estimates from the 10th and 20th price percentile regressions for majors, -0.238 and -0.266. The results for LCCs are similar like those for majors. In addition, the estimated effects of route competition in the mixed-carrier routes on each price percentile for majors are much

larger than those for LCCs.

Overall, the effect of competition on price dispersion depends on whether or not majors compete with LCCs. If majors compete against one another, competition has a positive effect on price dispersion since majors perform competitive-type discrimination. If they compete with LCCs, competition has a negative effect on price dispersion since LCCs compete on more profitable consumers so that majors are forced to reduce higher-end prices much larger than lower-end prices. The positive relationship between competition and price dispersion found by BR is still evident in the major-carrier routes whereas the negative relationship by GS exists in the mixed-carrier routes.

2.4. Effects of Other Variables

Since the fixed-effects panel estimations do not provide the effects of other variables, I rely on the results of the pooled and rolling cross-sectional estimations in interpreting the effects of the other variables on price dispersion in each type of routes with respect to carrier types. All Chow tests reject the null hypothesis of identical coefficients between (1) and (2) and between (3) and (4), which suggests that majors are different in discriminatory pricing when they compete with the same type of carriers or the other different type of carriers.

Table VII contains the results from the pooled cross-sectional estimation during the period of 1993.Q1 \sim 2006.Q3.³⁷ If the instrument variables are invalid according to the results of the Hausman tests in the panel analysis, the estimated effects of the instrumented variables, $-\ln \widehat{HERF}$, $\ln \widehat{MKTSHARE}$, $\ln \widehat{FLTOT}$, and $\ln \widehat{ASEATCAP}$ could be asymptotically biased, and so the interpretations for

³⁷Appendix B depicts the results obtained from the quarterly and rolling estimations.

TABLE VII
 POOLED CROSS-SECTIONAL ESTIMATES FOR OTHER VARIABLES
 (DEPENDENT VARIABLE: G_{ij}^{load})

	Majors		LCCs	
	(1) major routes	(2) mixed routes	(3) mixed routes	(4) LCC routes
$-\ln \widehat{HERF}$	0.307*** (0.013)	0.071*** (0.021)	-0.130*** (0.028)	0.065** (0.029)
$\ln \widehat{MKTSHARE}$	0.023*** (0.005)	0.086*** (0.008)	-0.028 (0.018)	0.120*** (0.014)
$\ln \widehat{FLTOT}$	-0.118*** (0.005)	0.037*** (0.007)	0.058*** (0.008)	0.019*** (0.004)
$\ln \widehat{TOURIST}$	-0.179*** (0.005)	-0.041*** (0.004)	-0.005 (0.005)	-0.001 (0.004)
\widehat{HUB}	0.239*** (0.008)	0.161*** (0.011)	0.114*** (0.026)	-0.076*** (0.023)
\widehat{SMALL}	-0.037*** (0.010)	-0.194*** (0.015)	-0.064*** (0.017)	-0.031*** (0.010)
$\ln \widehat{ASEATCAP}$	1.407*** (0.031)	0.186*** (0.036)	-0.961*** (0.135)	1.338*** (0.106)
Observations	39,502	14,149	11,235	14,390

Notes: 1) All regressions include time dummies and carrier-specific dummies. Route-specific effects are treated random. Hats over the variables indicate that the variables were instrumented. Standard errors are in parentheses.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

these estimates must be restricted indeed.

One thing distinguished from GS is that a carrier's relative market position generally has a positive and significant effect on price dispersion. GS implicitly interpreted that a negative estimate for market share with including plane size could be supported by the findings of Evans and Kessides (1993) saying that airfare is not correlated with market share.³⁸ The relative market position of majors in the mixed-carrier routes seems to price discriminate more strongly than in the major-carrier routes. The es-

³⁸Some of the estimates on market share from the quarterly and rolling cross-sectional estimations for majors in the mixed-carrier routes are negative as seen in Appendix B.

timate for market share in the second column of Table VII is 0.086, significant at 1 percent level, larger than 0.023 in the first column. If the higher market share in the mixed-carrier routes indicates consumers' stronger preference on majors' brand, a major airline may exploit its high market share to price discriminate to a greater extent. So, it seems that a major airline would be less affected by LCCs if its market share is relatively large with holding other variables as constant.

On the other hand, if a LCC has a larger market share in a mixed-carrier route, majors in the route may respond by reducing prices since the LCC attracts customers by offering lower prices than majors. So, the larger market share of the LCC in the route could be obtained by offering much lower prices than the other carriers in the route. The estimate for LCCs' market share in the mixed-carrier routes is -0.028, insignificant. However, when LCCs compete with one another, they also seem to exploit the relative market position in discriminatory pricing. The estimate for LCCs' market share in the LCC routes is 0.120, significant at 1 percent level.

The estimated effects of route density measured by $FLTTOT$ are mixed across the estimations. The estimate on $\ln \widehat{FLTTOT}$ is -0.118 for majors in the major-carrier routes while it is 0.037 for majors in the mixed-carrier routes. The negative effect of route density in the major-carrier routes is consistent with the finding of BR. In contrast, it is not obvious to interpret the positive effect of route density in (2) through (4) of Table VII. It could be interpreted that any carriers price discriminate to a larger extent since they compete on more profitable consumers so that the increased number of flights may increase market power to discriminate.

The results for the other variables suggest that majors are price discriminating to a greater extent when they compete with one another rather than when they compete with LCCs. These findings are somewhat consistent with the finding that competition has a positive effect on price dispersion in the major-carrier routes. If

majors perform competitive-type discrimination in the major-carrier routes, it implies that competition does not affect much on the upper portion of the prices. That is, a major airline does not lose much its discriminatory power to charge higher prices to less cross-price elastic consumers. However, if majors are forced to reduce the upper portion much greater than the lower portion due to competition by LCCs, they lose their own discriminatory power much more than majors in the major-carrier routes.

The estimate on $\ln TOURIST$ is -0.179 for majors in the major-carrier routes, which is much greater in absolute value than -0.041 for majors in the mixed-carrier routes. Both coefficient estimates are significant at 1 percent level. Since travelers are much more sensitive to differences in price across airlines in a route than businessmen, majors may lose their discriminatory power as consumer heterogeneity decreases or as the value of $\ln TOURIST$ increases. Thus, the larger magnitude of the estimate implies that majors use information on consumer heterogeneity in price discrimination.

Also, the estimate for hub dominance in the major-carrier routes is 0.239 while it is 0.161 in the mixed-carrier route. Both are significant at 1 percent level. That is, if a major airline has a hub dominance in a route, it price discriminates to a larger extent when it competes with other majors than when it compete with LCCs. The effect of route congestion by the dummy *SMALL* is -0.037 for majors in the major-carrier routes, much less in absolute value than -0.194 for majors in the mixed-carrier routes. Thus, majors use route congestion in systematic peak-loading pricing when they compete against one another much more than when they compete with LCCs. In addition, the estimate for plane size is 1.407 for majors in the major-carrier routes while it is 0.186 for majors in the mixed-carrier routes. Both are also significant at 1 percent level. It implies that a major airline with a larger plane in a given route price discriminate to a greater extent in the major-carrier routes than in the mixed-carrier

routes.

The estimation results for LCCs are somewhat mixed in that LCCs seem to also price discriminate to a greater degree when they compete with one another whereas some of the results do not support it. For instance, the estimated effect of hub dominance is 0.114 for LCCs in the mixed-carrier routes while it is -0.076 for LCCs in the LCC routes. Meanwhile, the estimated effect of plane size is -0.961 for LCCs in the mixed-carrier routes while it is 1.338 for LCCs in the LCC routes.

D. Summary

As a way of reconciling the opposite results of the literature, the paper examines whether major airlines price discriminate differently when they compete with LCCs from when they don't. It turns out that all cross-sectional estimates on route competition suffer from the omitted variables biases as Gerardi and Shapiro (2009) found. However, the possible omitted variable bias are not large enough to flip the sign of the estimator on route competition for major airlines in the major-carrier routes which are similar to the routes selected by Borenstein and Rose (1994).

The primary finding of the paper is that the opposite results are both evident in the airline domestic industry. Price dispersion can increase or decrease with competition. It depends on the different forces of competition which is not ever investigated in the literature. In the major-carrier routes, competition has a positive effect on price dispersion as estimated by Borenstein and Rose (1994). On the other hand, in the mixed-carrier routes, competition has a negative effect on price dispersion as found by Gerardi and Shapiro (2009). Gerardi and Shapiro (2009) interpret their results as being evident in all routes. However, the negative relationship between route competition and price dispersion should be limited to the mixed-carrier routes

where major airlines compete with LCCs.

The overall findings suggest that major airlines compete on more cross-price elastic or less brand-loyal consumers when they compete with one another whereas LCCs compete on more profitable consumers with higher reservation prices. Thus, when both types of carriers compete together in the mixed-carrier routes, major airlines are forced to reduce higher-end prices much more than lower-end prices since LCCs offer much lower fares even to less cross-price elastic consumers than them. Moreover, the results for the other variables also suggest that major airlines are price discriminating to a greater extent when they compete with one another rather than when they compete with LCCs.

Finally, there are possible preemptive responses to the threat of entry by LCCs which is not considered in the paper. Goolsbee and Syverson (2008) find that major airlines significantly cut fares when threatened by Southwest Airlines before actual entries. Therefore, it is certainly possible that there would exist threat effects on price dispersion. Moreover, these empirical findings demand a theoretical explanation of why major airlines price discriminate differently when they compete with LCCs. In the context of Borenstein (1985) and Holmes (1989), there must be changes in the cross-price elasticities of demand when any LCCs enter into a market. It could be seen as the effect of consumers' benefits obtained from switching to LCCs which has been not yet incorporated in theories of price discrimination.

CHAPTER III

WHEN DO INCUMBENTS REDUCE PRICE DISPERSION PREEMPTIVELY? NEW EVIDENCE FROM THE MAJOR AIRLINES

A. Introduction

Whether incumbents respond preemptively to potential competitors is a classic debate in the pricing theory of economics, and empirical studies in the airline industry had not supported that incumbents cut prices before actual entry, prior to Goolsbee and Syverson (2008). The airline industry has been a free-entry (exit) market since the Airline Deregulation Act of 1978. Many studies investigate whether a potential competitor servicing both endpoints of a route can motivate incumbents to cut prices before actual entry, by using cross-sectional data. Borenstein (1992) reviews that cross-sectional studies find no substitute effect of potential competition for actual competition. In contrast, Goolsbee and Syverson (2008) suggest new evidence for incumbents' preemptive responses to the threat of entry, by using panel data. They find that incumbents cut the average price significantly when threatened by Southwest.

The paper examines the effects of entry threat on price dispersion rather than on the average price since the airline industry has been price discriminating after the deregulation. Goolsbee and Syverson (2008) identify incumbents' preemptive responses on the average price, but do not explain how incumbents adjust incumbents' discriminatory pricing. Gerardi and Shapiro (2009) and Lee (2010) investigate the relationship between actual competition and price dispersion by using panel data, but both studies do not examine the effects of the inclusion of potential competition.

The paper is further focused on identifying incumbents' motives of preemptive responses if they respond to the threat of entry, by comparing the estimated effects

of entry threat on price dispersion between the routes which Southwest entered later and the routes which Southwest didn't. If incumbents' price cuts are motivated by uncertainty about a rival's entry, the rival also has motives to inform its entry earlier and discourage incumbents from pursuing entry deterrence. Therefore, incumbents' preemptive responses may depend on whether they are informed about the potential rival's entry.

Goolsbee and Syverson (2008) attempt to find the motives of preemptive responses, but their results from pooling all threatened routes do not clearly identify whether incumbents are responding in order to deter or accommodate entry. If incumbents don't know about the rival's future entry, they may choose to deter or accommodate entry depending on which strategy is more profitable to incumbents. In this case, it is difficult to identify the motives of preemptive responses since the equilibrium strategic response in each route depends on the belief about the rival's future entry which are different across the threatened routes. Therefore, the price cuts in the threatened routes could be seen as for both deterring or accommodating entry.

Their suggestive evidence for entry deterrence is obtained from the immediately-serviced (pre-announced) routes. Southwest announces its beginning service before it immediately enters a route upon establishing presence in both endpoints of the route. So, incumbents have no motives to deter Southwest's entry so that they do not cut fares significantly before actual entry in these routes. However, even in the routes threatened by Southwest, incumbents can be privately informed about the timing of Southwest's entry which is revealed in the process of advertising, negotiating gate leases, and so on.¹ That is, if incumbents' preemptive responses are affected

¹Goolsbee and Syverson (2008) also addresses that incumbents may find out impending entries before the public announcement.

by Southwest's entry signaling, incumbents do neither cut prices nor reduce price dispersion when they are almost certain about the rival's entry like in the immediately-serviced routes.

Not surprisingly, incumbents reduce price dispersion in the routes which are still threatened by Southwest whereas they do not significantly reduce price dispersion in the routes which are once-threatened and serviced by Southwest. The results are obtained from separating the threatened routes depending on whether Southwest entered later and from excluding the routes that were never significantly serviced by any LCCs. If the still-threatened routes were never really attractive to Southwest, the preemptive reduction in price dispersion could not be interpreted as incumbents' deterring Southwest's entry. In other words, if other LCCs significantly serviced a route, the route could be also attractive to Southwest. Thus, these results suggest that incumbents successfully deter Southwest's entry by reducing price dispersion preemptively.

Because of limitations of information on whether Southwest announced before actual entry among the threatened routes, the effects of pre-announcements are not directly controlled for. Like the finding of Goolsbee and Syverson (2008), the results from the immediately-serviced (pre-announced) routes support that incumbents do not significantly reduce price dispersion when pre-announced by Southwest. Even when the rival's entry is pre-announced, incumbents still have incentives to accommodate Southwest's entry by locking in valuable customers. So, they may engage in generating switching cost like offering double or triple miles or upgrading customer services, which leads to increased prices.

The estimated effects of actual competition on price dispersion are generally consistent with the findings of Lee (2010) that the negative effect of actual competition is from the competitive effects of LCCs where the positive effect is from those of

majors. In contrast, when incumbents reduce price dispersion for entry deterrence, the number of major airlines has a negative effect on price dispersion during the threat period. Unlike the previous studies, I include the effects of Southwest's exit on price dispersion. When Southwest exits a route, high-end prices are quickly adjusted up to the level before threatened by Southwest, whereas lower-end prices are still lower than the level before threatened by Southwest.

The paper restricts the analysis to the 8 major airlines. They are all network full-service airlines and have relatively higher cost structures than Southwest. Lee (2010) finds that major airlines price discriminate differently when they compete with LCCs comparing to when they don't. Therefore, major airlines could be affected by other incumbent LCCs' responses to Southwest's threat of entry. For this reason, the paper primarily analyzes the routes where major airlines compete against one another before threatened by Southwest and then compete with any LCCs. However, the results from analyzing the routes where major airlines compete with other LCCs even before threatened by Southwest are generally consistent with the results from the former type of routes.

The remainder of the paper is organized as follows: Subsection B presents the data along with the way of identifying Southwest's threat, entry, and exit, and discusses incumbents' hypothetical motives of preemptive responses and suggests empirical strategy to identify the motives of reducing price dispersion preemptively. Subsection C includes the fixed-effects panel specifications and reports the empirical findings. Finally, Subsection D concludes.

B. Data and Identifying Motives of Preemptive Responses

1. Data

The empirical analysis focuses on the U.S. airline routes once threatened by Southwest airlines. Southwest, one of low-cost carriers, is well-known for the most profitable U.S. airline. It has brought significant falls in ticket fares and increases in passengers since the Airline Deregulation Act of 1978.² The data are built upon Gerardi and Shapiro (2009) and Lee (2010). They are originally collected from the DB1B and the T-100 domestic direct segments. The DB1B data are a 10 percent random sample of all domestic tickets, and the T-100 data contain ticket information on domestic nonstop flights. It covers domestic, direct, directional, and coach-class airline tickets over the period of 1993:Q1 - 2006:Q3.

A route is defined by its two endpoint airports. The core sample includes routes between 65 airports at which Southwest ever serviced non-stop flights. Figure 6 depicts the number of airports serviced by Southwest from 1993:Q1 to 2006:Q3. Southwest serviced at 36 airports prior to the first quarter of 1993, and serviced at 62 airports in the third quarter of 2006.³

Southwest's threat to a route is identified by airport presence in both two endpoints of the route. Airport presence could be regarded as a predictor of future

²Until 1978, the Civil Aeronautics Board (CAB) awarded routes to airlines, limited the entry of new carriers, and regulated fares for passengers. After the Airline Deregulation Act of 1978, airlines had full freedoms to enter the routes and (from 1982) to set their fares. In 1984, the CAB was finally abolished as their major controls were no longer necessary.

³Southwest exited three airports during the sample period: Detroit City(DET) in 1993:Q4, San Francisco(SFO) in 2001:Q2, and Bush International(IAH) in 2005:Q2. Though it stopped its service in these three airports, it continued to provide its direct flights in a neighboring airport of each multiple-airports area.

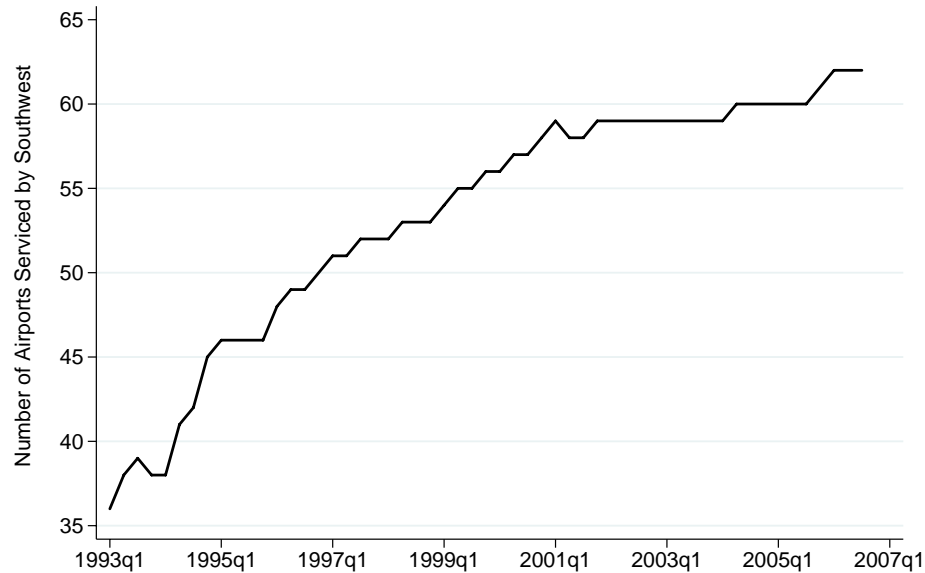


FIG. 6.— Number of Airports Serviced by Southwest

entry.⁴ For example, Southwest began its service at Philadelphia on May 9, 2004. It started its non-stop flights in 7 routes from 2004:Q2, and threatened incumbents in 19 additional routes.⁵ Among the 19 routes, 12 routes were eventually operated by Southwest in at most three years later.⁶ Moreover, it exited routes from Louis Armstrong New Orleans to Philadelphia (2004:Q3 - 2005:Q3), Philadelphia to San Diego (2004:Q3 - 2005:Q1), and Salt Lake City to Philadelphia (2005:Q1).

⁴Goolsbee and Syverson (2008) provides a good review including Bailey (1981), Berry (1992), and Peteraf and Reed (1994). Bogulaski, Ito, and Lee (2004) use some variables controlling for Southwest's pre-entry presence at the endpoints of each market in estimating Southwest's entry decision.

⁵Six non-stop destinations were immediately serviced by Southwest on May 9, 2004: Chicago Midway, Las Vegas, Orlando, Phoenix, Providence, and Tampa Bay. Later within 2004:Q2, it also provided services to Los Angeles.

⁶Six routes (Fort Lauderdale-Hollywood, Manchester, Los Angeles, Louis Armstrong New Orleans, Palm Beach, and Raleigh-Durham) are serviced in one quarter later, two routes (Bradley and Jacksonville) in two quarters later, one route (Salt Lake) in three quarters later, one route (Kansas) in two years later, and two routes (Port Columbus and Nashville) in two and half years later.

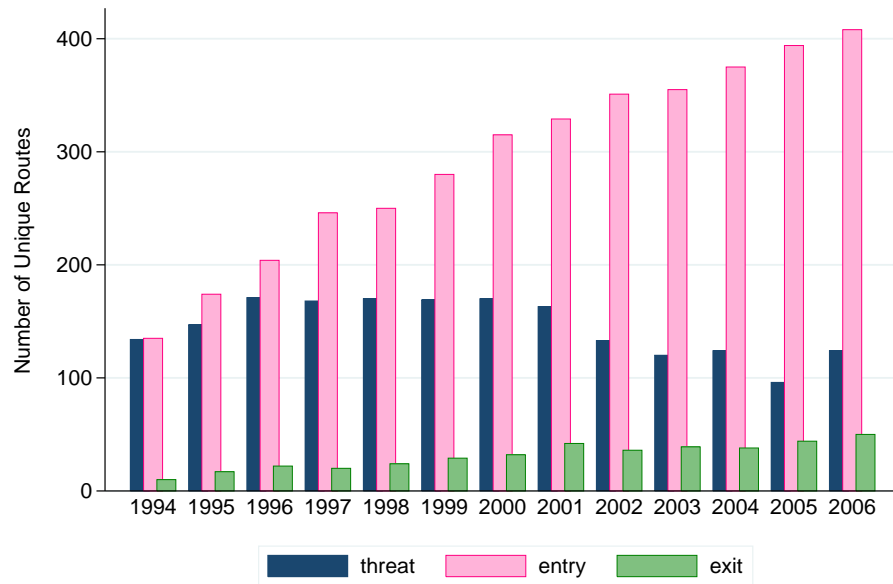


FIG. 7.— Southwest's Threat, Entry, and Exit

Figure 7 shows the overall dynamics of Southwest's threat, entry, and exit during the sample period. The number in Figure 7 represents the number of unique routes at the third quarter of each year. It is obvious that the number of routes serviced by Southwest has been increasing over time while the number of the threatened routes has been decreasing. First of all, I identify routes which Southwest ever serviced during the sample period. It gives information on the 65 airports serviced by Southwest. Then, the first quarter when Southwest reported its ticket information from or to a given airport is the first time when Southwest began direct services in the airport. By comparing between the time when it established presence in both endpoints of the route and the time when Southwest began service in the given route, the periods threatened by Southwest are identified. The time when Southwest exits a given route is also identified in the same way. As a result, three types of routes are identified as follow: still-threatened (not-yet-serviced), threatened-and-serviced, and immediately-

served. The first two types of routes were once threatened by Southwest, but the latter ones were eventually serviced by Southwest. The third type of routes are the routes where Southwest began service upon establishing presence in both endpoints.

The analysis is restricted to the 8 major airlines during the period: American, Continental, Delta, Northwest, United, USAir, TWA, and Alaska. Their responses can depend on whether they are already competing with other LCCs. Lee (2010) find that majors price discriminate differently when they compete with LCCs from when they don't. An entry of any LCCs reduces the upper portion of the price distribution much more than the lower portion. Thus, though the effects of entry threat would be identical in the direction, the magnitude could be different depending on the presence of other LCCs before threatened by Southwest.

As in Lee (2010), a route is named as a major-carrier route if the quarterly market share of LCCs is less than 5 percent. If not, the route is classified into a mixed-carrier route. Among 442 threatened routes, there are 224 routes where major airlines significantly compete with other LCCs before Southwest's presence in both endpoints, whereas there are 198 routes where major airlines do not significantly compete with other LCCs before Southwest's presence. Therefore, the paper separately analyzes the effects of entry threat depending on whether incumbents compete with other LCCs before Southwest's presence in both endpoints.⁷

When analyzing the threatened routes, I exclude the routes which were never significantly serviced by any LCCs since there are possibly route-specific factors to impede any LCCs from entering a route regardless of incumbents' preemptive responses.⁸ Of course, the routes which began services prior to the first quarter of

⁷Daraban and Fournier (2009) include other LCCs' events of entry and exit, independently, but do not take account for interactive effects of other LCCs on incumbents' preemptive responses.

⁸The 88 routes with 4,938 carrier-route-quarter observations are the routes threat-

the sample (1993:Q1) are excluded.⁹ Also, if the time-series observations in a route are not less than 20 consecutive quarters or the consecutive periods are at most 20 quarters, the route is excluded.

In all, the final core sample includes 545 routes with 30,270 carrier-route-quarter observations¹⁰: 217 still-threatened routes with 12,413 observations, 205 threatened-serviced routes with 11,431 observations, and 123 immediately-serviced routes with 6,426 observations.

2. *Identifying Motives of Preemptive Responses*

Firms in an oligopoly market may respond preemptively to the threat of entry when they are uncertain about a rival's future entry or even when they know about it. Since the airline industry is price discriminating over consumers, it is possible that incumbents adjust their discriminatory pricing responding to the threat of entry for either of entry deterrence or accommodation. Lee (2010) shows that when a LCC like Southwest enters a market, major airlines reduce price dispersion. So, firms in this oligopoly market, may respond preemptively to the threat of entry by reducing price dispersion.¹¹

ened by Southwest but never significantly serviced by any LCCs. In some sense, these routes could be also regarded as routes that incumbents had strongly deterred LCCs' entry. The preliminary estimates on entry threat do not support the idea of strongly-deterred routes.

⁹This criterion drops 38 routes with 2,179 carrier-route-quarter observations.

¹⁰Both directions of routes are kept. The standard errors are clustered by routes to control for serial correlation and correlation between incumbents on the same route like Goolsbee and Syverson (2008) and Gerardi and Shapiro (2009). If one direction of a given route is dropped, the number of routes is not enough to cluster the standards errors. None of the previous researches using the DB1B data indicates whether it use only one direction: Goolsbee and Syverson (2008), Daraban and Fournier (2009), and Prince and Simon (2010).

¹¹See Goolsbee and Syverson (2008): incumbents significantly reduce fares when threatened by Southwest but do not significantly increase either capacity or available

2.1. Hypothetical Motives: Deterrence or Accommodation?

The preemptive responses are for the purpose of either deterring or accommodating the rival's actual entry.¹² Incumbents may attempt to deter the potential rival's entry when erecting a barrier to entry is more profitable than letting the rival enter the market. If entry deterrence is too costly, incumbents may choose to accommodate the rival's entry. The difference between the two strategic responses is whether to allow the rival's entry.

Berry (1992) suggests that the entry decision of airlines indicates underlying profitability of a route after the entry. If a market is price discriminating like the airline industry, a potential rival would not enter the market if incumbents preemptively reduce higher-end prices much more than lower-end prices. The rival may expect some profits from incumbents' discriminatory pricing, but it will expect lower profitability if incumbents give up some profits from higher-end prices by cutting them preemptively. That is, the profitability of a market may depend on the degree of price dispersion so that the rival's entry decision may be affected by incumbents' preemptive reduction in price dispersion. So, a reduction in price dispersion may indicate incumbents' motives to deter the rival's entry.¹³

Meanwhile, incumbents may also reduce price dispersion preemptively to lock

passengers.

¹²Bain (1956) suggests three kinds of responses by incumbents to the threat of entry: (1) blockaded entry, (2) deterred entry, and (3) accommodated entry. Entry is blockaded if structural barriers are so high that the incumbents need to do nothing to deter entry.

¹³Strassmann (1990) finds that future entry is influenced by current prices. This argument is quite related to the contestability of the airline industry: if a market is contestable, then potential competitors would not enter the market. Most empirical cross-sectional studies do not support the contestability of the airline industry. See Borenstein (1992) for more details. However, regarding the fixed-effects panel results in Goolsbee and Syverson (2008), the prior cross-sectional results could indeed suffer from omitted unobservable time-invariant factors.

in more valuable customers before the rival's actual entry, particularly in a case that the rival has advantage of lower marginal cost than incumbents. For instance, Southwest is well-known for being a low-cost carrier while major airlines are burdened by relatively high operating costs. Thus, incumbents may attempt to increase demand for today's flights by cutting prices for customers paying higher-end prices and so stimulating old customers as well as generating new customers, resulting that the old customers are less likely to switch later to the low-cost rival due to lowered prices. Also, increases in demand due to lower prices generate switching cost to the customers so that the more customers are less likely to switch to the rival later. So, a reduction in price dispersion may be a result from incumbents' entry accommodation.

If incumbents reduce price dispersion for accommodation as well as for deterrence, it is very difficult to identify the motives of incumbents' preemptive responses by looking at the effects on price dispersion. Moreover, though incumbents intend to deter entry by reducing price dispersion, they might be unsuccessful in deterring entry so that the preemptive reduction in price dispersion could not tell what was the purpose of reducing price dispersion. Then, it would be concluded that incumbents reduce price dispersion responding to the threat of entry but the reason for reducing price dispersion is not clearly identified.

Incumbents may deter or accommodate entry preemptively to the threat of entry since they are uncertain about the rival's future entry. depending on which strategy is more profitable on the belief of the likelihood of the rival's entry. That is, incumbents' motive of preemptive responses is determined by the equilibrium payoffs of each choice and the belief on the rival's entry.

However, in some sense, if incumbents are informed about the rival's future entry, they might try to accommodate actual entry rather than to deter entry. Specially, if consumers incur cost of switching from incumbents to the rival, incumbents may

prefer generating switching cost to reducing price dispersion. Or, they may engage in both strategies of reducing price dispersion and generating switching cost. The resulted price dispersion may depend on how much incumbents concentrate on one of both strategies. If incumbents can respond in prices as quickly as the potential rival can enter, the incumbents may not reduce price dispersion in advance of actual entry, but rather engage in generating switching cost.¹⁴ So, when incumbents are informed about the rival's entry, incumbents may not reduce price dispersion preemptively for entry accommodation.

The rival also has motives to announce its future entry if they know that incumbents reduce price dispersion for the purpose of entry deterrence. Then, incumbents may not significantly reduce price dispersion, but rather accommodate entry. Gerlach (2004) shows that announcements have a positive demand pull effect on consumers with switching costs if incumbents do not intend to deter pre-announced entry. The timing of announcing entry would also matter with incumbents' preemptive responses. Ellison and Ellison (2004) find that the entry-detering behavior is not observed in blockbuster drugs whose U.S. patent protection is scheduled to expire.¹⁵ Since incumbents certainly expect that generic drugs enter for replacing blockbuster drugs, they have no motives to deter generic entry. In contrast, the entry-detering behavior occurs for more drugs with relatively low revenues which are less certain about the timing of generic entry. Thus, if incumbents have no motives to deter entry or if their deterrence is not effective, incumbents may not reduce price dispersion significantly.¹⁶

¹⁴See Stiglitz (1987): potential competition could be ineffective on price competition while it may affect incumbents' decision on increasing sunk costs, in his paper, R&D expenditures. In line with the airline industry, generating switching cost could be seen as a sunk cost to incumbents.

¹⁵Their data include 63 distinct chemical compounds that faced potential generic entry as the result of a patent expiration between 1986 and 1992.

¹⁶It is analogous to separating equilibria driven by signaling in an extensive game

2.2. Empirical Strategy: Comparing Still-threatened vs. Serviced Markets

Goolsbee and Syverson (2008) attempted to identify what is the motive of the preemptive price cuts, and they suggest that incumbents cut prices in a hope to deter Southwest's entry. If price cuts were for entry accommodation rather than deterrence, then price cuts should be observed on routes where deterrence isn't possible. In the immediately-serviced (pre-announced) routes as no-deterrence-motive routes, they find that preemptive price cuts are not significant. So, incumbents may not reduce price dispersion even when seemingly threatened by Southwest if they are informed about Southwest's entry. If incumbents cut prices for the purpose of entry deterrence, Southwest may prefer announcing its beginning service prior to actual entry, to discourage incumbents from reducing price dispersion.

As depicted in Figure 8, Southwest has never serviced the Philadelphia-Cleveland route since the second quarter of 2004. In contrast, the Philadelphia-Nashville route was threatened by Southwest upon the fourth quarter of 2004 when it established presence in both endpoints. It took 8 quarters for Southwest to take off non-stop flights. By using this criterion, there are the two types of routes threatened by Southwest. The first type is routes which are still threatened and not serviced yet by Southwest. The second type is routes which were once-threatened and is serviced by Southwest.

The threatened-serviced routes would be the routes where incumbents were privately informed before Southwest entry. In some sense, incumbents may know about the timing of Southwest's entry even before Southwest announces its detailed schedules. Then, their preemptive responses could be affected by the information about Southwest's service beginning even before the announcement. During the processes

with asymmetric information.

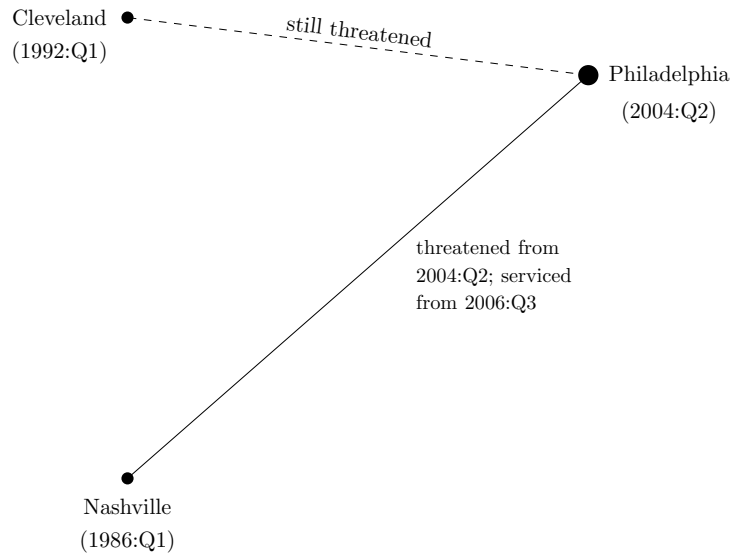


FIG. 8.— Differences between PHL-CLE and PHL-BNA: The date in parenthesis indicates the first quarter of Southwest’s service in each airport. Cleveland airport is one of the airports serviced by Southwest prior to the first quarter of 1993. The start-up date in Cleveland is February 13, 1992.

of establishing a new service for a route, the information on the new flight may reveal to incumbents prior to the announcement date or beginning date.

Goolsbee and Syverson (2008) estimate the effects of entry threat on the average price by pooling the threatened routes regardless of whether Southwest entered later. The underlying assumption is that the effects of entry threat are identical across the threatened routes and that incumbents are uncertain about Southwest’s future entry. They recognize that incumbents may know about Southwest’s entry even before the public announcement, but they do not explain why incumbents cut prices even when they know about the future entry in the threatened routes. Therefore, pooling all threatened routes may result in some average estimates for entry threat between the two possible separating equilibria.

One of the possible equilibria is that the rival announces its entry and incumbents accommodate entry. The other equilibrium is that the rival does not announce its entry and incumbents deter entry. The former type of equilibrium would be observed in the threatened-serviced routes while the latter in the still-threatened routes. That is, among the threatened routes, the effects of entry threat on price dispersion can be different depending on whether Southwest announced before actual entry. So, the comparison of incumbents' preemptive responses on price dispersion between the two types of the threatened routes may help to understand the motives of preemptive responses.¹⁷

Unfortunately, the DB1B and T-100 data do not include information about entry announcement for the threatened routes, and other available local and business press releases would contain full information of entry announcement for all threatened routes. Instead of identifying all information of pre-announcements, I take a easier course to deal with this problem since most of selected routes among the threatened-serviced routes are pre-announced before its actual entry.¹⁸ I treat the threatened-serviced routes as pre-announced routes among the threatened routes. For instance, when it began its Philadelphia service from May 9, 2004, it announced that additional 14 flights will begin July 6, 2004, to Fort Lauderdale-Hollywood, Manchester,

¹⁷Let the variable $y = (y_1, y_2)$ indicate the degree of price dispersion in each type of routes, $x_1 = (x_{11}, x_{21})$ entry threat, and $x_2 = x_{12}$ actual entry which does not happen in the second group of a market:

$$\begin{aligned} y_1 &= x_{11}\beta_{11} + x_{12}\beta_{12} + \epsilon_1, \\ y_2 &= x_{21}\beta_{21} + \epsilon_2, \end{aligned}$$

where $\mathbb{E}[x'_{ij}\epsilon_i] = 0$ for $i, j = 1, 2$ and $\mathbb{E}[\epsilon'_i\epsilon_j] = 0$ if $i \neq j$ and σ_i if $i = j$. If $\beta_{11} = \beta_{21}$, pooling all routes produces consistent estimates for entry threat and actual entry. In contrast, if $\beta_{11} \neq \beta_{21}$, pooling all routes results in inconsistent estimates.

¹⁸I searched information about pre-announcements via Lexis-Nexis and Southwest official site.

Los Angeles, and so on. So, incumbents in these routes may know about the timing of Southwest's entry as much as those in 6 routes which are immediately serviced.

In cases that Southwest immediately began service upon establishing presence in both endpoints of a route, Southwest always announced its arrival in a new airport at least before 3 months.¹⁹ Therefore, it is possible to examine whether incumbents do not reduce price dispersion in these routes. It is also possible that incumbents in the threatened routes had engaged in entry deterrence by reducing price dispersion before Southwest announces and then altered its response to entry accommodation. That is, incumbents would be unsuccessful in deterring Southwest's entry, and subsequently let Southwest entry after they are informed about Southwest entry in some ways. For instance, in the case of the Nashville-Philadelphia route where Southwest entered in two and half years later after its presence, it officially announced two months ago that two new daily nonstop flights will be provided between Philadelphia and Nashville.²⁰

Though it is not known how long before incumbents know about the entry and there would be unsuccessful entry deterrence, separating the threatened routes depending on whether Southwest entered later and comparing the effects of entry threat on price dispersion between the still-threatened and threatened-serviced routes help understand incumbents' motives of reducing price dispersion prior to actual entry, more than the prior studies.

¹⁹Appendix C contains the information about the initial destinations from the new airport, the date of beginning service, and the announcement date.

²⁰Usually, the announcement date is not longer than two or three months before actual entry if the route is already threatened by Southwest.

C. Empirical Analysis

1. Model Specifications

1.1. Gini Coefficient Regression

The specification is based on Gerardi and Shapiro (2009) since the analysis focuses on price dispersion instead of average price. Like Goolsbee and Syverson (2008), dummies for indicating Southwest's presence, entry, and exist are included in the panel model:

$$\begin{aligned}
 G_{ijt}^{lodd} = & \beta_0 + \beta_1 N_{jt}^{LEG} + \beta_2 N_{jt}^{LCC} + \beta_3 d_p \cdot N_{jt}^{LCC} + \beta_4 d_e \cdot N_{jt}^{LCC} \\
 & + \sum_{s=-(5+)}^{5+} \gamma_s T_{j,t_p+s}^{WN} + \sum_{s=0}^{5+} \theta_s E_{j,t_e+s}^{WN} + \sum_{s=0}^4 \phi_s X_{j,t_x+s}^{WN} \\
 & + \beta_5 Bkrpt_{it} + \tau_t + \nu_{ij} + \varepsilon_{ijt},
 \end{aligned}$$

where i indicates carrier, j route and t quarter.²¹

The Gini log-odds ratio G_{ijt}^{lodd} is given by $\ln G/(1 - G)$ where G is the Gini coefficient.²² To isolate the competitive effect of major airlines from that of other LCCs, the number of major competitors N^{LEG} and the number of other LCCs N^{LCC} in an airport-pair route are separately used for actual competition.²³ Moreover, to control for the competitive effects of other LCCs during the threat period and the entry period, I introduce the interaction terms for the competitive effects of other LCCs during the threat period and the entry period, $d_p \cdot N^{LCC}$ and $d_e \cdot N^{LCC}$. The dummies d_p and d_e indicate whether a route is threatened or serviced at time t by Southwest,

²¹Note that 'WN' is the official IATA airline abbreviation for Southwest.

²²The Gini coefficient is bounded between zero and one whereas the log-odds ratio produces an unbounded statistic.

²³The number of LCCs is calculated as follows: i) regional airlines are included, ii) Southwest is excluded in the number of LCCs in the route from the time of entry, as its presence will be captured by entry dummies.

respectively. For instance, the competitive effect of N^{LCC} during the threat period d_p is given by $\beta_2 + \beta_3$. So, the idea is that the effect of an LCC on price dispersion may differ depending on whether incumbent major airlines are also contending with the threat of entry from Southwest.

Like Goolsbee and Syverson (2008), a window of 25-quarter period is used for time dummies of Southwest's presence in a route, T_{j,t_p+s}^{WN} (Southwest's threat of entry), where t_p indicates the first quarter when Southwest establishes presence in both endpoints of a route but does not begin service yet. I include 5 dummies before Southwest's establishment in both endpoints. One of them is for the 5th through 8th quarters prior to t_p . So, I exclude the period between the 9th through 12th quarters prior to t_p . Also, after t_p , I include time dummies in the same way. The last dummy after t_p is for the 5th through 12th quarters after t_p . When I look at the effect of pre-announcement by Southwest in the immediately-serviced routes, I use 5 dummies, A_{j,t_e-s}^{WN} (Southwest's pre-announcement), instead of using the dummies for entry threat.

I add 6 time dummies, E_{j,t_e+s}^{WN} (Southwest's actual entry), that explain the effects of Southwest's actual entry to a given route. The t_e indicates the first quarter when Southwest starts to take off its direct flights. The last dummy for actual entry is for the 5th and 8th quarters after t_e . Moreover, following Daraban and Fournier (2008), I add 5 dummies, X_{j,t_x+s}^{WN} (Southwest's exit), for identifying the effects of Southwest's exit. The t_x indicates the first quarter that Southwest exits a given route.²⁴

I use time dummies and quarter dummies, τ_t , in order to control for exogenous events on cost variables and cyclical demand effects. Further, in order to control for carrier-specific events, I use bankruptcy dummy, $Bkrpt_{it}$, which indicates whether

²⁴Goolsbee and Syverson (2008) do not include dummies for route exit in the estimation.

the i th airline is in bankruptcy at time t . Finally, carrier-route-specific effects, ν_{ij} , are treated as fixed effects in the estimation.

Originally, Goolsbee and Syverson (2008) control for both of carrier-route-specific and carrier-quarter-specific effects as fixed. On the other hand, Huse and Oliveira (2009) suggest that the usual approach to fixed-effects even like Goolsbee and Syverson (2008) may lead to inconsistent estimation of pricing equations since it fails to account for relevant time-varying effects at the airline and city levels and those unobservable time-varying effects are correlated with dummies for actual entry and potential entry.²⁵ It is possible that incumbents may respond to the threat of entry by enhancing miles or by upgrading customer service, which are mostly unobservable to econometricians. These unobservable effects could be understood as being triggered by the threat of entry, and so the estimates on time dummies for threat, entry, and exit could be also biased if those unobservable time-varying effects are not controlled for.²⁶

Meanwhile, since I analyze the effects on price dispersion rather than on the average price, it is not clear whether the biases of not controlling for the unobservable time-varying effects at the airline and city levels are significant. Moreover, the specification following Gerardi and Shapiro (2009) has the advantage of controlling for financial conditions by using bankruptcy dummy, which could be a reason that an incumbent with financial difficulty would not respond preemptively to the threat of entry.

²⁵Huse and Oliveira (2009) treat time dummies before actual entry as potential entry regardless of whether or not the LCCs establishes presence in both endpoints.

²⁶Huse and Oliveira (2009) interpret their insignificant estimates on potential entry as empirical evidence that incumbents do not respond preemptively to the potential entry. However, the estimates could be insignificant since the time dummies do not actually indicate the threat of entry by LCCs.

1.2. Price Percentile Regression

The price percentile regression use the price percentiles for the denpendent variable instead of the Gini log-odds ratio. The results from the price percentile regressions help explain incumbents' responses on the tails of the price distribution.

The specification is given by

$$\begin{aligned} \ln P(k)_{ijt} = & \beta_0 + \beta_1 N_{jt}^{LEG} + \beta_2 N_{jt}^{LCC} + \beta_3 d_p \cdot N_{jt}^{LCC} + \beta_4 d_e \cdot N_{jt}^{LCC} \\ & + \sum_{s=-(5+)}^{5+} \gamma_s T_{j,t_p+s}^{WN} + \sum_{s=0}^{5+} \theta_s E_{j,t_e+s}^{WN} + \sum_{s=0}^4 \phi_s X_{j,t_x+s}^{WN} \\ & + \beta_5 Bkrpt_{it} + \tau_t + \nu_{ij} + \varepsilon_{ijt}, \end{aligned}$$

where k is the 10th, 20th, 80th, or 90th price percentile.

If the 10th and 20th percentile prices are more negatively sensitive over an independent variable than the 80th and 90th percentiles, it could be interpreted that price dispersion increases with the independent variable. However, if the 10th and 20th percentiles are more positively sensitive than the 80th and 90th percentiles, it could be interpreted that price dispersion decreases with the independent variable. Also, it is possible that the effects of an independent variable on the 10th and 20th percentiles are opposite in direction to those on the 80th and 90th percentiles. According to the directions and magnitudes of the estimates, the effect of the independent variable on price dispersion is determined.

2. Estimation Results

To enhance comparability across studies, I perform the Gini log-odds ratio and price percentile regressions of pooling all routes except the immediately-serviced routes. Next, the effects of entry threat in the still-threatened routes are compared to those in the threatened-serviced routes, in order to investigate the motives of incumbents'

preemptive responses. The results from selecting the immediately-serviced (pre-announced) routes are reported to see whether incumbents do not reduce price dispersion before actual entry when they are informed about Southwest's entry. Finally, it is examined how differently incumbents respond when they compete with other LCCs even before Southwest's threat.

2.1. Results from Pooling All Threatened Routes

Table VIII presents the results from estimating the Gini log-odds ratio by: (1) pooling all routes threatened by Southwest, (2) selecting major-carrier routes before threatened by Southwest but then serviced by other LCCs, and (3) selecting mixed-carrier routes even before threatened by Southwest.²⁷ Essentially, the estimates represent the effect of each dummy on price dispersion relative to the constant term since all dummies are exclusively independent. So, the estimates on dummies for threat, entry, and exit are not additive.

The results obtained from pooling all routes in (1) of Table VIII are generally consistent with the results in Goolsbee and Syverson (2008). The estimates on dummies for entry threat, $d(t_p)$ through $d(t_p + 5$ to $t_p + 12)$, are negative and mostly significant at 1 percent level. Moreover, the negative impacts of Southwest's threat on an incumbent's price dispersion seem to be lowered as the threat period gets longer. Goolsbee and Syverson (2008) also find that the average price falls further as time passes before Southwest entry, and they interpret that these results would be negatively skewed if Southwest waits longer to enter routes where incumbents cut fares the most. However, the results from estimating price dispersion indicates that

²⁷The estimation results from selecting major-carrier routes which are never significantly serviced by any LCCs are reported in in Appendix D, along with the results from the price percentile regressions for each groups.

TABLE VIII
 POOLING ALL THREATENED ROUTES
 (DEPENDENT VARIABLE: G_{ijt}^{lodd})

	pooling all routes	mixed-carrier	
	(1)	(2)	(3)
N^{LEG}	-0.006	-0.004	-0.012**
N^{LCC}	-0.000	-0.015	-0.002
$d_p \cdot N^{LCC}$	-0.008	0.011	-0.012
$d_e \cdot N^{LCC}$	-0.034**	-0.045*	-0.015
Southwest' Presence:			
$d(t_p - 8 \text{ to } t_p - 5)$	-0.002	0.002	-0.006
$d(t_p - 4)$	0.028	0.001	0.028
$d(t_p - 3)$	0.004	0.003	-0.015
$d(t_p - 2)$	-0.040	-0.017	-0.075**
$d(t_p - 1)$	-0.026	0.007	-0.057**
$d(t_p)$	-0.004	0.029	-0.037
$d(t_p + 1)$	-0.075***	-0.051*	-0.126***
$d(t_p + 2)$	-0.073***	-0.079***	-0.088***
$d(t_p + 3)$	-0.053***	-0.064***	-0.068**
$d(t_p + 4)$	-0.049**	-0.062**	-0.070**
$d(t_p + 5 \text{ to } t_p + 12)$	-0.041***	-0.009	-0.064***
Southwest' Actual Entry:			
$d(t_e)$	0.022	0.125***	-0.063**
$d(t_e + 1)$	-0.008	0.110**	-0.086***
$d(t_e + 2)$	0.004	0.113*	-0.077**
$d(t_e + 3)$	0.040	0.202***	-0.077**
$d(t_e + 4)$	0.009	0.170***	-0.094***
$d(t_e + 5 \text{ to } t_e + 8)$	0.017	0.162***	-0.087***
Southwest' Exit:			
$d(t_x)$	0.015	0.089**	-0.035
$d(t_x + 1)$	0.014	0.077*	-0.034
$d(t_x + 2)$	-0.027	0.020	-0.061*
$d(t_x + 3)$	-0.011	0.036	-0.047
$d(t_x + 4)$	-0.022	0.054	-0.074**
$Bankruptcy$	-0.101***	0.026	-0.158***
Observations	28,585	9,953	13,719

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are clustered by route and are not reported for brevity.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

the continued declines in the average price are (partly) because incumbents also cut the lower portion of the price distribution.²⁸

According to the results in (1) of Table VIII, price dispersion does not significantly change with dummies for actual entry. It is not because incumbents do not respond to Southwest's entry but because they cut prices uniformly after actual entry.²⁹ The results in (2) and (3) of Table VIII indicate that the estimated effects of actual entry on price dispersion may be different. They are mixed-carrier routes over the sample period so that the effects of actual entry would be expected to be negative like the findings of Lee (2010). It is possible that Southwest's actual entry stimulates competition among incumbents so that the lower portion of the price distribution are much more reduced than the upper portion, which could be the reason of resulting in a positive effect of actual entry on price dispersion in (3) of Table VIII.³⁰

The estimates on dummies, $d(t_x)$ through $d(t_x + 4)$, in (1) of Table VIII indicate that incumbents seem to not change price dispersion when Southwest exits a route. However, the results from the price percentile regressions indicate that incumbents adjust higher-end prices quickly up to the level of the constant term whereas they keep lower-end prices relatively higher than during the entry period but lower than even during the threat period.³¹ The declines in the lower-end prices are only observed in

²⁸See Appendix D: Table XV presents that the estimates on dummies for entry threat are decreasing as time passes in the 10th and 20th percentile regressions.

²⁹See Appendix D: Table XV shows that the estimates on dummies for actual entry in the percentile regression are significantly negative and similar in magnitude.

³⁰The average of Southwest's market shares in the routes where incumbents do not significantly compete with other LCCs before threatened by Southwest is relatively greater than that in the routes where incumbents compete with other LCCs before threatened by Southwest. Meanwhile, the standard deviation in the former type of routes is less than that in the latter type of routes. Thus, incumbents in the former type of routes are more likely to compete on the rest of the market share, resulting in reducing the lower portion of the price dispersion much more than the upper portion.

³¹See Appendix D: in Table XV, the estimates on dummies for exit in the 10th

the routes selected for (2) of Table VIII, which is related to the continued declines in the lower-end prices during Southwest’s actual entry. If competition among incumbents stimulated by Southwest’s entry induces new demand for relatively cheaper tickets, incumbents may not instantly increase fares to hold the new customers even after Southwest exists.

The overall effects of actual competition on price dispersion seem to be generally consistent with the findings of Lee (2010) which does not consider the competitive effects of potential competition on price dispersion. The results in (1), (3), and (4) of Table VIII show that the negative effects of competition on price dispersion are mostly due to the competitive effects of other LCCs. The negative effects of the number of major airlines in (3) and (4) of Table VIII are partly because they reduce price dispersion preemptively during the threat period and partly because they compete with other LCCs.

More importantly, Table VIII depicts how important sample selection is in analyzing the competitive effects of the threat of entry on price dispersion. Particularly, since Southwest’s entry decision has a self-selection problem reflecting whether it announces its entry and so incumbents do not deter entry preemptively, pooling all threatened routes may mislead to (asymptotically) biased estimates for the threat of entry. Moreover, since the regression model includes lots of dummy variables, there would be gains and losses in directly controlling for incumbents’ preemptive responses affected by other incumbent LCCs. Instead, the paper primarily investigates incumbents’ preemptive responses in the routes where incumbents compete against one another before threatened by Southwest, like the routes used in (2) of Table VIII.

and 20th price percentile regressions are negative and significant at 5 percent level, whereas the estimates in the 80th and 90th price percentile regressions are mostly insignificant.

2.2. Different Responses to the Threat of Entry

First of all, I look at the still-threatened routes among the major-carrier routes before Southwest's presence in both endpoints.³² The estimated coefficients on dummies for entry threat, $d(t_p)$ through $d(t_p + 5$ to $t_p + 12)$, in Table IX suggest that incumbents respond to Southwest's threat of entry by cutting the upper portion of the price distribution after t_p . The estimates on dummies for entry threat from the 80th and 90th percentile regressions are around -1 and relatively persistent over time, while those from the 10th and 20th percentile regressions are mostly insignificant. These results suggest that incumbents significantly reduce price dispersion preemptively in response to Southwest's threat of entry, in the still-threatened routes where incumbents are uncertain about Southwest's actual entry. Incumbents in these routes may know that Southwest does not begin service at t_p , but that it can service non-stop flights anytime after t_p , which could be the reason why incumbents do not respond before t_p but significantly reduce price dispersion after t_p .

It is surprising that the estimated competitive effects of major airlines in Table IX is negative and significant at 5 percent level. Lee (2010) shows that competition has a positive effect on price dispersion when major airlines compete against one other. However, the estimates on the number of major airlines seem to be opposite to the finding in Lee (2010). When the competitive effects of major airlines during the threat period is isolated by using $d_p \cdot N^{LEG}$, the results indicate that price dispersion increases with the number of major airlines before threatened by Southwest. Since incumbents reduce price dispersion preemptively to the threat of entry, a new entry

³²Four routes which have been serviced by Southwest after the end of the sample period (2006:Q3) are included in the estimation: Denver-Spokane (2010:Q1), Log Angeles-San Francisco (2007:Q4), Philadelphia-St. Louis (2008:Q1), and Raleigh-Durham-St. Louis (2010:Q2). The results hold though these four routes are excluded.

TABLE IX
SELECTING STILL-THREATENED ROUTES

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.016**	0.000	-0.005	-0.009	-0.015**
N^{LCC}	-0.011	-0.011	-0.005	0.011	-0.021
$d_p \cdot N^{LCC}$	-0.007	-0.018	-0.033	-0.057**	-0.038
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	0.053	0.002	-0.029	0.011	0.057
$d(t_p - 4)$	0.065	0.016	-0.033	-0.091	0.030
$d(t_p - 3)$	0.002	0.015	-0.038	-0.143**	0.007
$d(t_p - 2)$	0.055	-0.004	-0.042	-0.099	-0.008
$d(t_p - 1)$	0.012	0.030	0.006	0.026	-0.009
$d(t_p)$	-0.051	0.040	0.031	-0.016	0.006
$d(t_p + 1)$	-0.090**	0.014	0.010	-0.083*	-0.091*
$d(t_p + 2)$	-0.114***	0.021	0.011	-0.103**	-0.082*
$d(t_p + 3)$	-0.079***	0.001	-0.022	-0.076	-0.127***
$d(t_p + 4)$	-0.099***	0.020	-0.020	-0.158***	-0.142***
$d(t_p + 5 \text{ to } t_p + 12)$	-0.053***	-0.037*	-0.053**	-0.116***	-0.092***
<i>Bankruptcy</i>	-0.005	0.066***	0.063***	0.009	0.053
Observations	5,399	5,399	5,399	5,399	5,399

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are clustered by route and are not reported for brevity.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

of major airlines may also reduce price dispersion during the threat period.

Next, I look at the threatened-serviced routes among the major-carrier routes before threatened by Southwest, which is presented in Table X. In these routes, incumbents are more likely to be informed about Southwest's future entry, and thus they may not significantly reduce price dispersion for entry deterrence. Goolsbee and Syverson (2008) address that incumbents in a route do respond preemptively to the threat of entry regardless of whether Southwest serviced later. In contrast, the estimates on dummies for entry threat, $d(t_p)$ through $d(t_p + 5 \text{ to } t_p + 12)$, are mostly insignificant, as shown in Table X. Suggestively, if incumbents are privately known about the timing of Southwest's future entry at t_p , they might have no motives to

TABLE X
SELECTING THREATENED-SERVICED ROUTES

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	0.011	-0.011*	-0.012*	-0.016*	-0.007
N^{LCC}	-0.024	0.039	0.050	0.002	0.069**
$d_p \cdot N^{LCC}$	0.035	-0.074**	-0.087***	-0.037	-0.104***
$d_e \cdot N^{LCC}$	-0.034	-0.042	-0.049	-0.012	-0.100***
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	-0.033	0.110***	0.116***	0.193***	0.105**
$d(t_p - 4)$	-0.035	0.103**	0.122**	0.159**	0.087
$d(t_p - 3)$	0.026	0.099*	0.077	0.117*	0.046
$d(t_p - 2)$	-0.051	0.135***	0.131***	0.170***	0.082*
$d(t_p - 1)$	0.005	0.116**	0.120**	0.148***	0.106**
$d(t_p)$	0.095**	0.001	-0.007	0.066	0.072
$d(t_p + 1)$	-0.007	0.049	0.070*	0.038	0.057
$d(t_p + 2)$	-0.008	0.049	0.048	0.041	0.053
$d(t_p + 3)$	-0.024	0.089**	0.065*	0.052	0.052
$d(t_p + 4)$	-0.032	0.017	0.014	0.008	-0.014
$d(t_p + 5 \text{ to } t_p + 12)$	0.063	-0.008	-0.015	-0.021	0.027
Southwest' Actual Entry:					
$d(t_e)$	0.128***	-0.176***	-0.166***	-0.129***	-0.077**
$d(t_e + 1)$	0.105*	-0.301***	-0.351***	-0.281***	-0.202***
$d(t_e + 2)$	0.123**	-0.325***	-0.334***	-0.281***	-0.259***
$d(t_e + 3)$	0.197***	-0.293***	-0.332***	-0.205***	-0.181***
$d(t_e + 4)$	0.163***	-0.296***	-0.312***	-0.203***	-0.175***
$d(t_e + 5 \text{ to } t_e + 8)$	0.169***	-0.242***	-0.208***	-0.162***	-0.108**
Southwest' Exit:					
$d(t_x)$	0.049	-0.085***	-0.102***	-0.027	0.007
$d(t_x + 1)$	0.035	-0.062**	-0.065**	-0.044	-0.018
$d(t_x + 2)$	-0.030	-0.067**	-0.046	-0.054	-0.048
$d(t_x + 3)$	-0.000	-0.063**	-0.045*	-0.042	-0.048
$d(t_x + 4)$	0.022	-0.071**	-0.052*	-0.034	-0.001
<i>Bankruptcy</i>	0.035	-0.071**	-0.073**	-0.127***	-0.109***
Observations	4,554	4,554	4,554	4,554	4,554

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are clustered by route and are not reported for brevity.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

deter Southwest's entry by cutting prices or reducing price dispersion. Though there are no significant price declines in these routes, the results do not indicate that there would no incumbents' preemptive responses of discounting ticket fares and/or upgrading customer services like frequent flyer miles.³³ As discussed earlier, incumbents may engage in locking in more valuable customers by generating switching cost with other ways rather than directly reducing price dispersion.

The reason that incumbents increase prices before t_p in the threatened-serviced routes seems not to be obvious, because incumbents in the still-threatened routes do not significantly respond before t_p . However, if incumbents are informed about Southwest's future entry prior to t_p , they may engage in locking in valuable customers as much as possible, resulting in possible increases in ticket fares. If incumbents are uncertain about Southwest's entry prior to t_p , they don't have any motives to deter or accommodate entry preemptively even before Southwest's presence in both endpoints at t_p . As a result, the estimates on dummies, $d(t_p - 8 \text{ to } t_p - 5)$ through $d(t_p - 1)$, in the price percentile regressions for the threatened-serviced routes as shown in Table X, are mostly around 0.1 and significant at 10 percent level or less, whereas those for the still-threatened routes are mostly insignificant.

When Southwest actually enter a route among the threatened-serviced routes, incumbents do not reduce price dispersion. They cut lower-end prices much more than higher-end prices, resulting in increased price dispersion. The estimates on dummies for actual entry, $d(t_e)$ through $d(t_e + 5 \text{ to } t_e + 8)$, from the 10th and 20th percentile regressions, are around -0.3 and significant at 1 percent level. They are also larger in

³³US Airways which accounts for more than 68 percent passengers from and to Philadelphia started to service "unbelievable acts of kindness" - from putting money in customers' parking meters to providing cheese steaks even before Southwest's entry while it was known to delay matching fares with Southwest. See Speer (2006) and Mohl (2006).

absolute value than those from the 80th and 90th percentile regressions. The estimates on dummies for actual entry from the 80th and 90th percentile regressions are around -0.2 and significant at at least 5 percent level. As mentioned earlier, Southwest may stimulate incumbents to compete against one another so that lower-end prices are reduced to a greater extent.

These reduction in lower-end prices may generate new demand for flights. As a result, even when Southwest exits a route among the threatened-serviced route, incumbents tend to slightly reduce lower-end prices relative to the excluded period while they increase lower-end prices relative to the entry period. In contrast, they adjust higher-end prices quickly up to the level before the threat and entry periods. The estimates on dummies for exit, $d(t_x)$ through $d(t_x + 4)$, from the 10th and 20th price percentile regressions, are significantly around -0.05, whereas those from the 80th and 90th price percentile regressions are all insignificant.

It is distinguishable from the results of Goolsbee and Syverson (2009) that incumbents reduce price dispersion preemptively in response to Southwest's entry threat in the still-threatened routes. In the threatened-serviced routes, they do not reduce price dispersion preemptively. If incumbents in the threatened-serviced routes are privately or publicly informed about Southwest's future entry, they may not be actually threatened by Southwest's presence in both endpoints though they are seemingly threatened.

Table XI presents how incumbents respond to pre-announced entry. Since Southwest always announces new non-stop flights when it begins service at a new airport, incumbents is not able to deter Southwest's entry in these routes, so they may choose to accommodate it by locking in more profitable customers. The estimates on dummies for prior to actual entry, $d(t_e - 8$ to $t_e - 5)$ through $d(t_e - 1)$, are mostly insignificant. That is, these results suggest that incumbents do not reduce price dispersion

TABLE XI
SELECTING IMMEDIATELY-SERVICED ROUTES

	G^{lodd}	$\ln P(10)$	$\ln P(20)$	$\ln P(80)$	$\ln P(90)$
	(1)	(2)	(3)	(4)	(5)
N^{LEG}	-0.028***	0.017***	0.015**	-0.005	-0.003
N^{LCC}	0.038**	-0.004	-0.010	-0.014	0.009
$d_p \cdot N^{LCC}$	-0.087***	0.143***	0.147***	0.040*	0.077***
$d_e \cdot N^{LCC}$	-0.055**	-0.022	-0.016	-0.021	-0.051***
Southwest' Announcement:					
$d(t_e - 8 \text{ to } t_e - 5)$	-0.010	-0.017	-0.019	-0.012	-0.035
$d(t_e - 4)$	0.050	-0.067*	-0.052	-0.034	-0.023
$d(t_e - 3)$	-0.031	0.029	0.003	-0.010	-0.038
$d(t_e - 2)$	-0.010	0.050*	0.028	0.052	0.013
$d(t_e - 1)$	-0.089***	0.066**	0.044	0.045	-0.013
Southwest' Actual Entry:					
$d(t_e)$	-0.099**	-0.067**	-0.109***	-0.177***	-0.150***
$d(t_e + 1)$	-0.145***	-0.123***	-0.157***	-0.301***	-0.257***
$d(t_e + 2)$	-0.156***	-0.095***	-0.156***	-0.274***	-0.254***
$d(t_e + 3)$	-0.099***	-0.121***	-0.149***	-0.236***	-0.233***
$d(t_e + 4)$	-0.092**	-0.129***	-0.126***	-0.148***	-0.183***
$d(t_e + 5 \text{ to } t_e + 8)$	-0.117***	-0.145***	-0.157***	-0.177***	-0.194***
Southwest' Exit:					
$d(t_x)$	-0.115*	-0.198***	-0.218***	-0.159***	-0.314***
$d(t_x + 1)$	-0.191**	-0.035	-0.108*	-0.132***	-0.186***
$d(t_x + 2)$	-0.124*	0.028	-0.035	-0.038	-0.087*
$d(t_x + 3)$	-0.120	0.024	-0.030	-0.014	-0.076
$d(t_x + 4)$	-0.073	0.001	-0.010	-0.001	0.033
$Bankruptcy$	-0.172***	-0.006	0.007	-0.090***	-0.134***
Observations	7,782	7,782	7,782	7,782	7,782

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

in response to the pre-announced entry though they have motives to accommodate it, like in Goolsbee and Syverson (2008).

However, these results are obtained from the routes where incumbents compete with other LCCs before Southwest's entry. The number of the major-carrier routes before Southwest's entry is not sufficient to perform the regressions. If I include the other immediately-serviced routes, the estimates on $d(t_e - 4)$ through $d(t_e - 1)$ from the price percentile regressions are rather positive³⁴, contrasted to the result in Goolsbee and Syverson (2008) that prices do not significantly fall nor increase in the pre-announced routes in their sample. First of all, the results suggest that incumbents do not reduce prices nor price dispersion when they are not able to deter Southwest's entry or when they are informed about Southwest's entry. So, as a result of incumbents' entry accommodation, they upgrading service qualities, resulting in increasing ticket fares. Next, the different results between the two studies can be explained by the difference between the two studies' sampling. Goolsbee and Syverson (2009) do not use the T-100 data in estimating the average price. So, their sample must include mixed-carrier routes before entry relative to my sample, which is because the results from the mixed-carrier routes before entry among the immediately-serviced routes are consistent with the results in Goolsbee and Syverson (2008).³⁵

In short, if incumbents do not reduce price dispersion when they are informed

³⁴Table XIX in Appendix ?? indicate that incumbents seem to increase prices before actual entry. The estimates on $d(t_e - 4)$ through $d(t_e - 1)$, are positive and significant at 5 percent level or less

³⁵Since direct flights with few passengers are not reported in the T-100 data, the routes where major airlines compete with low-cost carrier are dropped when the DB1B and T-100 data are merged. Goolsbee and Syverson (2008) includes 223 immediately-serviced routes in their sample, while I have 123 routes. That is, the immediately-serviced routes in Goolsbee and Syverson's sample are mostly likely to be mixed-carrier routes as much as the difference in the number of immediately-serviced route between the two studies.

TABLE XII

SELECTING STILL-THREATENED ROUTES AMONG THE MIXED-CARRIER ROUTES BEFORE
THREAT

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.011	0.014***	0.018***	0.007	0.017**
N^{LCC}	-0.017	-0.039***	-0.051***	-0.080***	-0.074***
$d_p \cdot N^{LCC}$	-0.003	0.005	0.013	0.031	0.006
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	-0.041	-0.034	-0.031	-0.060	-0.096**
$d(t_p - 4)$	0.003	-0.041*	-0.035	-0.085**	-0.062
$d(t_p - 3)$	-0.028	-0.043	-0.055**	-0.126***	-0.114***
$d(t_p - 2)$	-0.197***	0.012	0.018	-0.116***	-0.149***
$d(t_p - 1)$	-0.129***	-0.018	-0.018	-0.102**	-0.130***
$d(t_p)$	-0.069	-0.079**	-0.073**	-0.153***	-0.132***
$d(t_p + 1)$	-0.136***	-0.043	-0.057*	-0.173***	-0.169***
$d(t_p + 2)$	-0.102***	-0.056*	-0.068**	-0.126***	-0.158***
$d(t_p + 3)$	-0.055	-0.069*	-0.083**	-0.127**	-0.113**
$d(t_p + 4)$	-0.023	-0.086**	-0.095**	-0.109**	-0.127***
$d(t_p + 5 \text{ to } t_p + 12)$	-0.074*	-0.051*	-0.044*	-0.080*	-0.111**
<i>Bankruptcy</i>	-0.186***	0.001	0.011	-0.111***	-0.170***
Observations	6,938	6,938	6,938	6,938	6,938

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

about Southwest's future entry, incumbents' preemptive reduction in price dispersion before entry can be interpreted as entry deterrence even though they seem to be threatened by Southwest's presence in both endpoints. Also, if incumbents reduce price dispersion preemptively for entry deterrence, Southwest may discourage incumbents from reducing price dispersion by announcing or revealing its' future entry.

2.3. When Incumbents Compete with other LCCs Before Threatened by Southwest

Table XII shows the results from estimating price dispersion in the mixed-carrier routes before threat among the still-threatened routes. In these routes, incumbents

TABLE XIII
SELECTING THREATENED-SERVICED ROUTES AMONG THE MIXED-CARRIER ROUTES
BEFORE THREAT AND SERVICED

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.013**	0.007*	0.007*	0.002	0.002
N^{LCC}	0.025*	-0.007	-0.016*	-0.016	0.003
$d_p \cdot N^{LCC}$	-0.030**	-0.029***	-0.019**	-0.011	-0.042***
$d_e \cdot N^{LCC}$	-0.041**	-0.054***	-0.050***	-0.045***	-0.070***
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	0.035	-0.040*	-0.051**	-0.025	0.013
$d(t_p - 4)$	0.043	-0.075***	-0.079***	-0.087***	-0.059
$d(t_p - 3)$	-0.016	-0.074***	-0.105***	-0.116***	-0.141***
$d(t_p - 2)$	0.022	-0.098***	-0.111***	-0.085***	-0.104***
$d(t_p - 1)$	-0.015	-0.081***	-0.092***	-0.057	-0.101***
$d(t_p)$	-0.022	-0.072***	-0.069***	-0.081***	-0.082***
$d(t_p + 1)$	-0.074**	-0.028	-0.031	-0.045	-0.090***
$d(t_p + 2)$	-0.062**	0.018	0.008	-0.004	-0.034
$d(t_p + 3)$	-0.091***	0.027	0.008	-0.010	-0.059*
$d(t_p + 4)$	-0.096**	0.019	-0.003	-0.021	-0.095***
$d(t_p + 5 \text{ to } t_p + 12)$	-0.012	-0.059***	-0.039**	-0.017	-0.073***
Southwest' Actual Entry:					
$d(t_e)$	-0.213***	-0.073***	-0.083***	-0.166***	-0.182***
$d(t_e + 1)$	-0.208***	-0.050**	-0.066**	-0.180***	-0.177***
$d(t_e + 2)$	-0.240***	-0.079***	-0.097***	-0.221***	-0.224***
$d(t_e + 3)$	-0.206***	-0.074***	-0.092***	-0.174***	-0.180***
$d(t_e + 4)$	-0.166***	-0.091***	-0.082***	-0.170***	-0.172***
$d(t_e + 5 \text{ to } t_e + 8)$	-0.129***	-0.070***	-0.079***	-0.126***	-0.139***
Southwest' Exit:					
$d(t_x)$	-0.044	-0.013	-0.018	0.007	-0.056**
$d(t_x + 1)$	-0.035	-0.022	-0.009	0.024	-0.038
$d(t_x + 2)$	-0.068**	-0.015	-0.009	-0.037	-0.062**
$d(t_x + 3)$	-0.052	-0.031	-0.021	-0.015	-0.038
$d(t_x + 4)$	-0.044	-0.037	-0.034	-0.045	-0.084**
<i>Bankruptcy</i>	-0.080**	-0.026	-0.030	-0.081***	-0.133***
Observations	9,769	9,769	9,769	9,769	9,769

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

reduce price dispersion even before t_p . The estimates on dummies, $d(t_p - 3)$ through $d(t_p - 1)$, in (4) and (5) of Table XII are around -0.12. After Southwest's presence in both endpoints, incumbents also reduce the upper portion of the price distribution much more than the lower portion. Moreover, incumbents' price cuts are persistent from $d(t_p - 3)$. The estimates on dummies for entry threat, $d(t_p)$ through $d(t_p + 5$ to $t_p + 12)$, are negative as much as those on dummies for before threat.

Table XIII shows the results from estimating price dispersion in the mixed-carrier routes before threat among the threatened-served routes. Before Southwest's presence in both endpoints, incumbents seem to reduce the upper portion of the price distribution much more than the lower portion. The estimates on dummies, $d(t_p - 3)$ through $d(t_p - 1)$, in (2) through (5) of Table XIII, are mostly significantly negative at 1 percent level.³⁶ However, after Southwest's presence in both endpoints, incumbents do not significantly cut the 10th, 20th, and 80th percentiles, except the 90th percentile price. Generally, incumbents' responses to Southwest's presence in both endpoints are consistent with those in the major-carrier routes before threatened by Southwest, which are depending on whether Southwest serviced later or on whether incumbents are informed about Southwest's future entry.

D. Summary

The paper examines when incumbents respond preemptively to the threat of entry, reflecting two possible separating equilibria in the airline industry when threatened by Southwest. When a potential rival signals its entry, incumbents do not deter the rival's entry. Otherwise, incumbent deter the rival's entry by reducing prices. Instead of looking at the average price like Goolsbee and Syverson (2009), the paper analyzes

³⁶The price cuts even before Southwest's presence would be due to other LCCs' preemptive responses.

how incumbents adjust their discriminatory pricing preemptively in response to the threat of entry.

The primary finding is that incumbents do not always reduce price dispersion when threatened by Southwest. Even when they seem to be threatened by Southwest's presence in both endpoints, incumbents do not significantly reduce price dispersion in the routes where Southwest entered later. In these routes, incumbents don't have motives to deter Southwest's entry since they may be informed about Southwest's entry even before the announcements. So, only when incumbents are uncertain about Southwest's entry, they do significantly reduce price dispersion in a hope of deterring Southwest's entry. As suggestive evidence on how incumbents respond when incumbents are possibly informed about Southwest's future entry, the paper analyzes the cases when Southwest immediately entered upon establishing presence in both endpoints. The results support that incumbents do not significantly reduce price dispersion when they are informed about Southwest's entry. Thus, if incumbents reduce price dispersion preemptively to deter Southwest's entry, Southwest may discourage incumbents from deterring its entry by informing its future entry.

The paper documents the effects of exit on price dispersion. When Southwest exits a route, incumbents adjust higher-end prices quickly up to the level before the threat or entry periods. They also increase lower-end prices relative to the entry period but still discount lower-end prices relative to the excluded period, in order to service new demand stimulated by Southwest's actual entry. Moreover, as a result of controlling potential competition, incumbents reduce price dispersion in response to a new entry of major airlines during the period when they reduce price dispersion in a hope of deterring Southwest's entry. Otherwise, the results on the relationship of market competition and price dispersion are consistent with the findings of Lee (2010).

CHAPTER IV

THE EFFECTS OF ISSUER COMPETITION ON THE CREDIT CARD INDUSTRY

A. Introduction

It is a well-established economic principle that higher levels of competition lead to lower prices. In the credit card industry, empirical data described in Weiner and Wright (2005) indicate that competition among card issuers has played an opposite role of increasing interchange fees which are paid by merchants to issuers for consumers' card payments.¹ This puzzling positive relationship between competition and interchange fees has received little attention in the literature.²

The paper analyzes the issuing side of the credit card industry by assuming a standard Cournot oligopoly market, based on the framework of Rochet and Tirole (2002). The card payment industry is a two-sided market with positive externalities: it requires a platform such as Visa or MasterCard (a card association) to connect the issuing and acquiring sides of the market. On the issuing side, the customer fee and the interchange fee are determined in equilibrium as functions of the number of issuers, respectively. The customer fee is a fee paid by consumers to issuers for card purchases. On the acquiring side, the acquirers are assumed to be perfectly

¹See Appendix E: “Only a weak” positive correlation between competition and the average interchange fee becomes clear, if not including the data of 1998-99 when Citibank switched to MasterCard. The Herfindahl index for concentration measure is calculated by using the Top 20 issuers of Visa from 1990 to 2003.

²See Chakravorti (2003) and Verdier (2009). Most studies focus on whether high interchange fees are good for social welfare: Baxter(1983), Carlton and Frankel (1995), Frankel (1998), Schmalensee (2002), Rochet and Tirole (2002,2003a, 2003b, 2006, 2008), Wright (2003,2004), Rochet and Wright (2009), Wang (2010). Moreover, discussions on competition are about platform competition: Caillaud and Jullien (2003), Chakravorti and Rosen (2006), Armstrong (2006), Guthrie and Wright (2007), Marenzi and Somma (2009).

competitive and thus they pass through the interchange fee to the merchants.

The model assumes a single card association (called a platform). It imposes the no-surcharge rule that restricts merchants to set the same price for cash and card purchases. The roles of the no-surcharge rule has been controversial across studies. It has been viewed as a necessary instrument for internalizing the positive network externalities and thus maximizing welfare.³ In contrast, it has been also viewed as an anti-competitive legal imposition for issuers' leveraging their market power within the association.⁴

Intuitively, under the no-surcharge rule, issuers (members of the platform) have a collective interest in setting the interchange fee such that all merchants accept the credit cards. Since the issuers' profits are increasing in the interchange fee, they will set the largest interchange fee resulting in all merchants' card acceptance. Moreover, under the no-surcharge rule, merchants pass through the interchange fee to the consumers, but the consumers are not informed about the level of the interchange fee, since all they observe is the retail price. Subsequently, the paper shows that the interchange fee increases with competition since the issuers can compensate losses from competing on the issuing side by collectively increasing the interchange fee.

In contrast, Rochet and Tirole (2002) implicitly show that the interchange fee is decreasing in competition. In their model, they assume that the customer fee is a sunk cost. Thus, the customer fee does not directly affect either the consumers' decision of selecting a merchant or the merchants' decision of accepting the cards. I follow Wright (2003, 2010), by modeling the customer fee as a fee per transaction, which leads to the result that the interchange fee increases with competition while the

³See Rochet and Tirole (2002, 2003) and Evans and Schmalensee (2005).

⁴See Frankel (1998), Carlton and Frankel (1995), and Gans and King (2003).

customer fee decreases. Rosenthal (1980) shows a similar setting of price-increasing competition: competition lowers the price of a common market, but increases that of a captive market. In this context, the issuing side is the common market to the issuers, and the acquiring side is the captive market since the issuers can collectively charge the interchange fee to the merchants under the no-surcharge rule.

The paper also analyzes the effect of the competition policy. It shows that limiting competition may increase social welfare under the no-surcharge rule. An issuer must be a member of the association to provide its card payment services through the platform, and thus the association serves a barrier for entry or exit. That is, even though the privately optimal number of issuers is less than the number of member issuers, no issuers will exit the market as long as their profit is positive. As a result, there would be too many issuers so that the customer fee is lower and the interchange fee is higher than the socially optimal levels. In this case, limiting competition improves social welfare.

If the no-surcharge rule restricts issuers to compete only on the customer fee, lifting the no-surcharge rule may induce issuers to compete over the total fee including the interchange fee. Without the no-surcharge rule, the total fee paid by the consumers decreases with competition among issuers. If the issuers collectively determine the interchange fee even after the no-surcharge rule is lifted, the privately optimal fee is greater than the socially optimal level so that the card payment services are under-provisioned. It suggests that a fee policy can restrict a potential collusion even after abolishing the no-surcharge rule.

The rest of the paper is organized as follows: Subsection B outlines the model. Subsection C derives the equilibrium by using backward induction. Subsection D discusses the welfare implications of limiting competition under the no-surcharge rule and abolishing the no-surcharge rule. Subsection E concludes.

B. The Model

There is a single payment card association.⁵ It operates a platform that interconnects issuers and acquires who offer credit card services to the consumers and merchants, respectively. Figure 9 depicts the flow of card payment services. A consumer purchases a unit of goods at the retail price p with a credit card from a merchant. The merchant requests its bank (acquirer) to acquire the transaction made with the card. The acquirer sends its merchant the amount of $p - m$ where m is the merchant fee. It asks the consumer's bank (issuer) to interchange the transaction with the amount of $p - f_I$ where f_I is the interchange fee. Then, the consumer pays the issuer the amount of $p + f_C$ where f_C is the customer fee.⁶

The issuing side is a symmetric Cournot oligopoly with n firms. The acquiring side is assumed to be perfectly competitive so that the issuing side is the focus of the analysis. Consumers have a fixed number of transactions, normalized to one transaction per consumer, and merchants are homogeneous competing in a spatially differentiated market.

⁵The paper focuses on an open platform like Visa and MasterCard. A platform is open if the platform is jointly operated by its members (issuers). A platform is closed if the platform plays roles of issuers and acquirers. American Express is an example of closed platform. See Manenti and Somma (2009).

⁶In practice, a credit card has a grace period from the point of purchase to the payment due date, and neither interest nor fees are charged on the credit card during the grace period.

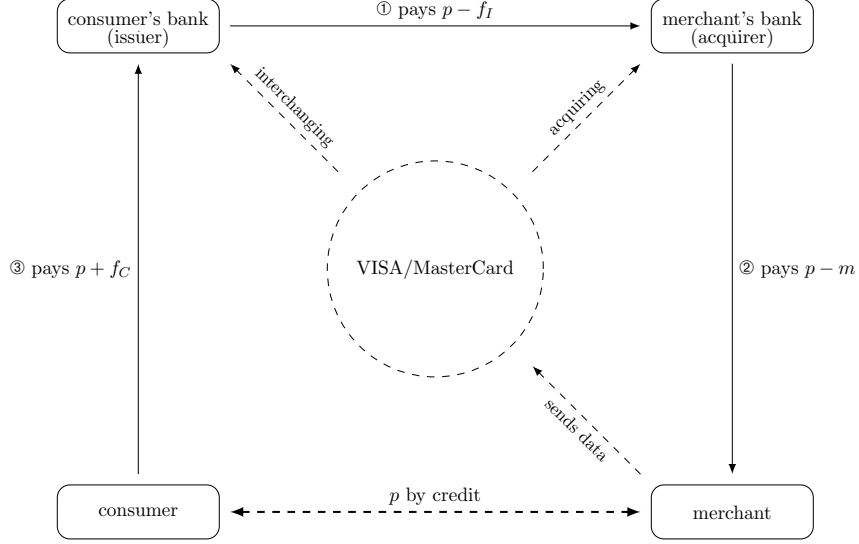


FIG. 9.—Flow of Card Payment Service

1. Card Association

The association requires its members to pay an access cost $l(n; \alpha)$ per transaction where n is the number of members and α is the state of technology ⁷:

$$\frac{\partial l(n; \alpha)}{\partial n} < 0; \quad \frac{\partial^2 l(n; \alpha)}{\partial n^2} > 0, \quad (4.1)$$

$$\frac{\partial l(n; \alpha)}{\partial \alpha} < 0; \quad \frac{\partial^2 l(n; \alpha)}{\partial \alpha^2} > 0. \quad (4.2)$$

I assume that the state of technology is exogenously given, and denote the initial value by α_0 . The assumptions on the access cost reflect that the platform has increasing economies of scale and that its cost efficiency also depends on the level of technological

⁷For instance, the marginal access cost may depend on the speed of telecommunication since credit card payments are made through the infrastructure of telecommunication that are exogenously determined.

advancements.

The association imposes a no-surcharge rule on merchants who accept its members' credit cards. It requires uniform pricing for cash and credit purchases. The association maximizes the total profit of its members by setting the interchange fee such that all merchants accept its platform cards.

2. Consumers

Each consumer seeks to acquire a single indivisible good of value ν , which can be either through cash or card. Consumers are heterogeneous in their convenience benefit b_B from using a payment card, which is related to the transactional cost of cash. The benefit b_B is drawn from a uniform distribution $H(b_B)$ with support $[\underline{b}_B, \bar{b}_B]$. If all merchants accept the card, a consumer with benefit b_B will choose to use her card if $b_B \geq f_C$. Thus, the total demand for card payment service will be

$$D(f_C) = 1 - H(f_C). \quad (4.3)$$

Thus, given that the consumers with $b_B \geq f_C$ transact using the credit cards and those with $b_B < f_C$ do not, the expected benefit enjoyed by the consumers who pay by card is expressed by

$$\beta(f_C) \equiv E[b_B | b_B \geq f_C] = \frac{\int_{f_C}^{\bar{b}_B} b_B dH(b_B)}{1 - H(f_C)} \quad (4.4)$$

3. Issuers

Each issuer's marginal cost is $c_I + l(n; \alpha)$, so the issuing side consists of n homogeneous issuers. The issuers are all members of the card association and they use the same

brand of the association like Visa or MasterCard on their cards.⁸ The issuing side is not a free-entry market in this model since a bank is not allowed to issue the platform-branded card and to use the platform if it is not a member. The issuers within the platform compete for customers in a Cournot oligopoly market. Each issuer chooses the quantity of card payment services so that the equilibrium customer fee, f_C , is determined by the equilibrium quantity.

4. *Acquirers*

Acquirers are perfectly competitive having constant marginal cost, c_A . Therefore, they set their price equal to their marginal cost:

$$m = f_I + c_A, \tag{4.5}$$

where m is the merchant fee paid by merchants to acquirers. In this model, acquirers play a role of passing through the interchange fee to the merchants.

5. *Merchants*

Merchants compete in the standard Hotelling linear city, like in Rochet and Tirole (2002). Consumers are uniformly located between two merchants, a segment of the market with length of 1. There may be an arbitrary number of such segments, and each part of merchants are selling the identical goods at the endpoints of the segment. Each consumer in the linear segment incurs a transportation cost t per unit of distance. Each merchant has constant marginal cost including cash transaction cost,

⁸See Armstrong (2006), Caillaud and Jullien (2003), and Manenti and Somma (2009) for competition among platforms. Armstrong (2006) present three cases: i) a monopoly platform, ii) a model of competing platforms where agents join a single platform, and iii) a model of competitive bottleneck where one group joins all platforms.

d , and obtains benefit per card transaction, b_S . Merchants' benefit from accepting cards are assumed to be homogeneous across merchants.

Besides choosing his retail price, each merchant also decides whether to accept credit cards. If he chooses to accept credit cards, the no-surcharge rule restricts the merchant to charge the same price for cash and credit card purchases. That is, the two decisions are sequential: whether to accept credit cards is followed by setting price.⁹

6. Decision Timing

The use of a credit card is associated with benefits for each merchant who accepts cards and each consumer who pays by card. The model assumes that it is not socially optimal for all consumers to pay by card: for all n and α ,

$$\underline{b}_B + b_S < c_I + l(n; \alpha) + c_A < \bar{b}_B + b_S. \quad (4.6)$$

That is, given n and α , there always exist some cash purchases in the economy. If $c_I + l(n; \alpha) + c_A < \underline{b}_B + b_S$ for some n , limiting competition can improve social welfare, which could be an arbitrary result driven by the condition of $c_I + l(n; \alpha) + c_A < \underline{b}_B + b_S$.¹⁰

The decision timing is as follows:

Stage 1: The association sets the interchange fee, and the issuers set the customer fee on the issuing side.

⁹The same equilibrium is obtained when the two decisions are simultaneous, because in equilibrium all merchants are symmetric in their choice of accepting credit cards and because the model assumes that the merchants are homogeneous in convenience benefits.

¹⁰If issuers incur a non-trivial but small fixed-cost to enter the market, limiting competition can improve social welfare in any cases. In the model, I assume no fixed cost that is consistent with the condition (4.6).

Stage 2: Merchants decide whether to accept payment cards, which becomes publicly observable.

Stage 3: Merchants set their prices simultaneously.

Stage 4: Consumers observe merchants' retail prices, choose their payment method, and visit a merchant of their choice.

The solution concept employed here is Subgame Perfect Nash equilibrium. The following subsection derives the equilibrium by using backward induction. (all proofs are provided in Appendix F)

C. The Privately Optimal Fees

Let f_C^* be the customer fee in a symmetric Cournot Oligopoly equilibrium. Consumers with $b_B < f_C^*$ will choose to pay by cash while consumers with $b_B \geq f_C^*$ will choose to pay by card. If all merchants accept the platform cards and set the same price on cash and card, consumers located at x_i will choose merchant i if

$$\nu - p_i + tx_i \geq \nu - p_j + t(1 - x_i)$$

where x_i becomes the merchant i 's market share.

Merchants can accept or not accept credit cards and then set the retail price in a segment of length 1. Lemma 1 shows that there exists an equilibrium, in which the association sets the largest interchange fee such that all merchants accept credit cards.

Lemma 1. *Let f_C^* and f_I^* be the equilibrium customer and interchange fees, respectively, under the no-surcharge rule.*

(i) *There exists an equilibrium in which all merchants accept the card if and only if*

$f_I \leq \bar{f}_I$ where \bar{f}_I is given by

$$\beta(f_C^*) - f_C^* = \bar{f}_I + c_A - b_S. \quad (4.7)$$

(ii) *The equilibrium interchange fee will be the largest interchange fee such that all merchants accept the platform cards:*

$$f_I^* = \bar{f}_I.$$

It is worth noting that the equilibrium customer fee f_C^* is a function of $c_A - f_I$. Thus, the largest interchange fee \bar{f}_I is given by equation (4.7). Lemma 1 - (i) reveals that all merchants accept the cards if the average total benefit ($\beta(f_C^*) + b_S$) is at least as large as the average total cost ($f_C^* + f_I + c_A$).¹¹ Lemma 1 - (ii) is obvious since the total profit of issuers is increasing over the interchange fee: $\partial \pi^{total} / \partial f_I > 0$. So, the largest interchange fee \bar{f}_I is the privately optimal level under the no-surcharge rule.

Note that issuers do not compete on the interchange fee under the no-surcharge rule. When all merchants accept the cards and set the identical price on cash and card purchases, consumers are not informed about the interchange fee and thus merchants do not care about the interchange fee as long as the condition (4.7) is satisfied. Therefore, even when the interchange fee is independently set by each issuer, the equilibrium interchange fee will be \bar{f}_I .¹²

Let $k \equiv \bar{b}_B - \underline{b}_B$. The demand for card payment services at f_C will be given by

¹¹In Rochet and Tirole (2002), the condition is given as $\beta(f_C^*) = f_I + c_A - b_S$ since they assume that the customer fee is a sunk cost to cardholders. They show that the largest interchange fee is uniquely determined given by $\beta(f_C^*) = f_I + c_A - b_S$ in their analysis.

¹²It is driven that issuers are homogeneous in cost. It is possible that all issuers will not agree with the level of the interchange fee set by the association if they are heterogeneous. However, since all issuers are within the platform, the interchange fee is likely to be set enough to cover the marginal cost of the most inefficient member.

$D(f_C) = 1 - H(f_C)$ where $H(f_C) = \frac{1}{k}(f_C - \bar{b}_B)$. Then, the inverse demand for card payment services is

$$f_C = \bar{b}_B - k \sum_{j=1}^n q_j. \quad (4.8)$$

Since the issuing side is a Cournot Oligopoly market, the equilibrium customer fee is determined through the profit-maximizing quantity of card payment services. So, each issuer solves,

$$\max_{q_i} (\bar{b}_B - k \sum_{j=1}^n q_j + f_I - c_I - l(n; \alpha)) q_i. \quad (4.9)$$

given $f_I \leq \bar{f}_I$.

Proposition 1. *Under the no-surcharge rule, the equilibrium fees are given by*

$$f_C^*(n) = \bar{b}_B - \frac{2n}{(n+2)} (\bar{b}_B + b_S - c_I - l(n; \alpha) - c_A), \quad (4.10)$$

$$f_I^*(n) = c_I + l(n; \alpha) - \bar{b}_B + \frac{2(n+1)}{(n+2)} (\bar{b}_B + b_S - c_I - l(n; \alpha) - c_A), \quad (4.11)$$

yielding

$$\frac{\partial f_C^*(n)}{\partial n} < 0 ; \quad \frac{\partial f_I^*(n)}{\partial n} > 0. \quad (4.12)$$

In contrast, Rochet and Tirole (2002) shows that both fees are decreasing with competition under the assumption that the customer fee is a sunk cost. If the customer fee is a sunk cost, it does not affect the consumers' decision of selecting a merchant, and also does not directly affect the merchants' decision of accepting credit cards.¹³ Proposition 1 occurs only if the customer fee is a fee per transaction, not a sunk cost.¹⁴

¹³If the customer fee is a sunk cost, the merchant not accepting the cards will have the market share among consumers with $b_B > f_C^*$ such that $p_i + tx_i^r = p_j + t(1 - x_i^r) - b_B$. Condition (4.7) will become $\beta(f_C^*) = \bar{f}_I + c_A - b_S$ as in Rochet and Tirole (2002).

¹⁴Wright (2003, 2010) also assumes that the customer fee is a fee per transaction

Interestingly, the customer fee could be negative in equilibrium whenever the privately optimal number of issuers is larger. Let \tilde{n} be $2n/(n+2)$. Note that $\frac{2}{3} \leq \tilde{n} < 2$. Then, the condition for a negative customer fee from (4.10) is given by

$$(\bar{b}_B + b_S - c_I - l(n; \alpha) - c_A) > \frac{1}{\tilde{n}} \bar{b}_B.$$

Proposition 2 addresses that the association serves a barrier for entry and exit. That is, incumbent issuers may not agree with new entry unless they are able to compensate losses from competing in the issuing side by increasing the interchange fee in equilibrium. Let $g(n) = \bar{b}_B + b_S - c_I - l(n; \alpha) - c_A$ for brevity. From (4.10) and (4.11), issuer i 's profit is given by

$$\pi_i(n) = \frac{4}{k(n+2)^2} g(n)^2. \quad (4.13)$$

Proposition 2. *Under the no-surcharge rule, there exists an (unique) n^* that maximizes an individual issuer's profit function.*

It can be shown that $n^* = 1$ if the marginal access cost, $l(n; \alpha)$, is constant, because the profit function is monotonic decreasing in n when $l(n; \alpha)$ is constant. Therefore, the assumption of increasing economies of scale derives the equilibrium result of $n^* > 1$. Two examples describe a unique solution given the functional forms of $l(n; \alpha)$ as follow.¹⁵

□ *Example 1.* Assume $l(n; \alpha) = 1/\alpha n$ for $\alpha > 0$ and $n > 0$, satisfying (4.1) and (4.2). The privately optimal number of issuers n^* is uniquely determined at $\sqrt{2/\alpha(\bar{b}_B + b_S - c_I - c_A)}$.

□ *Example 2.* Assume $l(n; \alpha) = 1/\alpha\sqrt{n}$ for $\alpha > 0$ and $n > 0$, satisfying (4.1)

for using cards.

¹⁵The condition for a concave profit function with respect to n is addressed in the proof of Proposition 2, See Appendix F.

and (4.2). The privately optimal number of issuers n^* uniquely solves $\alpha(\bar{b}_B + b_S - c_I - c_A)n^{\frac{3}{2}} + \frac{1}{2}n - 1 = 0$.¹⁶

Given the state of technology by α , Proposition 2 implies that the association does not allow any entry if the number of members is equal to the privately optimal number of issuers, n^* . However, given the number of issuers by some n , any issuers will not exit the market even if $n^* < n$. It can be shown that n^* decreases with α (see *Example 1*). Meanwhile, since $\pi_i(n)$ increases with α , no issuers will exit the market as long as they are already the members of the association. As a result, there would be too many issuers so that the customer fee is too low and the interchange fee is too high. In this case, limiting competition may result in improved social welfare.

It is worth noting that the privately optimal number of issuers will be one if the marginal access cost is constant or independent of the number of issuers. Moreover, the assumption of the state of technology on the marginal access cost is critical to show that limiting competition can improve social welfare.

D. Competition Policy and the No-surcharge Rule

1. Under the No-surcharge Rule

A social planner may determine the number of issuers that maximizes social welfare, $W(f_C^*(n))$ ¹⁷ :

$$n' = \operatorname{argmax}_n \int_{f_C^*(n)}^{\bar{b}_B} [b_B + b_S - c_A - c_I - l(n; \alpha)] dH(b_B). \quad (4.14)$$

¹⁶Note that $\alpha(\bar{b}_B + b_S - c_I - c_A)n^{\frac{3}{2}} + \frac{1}{2}n - 1$ is monotonic increasing in $[0, \infty)$ while it is negative for $n = 0$ and positive for $n > n^*$.

¹⁷It does not include a constant term. The original social welfare function consists of different components: consumer surplus $\nu - p - f_C(1 - H(f_C)) - \int_{\underline{b}_B}^{f_C} b_B dH(b_B)$, merchants' profit $p - d - (m - b_S)(1 - H(f_C))$, and issuers' profit $(f_C + f_I - c_I - l(n; \alpha))(1 - H(f_C))$.

Given the number of issuers determined by the social planner, the association sets the interchange fee and the issuers set the customer fee through determining the quantity of card payment services.

Let n^* be the privately optimal number of issuers at α_0 . Intuitively, since an increase in the state of technology has the same effect on social welfare like an increase in competition, the socially optimal number can equal the number of incumbent issuers for some $\alpha > \alpha_0$.

Let $\tilde{\alpha}$ be the state of technology such that $n' = n^*$. Two cases are considered:

- (i) $n' < n^*$: For $\alpha > \tilde{\alpha}$, the socially optimal number of issuers is less than the number of incumbent issuers. Intuitively, the rapid developments in technology may require to lessen the number of incumbent issuers, but the issuers enjoy the technology developments as long as their profits are positive. Thus, the number of incumbent issuers can be larger than the socially optimal level. In this case, limiting competition improves social welfare.
- (ii) $n^* < n'$: In this case, the socially optimal number of issuers is larger than the privately optimal number. So, the customer fee will be lower and the interchange fee will be higher when intervened by the social planner. That is, the privately optimal output is socially inefficient, and thus an increase in competition improves social welfare. This case can happen when $\alpha < \tilde{\alpha}$.

Proposition 3. *Let $\tilde{\alpha}$ be the state of technology such that $n' = n^*$. Given the number of issuers by n^* , limiting competition improves social welfare for $\alpha > \tilde{\alpha}$; for $\alpha < \tilde{\alpha}$, increasing competition improves social welfare.*

Proposition 3 suggests that limiting competition improves social welfare when $f_C^*(n^*) < f_C^*(n')$ and $f_I^*(n^*) > f_I^*(n')$ due to the improved state of technology. To understand how limiting competition can improve social welfare, let suppose that the

social planner directly sets the fees given the number of issuers by n^* . In this case, the social planner does not care about the social efficiency of the platform, but the socially optimal provision of card payment services. Under the no-surcharge rule, the socially optimal level of the customer fee is

$$f_C^S(n^*; \alpha) = c_I + l(n^*; \alpha) + c_A - b_S,$$

which is higher than the privately optimal customer fee $f_C^*(n^*; \alpha)$ for $n^* > 2$. So, the privately optimal interchange fee is higher than the socially optimal level. That is, the collective determination of the interchange fee even under the no-surcharge rule lead to an over-provision of card payment services, given the fixed number of issuers.¹⁸ Thus, limiting competition so that f_C^* increases and f_I^* decreases can improve social welfare.

Proposition 3 also indicates that increasing competition improves social welfare when $\alpha < \tilde{\alpha}$. In this case, the quantity of card payment services is under-provisioned due to the cost inefficiency of the platform. It is worth noting that competition has two effects on the customer fee: improving the cost efficiency of the platform ($\partial l(n; \alpha) / \partial n < 0$) and lowering the customer fee directly.. Thus, an increase in the cost efficiency of the platform would be larger than a decrease in the customer fee, and so a rise in competition can increase the under-provisioned quantity of card payment services.

Without modeling the state of technology, it can be shown that the privately optimal number of issuers is always less than the socially optimal number of issuers. So, the privately optimal interchange fee is less than the socially optimal level. That

¹⁸See Proposition 3 - (ii) in Rochet and Tirole (2002). They propose that there would be an equilibrium of $f_C^S < f_C^*$, but I do not have this case in the equilibrium of the model.

is, even under the no-surcharge rule, the platform may not internalize positive network externalities efficiently.

To sum up, competition policy under the no-surcharge rule should depend on the status of the economy: if the card payment services are over-provisioned, a decrease in the number of issuers improves social welfare; if they are under-provisioned, an increase in the number of issuers improves social welfare. In any cases, the privately optimal fees are likely to differ from the socially optimal level under the no-surcharge rule.

2. *Without the No-surcharge Rule*

If the no-surcharge rule is lifted, merchants may surcharge on card payments, resulting in different prices for card and cash purchases (let p^r be the card price and p^c be the cash price). That is, consumers may indirectly observe the interchange fee included in the retail price for card purchases. Without the no-surcharge rule, consumers' demand for card purchases depends on the total price of a card payment service, $f_C + p^r - p^c$.

2.1. Merchants' Responses

Lemma 2. *Without the no-surcharge rule, all merchants surcharge on card payments if $m \neq b_S$ in equilibrium.*

Lemma 2 is obvious in that the convenience benefit of homogeneous merchants is the willingness-to-pay price for a card payment service. Therefore, they do not surcharge on card purchases when $m = b_S$.

2.2. Issuers' Responses

Without the no-surcharge rule, the level of the interchange fee is neutral to the quantity of the card payment services since consumers pay $f_C + p^r - p^c$ for card purchases. Under the no-surcharge rule, the higher interchange fee followed by the lower customer fee increases demand for card purchases, because the effective cost of a card payment service is not informed to consumers. In contrast, without the no-surcharge rule, demand for card purchases is determined by $f_C + p^r - p^c$, instead of by f_C . Therefore, keeping $f_C + p^r - p^c$ constant, the lower customer fee and the higher interchange fee does not affect the quantity of the card payment services in equilibrium.

Though the no-surcharge rule is lifted, issuers are able to collectively determine the interchange fee rather than compete on $f_C + p^r - p^c$. Under the no-surcharge rule, the levels of the interchange fee are identical regardless of whether they are collectively determined. However, the collective determination of the interchange fee within the association can be viewed as a collusion without the no-surcharge rule. After the no-surcharge rule is lifted, no one is constrained by all merchants accepting the credit cards so that the non-cooperative interchange fee can be less than the collusive interchange fee.

Also, the collective determination of the interchange fee can be ruled out by the social planner. Then, the issuing side competes on the total price $f_C + f_I$ instead of the customer fee f_C , which is the reason why the restriction on the collective determination of the interchange fee improves social welfare. After the no-surcharge rule is lifted, the total price is definitely decreasing in the number of issuers while the collectively-determined interchange fee is increasing. Thus, prohibiting the collective determination of the interchange fee leads to competition over the total price, resulting in an improved social welfare.

To analyze the effect of the collective determination of the interchange fee within the association on social welfare, let $\tau = f_C + f_I + c_A - b_S$ for brevity, which is the effective price for card purchases. The social welfare without the no-surcharge rule is given by¹⁹:

$$W(\tau) = \int_{\tau}^{\bar{b}_B} [b_B + b_S - c_A - c_I - l(n; \alpha)] dH(b_B). \quad (4.15)$$

Then, the socially optimal effective fee paid by the consumers with $b_B \geq \tau^S$ is,

$$\tau^S = c_A + c_I + l(n; \alpha) - b_S,$$

yielding

$$f_C^S + f_I^S = c_I + l(n; \alpha), \quad (4.16)$$

which is called the total (marginal) price for a card payment service in the issuing side. That is, the optimal social welfare is driven when the total price of a card payment service equals the marginal cost in the issuing side.

Proposition 4 shows that the implications of abolishing the no-surcharge rule may depend on whether the association sets the interchange fee collectively.

Proposition 4. *Without the no-surcharge rule,*

- (i) *If the association sets the interchange fee, the privately optimal total price is greater than the socially optimal level so that the card payment services are under-provisioned.*
- (ii) *Otherwise, the privately optimal total price approaches the socially optimal level as $n \rightarrow \infty$.*

Proposition 4 - (i) indicates that the abolishment of the no-surcharge rule is not

¹⁹It originally consists of different components: consumer surplus $(\nu - p^c)H(\tau)(\nu - p^r - f_C)(1 - H(\tau)) - \int_{b_B}^{\tau} b_B dH(b_B)$, merchants' profit $(p^c - d(H(\tau) + (p^r - d - m + b_S)(1 - H(\tau))))$, and issuers' profit $(f_C + f_I - c_I - l(n; \alpha))(1 - H(\tau))$.

enough to attain the socially optimal quantity of card payment services by itself as long as the interchange fee is set by the association. In this case, an increase in the number of issuers may improve social welfare, which is described in Proposition 4 - (ii).

E. Summary

The paper analyzes the issuing side of the credit card industry, and finds that the economic principle between competition and price does not hold under the no-surcharge rule. The no-surcharge rule not only internalizes the positive network externalities but also restricts competition only on the customer fee. Moreover, the card association serves as a barrier for entry and exit. So, the incumbent issuers can be larger than the socially optimal level so that limiting competition may improve social welfare. If the social planner does not care about the efficiency of the platform like the model in Rochet and Tirole, the privately optimal customer fee is always less than the socially optimal level given the fixed number of issuers. So, limiting competition can improve social welfare.

The paper also shows that the abolishment of the no-surcharge rule leads issuers to compete on the total fee including the interchange fee unless the association sets the interchange fee collectively. As a result, the total fee is decreasing with competition, and so competition may improve social welfare. However, if the association sets the interchange fee in the absence of the no-surcharge rule, the quantity of the card payment services are under-provisioned. In this case, a fee policy may improve social welfare by restricting the collective determination of the interchange fee.

There are several directions for further theoretical researches. For instance, there are multiple platforms in the real economy. So, any issuers may switch its platform

with some transfer costs. Moreover, merchants and issuers can be heterogeneous in convenience benefits and in marginal costs, respectively.

CHAPTER V

CONCLUSION

The study examines how firms respond to changes in actual or potential competition, particularly their responses in pricing. Though competition reduces firms' market power so that prices are expected to be lower, firms may still enjoy their market power to some extent if the market has some characteristics that prevent the forces of competition from spilling over the market.

The airline industry investigated in Chapter II and Chapter III is characterized by a price-discriminating market with segments of heterogeneous consumers. So, the effects of competition on price discrimination can be different depending on whether firms compete more on one group of consumers than on another group of consumers. I find that competition may have a positive effect on price discrimination in a case that firms are more competitive on consumers who are more likely to switch firms. Thus, when firms face new entry, they would like to reduce lower-end prices much more than higher-end prices. However, I also find that competition can have a negative effect on price discrimination when firms face with new entry by low-cost rivals. In this case, new entry by low-cost rivals can change consumers' tendencies of switching firms. As a result, incumbents may be restricted in price discriminating consumers rather than when they compete with relatively homogeneous competitors. In this case, firms reduce higher-end prices much more than lower-end prices, resulting in reducing price discrimination.

This study has two contributions to the literature of price discrimination. First, it recognizes the importance of identifying different forces of competition on price discrimination in the airline industry. Gerardi and Shapiro (2009) suggest that the positive cross-sectional estimate on competition in Borenstein and Rose (1994) may

suffer from omitted variable biases. However, the opposite results are mainly because of whether to include low-cost carriers in the analysis. Second, the opposite results in the literature are not contradictory but both are empirically evident in the industry. The hypothesis that major airlines price discriminate differently depending on whether to compete with low-cost carriers, is not rejected. Major airlines reduce lower-end prices much more than upper-end prices when they compete against one other, while they reduce upper-end prices to a greater extent when they compete with low-cost carriers.

Moreover, I find that major airlines may reduce price discrimination responding to a low-cost carrier's (Southwest) threat of entry. It is distinguished from the existing literature in that the analysis focuses on price discrimination (price dispersion) rather than on the average price. Based on the understanding of entry game as a signaling game, I identify that the preemptive reduction in price discrimination is for the purpose of entry deterrence. That is, the low-cost rival can discourage incumbents from entry deterrence by informing its entry while the incumbents have no motives to deter the scheduled entry. In contrast, if incumbents are not certain about the rival's future entry, they are more likely to persistently reduce price discrimination for entry deterrence.

The credit card industry analyzed in Chapter IV has also some characteristics that restricts the effects of competition on prices. First of all, it is a two-sided market that requires a platform to interconnect issuers and acquires for card payments. Furthermore, it has positive network externalities between consumers and merchants, under the no-surcharge rule that prohibits merchants from setting different prices for cash and card purchases. As a result, competition among issuers are not effective in lowering the interchange fee paid by the merchants to the issuers. It is because the issuers can compensate losses from competing on the issuing side by collectively

increasing the interchange fee. As long as the issuers in the platform enjoy a positive profit, no one will not exit the market under the no-surcharge rule. In this case, limiting the number of issuers can improve social welfare because there would be too many issuers in the market.

The further researches must be followed in the quest of the relationship of competition and firms' responses in pricing. The market characteristics that limit the effects of competition on prices may also exist in other industries so that there would be similar or different implications on the relationship between competition and firms' pricing. For instance, the mortgage loan markets are similar to the airline routes in that consumers are heterogeneous in switching cost and firms can price discriminate with respect to consumer heterogeneity. In addition, the parametric approaches of the study do not explain possible non-linear (non-parametric) relationships between competition and price dispersion. For example, I show that competition can have a positive effect on price dispersion. However, since lower-end prices can not be lower than the marginal cost, there would be a threshold from which price dispersion starts to decrease with competition. Finally, the recent debates on high interchange fees and the no-surcharge rule in the United States stimulate further investigations on the effects of competition on interchange fees and the effects of banning the no-surcharge rule, in a more general case like multiple platforms.

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APPENDIX A

VARIABLES AND INSTRUMENTS

Variables¹

G_{ijt}^{lodd} - The Gini log-odds ratio, given by $G_{ijt}^{lodd} = \ln(\frac{G_{ijt}}{1-G_{ijt}})$, where G_{ijt} is the Gini coefficient of carrier i 's price distribution on route j in period t , calculated using data from DB1B. The formula is given as in Borenstein and Rose (1994):

$$G = 1 - 2 \times \sum_{m=1}^N \left(\text{fare}_m \times \frac{PAX_m}{\text{total revenues}} \right) \times \left[\frac{PAX_m}{\text{total } PAX} + \left(1 - \sum_{k=1}^m \frac{PAX_k}{\text{total } PAX} \right) \right],$$

where N is the number of different fare level tickets reported by a carrier on a route, fare_m is the reported fare for the m th ticket, and PAX_m is the reported number of passengers traveling at that fare.

$\ln P(k)_{ijt}$ - The logarithm of the k th price percentile of carrier i on route j in period t , obtained from the DB1B.

$\ln HERF_{jt}$ - The logarithm of the Herfindahl index of route j in period t , calculated using passenger shares obtained from the DB1B.

$\ln N_{jt}$ - The logarithm of the total number of carriers operating on route j in period t , obtained from the DB1B.

N_{jt}^{LEG} : The number of legacy carriers on city-pair route j in period t obtained from the DB1B.

N_{jt}^{LCC} : The number of low-cost carriers (not including regional carriers) on city-pair route j in period t obtained from the DB1B.

¹It is reproduced from Gerardi and Shapiro (2009) and Borenstein and Rose (1994).

$\ln MKTSHARE_{ijt}$ - The logarithm of the share of total passengers originating on route j operated by carrier i in period t , calculated from the DB1B.

$\ln FLTTOT_{jt}$ - The logarithm of the total number of departures performed on route j in period t , obtained from the T-100 Domestic Segment Databank.

HUB_{ij} - A dummy variable indicating whether either the origin or destination of route j is a hub airport of carrier i .

$SMALL_j$ - A dummy variable indicating if both the origin and the destination airport are not in our list of big cities.

$\ln TOURIST_j$ - The logarithm of the maximum of the ratio of accommodation earnings to total non-farm earnings for the origin and destination cities on route j , obtained from the Bureau of Economic Analysis.

$\ln ASEATCAP_{ij}$ - The logarithm of average seat capacity (total available seats divided by total number of departures) on route j by carrier i obtained from the T-100 Domestic Segment Databank.

Instruments

$\ln DISTANCE_j$ - The logarithm of non-stop distance in miles between endpoint airports of route j .

$AMEANPOP$ - The arithmetic mean of the metropolitan population of endpoint cities taken from the 2000 U.S. Census.

$GMEANPOP$ - The geometric mean of the metropolitan population of endpoint cities taken from the 2000 U.S. Census.

$\ln PASSRTE_{jt}$ - The logarithm of total enplaned passengers on route j in period t from the T-100 Domestic Segment Databank.

$IRUTHERF$ - This instrument is identical to one used by Borenstein and Rose

(1994). This variable is the square of the fitted value for $MKTSHARE_{ijt}$ from its first-stage regression, plus the rescaled sum of the squares of all other carrier's shares. See Borenstein and Rose (1994) for a more detailed explanation. It is equal to

$$MKT\widehat{SHARE}_{ijt}^2 + \frac{HERF_{jt} - MKTSHARE_{ijt}^2}{(1 - MKT\widehat{SHARE}_{ijt})^2} * (1 - MKT\widehat{SHARE}_{ijt})^2.$$

$GENPSH - \sqrt{ENP_{j1} * ENP_{j2}} / \sum_k \sqrt{ENP_{k1} * ENP_{k2}}$, where k indexes all airlines, j is the observed airline, and ENP_{k1} and ENP_{k2} are airline k 's average quarterly enplanements at the two endpoint airports. This instrument is similar to one used by Borenstein and Rose (1994), with the difference being that Borenstein and Rose use average daily enplanements, while I use average quarterly enplanements, as a result of data availability. Data on enplanements were obtained from the T-100 Domestic Segment Databank.

APPENDIX B
QUARTERLY AND ROLLING CROSS-SECTIONAL ESTIMATES
FOR OTHER VARIABLES

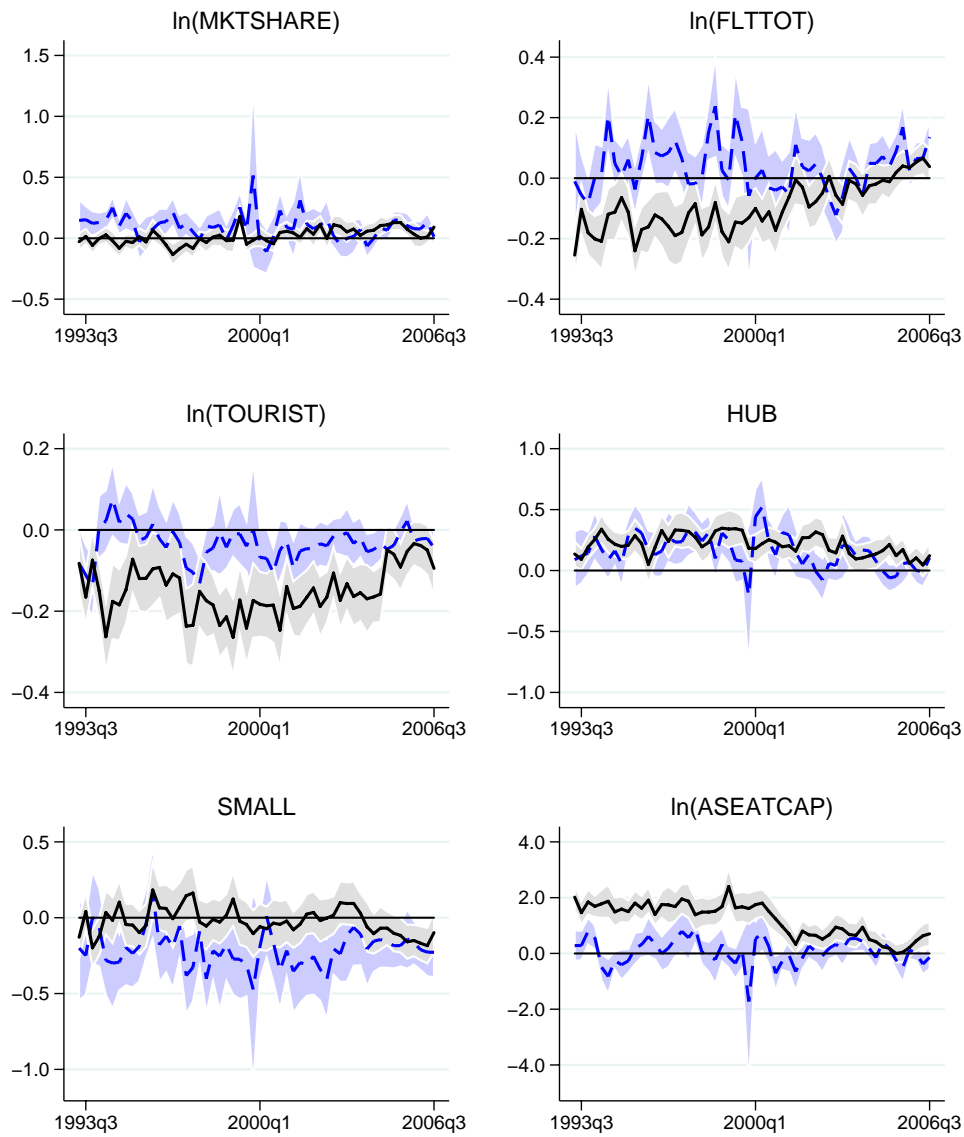


FIG. 10.— Quarterly Cross-sectional Estimates for Major Airlines: The thick line indicates the estimates in major-carrier routes while the dashed line does the estimates in mixed-carrier routes. The colored area stands for the 95 percent confidence interval.

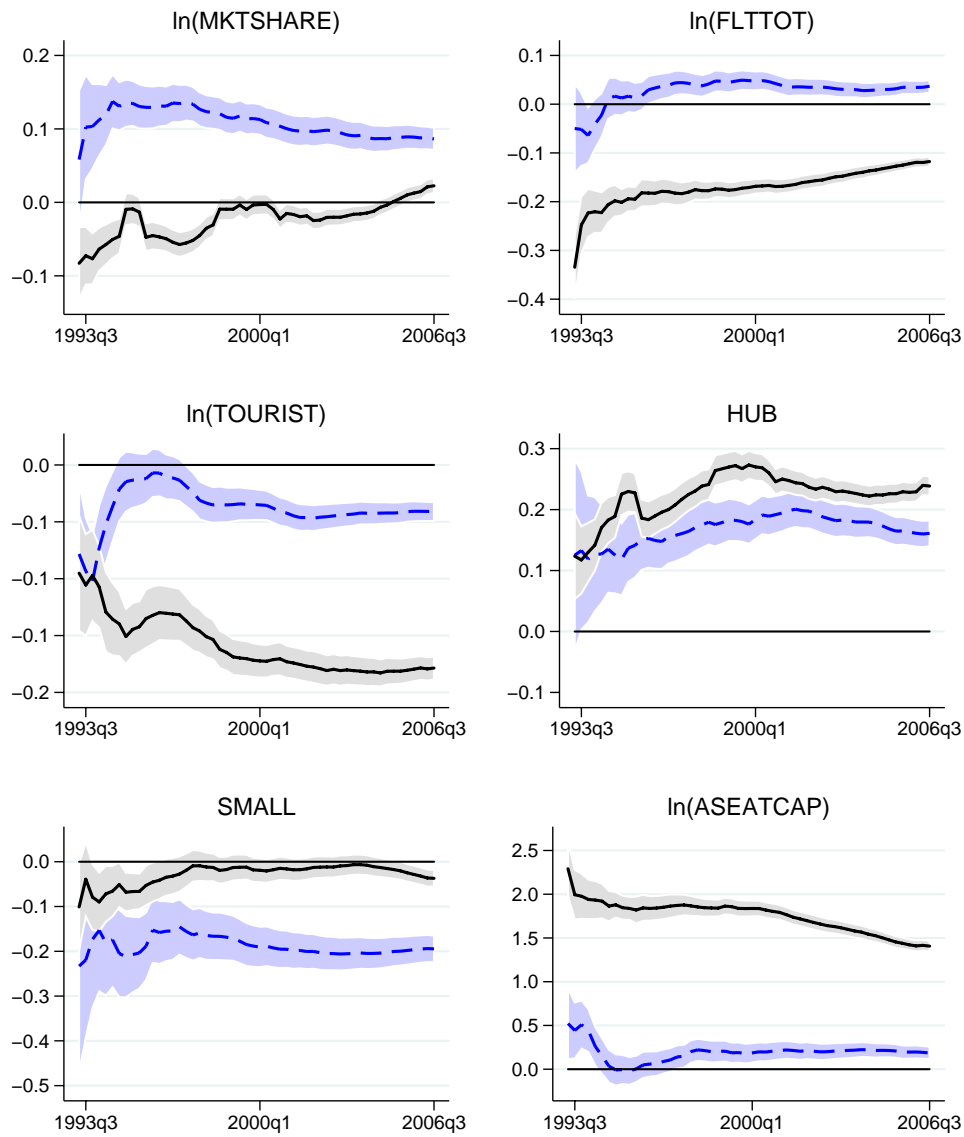


FIG. 11.— Rolling Cross-sectional Estimates for Major Airlines: The thick line indicates the estimates in major-carrier routes while the dashed line does the estimates in mixed-carrier routes. The colored area stands for the 95 percent confidence interval.

APPENDIX C
PRE-ANNOUNCED NON-STOP DESTINATIONS AMONG ROUTES
IMMEDIATELY SERVICED BY SOUTHWEST

TABLE XIV

PRE-ANNOUNCED NON-STOP DESTINATIONS AMONG ROUTES IMMEDIATELY SERVICED
BY SOUTHWEST

Origin Airport	Code	Service Started	Announced Destination	Announced
Long Island, NY	(ISP)	03/14/99	Baltimore/Washington Chicago Midway Nashville Tampa Bay	12/09/98*
Raleigh-Durham, NC	(RDU)	06/06/99	Baltimore/Washington Chicago Midway Nashville Tampa Bay Orlando	03/04/99*
Hartford/Springfield, CT	(BDL)	10/31/99	Baltimore/Washington Chicago Midway Nashville Orlando	07/13/99*
Albany, NY	(ALB)	05/07/00	Baltimore/Washington Las Vegas Orlando	01/06/00 01/18/00*
Buffalo/Niagara Falls, NY	(BUF)	10/08/00	Baltimore/Washington Las Vegas Orlando Phoenix	06/20/00
West Palm Beach, FL	(PBI)	01/21/01	Baltimore/Washington Nashville Tampa Bay Orlando	09/14/00 10/19/00*
Norfolk, VA	(ORF)	10/07/01	Baltimore/Washington Jacksonville Las Vegas Orlando	05/24/01 07/24/01*
Philadelphia, PA	(PHL)	05/09/04	Chicago Midway Las Vegas Phoenix Orlando Providence Tampa Bay	10/28/03 12/11/03*

* indicates the date of announcing non-stop flights with fares from the airport.

APPENDIX D
RESULTS FROM DIFFERENT SAMPLE SELECTIONS

TABLE XV
POOLING ALL THREATENED ROUTES

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.006	0.004*	0.004	-0.001	0.002
N^{LCC}	-0.000	-0.028***	-0.038***	-0.053***	-0.047***
$d_p \cdot N^{LCC}$	-0.008	-0.011*	-0.006	0.009	-0.010
$d_e \cdot N^{LCC}$	-0.034**	-0.008	-0.004	0.014	-0.017
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	-0.002	0.003	-0.000	0.024	0.013
$d(t_p - 4)$	0.028	-0.008	-0.002	-0.016	0.014
$d(t_p - 3)$	0.004	-0.008	-0.023	-0.048**	-0.026
$d(t_p - 2)$	-0.040	0.010	0.008	-0.030	-0.029
$d(t_p - 1)$	-0.026	0.016	0.008	0.011	-0.019
$d(t_p)$	-0.004	-0.027**	-0.030**	-0.051***	-0.037**
$d(t_p + 1)$	-0.075***	0.007	0.003	-0.065***	-0.075***
$d(t_p + 2)$	-0.073***	0.004	0.006	-0.053***	-0.065***
$d(t_p + 3)$	-0.053***	0.001	-0.019	-0.046**	-0.079***
$d(t_p + 4)$	-0.049**	-0.015	-0.030**	-0.059***	-0.086***
$d(t_p + 5 \text{ to } t_p + 12)$	-0.041***	-0.050***	-0.047***	-0.076***	-0.091***
Southwest' Actual Entry:					
$d(t_e)$	0.022	-0.167***	-0.161***	-0.165***	-0.168***
$d(t_e + 1)$	-0.008	-0.207***	-0.230***	-0.246***	-0.212***
$d(t_e + 2)$	0.004	-0.251***	-0.261***	-0.294***	-0.294***
$d(t_e + 3)$	0.040	-0.244***	-0.250***	-0.222***	-0.231***
$d(t_e + 4)$	0.009	-0.234***	-0.216***	-0.237***	-0.237***
$d(t_e + 5 \text{ to } t_e + 8)$	0.017	-0.197***	-0.171***	-0.180***	-0.181***
Southwest' Exit(no flights):					
$d(t_x)$	0.015	-0.046***	-0.057***	-0.002	-0.016
$d(t_x + 1)$	0.014	-0.045***	-0.040**	-0.016	-0.016
$d(t_x + 2)$	-0.027	-0.039**	-0.027*	-0.043*	-0.035
$d(t_x + 3)$	-0.011	-0.042**	-0.031*	-0.035	-0.033
$d(t_x + 4)$	-0.022	-0.048***	-0.039**	-0.046*	-0.053**
<i>Bankruptcy</i>	-0.101***	-0.015*	-0.013	-0.101***	-0.127***
R-square	0.161	0.165	0.151	0.113	0.152
Observations	28,585	28,585	28,585	28,585	28,585

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

TABLE XVI
SELECTING MAJOR-CARRIER ROUTES OVER THE SAMPLE PERIOD

	G^{lodd}	$\ln P(10)$	$\ln P(20)$	$\ln P(80)$	$\ln P(90)$
	(1)	(2)	(3)	(4)	(5)
N^{LEG}	0.013*	-0.005	-0.009	0.004	0.005
N^{LCC}	0.077***	0.023	0.006	0.084*	0.084***
$d_p \cdot N^{LCC}$	-0.043	-0.052**	-0.039*	-0.125***	-0.104***
$d_e \cdot N^{LCC}$					
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	0.032	0.047**	0.037	0.073*	0.094**
$d(t_p - 4)$	0.076*	0.011	0.040	0.057	0.082
$d(t_p - 3)$	0.091**	0.010	0.034	0.024	0.152***
$d(t_p - 2)$	0.072*	0.040	0.042	-0.005	0.094*
$d(t_p - 1)$	0.049	0.077**	0.069*	0.080*	0.118**
$d(t_p)$	0.081**	0.016	-0.017	-0.050	0.012
$d(t_p + 1)$	0.033	0.031	-0.009	-0.009	-0.018
$d(t_p + 2)$	-0.023	-0.006	0.006	-0.046	-0.037
$d(t_p + 3)$	0.018	-0.033	-0.071**	-0.052	-0.116**
$d(t_p + 4)$	0.056	-0.052*	-0.045	-0.016	-0.013
$d(t_p + 5 \text{ to } t_p + 12)$	0.003	-0.098***	-0.096***	-0.092***	-0.116***
<i>Bankruptcy</i>	-0.030	0.010	0.015	-0.050	-0.017
R-square	0.167	0.171	0.167	0.114	0.186
Observations	4,661	4,661	4,661	4,661	4,661

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

TABLE XVII
SELECTING MAJOR-CARRIER ROUTES BEFORE THREATENED BY SOUTHWEST

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.004	-0.004	-0.008**	-0.010*	-0.011**
N^{LCC}	-0.015	0.003	0.012	0.011	-0.006
$d_p \cdot N^{LCC}$	0.011	-0.035**	-0.050***	-0.053***	-0.042
$d_e \cdot N^{LCC}$	-0.045*	-0.008	-0.018	-0.028	-0.028
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	0.002	0.069***	0.061**	0.128***	0.101**
$d(t_p - 4)$	0.001	0.080**	0.065**	0.045	0.081
$d(t_p - 3)$	0.003	0.074**	0.039	0.005	0.050
$d(t_p - 2)$	-0.017	0.089***	0.071**	0.058	0.057
$d(t_p - 1)$	0.007	0.082***	0.074**	0.103**	0.065*
$d(t_p)$	0.029	0.022	0.014	0.043	0.045
$d(t_p + 1)$	-0.051*	0.036	0.046**	-0.015	-0.016
$d(t_p + 2)$	-0.079***	0.051**	0.047**	-0.027	-0.018
$d(t_p + 3)$	-0.064***	0.057***	0.036*	-0.002	-0.044
$d(t_p + 4)$	-0.062**	0.025	0.002	-0.064*	-0.076**
$d(t_p + 5 \text{ to } t_p + 12)$	-0.009	-0.015	-0.027*	-0.070***	-0.039
Southwest' Actual Entry:					
$d(t_e)$	0.125***	-0.193***	-0.186***	-0.155***	-0.097***
$d(t_e + 1)$	0.110**	-0.332***	-0.386***	-0.313***	-0.233***
$d(t_e + 2)$	0.113*	-0.346***	-0.361***	-0.324***	-0.302***
$d(t_e + 3)$	0.202***	-0.313***	-0.353***	-0.228***	-0.200***
$d(t_e + 4)$	0.170***	-0.315***	-0.333***	-0.229***	-0.195***
$d(t_e + 5 \text{ to } t_e + 8)$	0.162***	-0.250***	-0.219***	-0.179***	-0.130***
Southwest' Exit(no flights):					
$d(t_x)$	0.089**	-0.089***	-0.104***	-0.021	0.038
$d(t_x + 1)$	0.077*	-0.071**	-0.075**	-0.042	0.010
$d(t_x + 2)$	0.020	-0.078**	-0.060**	-0.058*	-0.020
$d(t_x + 3)$	0.036	-0.072**	-0.053*	-0.047	-0.030
$d(t_x + 4)$	0.054	-0.076***	-0.060**	-0.033	0.021
<i>Bankruptcy</i>	0.026	-0.009	-0.012	-0.060**	-0.018
R-square	0.176	0.174	0.170	0.113	0.125
Observations	9,953	9,953	9,953	9,953	9,953

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

TABLE XVIII
SELECTING MIXED-CARRIER ROUTES BEFORE THREATENED BY SOUTHWEST

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.012**	0.012***	0.013***	0.004	0.009
N^{LCC}	-0.002	-0.029***	-0.040***	-0.058***	-0.049***
$d_p \cdot N^{LCC}$	-0.012	-0.011	-0.000	0.019*	-0.011
$d_e \cdot N^{LCC}$	-0.015	-0.030*	-0.024	0.009	-0.031
Southwest' Presence:					
$d(t_p - 8 \text{ to } t_p - 5)$	-0.006	-0.035**	-0.034**	-0.035	-0.042
$d(t_p - 4)$	0.028	-0.050***	-0.048***	-0.072***	-0.044
$d(t_p - 3)$	-0.015	-0.053***	-0.075***	-0.106***	-0.114***
$d(t_p - 2)$	-0.075**	-0.032*	-0.034*	-0.085***	-0.104***
$d(t_p - 1)$	-0.057**	-0.036**	-0.043***	-0.060**	-0.095***
$d(t_p)$	-0.037	-0.061***	-0.057***	-0.107***	-0.082***
$d(t_p + 1)$	-0.126***	-0.011	-0.020	-0.113***	-0.125***
$d(t_p + 2)$	-0.088***	-0.007	-0.017	-0.068***	-0.098***
$d(t_p + 3)$	-0.068**	-0.016	-0.036*	-0.070**	-0.082***
$d(t_p + 4)$	-0.070**	-0.023	-0.047**	-0.069**	-0.109***
$d(t_p + 5 \text{ to } t_p + 12)$	-0.064***	-0.057***	-0.046***	-0.062***	-0.105***
Southwest' Actual Entry:					
$d(t_e)$	-0.063**	-0.136***	-0.128***	-0.157***	-0.215***
$d(t_e + 1)$	-0.086***	-0.128***	-0.133***	-0.201***	-0.202***
$d(t_e + 2)$	-0.077**	-0.182***	-0.192***	-0.282***	-0.294***
$d(t_e + 3)$	-0.077**	-0.190***	-0.175***	-0.222***	-0.252***
$d(t_e + 4)$	-0.094***	-0.178***	-0.136***	-0.233***	-0.252***
$d(t_e + 5 \text{ to } t_e + 8)$	-0.087***	-0.152***	-0.129***	-0.176***	-0.211***
Southwest' Exit(no flights):					
$d(t_x)$	-0.035	-0.021	-0.018	0.010	-0.056**
$d(t_x + 1)$	-0.034	-0.034	-0.017	0.018	-0.039
$d(t_x + 2)$	-0.061*	-0.020	-0.011	-0.027	-0.050
$d(t_x + 3)$	-0.047	-0.035	-0.021	-0.019	-0.038
$d(t_x + 4)$	-0.074**	-0.039	-0.031	-0.054	-0.098***
<i>Bankruptcy</i>	-0.158***	-0.011	-0.005	-0.112***	-0.175***
R-square	0.194	0.207	0.192	0.158	0.214
Observations	13,719	13,719	13,719	13,719	13,719

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

TABLE XIX
SELECTING ALL IMMEDIATELY-SERVICED ROUTES

	G^{lodd} (1)	$\ln P(10)$ (2)	$\ln P(20)$ (3)	$\ln P(80)$ (4)	$\ln P(90)$ (5)
N^{LEG}	-0.024***	0.010**	0.009*	-0.006	-0.004
N^{LCC}	0.046***	-0.010	-0.017	-0.021*	0.007
$d_p \cdot N^{LCC}$	-0.117***	0.173***	0.174***	0.058**	0.091***
$d_e \cdot N^{LCC}$	-0.061***	-0.013	-0.009	-0.008	-0.038**
Southwest' Announcement:					
$d(t_e - 8 \text{ to } t_e - 5)$	0.005	0.010	0.013	0.051	0.016
$d(t_e - 4)$	0.058	0.020	0.039	0.095***	0.078**
$d(t_e - 3)$	-0.007	0.105***	0.099***	0.124***	0.080**
$d(t_e - 2)$	0.035	0.102***	0.105***	0.176***	0.145***
$d(t_e - 1)$	-0.009	0.108***	0.099***	0.159***	0.105***
Southwest' Actual Entry:					
$d(t_e)$	-0.094***	-0.062***	-0.104***	-0.179***	-0.144***
$d(t_e + 1)$	-0.131***	-0.106***	-0.141***	-0.257***	-0.228***
$d(t_e + 2)$	-0.137***	-0.096***	-0.148***	-0.237***	-0.233***
$d(t_e + 3)$	-0.118***	-0.097***	-0.131***	-0.224***	-0.225***
$d(t_e + 4)$	-0.096***	-0.102***	-0.111***	-0.169***	-0.177***
$d(t_e + 5 \text{ to } t_e + 8)$	-0.115***	-0.107***	-0.124***	-0.172***	-0.174***
Southwest' Exit(no flights):					
$d(t_x)$	-0.090	-0.221***	-0.240***	-0.175***	-0.329***
$d(t_x + 1)$	-0.166**	-0.057	-0.122*	-0.140***	-0.194***
$d(t_x + 2)$	-0.114	0.015	-0.035	-0.037	-0.082*
$d(t_x + 3)$	-0.091	0.010	-0.039	-0.005	-0.057
$d(t_x + 4)$	-0.036	-0.011	-0.022	0.018	0.052
<i>Bankruptcy</i>	-0.213***	-0.015	-0.020	-0.124***	-0.168***
R-square	0.150	0.234	0.287	0.340	0.343
Observations	13,863	13,863	13,863	13,863	13,863

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

TABLE XX

SELECTING MIXED-CARRIER ROUTES BEFORE IMMEDIATELY SERVICED BY SOUTHWEST

	G^{lodd}	$\ln P(10)$	$\ln P(20)$	$\ln P(80)$	$\ln P(90)$
	(1)	(2)	(3)	(4)	(5)
N^{LEG}	-0.028***	0.017***	0.015**	-0.005	-0.003
N^{LCC}	0.038**	-0.004	-0.010	-0.014	0.009
$d_p \cdot N^{LCC}$	-0.087***	0.143***	0.147***	0.040*	0.077***
$d_e \cdot N^{LCC}$	-0.055**	-0.022	-0.016	-0.021	-0.051***
Southwest' Announcement:					
$d(t_e - 8 \text{ to } t_e - 5)$	-0.010	-0.017	-0.019	-0.012	-0.035
$d(t_e - 4)$	0.050	-0.067*	-0.052	-0.034	-0.023
$d(t_e - 3)$	-0.031	0.029	0.003	-0.010	-0.038
$d(t_e - 2)$	-0.010	0.050*	0.028	0.052	0.013
$d(t_e - 1)$	-0.089***	0.066**	0.044	0.045	-0.013
Southwest' Actual Entry:					
$d(t_e)$	-0.099**	-0.067**	-0.109***	-0.177***	-0.150***
$d(t_e + 1)$	-0.145***	-0.123***	-0.157***	-0.301***	-0.257***
$d(t_e + 2)$	-0.156***	-0.095***	-0.156***	-0.274***	-0.254***
$d(t_e + 3)$	-0.099***	-0.121***	-0.149***	-0.236***	-0.233***
$d(t_e + 4)$	-0.092**	-0.129***	-0.126***	-0.148***	-0.183***
$d(t_e + 5 \text{ to } t_e + 8)$	-0.117***	-0.145***	-0.157***	-0.177***	-0.194***
Southwest' Exit(no flights):					
$d(t_x)$	-0.115*	-0.198***	-0.218***	-0.159***	-0.314***
$d(t_x + 1)$	-0.191**	-0.035	-0.108*	-0.132***	-0.186***
$d(t_x + 2)$	-0.124*	0.028	-0.035	-0.038	-0.087*
$d(t_x + 3)$	-0.120	0.024	-0.030	-0.014	-0.076
$d(t_x + 4)$	-0.073	0.001	-0.010	-0.001	0.033
<i>Bankruptcy</i>	-0.172***	-0.006	0.007	-0.090***	-0.134***
R-square	0.123	0.283	0.322	0.336	0.333
Observations	7,782	7,782	7,782	7,782	7,782

Notes: 1) All regressions include time dummies and quarter dummies. The carrier-route-specific effects are treated as fixed. Standard errors are in parenthesis are clustered by route.

2) *, **, and *** indicate that the estimators are significant at 10%, 5%, and 1%, respectively.

APPENDIX E

EMPIRICAL RELATIONSHIP OF COMPETITION AND INTERCHANGE FEES

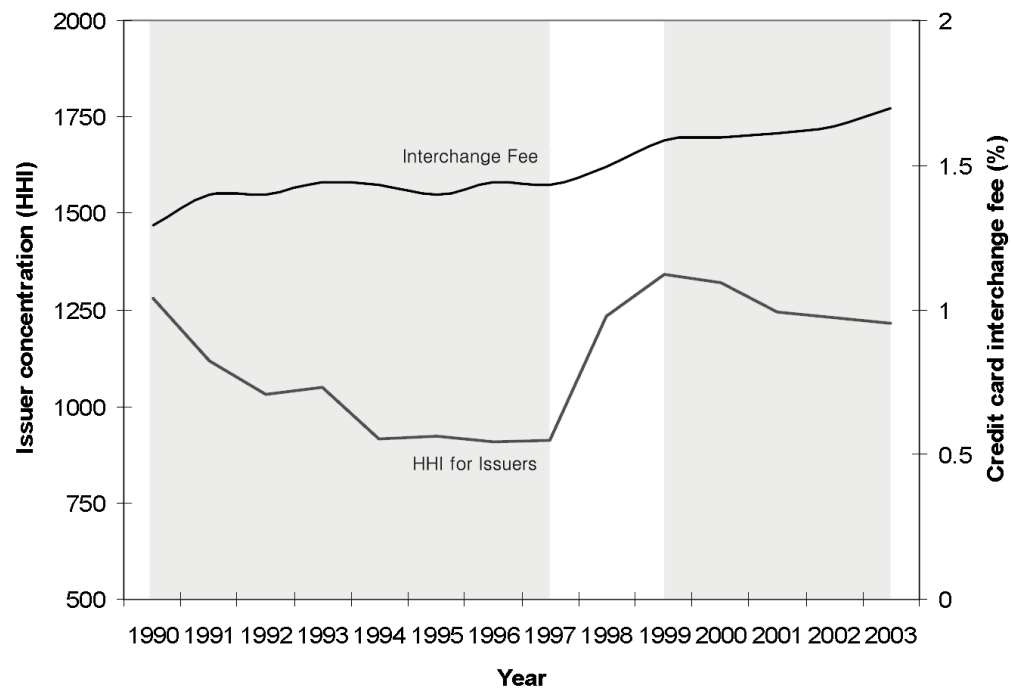


FIG. 12.—Empirical Relationship of Competition and Interchange Fees: The average interchange fee is calculated from Visa USA; the Herfindahl index for competition measure is calculated using data for the twenty largest issuers. The shaded area roughly indicates the period of Citibank's switching to MasterCard from Visa. Source: Figure 5 in Weiner and Wright (2005).

APPENDIX F

PROOFS

■ *Proof of Lemma 1.* (i) Suppose that both merchants accept credit cards. For given prices (p_i, p_j) , merchant i 's market share among consumers with $b_B \geq f_C^*$ is given by $p_i + tx_i^r = p_j + t(1 - x_i^r)$. Similarly, merchant i 's market share among consumers with $b_B < f_C^*$ is also given by $p_i + tx_i^c = p_j + t(1 - x_i^c)$. Then, merchant i solves

$$\max_{p_i} (p_i - d) \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) H(f_C^*) + (p_i - d - m + b_S) \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) (1 - H(f_C^*))$$

yielding at equilibrium

$$p^* = t + d(m - b_S)(1 - H(f_C^*)), \quad (\text{F.1})$$

$$\pi^* = \frac{t}{2}. \quad (\text{F.2})$$

To see if some merchant has an incentive to deviate from this proposed equilibrium, suppose now that merchant i does not to accept credit cards. Then, merchant i 's market share (x_i^c) among consumers with $b_B < f_C^*$ is given by $p_i + tx_i^c = p_j + t(1 - x_i^c)$ while its market share (x_i^r) among cardholders with $b_B \geq f_C^*$ is given by $p_i + tx_i^r = p_j + t(1 - x_i^r) - b_B + f_C^*$. Aggregating over all consumers, merchant i 's market share is

$$\begin{aligned} x_i &= \left(\frac{1}{2} + \frac{p_j - p_i}{2t} \right) H(f_C) + \int_{f_C^*}^{\bar{b}_B} \left(\frac{1}{2} + \frac{p_j - p_i - b_B + f_C}{2t} \right) dH(b_B) \\ &= \frac{1}{2} + \frac{1}{2t} [p_j - p_i - D(f_C)(\beta(f_C^*) - f_C^*)]. \end{aligned}$$

So, merchant i solves

$$\max_{p_i} [(p_i - d)x_i],$$

yielding

$$p_i = \frac{1}{2}[p_j + t + d - D(f_C^*)(\beta(f_C^*) - f_C^*)]. \quad (\text{F.3})$$

On the other hand, merchant j taking cards solves

$$\begin{aligned} \max_{p_j} \quad & \left[(p_j - d) \left(\frac{1}{2} + \frac{p_i - p_j}{2t} \right) H(f_C^*) \right. \\ & \left. + (p_j - d - m + b_S) \left(\frac{1}{2} + \frac{p_i - p_j + \beta(f_C^*) - f_C^*}{2t} \right) (1 - H(f_C^*)) \right], \end{aligned}$$

yielding

$$p_j = \frac{1}{2}[p_i + t + d + D(f_C^*)(\beta(f_C^*) - f_C^* + m - b_S)]. \quad (\text{F.4})$$

The equilibrium prices are obtained by solving merchants' best response function (F.3) and (F.4):

$$\begin{aligned} p_i &= t + d + \frac{1}{3}D(f_C^*)[(m - b_S) - (\beta(f_C^*) - f_C^*)], \\ p_j &= t + d + \frac{1}{3}D(f_C^*)[2(m - b_S) + (\beta(f_C^*) - f_C^*)] \end{aligned}$$

Each merchant's profit is given by

$$\pi_i = \frac{1}{2t} \left\{ t + \frac{1}{3}D(f_C^*)[(m - b_S) - (\beta(f_C^*) - f_C^*)] \right\}^2, \quad (\text{F.5})$$

$$\begin{aligned} \pi_j &= \frac{1}{2t} \left\{ t - \frac{1}{3}D(f_C^*)[(m - b_S) - (\beta(f_C^*) - f_C^*)] \right\}^2 \\ &\quad - \frac{1}{2t}(m - b_S)[\beta(f_C^*) - f_C^*]D(f_C^*)[1 - D(f_C^*)]. \end{aligned} \quad (\text{F.6})$$

Thus, merchant i 's not accepting the cards would be profitable ($\pi_i > t/2$) if and only if ²

$$\beta(f_C^*) - f_C^* < m - b_S.$$

Given that merchant i does not accept the cards, merchant j does not accept

²See Lemma 2 in Rochet and Tirole (2002): The set of the interchange fee such that all merchants reject the card is included in $(\underline{f}_I, \infty)$, where $\underline{f}_I \equiv b_S - c_A$.

the cards since its profit is less than $t/2$ when it accepts the cards. Therefore, there are only symmetric equilibria of all merchants accepting the cards or all merchants rejecting depending on whether $\beta(f_C^*) - f_C^* \geq m - b_S$ or not.

Let $f_C^* = f_C^*(c_I - \bar{f}_I)$ where \bar{f}_I is the interchange fee such that $\beta(f_C^*(c_I - \bar{f}_I)) - f_C^*(c_I - \bar{f}_I) = \bar{f}_I + c_A - b_S$. Given this, issuers may set the interchange fee slightly below \bar{f}_I , and then all merchants choose to accept the card. Furthermore, if merchant i are indifferent in accepting or not accepting the cards, both merchants are more likely to choose to accept the cards since accepting the cards provides high-quality services to consumers with $b_B > f_C$.

To see whether \bar{f}_I is unique, let $\psi(f_I)$ be as a function of the differences of the both sides of (4.7)³ :

$$\psi(f_I) = f_I + c_A - b_S - \beta(f_C^*(c_I - f_I)) + f_C^*(c_I - f_I). \quad (\text{F.7})$$

It is sufficient to show that $\psi(f_I)$ is monotonic increasing within an interval of f_I . The first-order derivative of (F.7) with respect to f_I is given by

$$\begin{aligned} \frac{\partial \psi(f_I)}{\partial f_I} &= 1 - \left(\frac{\partial \beta(f_C^*)}{\partial f_C^*} - 1 \right) \frac{\partial f_C^*}{\partial f_I} \\ &= 1 + \frac{1}{2} \frac{\partial f_C^*}{\partial f_I}. \end{aligned}$$

which is monotonic increasing if $\partial f_C^* / \partial f_I > -2$. From (4.10), $\partial f_C^* / \partial f_I = -n/(n+1) \in (-1, 0)$. By the definition of \bar{f}_I , $\psi(f_I) > 0$ for $f_I > \bar{f}_I$ while $\psi(f_I) < 0$ for $f_I < \bar{f}_I$. \square

(ii) It is sufficient that the unconstrained profit function is increasing over the interchange fee. Since the association is constrained by the condition that all merchants accept the platform cards, the largest interchange fee that satisfies the constraint will be the equilibrium interchange fee.

³In equilibrium, f_C^* is a function of $c_I - f_I$. See the equation (F.11).

Let π^{total} be the total profit of issuers which is given by

$$\pi^{\text{total}} = (f_C^*(c_I - f_I) + f_I - c_I - l(n; \alpha))(1 - H(f_C^*(c_I - f_I))). \quad (\text{F.8})$$

The first-order derivative of (F.8) with respect to f_I is

$$\frac{\partial \pi^{\text{total}}}{\partial f_I} = \left(\frac{\partial f_C^*}{\partial f_I} + 1 \right) (1 - H(f_C^*)) - (f_C^* + f_I - c_I) h(f_C^*) \frac{\partial f_C^*}{\partial f_I}.$$

It can be shown that $\partial \pi^{\text{total}} / \partial f_I > 0$ if

$$-1 \leq \frac{\partial f_C^*}{\partial f_I} < 0$$

which is satisfied with the first-order derivative of (4.10). Thus, the equilibrium interchange fee will be the largest interchange fee to satisfy (4.7). \square

■ *Proof of Proposition 1.* Given $f_I \leq \bar{f}_I$, an issuer under a Cournot Oligopoly sets the quantity of card payment services non-cooperatively to maximize its own profit:

$$\max_{q_i} (\bar{b}_B - k \sum_{j=1}^n q_j + f_I - c_I - l(n; \alpha)) q_i. \quad (\text{F.9})$$

The first-order condition with respect to q_i is

$$\bar{b}_B + f_I - c_I - l(n; \alpha) - k \sum_{j \neq i}^n q_j - 2k q_i = 0.$$

Since issuers are symmetric,

$$q^* = \frac{1}{k(n+1)} (\bar{b}_B + f_I - c_I - l(n; \alpha)). \quad (\text{F.10})$$

Plugging (F.9) into (F.7) yields

$$f_C^* = \frac{1}{(n+1)} \bar{b}_B - \frac{n}{(n+1)} (f_I - c_I - l(n; \alpha)). \quad (\text{F.11})$$

From (4.7), (4.8), and (F.11), the fees in equilibrium are given by

$$\begin{aligned} f_C^*(n) &= \bar{b}_B - \frac{2n}{(n+2)}(\bar{b}_B + b_S - c_I - l(n; \alpha) - c_A), \\ f_I^*(n) &= c_I + l(n; \alpha) - \bar{b}_B + \frac{2(n+1)}{(n+2)}(\bar{b}_B + b_S - c_I - l(n; \alpha) - c_A). \end{aligned}$$

Let $g(n) = \bar{b}_B + b_S - c_I - l(n; \alpha) - c_A$ for simplicity. The first-order derivatives of (4.10) and (4.11) with respect to n are

$$\frac{\partial f_C^*(n)}{\partial n} = -\frac{4}{(n+2)^2}g(n) + \frac{2n}{(n+2)}\frac{\partial l(n; \alpha)}{\partial n} < 0,$$

and

$$\frac{\partial f_I^*(n)}{\partial n} = \frac{2}{(n+2)^2}g(n) - \frac{n}{(n+2)}\frac{\partial l(n; \alpha)}{\partial n} > 0.$$

since $g(n) > 0$ for all n and $\partial l(n; \alpha)/\partial n < 0$.

■ *Proof of Proposition 2.* The first-order condition for maximizing (4.13) with respect to n is

$$\frac{\partial \pi_i(n)}{\partial n} = \frac{8}{k(n+2)^2}g(n) \left[g'(n) - \frac{g(n)}{(n+2)} \right] = 0.$$

Then, the optimal number of issuers, n^* , solves $g'(n) = g(n)/(n+2)$.⁴ The second-order condition is given by

$$\frac{\partial^2 \pi_i(n)}{\partial n^2} = \frac{8}{k(n+2)^2} \left[\left(\frac{2g(n)}{(n+2)} - g'(n) \right)^2 - \frac{g(n)^2}{(n+2)^2} + g(n)g''(n) \right],$$

which is negative at n^* since $g'(n^*) = g(n^*)/(n^*+2)$, $g(n^*) > 0$ and $g''(n^*) < 0$. Note that the condition for a global maximizer is $\partial^2 \pi_i(n)/\partial n^2$, which is equivalent to the condition that $(2g(n)/(n+2) - g'(n))^2 < g(n)^2/(n+2)^2 - g(n)g''(n)$ □

■ *Proof of Proposition 3.* The first-order derivative of (4.14) with respect to n

⁴Let $\phi(n) = g'(n) - g(n)/(n+2)$. Unless $g''(n) < g'(n)/(n+2) - g(n)/(n+2)^2$ for all n , there exist $n \neq n^*$ that solve $\phi(n) = 0$.

is given by

$$\frac{\partial W(f_C^*(n))}{\partial n} = \frac{1}{k} \left\{ (\bar{b}_B - f_C^*(n) - g(n)) \frac{\partial f_C^*(n)}{\partial n} + g'(n)(\bar{b}_B - f_I^*(n)) \right\}. \quad (\text{F.12})$$

Plugging (4.10) into (F.12) yields

$$\frac{\partial W(f_C^*(n))}{\partial n} = \frac{1}{k} \left\{ \frac{n-2}{n+2} g(n) \frac{\partial f_C^*(n)}{\partial n} + \frac{2n}{n+2} g'(n) g(n) \right\}.$$

Using $\partial f_C^*(n)/\partial n$,

$$\frac{\partial W(f_C^*(n))}{\partial n} = \frac{4}{k(n+2)^3} g(n) \left\{ -\frac{n-2}{n+2} g(n)^2 + 2n g'(n) g(n) \right\} = 0. \quad (\text{F.13})$$

By the definition of $\tilde{\alpha}$, the first-order condition (F.13) is satisfied at $n = n^*$ and $\alpha = \tilde{\alpha}$:

$$\frac{\partial W(f_C^*(n; \alpha))}{\partial n} \Big|_{n=n^*, \alpha=\tilde{\alpha}} = 0,$$

which is equivalent to

$$-\frac{n^*-2}{n^*+2} g(n^*; \tilde{\alpha}) + 2n \frac{\partial g(n^*; \tilde{\alpha})}{\partial n} = 0. \quad (\text{F.14})$$

Since $\partial g(n)/\partial \alpha > 0$ and $\partial g(n)/\partial n \partial \alpha < 0$, the condition (F.14) becomes negative for $\alpha > \tilde{\alpha}$:

$$\frac{\partial W(f_C^*(n; \alpha))}{\partial n} \Big|_{n=n^*, \alpha > \tilde{\alpha}} < 0.$$

For $\alpha < \tilde{\alpha}$, the condition (F.14) becomes positive for $\alpha > \tilde{\alpha}$:

$$\frac{\partial W(f_C^*(n; \alpha))}{\partial n} \Big|_{n=n^*, \alpha < \tilde{\alpha}} > 0.$$

Therefore, the socially optimal number of issuers is less than the number of issuers for $\alpha > \tilde{\alpha}$:

$$n' < n^*.$$

For $\alpha < \tilde{\alpha}$, it is greater than n^* .

■ *Proof of Lemma 2.* Since there is no reason to reject the card after lifting the no-surcharge rule, merchant i solves

$$\max_{p_i^c, p_i^r} \left[(p_i^c - d) \left(\frac{1}{2} + \frac{p_j^c - p_i^c}{2t} \right) H(f_C + p^r - p^c) \right. \\ \left. + (p_i^r - d - m + b_S) \left(\frac{1}{2} + \frac{p_j^r - p_i^r}{2t} \right) (1 - H(f_C + p^r - p^c)) \right],$$

where p^c and p^r denote cash and card prices, respectively. If both merchants decide to surcharge on card payment, then the prices will be given by

$$\begin{aligned} p^c &= t + d, \\ p^r &= t + d + m - b_S. \end{aligned}$$

Each merchant's profit is equal to

$$\pi^* = \frac{t}{2}.$$

To see whether surcharging on card payments is an equilibrium, suppose now that merchant i decides not to surcharge on card payment. Then, merchant i ' market share among each groups of consumers are determined by

$$\begin{aligned} p_i + tx_i^c &= p_j^c + t(1 - x_i^c) \quad \text{among consumers with } b_B < f_C + p^r - p^c, \\ p_i + tx_i^r &= p_j^r + t(1 - x_i^r) \quad \text{among consumers with } b_B \geq f_C + p^r - p^c. \end{aligned}$$

It can be shown that merchant i and j set the prices such that

$$p_j^c < p_i < p_j^r,$$

where $p_i = t + d + (m - b_S)(1 - H(f_C + p^r - p^c))$, $p_j^c = t + d + \frac{1}{2}(m - b_S)(1 - H(f_C + p^r - p^c))$, and $p_j^r = t + d + (m - b_S)(1 - H(f_C + p^r - p^c)) + \frac{1}{2}(m - b_S)H(f_C + p^r - p^c)$. Then,

merchant i and j obtain profits as follow:

$$\begin{aligned}\pi_i &= \frac{t}{2} - \frac{1}{4t}(m - b_S)^2 H(f_C + p^r - p^c)(1 - H(f_C + p^r - p^c)) \\ \pi_j &= \frac{t}{2} + \frac{1}{8t}(m - b_S)^2 H(f_C + p^r - p^c)(1 - H(f_C + p^r - p^c)).\end{aligned}$$

Therefore, merchant i has no incentives to deviate from surcharging on card payments unless $m = b_S$. Though $m = b_S$, each merchant's profit is $t/2$, respectively. Therefore, merchants are more likely to surcharge on card payments for providing high-quality services to consumers who benefit from using the cards. \square

■ *Proposition 4* . (i) Let f_C^{**} be the equilibrium customer fee in a symmetric Cournot oligopoly. The association solves

$$\max_{f_I} [f_C^{**} + f_I - c_I - l(n; \alpha)] [1 - H(f_C^{**} + f_I + c_A - b_S)]. \quad (\text{F.15})$$

The first-order condition of (F.15) is

$$1 - \frac{1}{k}(f_C^{**} + f_I - c_I - l(n; \alpha) - \underline{b}_B) - \frac{1}{k}(f_C^{**} + f_I - c_I - l(n; \alpha)) = 0,$$

yielding

$$f_C^{**} + f_I^{**} = c_I + l(n; \alpha) + \frac{1}{2}\bar{b}_B. \quad (\text{F.16})$$

Since $f_C^{**} + f_I^{**} > f_C^S + f_I^S$, the quantity of card payment services is under-provisioned

:

$$1 - H(c_I + l(n; \alpha) + \frac{1}{2}\bar{b}_B + c_A - b_S) < 1 - H(c_I + l(n; \alpha) + c_A - b_S)$$

(ii) Since the demand for card payment services is

$$D(f_C + f_I + c_A - b_S) = 1 - \frac{1}{k}(f_C + f_I + c_A - b_S - \underline{b}_B),$$

the inverse demand function is given by

$$f_C + f_I = \bar{b}_B + b_S - c_A - k \sum_{j=1}^n q_j.$$

Then, each issuer solves

$$\max_{q_i} (\bar{b}_B + b_S - c_A - k \sum_{j=1}^n q_j) q_i.$$

The first-order condition with respect to q_i is

$$\bar{b}_B + b_S - c_A - c_I - l(n; \alpha) - k \sum_{j \neq i}^n q_j - 2kq_i = 0.$$

Since issuers are symmetric,

$$q^{**} = \frac{1}{k(n+1)} (\bar{b}_B + b_S - c_A - c_I - l(n; \alpha)), \quad (\text{F.17})$$

$$(f_C + f_I)^{**} = c_I + l(n; \alpha) + \frac{1}{n+1} (\bar{b}_B + b_S - c_A - c_I - l(n; \alpha)). \quad (\text{F.18})$$

Therefore, it is obvious that

$$\begin{aligned} \lim_{n \rightarrow \infty} (f_C + f_I)^{**} &= c_I + l(\infty) \\ &= \tau^S. \end{aligned}$$

□

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